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EXCURSION GUIDE

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CONTENT

GEOLOGICAL OVERVIEW OF ROMANIAN CARPATHIANS

The Romanian Carpathians represent an arcuate belt formed in response to the Triassic-Tertiary evolution of the three continental blocks: Tisza represented by the **Inner Dacides**, Dacia represented by **Median Dacides** and Eastern European-Scythian-Moesian Platforms. These three blocks were separated by two oceanic domains which evolved during the extensive stage of Carpathians, and now are deformed and involved in **Transylvanide/ Pienide Units** in-between Inner and Median Dacides, and **Outer Dacide Units** in-between Median Dacides and platform's block (Săndulescu, 1980; 1984, 1988; Csontos&Vörös, 2004).

The **Transylvanides** or Vardar-Mureş Ocean is a branch of Tethys Ocean (Săndulescu, 1984, 1988; Fig. 1) opened in Triassic and closed during Cretaceous tectonic events. The **Outer Dacide** Trough or Ceahlău-Severin "Ocean" opened in Jurassic and evolved to Early Cretaceous (Săndulescu, 1980; 1984), the Middle Jurassic-Early Cretaceous black flysch being the only sedimentary deposit accumulated on oceanic crust (basalts and basic tuffs of intraplate type) in its the inner part (Black Flysch Nappe). The Outer Dacides might be an extension of the Silesian Basin (Golonka *et al.*, 2006) or of the Magura Ocean from Western Carpathians (Csontos & Vörös, 2004). Bădescu (2005) considers that Outer Dacides Trough merged into the Transylvanide Ocean, consequently the **Median Dacides** being a pinching out ribbon microplate. Schmidt et al. (2008) consider the Ceahlău-Severin Ocean to be the easternmost branch of the Alpine Tethys.

The internal margin of Ceahlău "Ocean" was represented by Median Dacides, while the external part was represented by Moldavide Realm, where were accumulated the Early Cretaceous-Miocene deposits built in **Moldavide Units** (during Miocene tectonic events). The Outer Dacides and Moldavide's Domains were separated by a forebulge (former periMoldavian Cordillera intuited by Băncilă, and named by Săndulescu, 1984), risen after Median Dacides thrusting over Outer Dacides domain since early Cretaceous. This forebulge was source area both for internal basin and external one beginning with Early Cretaceous. Between Early Cretaceous and Early Miocene the Moldavide's Basin behave as a foreland basin system whose sedimentary axis migrated from internal to external part (Bădescu, 2005). During Cretaceous the Moldavide's Basin depocenter was located onto the Convolute Flysch Nappe sedimentation area, where thick turbidites were sedimented, while during Paleogene onto Tarcău Nappe sedimentation area, where the so-called mixed or Tazlau/Moldovița "lithofacies" succession was sedimented (Atanasiu, 1943; Ionesi, 1971). During Miocene the depocenter of Moldavide's Basin was located onto the Pericarpathian Nappe sedimentation area.

The sedimentation in whole Moldavide's Basin was mainly of flysch type. Two anoxic events can be recognized as background sedimentation whose black shale-type deposits are the main potential source rock of the oil in Carpathian Realm (Popov *et al.*, 2002; Ştefănescu et al., 2006; Kotarba & Koltun, 2006): the first one in Early Cretaceous, and the second one in Oligocene-Early Miocene. The first one corresponds to the so-called Oceanic Anoxia Events, while for the second one there are more presumed controls such as: the isolation of the Paratethys basin from Mediterranean one after the collision between Africa and Eurasia plates during Oligocene (Rögl, 1999), the global climatic changes which begun since Middle Eocene (Pomerol&Premoli-Silva, 1986; Sotak *et al.*, 2002), or the sea level fluctuations.

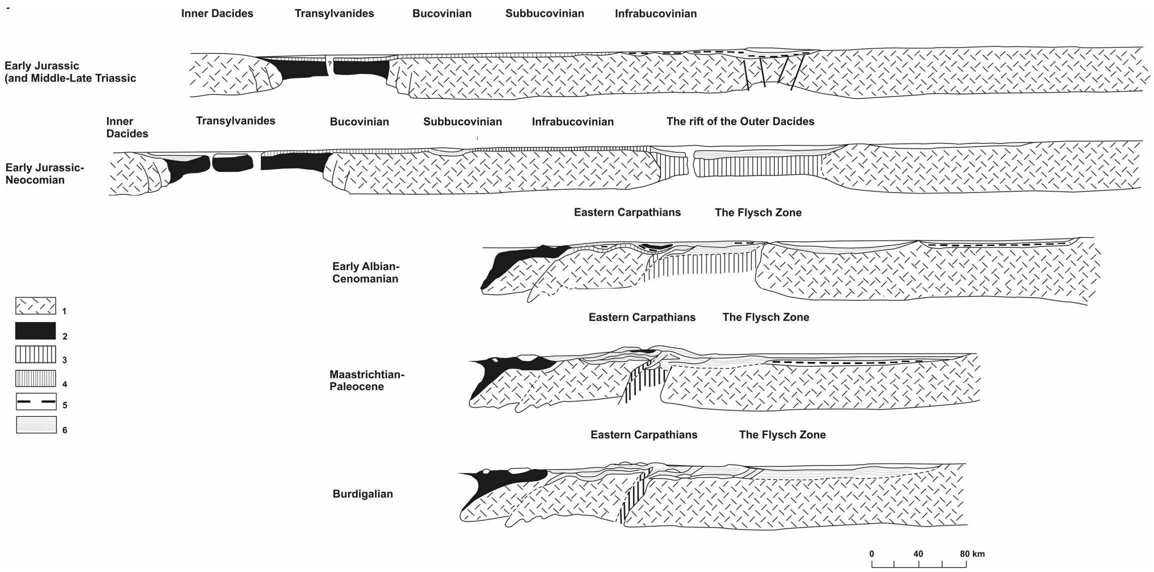

Fig. 1. The geo-tectonic evolution of Carpathians (after Săndulescu, 1984, 1988):
1 – continental crust; 2 – oceanic crust; 3 – thinned crust; 4 – pelagic deposits; 5 – flysch deposits.

The two anoxic events were separated by well oxygenated sedimentation conditions whose products were variegated shales, marls and grey-green shales known in whole Outer Carpathians Basin (Săndulescu, 1984, 1988, Kotarba&Koltun, 2006; Ştefănescu *et al*., 2006). The coarse material was supplied by two source areas: an internal one represented by Median Dacides in Early Cretaceous and by Median and Outer Dacides since Late Cretaceous, and an external one represented by cratonic area, proved by the presence of “green schist clasts” supplied by a Central Dobrogea type source area. In fact, the products of this latter source became obvious since Late Cretaceous, although there were also some signs before. The interference area of two sources was on future Tarcău Nappe “mixed” facies area of sedimentation.

The two source area supplied different types of sands, the reason for why, beginning with Eocene, on Tarcău Nappe sedimentation area were differentiated the so-called “Lithofacies” (Băncilă, 1958; Ionesi, 1971; Grasu *et al*., 1988): the internal Tarcău-Fusaru “Lithofacies”, the mixed Tazlău-Moldovița L., and the external Doamna-Kliwa L. The internal source supplied mainly litho-feldspathic sands rich in micas (Tarcău-Fusaru Sandstone), while the external one mainly quartzose sands (known in whole Carpathian Basin as Kliwa Sandstone).

During the Oligocene-Early Miocene anoxia in Paratethys, the most important hydrocarbon source rocks were accumulated in Carpathian Realm, which are known as “menilite facies” or Menilite member (Popov *et al*., 2002), and consist in black shale type deposits such as: dysodilic shale, bituminous marls and menilites. To the end of NP23 was the maximum isolation of Paratethys when the marker black cherts were accumulated (Nagymarosy, 2000; Rögl, 1999). The anoxic conditions were interrupted form time to time, like in NP 24 interval (Rögl, 1999). The main lithostratigraphic units defined for the Outer Dacides and Moldavides are shown in Table 1.

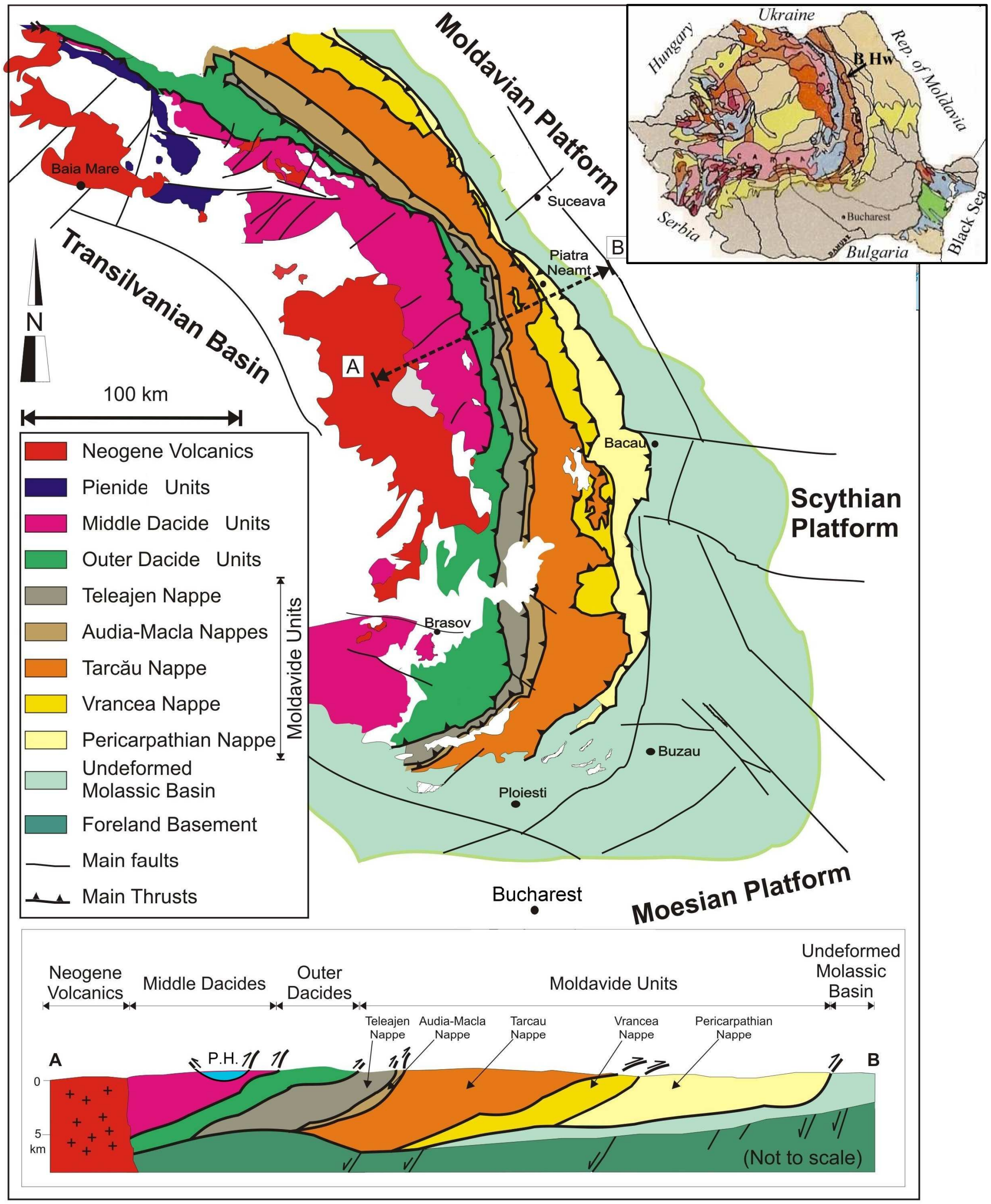

Fig. 2. Geological sketch of the East Carpathians modified after Bădescu (2005): BHw – Bistrița Half-window (see the text); P.H. – Hăşmaş Transylvanian Nappe.

The Moldavide's Basin deposits were built up in the so-called **Moldavide Units** (Teleajen or Convolute Flysch, Macla, Audia, Tarcău Nappe, Vrancea or Marginal Folds and Pericarpathian nappes) completely detached from their basement. The Moldavide Units are thin-skinned nappes folded and thrusted successively in Miocene tectonic events (intra-Burdigalian, intra-Badenian and intra-Sarmatian). The evolution of Moldavides stacking is considered well documented (Săndulescu, 1984, 1988; Roure *et al.*, 1993; Ellouz and Roca, 1994). Three compressive deformation of Moldavide's Basin were recognized: a) intra-Burdigalian tectogenesis (overthrusting of the Convolute Flysch, Macla and Audia Nappes); b) intra-Badenian (overthrusting of the Tarcău Nappe and of the Marginal Folds Nappe); c) intra-Sarmatian (overthrust of the Subcarpathian Nappe together with the other more internal nappes).

As a consequence of the latter tectonic events (Miocene), a **foredeep basin** developed in front of folded and thrusted chain in which Badenian-Quaternary autochtonous molasses deposits were accumulated. It belongs to the so-called "new" foreland basin system of Grasu *et al.* (1999, 2002).

Locally, in Carpathian Bend Area, the deposits of Pericarpathian Nappe were deformed in Pleistocene, during the Wallachian tectogenesis (Săndulescu, 1988).

THE CARPATHIAN GEOLOGICAL STRUCTURE

The Carpathians (Fig. 2) are the result of Tethys Ocean closure during Cretaceous and Miocene convergence events. Two main periods of compressive deformation can be recognized in the Romanian Carpathians (Săndulescu, 1988):

a. the Cretaceous events, during which the **Dacides** (=Inner Carpathians: Inner, Middle, Outer Dacides and Marginal Dacides only in the southern Carpathians) and **Transylvanides** were built up;

b. the Miocene events during which the **Moldavides** (=Outer Carpathians: Convolute Flysch, Macla, Audia, Tarcău, Marginal Folds or Vrancea and Pericarpathian Nappes from internal to external area) were built up.

As a result of these compressive periods, the Carpathian structure developed, which consists of the following units (Dumitrescu *et al.*, 1962; Rădulescu & Săndulescu, 1973; Săndulescu 1975, 1980, 1984; Debelmas *et al*., 1980):

1. the **Transylvanides** (southern Apuseni Mts), consisting of oceanic crust nappes, which represent the major Tethyan branch between Tisza (**Inner Dacides**) and Dacia (**Median Dacides**) blocks. These units are replaced by the **Pienides**, northward of N-Transylvanian crustal fracture, consisting of nappes built up both in Cretaceous and in Miocene tectogeneses. The obduction of **Transylvanian Nappes** onto Median Dacides can also be linked by these Cretaceous tectogeneses.

2. the **Inner Dacides** (Northern Apuseni Mts) consist of several northward and north-eastward vergent continental-crust nappes (prolonged below the *Pannonian Basin* and below the north-western *Transylvania*) made of pre-Cambrian and Palaeozoic metamorphic rocks (locally granites) and Upper Carboniferous-pre-Senonian sedimentary cover. They were considered as part of Fore-Apulian Plate (Săndulescu, 1984) or Tisza block (Csontos&Vörös, 2004).

3. the **Median Dacides** (also known as **Crystalline-Mesozoic Zone**) consist of continental basement nappes made of Precambrian and/or Palaeozoic crystalline units and Mesozoic (pre-Cenomanian) sedimentary cover. Csontos&Vörös (2004) consider that they belong to Dacia block. The age of deformation is Middle-Late Cretaceous, and Palaeogene post-nappe deposits unconformably lie above Median Dacides. There were recognized, from the geometrically base to top, Infrabucovinian, Subbucovinian, and Bucovinian Nappes. A review of this structural unit is presented in the next chapter.

Table 1. Lithostratigraphic units of the main nappes of central-northern Eastern Carpathian Flysch
(based on Grasu *et al*., 1988 and Grasu *et al*., 1996)

	OUTER DACIDE	**MOLDAVIDES**					
Age	**Ceahlău Nappe**	**Teleajen N.**	**Audia N.**	**Tarcău Nappe**			**Marginal Folds N.**
				Tarcău/Fusaru L.	Tazlău/Moldovița L.	Doamna/Kliwa L.	
E. MIOCENE	Post-tectonic deposits locally preserved	Post-tectonic cover mainly in Bend area	*Eroded in central-north area* Only locally preserved (mainly in the Bend area)	Vinețișu Fm (turbidites)		*Eroded on Bistrița Halfwindow area*	Gura Șoimului Formation; Upper dysodilic shale and menilites
OLIGOCENE				Fusaru Sst Fm. (litharenites)	Fusaru type+Kliwa type Sst interlayered	Kliwa Sst Fm (quartzarenites)	
				Lower Dyssodilic Shale Fm. (black shale)			
				Bituminous Marls Fm			
				Lower menilite Fm. (black cherts)			
				Ardeluța Fm	Lupoaia Fm.	Lucăcești Sst. (quartzarenite)	
EOCENE				Podu Secu Fm (flysch)	Plopu Fm (flysch)	Bisericani Fm. (mainly pelite)	
				Tarcău Sst. Fm. Litho-feldspathic sst	Tazlău Fm. (Tarcău sst with limestone	Doamna Limestone Fm	
						Sucevița Fm (turbidites)	Jgheabu Mare Fm. (spiculite)
PALEOCENE			Prisaca-Tomnatec Sst. Fm		Straja Fm (fine turbidites with spiculite)		Piatra Uscată Fm. (calcareous flysch)
				Horgazu Fm. (sandy-marly flysch)	Izvor Fm (coarse calcareous turbidites)		Runcu Fm.
L. CRETACEOUS		Upper Convolute Flysch			Hangu Fm (mainly marls)		Lepșa Fm.
E CRETACEOUS	*E or unsedim*; Ceahlau Cgls.; *E or unsedi*; Bodoc-Sanmartin Fm	Cotumba Sst and Lețesti conglomerates	Variegated shale	Cârnu-Șiclău Fm (variegated shale)			Tisaru Fm (variegated shale)
		Lower Convolute Flysch					
	Bistra F.; Piscu Fm; Comarnic F.	Toroclej Fm. Plăieși Fm.	Audia. Fm. (mainly black skale): Upper member: glauconitic quarzarenites Middle member: black shales with lidite Lower member: black shale with spherosiderites				Sărata Fm UM: limestone MM. black shale with lidite LM: clay-limestone
	U. Sinaia Fm	Not known					
L. JURASSIC	L. & M. Sinaia Fm.						

In blue the lithostratigraphic units examined during the fieldtrip

4. the **Outer Dacides** (Black Flysch, Baraolt, only in the Bend Area, Ceahlău, Bobu, and Severin, in Southern Carpathians, Nappes) were deformed during the Mesozoic and Paleocene and represent the second suture in Romanian Carpathians (Rădulescu& Săndulescu, 1973; Săndulescu, 1975, 1980, 1984; Debelmas *et al.*, 1980). The nappes resulted from the deformation of a region similar to the Afar-Red Sea area (Ceahlău-Severin "Ocean") wherein a Jurassic thinned or oceanic crust (proved by basic and ultrabasic eruptive rocks) developed. The sedimentary cover consists only of Tithonian-Cretaceous deposits, the Paleogene ones, which are preserved especially in Bend Area, representing their post-tectogenetic cover.

5. the **Moldavides** consist of sedimentary cover nappes which were stacked during the Miocene evolution and represent the most important part of the Eastern Carpathian. The Moldavide Units (excluding the Pericarpathian Nappe) are made up mainly of Cretaceous to Miocene flysch-type deposits. The Pericarpathian Nappe is mainly made up of molasses deposits.

The Moldavides were stacked during the Miocene, the resulted nappes being, from inward to outward: Convolute Flysch, Macla, Audia, Tarcău, Marginal Folds (Vrancea), and Pericarpathian Nappes.

6. the **foredeep** is filled with undeformed Middle Miocene to Recent clastic deposits, lying over the outer part of the deformed Moldavides and the foreland represented by platforms of different ages;

7. the **foreland** of the East Carpathians is represented by platforms (East European, Scythian and Moesian) of different ages and it includes, in a sector close to the Black Sea, the so-called North Dobrogea Orogen which represents a Cimmerian folded belt made up of deformed Paleozoic crystalline and sedimentary units, Triassic and Jurassic sedimentary and magmatic rocks (with Triassic intra-plate ophiolites) (Săndulescu& Visarion, 2000).

8. the **Neogene Volcanic arch** can be recognized in the internal part of the East Carpathians; it was generated during the consumption of the basement of the **Outer Dacides** and **Moldavides1**.

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THE CRYSTALLINE-MESOZOIC ZONE OF THE EAST CARPATHIANS. A REVIEW[1]

1. STRUCTURE

The Crystalline-Mesozoic Zone of the East Carpathians, if we are referring to the mobile Alpine belt, belongs to Median Dacides (Săndulescu, 1984) or, alternatively, to the eastern Getides (Balintoni, 1997). It means that continental margin of the Getic plate adjacent to the Outer Dacide rift, in the area opposite to the Moldavian Platform was sheared in order to generate several nappes. These are (from top to bottom): Bucovinian, Subbucovinian and Infrabucovinian nappes (Săndulescu, 1984). The Bucovinian Nappe supports in places the "Transylvanian Nappes" (Sandulescu, 1984), or the Wildflysch Nappe and gravity gliding Klippen (Hoeck *et al.*, 2009), devoid of a crystalline basement. In their turn, at least the Bucovinian and Subbucovinian nappes, consist of several Variscan tectonic units, as follows: (from top to bottom): Rarău Nappe, Putna Nappe, Pietrosu Bistriței Nappe and Rodna Nappe (Balintoni, 1981, Săndulescu *et al.*, 1981; Balintoni *et al.*, 1983).

1.1. Alpine tectonic units

a. Bucovinian Nappe - The Bucovinian Nappe - the uppermost nappe of the Getides or Median Dacides - preserves overlying its metamorphic basement, Mesozoic sedimentary cover on large areas, including Triassic, Jurassic and Early Cretaceous deposits (Săndulescu, 1984 and references there in). It is largely developed especially south of the Vatra Dornei town.

b. Subbucovinian Nappe - The Subbucovinian Nappe crops out in a series of tectonic windows below the Bucovinian Nappe, e.g. Tomeşti window in the southernmost part of the Crystalline-Mesozoic Zone, the windows in the basin of the Putna Valley and the large outcropping area northward of the Vatra Dornei town, along the Bistrița River valley. Likewise, in front of the Bucovinian Nappe several "rabotage" outliers, belonging to the Subbucovinian Nappe, crop out, like the one at Dămuc River confluence with Bicaz River. The Subbucovinian sedimentary succession covering the metamorphic basement is thinner than the Bucovinian one, with many gaps and unconformities. It starts with Permian verrucano deposits and ends with Neocomian calcareous breccias and calcarenites.

c. Infrabucovinian tectonics units - The Infrabucovinian tectonic units are found in a series of tectonic windows as fragments without continuity. In Maramureş, they are floating on the Black Flysch Nappe or on the Ceahlău Nappe. In places, they are represented only by sedimentary deposits, devoid of a crystalline basement. The presence of several sedimentary facies groups points out a large territory, highly sheared. From inside to outside the Infrabucovinian Units sedimentary covers can be grouped, according to the facies groups, in more and more complete sequences from Jurassic to Permian. Outside the Maramureş Mountains, the Infrabucovinian Units crop out in the Rodna Mountains, in the Rusaia, Vatra Dornei-Iacobeni and Arşița Barnarului windows. It is to note the Măgurele "rabotage" outlier in the frontal part of the Bucovinian Nappe, north of Sadova.

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[1] The text and associated figures are from Balintoni (2010).

1.2. Variscan Tectonic Units

The basements of the Bucovinian and Subbucovinian Nappes include all the four mentioned Variscan tectonic units, which are Rarău, Putna, Pietrosu Bistriței, and Rodna (Balintoni, 1981, 1997).

a. The Rodna Unit question - Rodna Unit has always been delimited in the base by an Alpine shear plane and therefore it probably constituted the autochtonous for the Variscan thrusts. Consequently, the Rodna Unit does not represent a Variscan nappe. When we refer to it, we have to consider this aspect because, in fact, there are only three true Variscan nappes: Rarău, Putna and Pietrosu Bistriței.

b. Extension of the Variscan Nappes - The Putna and Pietrosu Bistriței nappes, although discontinuous, crop out in the Bucovinian and Subbucovinian Nappes. It means that they have had a double extension compared with these nappes. The Rarău Nappe is part of the basement of the Bucovinian and Subbucovinian nappes and it forms the whole basement of the Infrabucovinian Nappes. This fact could indicate an ample Variscan thrusting if we consider that the outcrop width of the Crystalline-Mesozoic Zone of the East Carpathians can exceed 30 km. The minimum distance of the tectonic transport for the Putna and Pietrosu Bistriței Nappes is of 60 km and that for the Rarău Nappe of more than 100 km. If we follow transversally the components of the Bucovinian and Subbucovinian nappes basement then we observe the predominance of the Rarău and Putna Variscan nappes in the eastern part and of the Rodna Nappe in the western part, quite clearly due to the western vergence of the Variscan shear planes.

2. THE SUCCINCT FEATURES OF THE METAMORPHITES IN THE VARISCAN TECTONIC UNITS

Balintoni *et al.* (2009) described three pre-Alpine terranes in the basement of the East Carpathians: Bretila, Tulgheş and Rebra. The Bretila terrane is constituted from the Bretila metamorphic unit, Tulgheş from Tulgheş metamorphic unit and Rebra from Negrişoara and Rebra metamorphic units. The Variscan nappes consist of slices of these metamorphic units.

Rarău Nappe. In the Bucovinian and Subbucovinian Alpine nappes the Rarău nappe contains slices of the Bretila metamorphic unit. In the Infrabucovinian Units of the Rodna Mts., transgressive on the Bretila terrane fragments are known the Rusaia, Repedea and Cimpoiasa epizonal sequences (H. H. Kräutner, 1988).

Putna Nappe. Different slices of the Tulgheş metamorphic unit are located in the basement of the two upper Alpine nappes.

Pietrosu Bistriței Nappe. It is formed of the Negrişoara metamorphic unit.

Rodna Unit. It includes fragments of the Rebra metamorphic unit.

The Bretila, Negrişoara and Rebra metamorphic units are mesozonal polymetamorphic sequences, Early Paleozoic in age (Pană *et al*., 2002, Balintoni *et al*., 2009). The Tulgheş metamorphic unit is also a polymetamorphic sequence of the same age, but variable metamorphosed in the greenschists facies.

2.1. Description of the metamorphic sequences

a) Bretila metamorphic unit

Lithostratigraphy. Bretila metamorphic unit (Fig. 3) was defined in 1938 by T. Kräutner as the autochthonous mesozone of the East Carpathians. In 1968, H. Kräutner stressed out the lithostratigraphic correspondence of the Bretila Series with that of the Rarău gneisses. Bercia *et al.* (1971)[2] included in the Bretila Series the following sequences: Bretila Series in the Bistrița and Rodna Mts; Rarău Gneisses Series in the Rarău and Haghimaş, synclines; Novăț Series in the Vaser Basin; Pop Ivan mesozone; Belopotoc Series over the border.

This represents a decisive step in the knowledge of the similar features of successions belonging to this metamorphic unit in all the major outcropping places, excepting the Vatra Dornei-Iacobeni mezozone, which was assigned to the Rebra Series. That confusion was cleared up by Balintoni (1984).

Lithology. Although it is poorly divided in lithostratigraphic respect, the Bretila metamorphic unit is well known and characterized from lithologic point of view. The Infrabucovinian Nappes include: paragneisse, microcline gneiss, fine-grained white gneiss with leptinitic appearance alternating or not with amphibolite, augen gneiss, micaschist, porphyroid. In the Bucovinian Rarău sub-unit, beside micaschist, augen gneiss, paragneiss and amphibolite, a special rock suite - the Hăghimaş, and Mândra metagranitoids occurs as well. The carbonate rocks are practically missing.

Metamorphism. Bercia *et al.* (1971, 1976), H. Kräutner (1988) mentioned an initial metamorphism in the almandine amphibolite facies, followed by a Variscan and Alpine retromorphism.

Metallogeny. The known metallogeny of the Bretila terrane is poor.

b) Rebra metamorphic unit

Lithostratigraphy. The Rebra metamorphic unit (H. Kräutner, 1968) (Fig. 3) was essentially described by H. Kräutner (1968, 1980, 1988) and Bercia *et al.* (1971, 1976). It was divided by Kräutner *et al.* (1982) from bottom to top, in the Izvorul Roşu, Voşlobeni and Ineu "formations".

The *Izvorul Roşu sub-unit* consists of paragneiss, interfingered with micaschist that can include staurolite, kyanite, sillimanite, as well as subordinated intercalations of carbonate rock and quartzite.

The *Voşlobeni sub-unit* is represented by a thick pile of carbonate rock with intercalations of paragneiss, white and black quartzite. The carbonate rocks can be laterally substituted also by the other rocks mentioned above. On large areas, at the top and the bottom of the sub-unit, amphibolites or thick amphibolitic gneisses can be found which, in the Rodna Mts. at Bâzdâga (the lower ones), contain pyrrhotite-chalcopyrite-magnetite mineralizations and, in the Bistrița Mts. (the upper ones), lenses of massive magnetite of relatively small sizes. Due to them, the Subbucovinian Rebra metamorphic unit can be traced in geophysical respect between Bistricioara and Zugreni, in the right side of the Bistrița River. Also in the Rodna Mts, the carbonate portions of the Voşlobeni sub-unit, especially when they are related to quartzites and other terrigene lithons, host lead-zinc accumulations of industrial significance (Udubaşa *et al.*, 1981). Graphite occurs in carbonate rocks and there are zones where the graphitic black quartzites are very well represented. Graphite is usually accompanied by metallic minerals.

[2] Bercia, I., Bercia, E., Kräutner, Fl., Mureșan, M., Mureșan, G. & Iliescu, V. (1971): The monography of metamorphic units from the Crystalline-Mesozoic Zone of the East Carpathians, Arh. Inst. Geol., Bucureşti.

The *Ineu sub-unit* consists especially of quartz micaschists with intercalations of thin lithons of limestone, dolomite, biotitic quartzite, amphibolite and microlitic gneiss, white and black quartzite.

Lithology. From the beginning it is to mention the lithologic contrast between the Rebra and Bretila metamorphic units. Thus, in the Rebra metamorphic unit the well differentiated, mature rocks, distinct one from another, certainly of a sedimentary origin, are prevailing: micaschits with Al-silicates, quartzite, sometimes with organic supply, carbonate rocks in thick piles, paragneisses, and only few rocks of a possible acid magmatogene origin occur at the upper part of the metamorphic unit.

Metamorphism. Rebra unit is better studied as regards the metamorphic evolution in comparison with the Bretila unit. Thus, two mesozonal events (M1) and (M2), with proper mineralogic and structural features have been described (Balintoni & Gheuca, 1977). The (M1) event is a medium-pressure one, characterized by the presence of staurolite and kyanite in micaschists and paragneisses. The (M2) event is locally of low pressure with andalusite and cordierite substituting the staurolite and kyanite. This event is also characterized by the generation of transposition axial-plane foliations (S2) in relation to which the thermal culmination, during which cordierite and andalusite grow statically, is subsequent. According to Balintoni *et al.* (2009), the second event is Variscan, related to exhumation of the Rebra terrane after the Variscan collisions and thrusts.

Metallogeny. Rebra metamorphic unit is of economic importance for the Pb-Zn mineralizations hosted by the carbonatic rocks of the Subbucovinian Voşlobeni sub-unit in the Rodna Mts. A synthesis paper on these mineralizations was published by Udubaşa *et al.* (1981). Mineralization occurs either disseminated in the carbonate rocks or as massive pyrite flattened lithons. The major metallic minerals in the mineralized parts of the carbonatic sequence are pyrite, sphalerite, galena and subordinately pyrrhotite, chalcopyrite and magnetite. According to the mentioned authors, the mostly carbonate environment, the ore mineralogy, the regional extension of the mineralized lithons and their stratigraphic control are common for all ores of Mississippi Valley and Triassic type in the Alps.

c) Negrişoara Metamorphic Unit

Lithostratigraphy. This unit was delimited by Balintoni & Gheuca in 1977 and consists of a mostly terrigeneous lower sequence similar to the Subbucovinian Ineu sub-unit and of a metadacitic upper layer (Balintoni & Neacşu, 1980), quite typical mesoscopically, the Pietrosu Bistriței porphyroid gneiss.

Lithology. The Pinu lower sub-unit is represented by quartz-biotite paragneiss with intercalations of thin and discontinuous lithons of carbonate rock, amphibolite and microclinic white gneisse. The Pietrosu porphyroids might represent products of an intracrustal magmatic reservoir that is dacitic metaignimbrites.

Metamorphism. The metamorphic development of the Negrişoara metamorphic unit is similar, to a certain extent, to that of the Rebra metamorphic unit, minus the low pressure mineral assemblage.

Metallogeny. Up till now no mineralizations of economic interest are known in the Negrișoara metamorphic unit. Considering the lithology and the small thicknesses of this sequence, the prospect is null.

d) Tulgheş metamorphic unit

Lithostratigraphy. Kober (1931) and Streckeisen (1934) assigned the "epizonal "formations" of the East Carpathians to the "Tulgheş Series". Kräutner (1988) divided it into five "formations", numbered (from bottom to top) from 1 to 5. Further on we shall use the lithostratigraphic classification of the Tulgheş metamorphic unit proposed by Vodă (1993)[3].

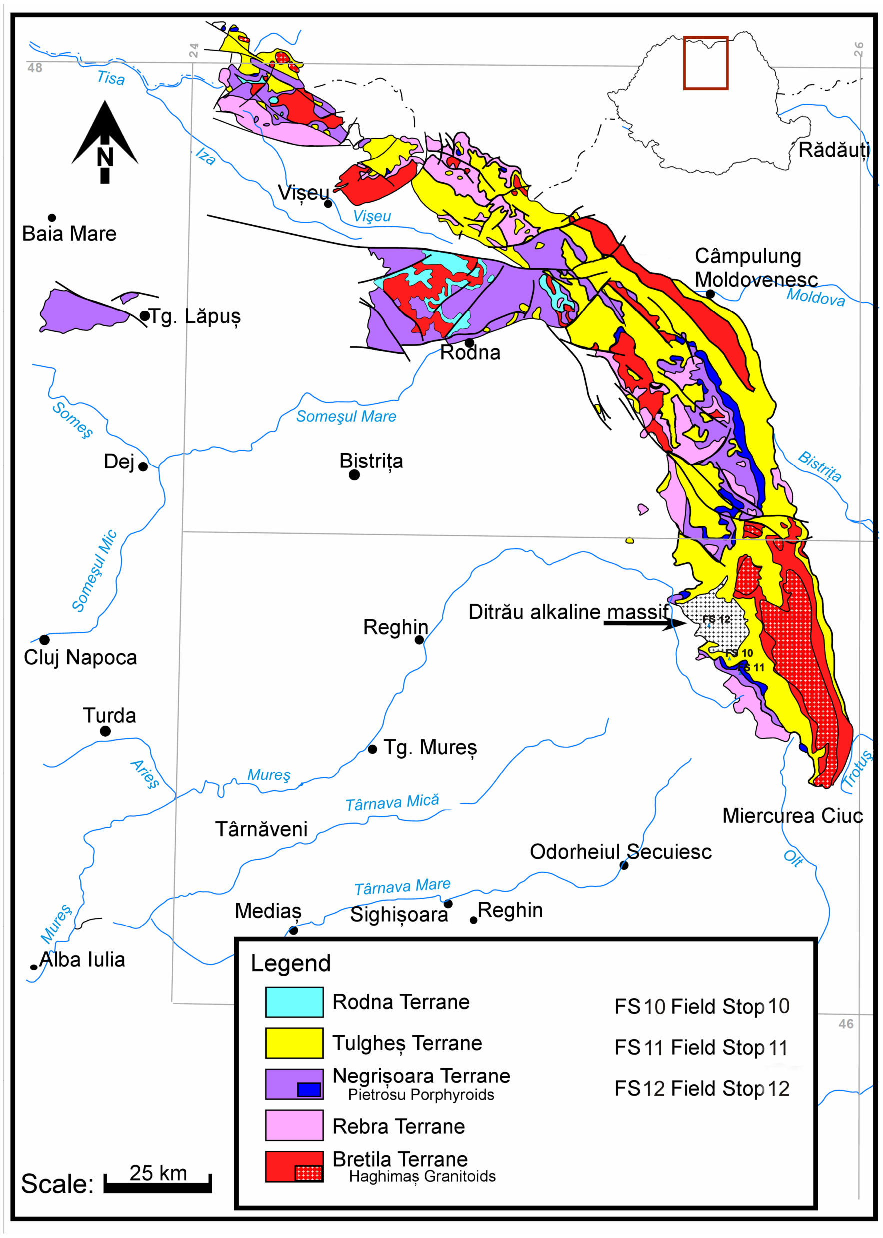

Fig. 3. Metamorphic Sequences of the East Carpathians
(Rodna Terrane, Tulgheş Terrane, Negrişoara metamorphic unit, Rebra metamorphic unit and Bretila Terrane)

[3] Vodă, A. (1993): Tulgheş Series. Geologic report, Arhiva S. C. "Prospecţiuni" S.A., Bucureşti (in Romanian).

The *Căboaia sub-unit,* predominantly terrigeneous, non-graphitous, constitutes the first term. It crops out on small areas, south of Zugreni, in the basement of the Bucovinian Nappe and in the upper course of the Vaser River in Maramureş, in the basement of the Subbucovinian Nappe, where it is known as Gliganu quartzites.

The *Holdiţa sub-unit,* quartzitic-graphitic, occurs along the East Carpathians, in the basement of both the Bucovinian Nappe and the Subbucovinian Nappe. Due to its black colour given by the presence of graphite, it can be easily recognized. This sub-unit hosts the Fe-Mn and baryte pre-metamorphic mineralizations.

The *Leşu Ursului sub-unit,* also well represented in the two upper Alpine nappes, consists of a sedimentary volcanogenic sequence which contains significant accumulations of stratiform metallic sulphides.

The *Arşiţa Rea sub-unit,* phyllitic-quartzitic, ends the succession of the Tulgheş metamorphic unit.

Lithology. Tulgheş terrane displays various lithologies, dominated by two rock types: white or black quartzites and quartz-feldspar rocks. The almost continuous variation of the ratio between quartz, feldspar, chlorite and sericite (in fact a phengitic variety) makes difficult the mapping of the varieties of these rocks, the more so as the lithons lose relatively quickly their individuality. The carbonate rocks are poorly represented; they crop out especially in the Holdiţa sub-unit where a characteristic association is found: black quartzite, white quartzite, carbonate rocks, chloritic and feldspar green rocks which do not represent metabasites but sedimentary rocks whose origin was favored by the iron abundance. Metabasites, like the carbonate rocks, are scarce or absent.

Metamorphism. Tulgheş metamorphic unit is polymetamorphic. Balintoni & Chiţimuş's data (1973), indicates the following stages of evolution: (1) the substitution of the detrital ilmenite by rutile I; (2) transposition of the ilmenite pseudomorphosis into S2 and recrystallization of rutile I into rutile II.

Metallogeny. The Tulgheş metamorphic unit is the major Mn producer in Romania and it represents a notable percentage from the output of Pb, Zn, Cu and pyrite, as well as of baryte.

e) Rodna low grade metamorphites.

Lithostratigtraphy. On sheets Rodna Veche, Pietrosu Rodnei, Ineu, and Rebra of the Geological Map of Romania scale 1:50,000 (Kräutner *et al*., 1978, 1982, 1983, 1989), Käutner separated several piles of low grade metamorphics, transgressively covering the Bretila terrane in the Infrabucovinian nappes and called Repedea, Rusaia and Cimpoiasa series of mid to late Paleozoic age and metamorphosed during the Variscan Orogeny.

Lithology. The rock varieties can be easily grouped into some major groups: metapsephites and metapelites, white and black quartzites (metapsamites), carbonate rocks, metabasites. All the rocks of sedimentary origin can be more or less graphitic. Hematite-magnetite, magnetite-siderite and metallic sulphides mineralizations are also known.

Metamorphism. The low-grade metamorphism of the above rocks is characterized by chloritoid, chlorite, actinolite (e.g. Kräutner, in Săndulescu *et al*., 1981). According to Balintoni *et al.* (1997), the Bretila terrane cover rocks were metamorphosed during the Alpine Orogeny.

Metallogeny. The hematite-magnetite and magnetite-sideritic mineralizations are related to the sedimentary rocks and the metallic sulphides are hosted by metabasites.

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THE DITRAU ALKALINE MASSIF[4]

Location, size, shape

The Mesozoic Ditrău Alkaline Massif (DAM), unique in Romania by size and petrographical variety, is emplaced within the metamorphic basement rocks at the interior of the East Carpathians. The DAM is an intermediate size massif (about 800 km^2) and exhibits an eccentric ring structure in which the more basic rocks tend to lie to the west, with an arcuate zone of syenitic rocks extending from the far north to the south-east, and a large area dominated by nepheline syenite on the eastern side (Fig. 4).

Geological location, Age, Tectonic setting

The DAM is considered to represent an intrusion body with an internal zonal structure, which was emplaced into pre-Alpine metamorphic rocks of the Bucovinian nappe complex close the Neogene-Quaternary volcanic arc of the Călimani-Gurghiu-Harghita Mountain chain (Ianovici, 1938; Kräutner & Bindea, 1998). The massif lies at the inner border of Mesozoic crystalline zone, within Tulgheş Group (Tulgheş Terrane according to Balintoni *et al.*, 2009). The DAM formed during the Variscan orogeny. The precise U-Pb zircon age of 229.6+1.5/-1.7 Ma determined by Pana *et al.* (2000) for the Ditrău syenite matches within error the hornblende $^{40}Ar/^{39}Ar$ dates obtained by Dallmeyer *et al.* (1997) from the diorite complex and hints to a relative short magmatic evolution of the DAM, within the Ladinian time (Mid-Triassic).

The alkaline massif of Ditrău has an intrusive character and its trend of enrootment has been proved by petrologic and geophysical arguments, too. It constitutes a multistage magmatic intrusion in a high level of the Earth's crust (Constantinescu & Anastasiu, 2004).

Parts o the DAM are unconformably overlain by andesitic pyroclastics with some interbedded basalt-andesite lava flows from the Neogene Harghita - Călimani and by Pliocene to Pleistocene lignite-bearing lacustrine deposits of the Jolotca basin (Rădulescu *et al.*, 1973). The intrusion developed a contact aureole against the country rocks, with hornfels containing cordierite, sillimanite, corundum, spinel and alkali amphibole (Streckeisen & Hunziker, 1974; Jakab, 1998; Hîrtopanu *et al*., 2000).

Short history

Since its discovery by Herbich (1859), the massif has been the subject of many investigations. However, because of its structural complexity and wide petrographic variety the petrogenesis is still not completely understood, and different studies led to different petrologic interpretations. Streckeisen (1960) explained the genesis of the massif by an origin through magmatic differentiation of an alkali syenite parental magma. Streckeisen & Hunziker (1974) presented a chronology of the magmatic events, suggesting early intrusion of the gabbros and diorites, followed by the syenites, nepheline syenites and granites culminating with emplacement of lamprophyric dykes, although without discussing the

[4] The text and associated figures are from Constantinescu *et al*. (2010).

source of the magmas. Anastasiu & Constantinescu (1982) considered a magmatic derivation with two principal rock suites, one generated from a mantle-derived basic magma, and the other from a felsic alkaline magma formed through partial melting of crustal rocks with low silica content.

Based on detailed geochemical data, according to Dallmeyer *et al.* (1997), the intrusion of the Ditrău Alkaline Massif was associated with mantle-plume activity which predated Jurassic rifting within the Eastern Carpathian Orogen. On the basis of K-Ar and $^{39}Ar/^{40}Ar$ data Kräutner & Bindea (1998) dated the DAM emplacement. Pană *et al.* (2000) performed a precise U-Pb zircon dating of the syenite phase from the Ditrău Massif. Morogan *et al.* (2000) suggested that the whole complex have originated from basanitic magmas with OIB-character, generated by low degrees of melting of asthenospheric garnet lherzolite. However, the general dominance of amphibole among the ferromagnesian minerals points to the relatively hydrous nature of the Ditrau magmas and leads to the speculation that the primitive melts may have been modified by passage through hydrated (possibly amphibole-bearing) lithospheric rocks.

Petrography, petrology, geochemistry

The center of the Ditrău Alkaline Massif was formed by nepheline syenite, which is surrounded by syenite and monzonite. Northwestern and northeastern marginal sectors are composed of hornblende gabbro/hornblendite, alkali diorite, monzodiorites, monzosyenites and alkali granite. Small discrete ultramafic bodies (kaersutite-bearing peridotite, olivine pyroxenite and hornblendite) and alkali gabbros occur in the Jolotca area. The later are also known from drill-cores in the Ditrău *s.s.* area (Morogan *et al*., 2000). Hornblende gabbro/hornblendite and diorite represent the earliest intrusive phase, and are embedded within younger syenite and granite (Dallmeyer *et al.*, 1997; Morogan *et al*., 2000). All these rocks are cut by late-stage dykes with a large variety of compositions including tinguaite, phonolite, nepheline syenite, microsyenite, and aplite, and later lamprophyre (Streckeisen 1952, 1954; Codarcea *et al*. 1958; Streckeisen & Hunziker, 1974; Anastasiu & Constantinescu, 1984; Anastasiu *et al*., 1994). The dykes rarely exceed one metre in width and have multiple orientations (Morogan *et al*., 2000). Streckeisen (1952, 1954, 1960) used the comprehensive term 'Ditro essexites' for the whole heterogeneous mesocratic suite of rocks from Güdücz complex (Fig. 4), including gabbros, diorites, monzodiorites and monzosyenites. According to the author, these rocks are different from normal diorites by their essexitic and theralitic chemistry, so the terms such as "alkali diorites" and "alkali gabbros" could be considered.

Structural features of the rocks are due to their degree of crystallinity and to the frequent transitions between the coarse, medium and micro-crystalline facies. Both massive and foliated rocks are common in the Ditrau alkaline massif (Pană *et al*., 2000; Pál Molnár & Árva-Sós, 1995; Pál Molnár, 2000). A short description of the most important rocks from the massif is presented bellow.

Granular textured *alkali granites* (grain size up to 5mm) and *microgranites* crop out on both the western and the eastern margins of the Jolotca area. They are hypersolvus rocks consisting mainly of quartz and perthitic feldspar (Morrogan *et al*., 2000). Although original ferromagnesian minerals have generally been chloritized or limonitized, biotite, alkali amphibole and aegirine-augite have been noted in some facies (Streckeisen & Hunziker, 1974).

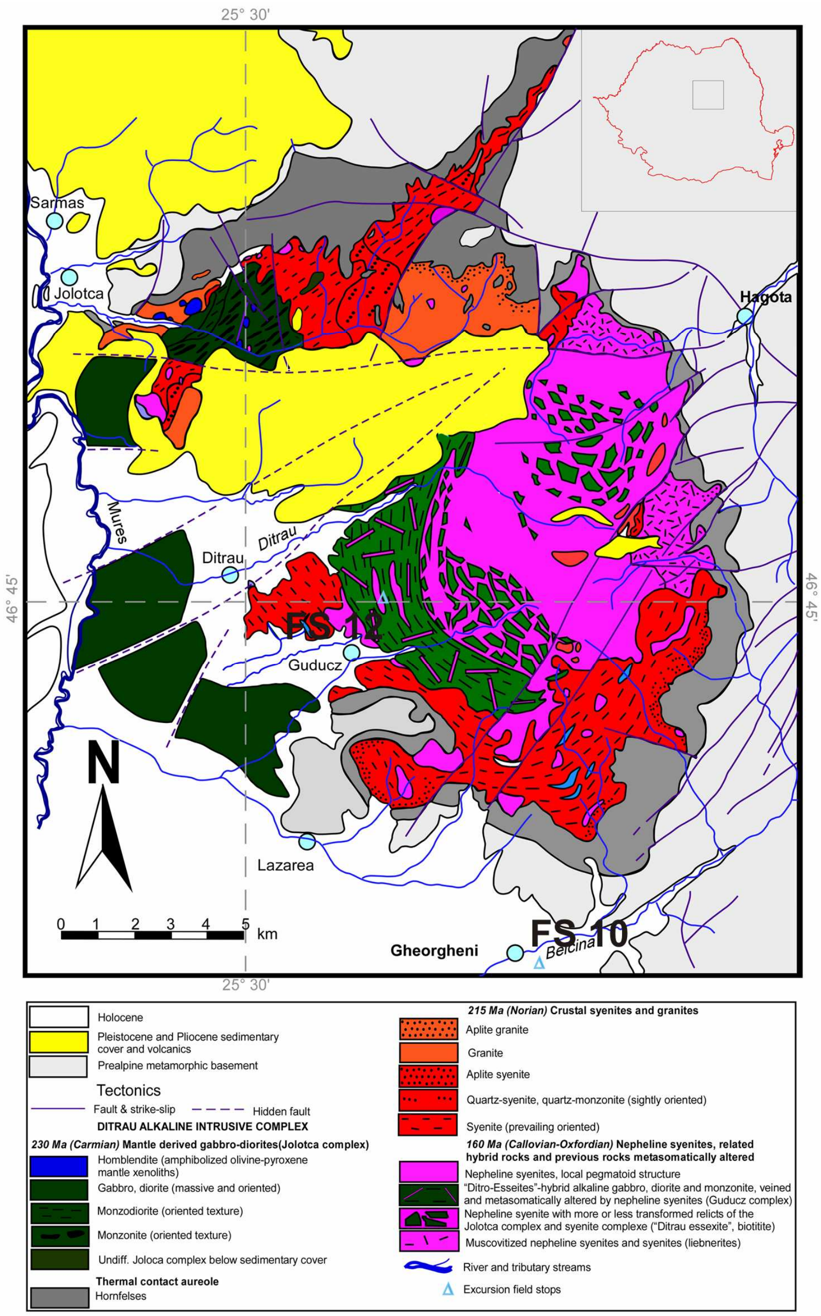

Fig. 4. The position of Mesozoic Ditrău Alkaline Massif (DAM)
(modified from Kräutner & Bindea, 1998).

Nepheline syenites are coarse- to medium-grained rocks, occur in massive or foliated varieties and consist of large (5-10 mm) euhedral grains of feldspar and nepheline. The mafic components are present in smaller amounts, and include biotite and clinopyroxene and rarely amphibole. Other important phases are calcite, cancrinite, sodalite and analcime. Apatite, titanite and zircon are present as accessory phases. The feldspars are mostly microcline-perthite and antiperthite, and plagioclase with anorthite content of An_4 to An_{28}

(Anastasiu & Constantinescu, 1975), corresponding to albite and oligoclase. The nepheline is commonly replaced by yellow cancrinite or blue sodalite. Nepheline syenite containing sodalite, calcite and cancrinite from DAM, actually named foyaite, was referred to as "ditroite" in the alkaline rock nomenclature, a term introduced by Zirkel (1866). At present "ditroite" is not an accepted petrographic term. More restricted is a laminated variety of nepheline syenite consisting of sub-parallel tablets of albitic feldspar with nepheline, aegirine and zircon. Close to the country rocks, some of the nepheline syenite contains both biotite and secondary muscovite. In the north-eastern part of the Ditrau s.s. area, the typical white nepheline syenite grades into a red, hydrothermally altered variety in which the nepheline has been entirely replaced by micaceous aggregates (liebnerite), the mafic phases by chlorite and epidote, and the feldspars have been haematitised (Morogan *et al*., 2000).

The *alkali diorites* are medium-to coarse-grained (rarely > 5mm) rocks with anhedral granular textures. They consist of plagioclase ($An_{28\text{-}25}$ $\pm$ An_{33} $\pm$ albite), amphibole (hastingsite $\pm$ kaersutite), titanite, biotite and apatite.The *monzodiorites* contain more biotite and less amphibole than the alkali diorites, together with oligoclase, albite, perthite and titanite. The alkali diorites/monzodiorites are generally interlayered (on a scale of cm. to dm.) with syenitic and dioritic material and are abundantly transected by veins of nepheline syenite (Morogan *et al.*, 2000).

Alkali gabbros where divided texturally and mineralogically by Morogan *et al*. (2000) into two groups: alkali gabbro I and alkali gabbro II. The alkali gabbro I relates to medium- to coarse-grained rocks (crystals up to 5mm) typically with granular or subophitic texture, composed of amphibole (kaersutite and/or Ti-rich ferroan pargasite), plagioclase ($An_{60\text{-}23}$), titanite and apatite. Diopside is scarce except in some samples from the Ditrau s.s. drill-holes where it is more abundant than the amphibole. Titanite is plentiful (>20%) and large, occurring as crystals up to 1cm across in some facies. Ilmenite, magnetite, pyrrhotite and zircon are accessory minerals. Alkali gabbro II is finer-grained (1±3mm or even <1mm grain-size) than the alkali gabbro I, sometimes with quenched fabrics involving dendritic amphibole (magnesian hastingsite) intergrown with elongate apatite prisms, titanite, biotite and plagioclase. Alkali gabbro II occur also as fine- to medium-grained large masses in which several populations of amphibole (magnesian hastingsite, magnesio-hastingsitic hornblende and actinolite) and feldspar (a) $An_{40\text{-}36}$, (b) $An_{28\text{-}13}$ and (c) K-feldspar (as rims or separate grains) occurs together with abundant biotite. Titanite and apatite crystals are less abundant than in the alkali gabbro I.

The general dominance of amphibole among the ferromagnesian minerals points to the relatively hydrous nature of the Ditrău magmas and leads to the speculation that the primitive melts may have been modified by passage through hydrated lithospheric rocks (Morogan *et al*., 2000).

Detailed major and trace element analyses of the DAM rocks may be found in Morogan *et al.* (2000). The authors suggest that not only were the alkaline peridotitic, gabbroic, dioritic and monzodioritic rocks derived through fractional crystallization from as basanitic parental magma but that the magmatic lineage persisted through to phonolitic residues from which the nepheline syenites crystallized. The complex, including the mafic rocks, is enriched in LILE, HFSE and REE. According to the same authors, Ni, Cr, Sc, V, Zn and Cu were strongly compatible throughout the fractionation theory and the quartz-bearing rocks at Ditrau are A-type granitoids with Y/Nb < 1.2 so they are considered to be derived from sources similar to those of OIB.

Associated ore deposits

The first data concerning the mineralizations belongs to Ianovici (1933, 1938), who describes occurrences of sphalerite, galena, pyrite, chalcopyrite and goethite in the Jolotca valley. Other minerals were identified in the area: Y-allanite, pyrochlore, baddeleyite, rhönite, xenotime and molybdenite. According to (Constantinescu & Anastasiu, 2004) the main rock forming minerals are: a) *salic minerals*: orthoclase, microcline, albite, oligoclase, andesine, nepheline, cancrinite, sodalite, very rare quartz; b) *femic mine*rals: ferrohornblende, biotite, Ti-augite, diopsidic augite, seldom olivine; c) *accessory minerals*: apatite, titanite, ilmenite, Y-allanite, epidote, etc. The mineralization consists of oxides, sulphides, carbonates, phosphates and subordinate silicates and native elements,i.e. bismuthinite, isocubanite, joséite, mackinawite, valleriite, tetradymite, native silver, anatase, brookite, Mn-rich ilmenite, pseudobrookite. All this aspects of the mineralization formed during the main (pneumatolitic and hydrothermal) stages, indicate a sequential formation. This is pointed out by the presence of several mineral generations and by the existence of important discontinuities marked by brecciation intervals. The REE mineralization (Nb-Th minerals) can be considered genetically affiliated to the alkaline rocks, the mineralogical and geochemical data showing a common geochemical trend for OIB setting of the REE, Ca and Nb with Th. Mineralogical heterogenity and petrochemical incompatibilities - the presence of supersaturated rocks (granitoides) beside the nonsaturated ones (foid syenites) - point towards two deep magmatic sources.

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DAY 1: Iaşi-Piatra Neamţ-Bicaz-Lacu Roşu

Along of this profile (Fig. 5) the whole East Carpathian structure can be seen, from foredeep through Moldavide nappes and Outer Dacide nappes to Median Dacides (Crystalline-Mesozoic Zone) overthrusted by Hăghimaş (or Hăşmaş) Transylvanian Nappe. From Iaşi to Stânca Şerbesti the fieldtrip crosses the backbulge, forebulge and foredeep depozones of the “new” foreland basins system of East Carpathians filled with Late Badenian-Middle Sarmatian deposits. At Stânca Şerbeşti, the wedge top of the same basin is tilted to 70ºW, probably a consequence of Wallachian tectogenesis. To Bicaz Chei Village the entire Flysch Area (Moldavides and Outer Dacides) is crossed then the fieldtrip enter in the Middle Dacides which support the Hăghimaş Transylvanian Nappe. The outcrops presented along of this transect belong to different Moldavide and Outer Dacide Nappes (Table 1).

STOP 1. STÂNCA ŞERBEŞTI – TILTED BESSARABIAN DEPOSITS[5]

Location: 17 km NE from Piatra Neamţ, on the right side of Roman-Piatra Neamţ road (DN 15D)

Coordinates: N 46°58' E 26°31'; altitude - 454m

[5] Based on Miclaus and Grasu (2002)

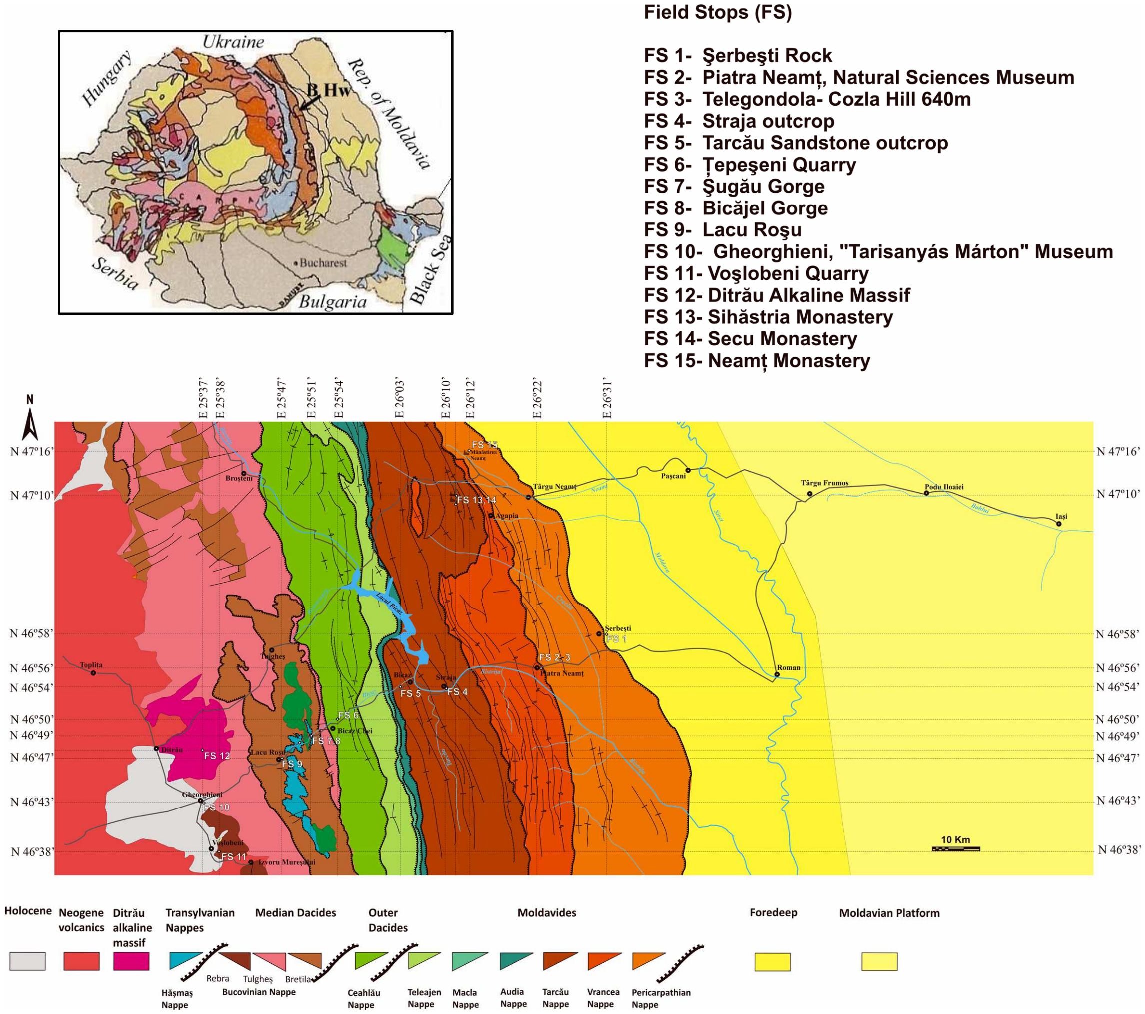

Fig. 5. The fieldtrip itinerary:
Day 1 – Iaşi-Piatra Neamţ-Bicaz-Lacu Roşu;
Day 2 - Lacu Roşu-Gheorgheni-Ditrău-Tulgheş-Tg. Neamţ-Iaşi.

The Stânca Şerbeşti point is a unique situation northward of Trotuş line where the Sarmatian deposits are deformed. The unusual structural position of these deposits was firstly mentioned by David (1932) as a unique occurrence in the landscape of the contact between the Pericarpathian molasse and the Sarmatian deposits considered to belong to the platform area. The latter ones are strongly tilted, and have high dip angles, up to 85ºW.

The age of these deposits, based on fauna assemblages is considered Volhynian-Bessarabian (David, 1932), Bessarabian (Macarovici, 1964) or only Early Bessarabian (Ionesi *et al*., 2005).

The facies analysis (Miclăuş & Grasu, 2002) revealed the existence of six facies associations which were interpreted as sub-environments of a non-deltaic clastic coast characterized by a gravelly barrier island-lagoon complex (Fig. 6). This depositional environment is a prolongation of the one reconstructed in Corni area some kilometers to NNW. As depositional mechanism for the gravelly barrier island the authors supposed strong longshore currents which rework a source of gravel as fan-deltas located northwestward in Ţolici area or Boiştea area (Fig. 6A).

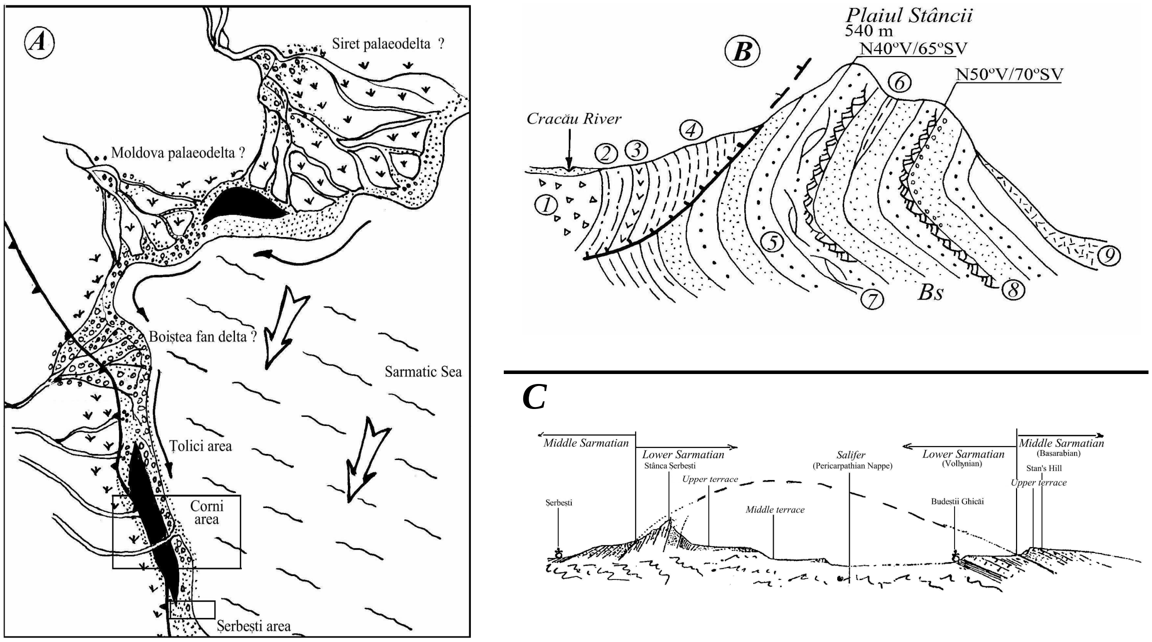

Fig. 6 A. Depositional environment of Bessarabian clastic deposits from Stânca Şerbeşti in its paleogeographic context (Miclăuş, 2001 in Miclăuş &Grasu, 2002). The supposed source of gravels for the barrier island (or spit) is either Ţolici area or Boiştea area; B) The structural solution of Miclăuş & Grasu (2002); C) The structural solution of David (1932):
Pericarpathian Nappe: 1 – Lower salt Formation; 2 – Măgireşti Formation; 3 – Perchiu Gypsum; 4 – Grey Formation; **Tilted Sarmatian deposits**: 6) mudstone; 7 – sands with HCS structure; 8 – sands with WRCL; 9 – covered area; Bs – Bessarabian.

For David (1932), the tilted Sarmatian deposits from Stânca Şerbeşti would be similar with the one described by Grozescu (1918) and Preda (1917) in the Trotuş Drainage Basin, which lies down on the pericarpathian molasse (in Viişoara - Brăteşti and Slobozia - Gura Văii areas). The author solved this structural problem considering that the Sarmatian deposits from Stânca Şerbeşti represent the western limb of a normal anticline (Fig. 6C), which was named „diapiric fold”. The problem with this solution is that the deposits of his anticline external limb (Stan’s Hill, Bozieni) are Late Bessarabian in age (Ionesi & Ciobanu, 1976, 1978).

Miclăuş & Grasu (2002) considered that these deposits were involved in the overturned limb of a footwall syncline (Fig. 6B; Fig. 7) dragged under Carpathian nappes during their post-Sarmatian thrusting, probably during the Wallachian tectogenesis. Recent observations (Miclăuş, unpublished data) infirm this latter solution since in last two years were exposed beautiful sandstone surfaces covered with wave ripples which prove the normal position of the beds. In this condition the tilted position of Sarmatian deposits in Stânca Şerbeşti remains an open problem.

Fig. 7. Tilted Sarmatian deposits in Stânca Şerbeşti (photo Crina Miclăuş).

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STOP 2. MUSEUM OF NATURAL SCIENCE PIATRA NEAMȚ - FOSSIL FISH COLLECTION

Location: 26 Petru Rareş Street, Piatra Neamț
Coordinates: N 46°56' E 26°22' , altitude - 326m

The Museum of Natural Science was opened for visitors in 1969. The exhibition is conceived as a monographic (geologic, paleontologic, floristic, faunistic and ecologic) itinerary on Neamț County.

Fig. 8. Cenozoic Room of Natural Science Museum in Piatra Neamț.

Fig. 9. *Zenopsis tyleri* Baciu et Bannikov, 2001, holotype, Oligocene, Lower Dysodilic Shales, Agârcia village, Piatra Neamț, România.

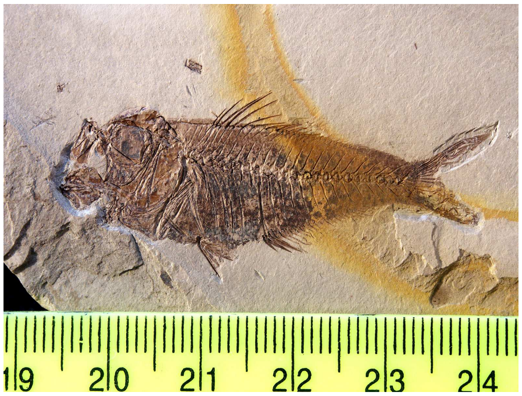

Fig. 10. *Agarcia agarciaensis* Baciu et Bannikov, 2004, holotype, Oligocene, Lower Dysodilic Dhales, Agârcia village, Piatra Neamț, România.

Fig. 11. *Scophthalmus stamatini* (Paucă, 1931), Oligocene, Bituminous Marls, Pietricica Mountain, Piatra Neamț, România.

Fig. 12. *Thynnus albui* Simionescu, 1905, holotype, Oligocene, Lower Dysodilic Dhales, Cozla Mountain, Piatra Neamț, România.

The Museum hosts collections of minerals and rocks, dioramas of representative ecosystems in Neamț County with rare plants and animals, particularly from the Ceahlău National Park and Hăşmaş-Cheile Bicazului National Park, fossils from Mesozoic and Cenozoic deposits, particularly the largest collection of Oligocene fish fossils in Romania (more than 600 specimens, with more than 30 holotypes).

Fish fossil study in Romania

Fishes are the main component of the vertebrate fossil record across all stages in the history of the Earth. Beginning in the 18th century, a systematically and biogeographically significant Oligocene to Miocene fish fauna has been collected from the External Flysch of the East Carpathians in Romania. The collection of such fossil fishes hosted by the Museum of Natural Science in Piatra Neamț is the largest and most important in the country.

In 1883 L. C. Cosmovici collected first fish fossils from Cozla Mountain (Piatra Neamț); subsequently he published the first paper about Oligocene ichthyofauna from Piatra Neamț (Cosmovici, 1887).

M. Ciobanu continued the study of fish fossils from Piatra Neamț area and based on the fossil material he organized, in 1960, the Natural Science Museum. The Ciobanu's (1977) paper represents the second Romanian monography about Oligocene fauna from Piatra Neamț.

These fishes are well preserved and the collection from Early Oligocene consists of the specimens of the more than 50 species, representing about 20 families. The most important species include sardinas (*Clupeidae*), bristlemouth (*Gonostomatidae*), hachetfishes (*Sternoptychidae*), lightfishes (*Photichthyidae*), lanternfishes (*Myctophidae*), codlets (*Bregmacerotidae*), squirrelfishes (*Holocentridae*), dories (*Zeidae*), boarfishes (*Caproidae*), shrimpfishes (*Centriscidae*), bigeyes (*Priacanthidae*), sharksuckers (*Echeneidae*), jaks and pomparos (*Carangidae*), pomfrets (*Bramidae*), snake mackerels (*Gempylidae*), cutlass fishes (*Trichiuridae*), mackerels and tunas (*Scombridae*), drift fishes (*Nomeidae*), lefteye fluoders (*Bothidae*), triplespines (*Triacanthidae*).

During the Oligocene and a part of the Early Miocene the Paratethys Sea, which Moldavide's Basin belong to, was dominated by anoxia conditions, consequently bituminous deposits (black cherts, bituminous marls and dysodilic shale) were accumulated.

The fish fossils (Figs. 9-12) were collected from Bituminous marls, Lower Dysodilic Shales and Upper Dysodilic Shales Oligocene-Early Miocene in age.

The Oligocene-Early Miocene fish fauna is mentioned in many areas of former Paratethys basin (Caucasus, Romania, Poland, Czech Republic, Germany, and France).

The Paratethys Sea was a large "inland" sea consisting of a chain of basins extending from the Alpine foredeep to the Caspian area (Fig. 13). This sea had various connections to the Atlantic, Mediterranean and Indo-Pacific marine basin. These pathways were blocked occasionally, during Oligocene and Early Miocene giving way to the development of endemic fauna. The study of Oligocene-Lower Miocene fish fauna from all area of Paratethys Sea (Caucasus, Romania, Poland, Czech Republic, Germany, and France) will obtain important data of the palaeogeography of marine basins and of phylogenetic relationships with marine fishes from Atlantic and Indo-Pacific oceans.

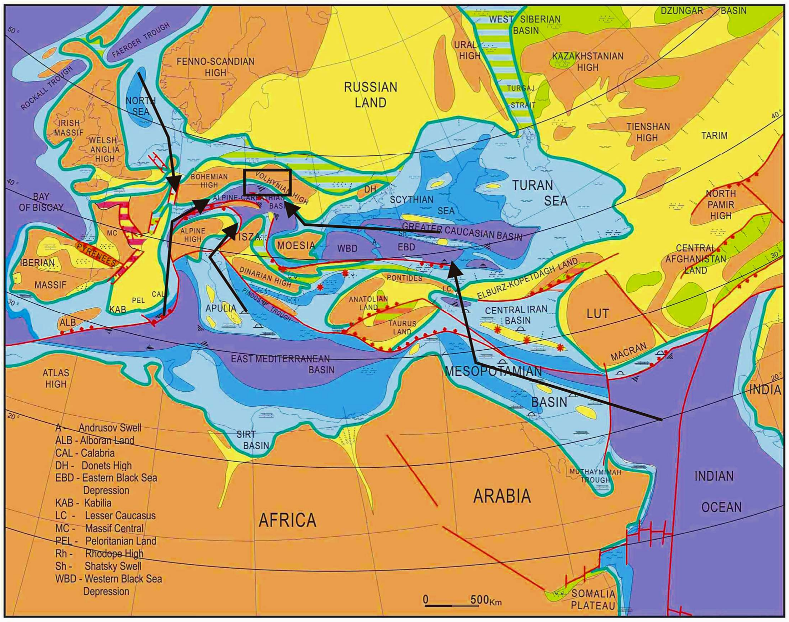

Fig. 13. The palaeogeography of the Paratethys Early Oligocene age (after Popov et al., 2004).

STOP 3. COZLA MOUNTAIN – PANORAMA POINT OVER THE BISTRIȚA HALFWINDOW AND OUTCROPS OF BITUMINOUS MARLS

Location: northern part of Piatra Neamț town
Coordinates: N 46°56' E 26°22'; altitude - 642m

The sedimentary succession of the Marginal Folds Nappe (or Vrancea Nappe) is characterized by a thick pelitic succession Early Cretaceous-Early Miocene in age (Table 1) locally interlayered with coarse grained beds, such as: calcareous turbidites, siliciclastic turbidites (Lucăceşti, Fierăstrău and Kliwa Sandstones) and conglomerates/breccias with “green schist” clasts. The coarses with green clasts occur beginning with Early Cretaceous Sărata Fm and ending with thick Gura Şoimului conglomerates, Early Miocene in age. In the Bistrița Halfwindow, where Vrancea Nappe is opened, the following units crop out from the bottom to the top, according to the Romanian geological literature: Sărata, Lepşa, Piatra Uscată, Jgheabu Mare, Doamna Limestone, Bisericani, Globigerina Marls and Lucăceşti Sandstone, Lower Menilites (LM), Bituminous Marls (BM), Lower Dysodilic Shales (LDS) with Kliwa Sandstones, Upper Dysodilic Shale and Menilite (UDSM) and, finally, Gura Şoimului formations (Table 1).

Cozla Mountain is shaped at the contact between Marginal Folds Nappe and Pericarpathian Nappe (Fig. 14), its western side on the Oligocene deposits consisting of Bituminous Marls and Lower Dysodilic Shales with Kliwa Sandstones and the eastern side on the Burdigalian Lower Salt Formation.

In Piatra Neamț area there were made excavations in the outcrops situated on Mountains Pietricica and Cozla and in Agârcia village.

On the **Pietricica Mountain** (527 m altitude), there are two important outcrops, one in LDS (Oligocene) and the other one in UDSM (Late Oligocene). By palaeontological point of view, this mountain represents an extremely rare situation where there is a more or less complete lithological column of the Oligocene, where important fish fossils were discovered.

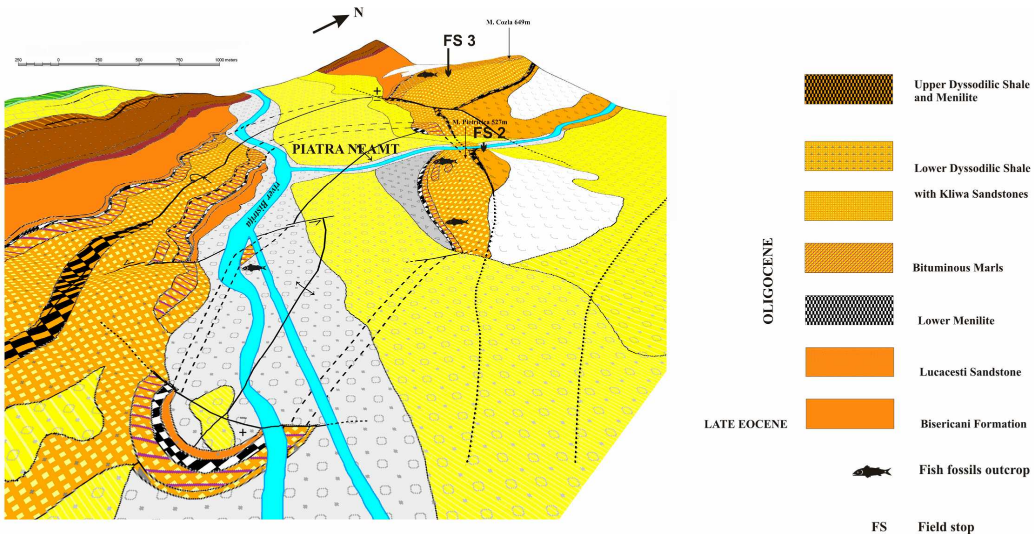

Fig. 14. The Outcrop of Bituminous Marls on Cozla Mountain and its structural context.

A) First outcrop (Early Oligocene) is situated on the south-eastern side of the mountain at about 430 m altitude; the fossil assemblage collected from this point consists of:

- one crustacean specimen;
- L a m n i f o r m e s: Odontaspididae (*Charcharias acutissima*), Cetorhinidae (*Cetorhinus parvus*);
- H e x a n c h i f o r m e s: Hexanchidae (*Heptranchias* sp);
- S t o m i i f o r m e s: Sternoptychidae (*Argyropelecus prisca*, *Valenciennellus sobnioviensis*, *Argyropelecus* sp.);
- M y c t o p h i f o r m e s: Myctophidae (*Eomyctophum* sp.);
- B e r y c i f o r m e s: Holocent ridae (*Praemyripristis longus*);
- P e r c i f o r m e s: Gempylidae (*Hemithyrsites* sp.), Priacanthidae (*Pritigenys* sp., *Ammodytes antipai*); Scombridae (*Scombrosarda cernegurae*), Eche nidae (*Echeneis* sp).

This outcrop is very important because is the only one in which were discovered fish fossils belonging to mezzo- and bathypelagic zone.

B) The second outcrop (Late Oligocene) is situated on north-westwrn side of the mountain, at about 480 m altitude. The outcrop, identified in the spring of 2002, is very important because is the richest point in fish fossils situated in Late Oligocene and most probably many species are new:

- G a s t e r o s t e i f o r m e s: Syngnathidae (*Syngnathus* sp.);
- G a d i f o r m e s: Gadidae (*Merluccius* sp.);
- P e r c i f o r m e s: Carangidae (*Scomberoides* sp., *Caranx* sp.), Priacanthidae (*Priacanthus* sp.);

- P l e u r o n e c t i f o r m e s: Bothidae (*Oranobothus* sp).

On the **Cozla Mountain** (642 m) there were made excavations in one outcrop, situated on the SW side of the mountain at about 500 m altitude, on the Borzogheanu Brook, in LDS (Oligocene). The fossil assemblage collected from this point consists of:

- a marine turtle, plate and counterplate, complete, length about 300 mm;
- a predator fish (*Palimphyes* sp. predator) with its fish prey in the mouth (*Caranx* sp.) an extremely rare situation;
- L a m n i f o r m e s: Odontaspididae (*Charcharais acutissima*);
- Z e i f o r m e s: Caproidae (*Capros caprosoides*);
- G a s t e r o s t e i f o r m e s: Centriscidae (*Aeoliscus* sp.), Syngnathidae (*Syngnathus incompletus* sp.);
- P e r c i f o r m e s: Palaeorhynchidae (*Homorhynchus* sp.), Serranidae (*Serranus budensis*), Carangidae (*Caranx* sp.), Euzaphlegidae (*Palimphyes* sp.), Trichiuridae (*Anenchelum glarisianus* - one big specimen about 1000 mm SL with other fish in his abdomen);
- T e t r a o d o n t i f o r m e s: Triacanthidae (*Acanthopleurus trispinosus*).

On the **Agârcia Mountain** were made excavations in an outcrop at 350 m altitude on the right bank of the Agârcia Brook at its confluence with Bistrița, in LDS (Oligocene). The fossil assemblage consists of: a bird fossil incomplete, plate and counterplate which is an extremely rare fossil and about 15 specimens of crabs, most of them well preserved, plate and counterplate, which may be belongs to genus *Portunus* sp.

The fish fossil assemblage collected from this point consists of:

- L a m n i f o r m e s: Odontaspididae (*Charcharais acutissima*);
- Z e i f o r m e s: Zeidae (*Zenopsis clarus*);
- G a s t e r o s t e i f o r m e s: Centriscidae (*Aeoliscus* sp.);
- G a d i f o r m e s: Bregmacerotidae (*Bregmaceros* sp.);
- P o l y m i x i i f o r m e s: Digoriidae (*Digoria* sp.);
- P e r c i f o r m e s: Trichiuridae (*Anenchelum glarisianus*), Priacanthidae (*Priacanthus* sp.), B r a m i d a e (*Paucaichthys neamtensis* n.g.n.sp.), N o m e i d a e (*Agarcia agarciaensis* n.g.n.sp., *Petrodavia roumanus* n.g.n.sp.), Ariommidae (*Isurichthys nirvanae* n.sp.)

Based on sedimentological, petrographic and paleontologic studies in Marginal Folds Nappe in Bistrița Halfwindow, Miclăuş *et al*. (2008, 2009) proposed a model of marginal basin evolution during Late Eocene-Late Oligocene. According to this model, the flysch deposits involved in the Moldavide units were accumulated in a foreland-type basin system (Fig. 15). The Marginal Folds Nappe sedimentation area was located on the internal part of the forebulge depozone. The forebulge resulted after the tectonic loading of the cratonic margin, possible of Moesian (Central Dobrogea) type as the "exotic" clasts would indicate, as a consequence of the Late Cretaceous closure of the Outer Dacide trough, and overthrusting of its nappes. Its outward migration could cause reactivation of older faults and/or tensional stresses which, in turn, could break the basin margin in uplifted and subsident blocks, hosting sub-basins. The forebulge was partly emerged during the Oligocene and later when increasing quantities of "green schist" clasts (meters in diameter) were supplied into the marginal basin (Grasu et al. 1999).

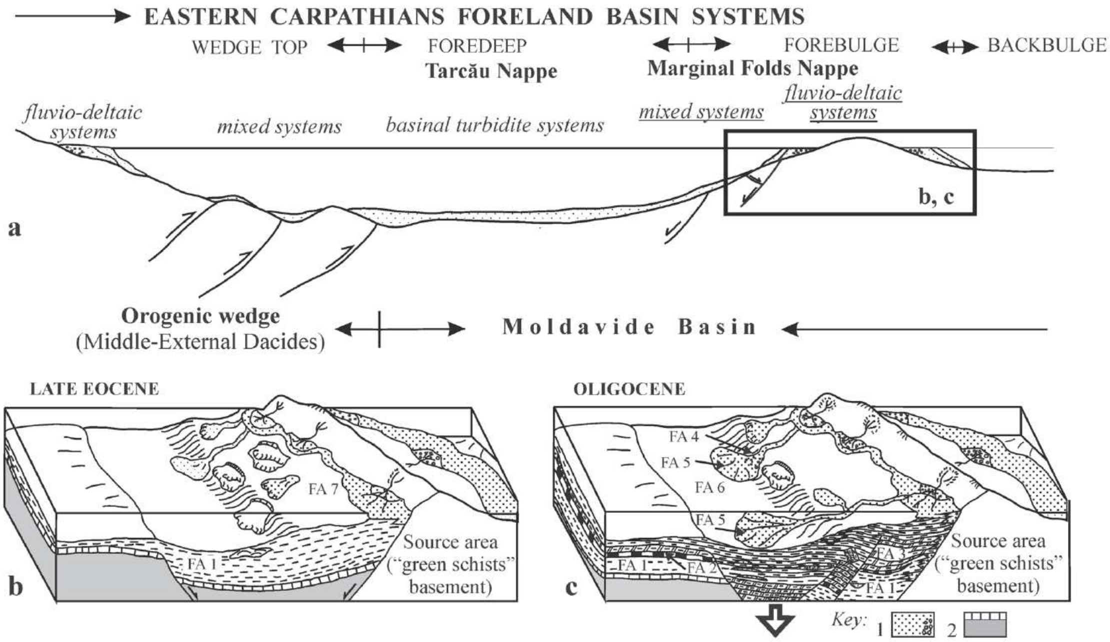

Fig. 15 A rough 3D paleogeographic interpretation of the Late Eocene-Oligocene depositional systems of studied sections within the Bistrița Halfwindow (Marginal Folds Nappe; East Carpathians) (after Miclăuş *et al*., 2009)

a – The position of the studied area in the foreland basin systems (the italics indicate the depositional systems defined by Mutti *et al*. (2003) for foreland basins; the underlined italics are their equivalents on forebulge depozone); **b** – The position of Late Eocene facies associations in a sub basin of the forebulge depozone; **c** – The position of Oligocene facies associations in a subsident sub-basin of the forebulge depozone; 1 – deposits of foreland basin systems; 2 – deposits older than Late Eocene; FA 1 - Greenish-grey pelites with slumps facies association of mud-rich slope apron system; FA 2 - Black shales with bedded cherts and sandstones facies association of shallow channels; FA 3 - Bituminous marls facies association of anoxic shelf; FA 4 - Sandstone and conglomerate facies association of channels with levee; FA 5 - Arenaceous-pelitic facies association of depositional lobes; FA 6 - Bituminous pelites with slumps and debrites facies association of fringe fans; FA 7 - Whitish marls with debrite facies association of oxic shelf.

The source area of coarse material was located entirely on the cratonic side of the foreland basin as is proved by very frequent "green schists" clasts, and by quartzarenite-type of sandstones (Lucăceşti, Fierăstrău, and Kliwa Sandstones). The quartzarenite petrographic characteristics prove a provenance from low-grade metamorphic rocks as green schists. Their high maturity might be a result of deep chemical weathering in a subtropical- and paratropical-like climate as was the case during the Oligocene time in the studied area.

The Bituminous Marls are characterized by sedimentary structures which prove their sedimentation on in shallow water, such as: sedimentary structures very similar to swaley and hummocky cross-stratification (SCS and HCS) together with parallel and low angle crossbedding and heterolithic bedding (wavy and lenticular). Thick sandstones (up to 1.5 m) with HCS were also recognized in different outcrops. The fossil fishes from this lithostratigraphic unit, especially the *Scophthalmus stamatini* Paucă, also arguments for shallow water environment.

Besides the depositional structures, numerous deformational (post-sedimentary) structures were recognized: intraformational slumps, convolutions, sandy dykes, sills and ptygmatic structures, load casts and flames associated with sandstone interlayers. The intraformational slumps may be the result of sinsedimentary subsidence and/or uplifting of the blocks which developed local slopes (Fig. 15).

From the Bituminous Marls of Marginal Folds Nappe in Bistrița Halfwindow were described 13 species which belongs to 13 families and 8 orders, such as (Fig. 16): mesopelagic fishes with vertical migration (*Scopeloides*, *Eovinciguerria*, *Oligophus*), shallow-water fishes (*Cetorhinus*, *Clupea*), benthopelagic fishes living on the outer shelf and upper slope (*Glossanodon*, *Anenchelum*, *Palaeogadus*, *Proantigonia*), fishes of epipelagic zone (*Auxides*) associated with the sea bottom on continental shelf - *Carcharias*, *Serranus*, *Scophthalmus*. The fish fossil assemblage confirms the sedimentologic data that Bituminous Marls are shallow water deposits at least in Marginal Folds Nappe opened in Bistrița Halfwindow.

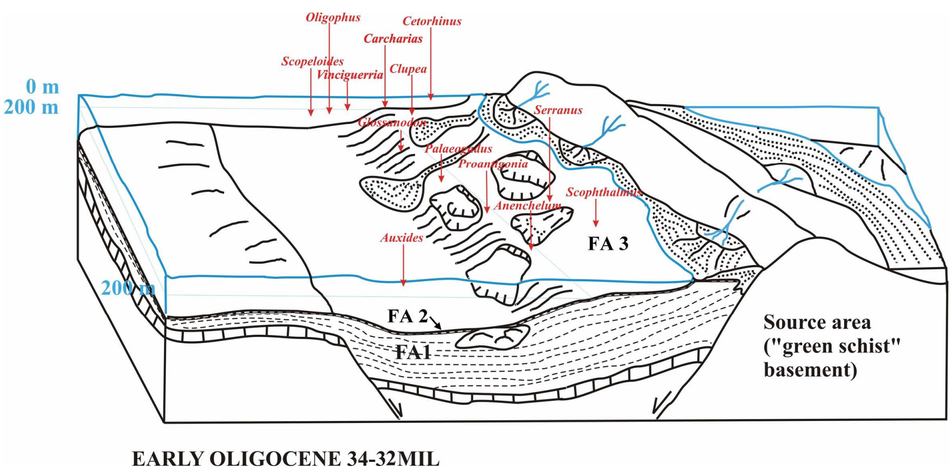

Fig. 16. The paleobatimetric and ecologic distribution of the collected fossil fishes from Piatra Neamț area during the Bituminous Marls (FA 3) sedimentation (modified from Miclăuş *et al*., 2009): FA 1 - Greenish-grey pelites with slumps facies association of mud-rich slope apron system; FA 2 – Black shales with bedded cherts and sandstones facies association of shallow channels; FA 3 – Bituminous marls facies association of anoxic shelf.

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STOP 4. STRAJA VILLAGE – IZVOR AND STRAJA (STRATOTYPE) FORMATIONS[6]

Location: at confluence of Stejarul Creek with Bistrița River at the entrance in Straja Village on the road from Piatra Neamț to Bicaz (DN 15)

Coordinates: N 46°54' E 26°10' , altitude- 368m

The two Paleocene to ?Eocene formations characterize the Tarcău Nappe which along of this transect is represented only by its internal and mixed "Lithofacies". The outer "lithofacies" of Tarcău Nappe was removed by erosion and revealed the Marginal Folds Nappe (=Vrancea Nappe) beneath in the Bistrița tectonic halfwindow (Fig. 2).

Izvor Formation (Paleocene)

It was defined by Ionesi (1961, 1966, 1971) and consists of many lithofacies. The petrographic and chemical analyses are from Grasu et al. (1988). In outcrops it is characterized by a dark grey color due to, sometime, it is called "black flysch". The fine grained is rock the darker is its color and this is probably a consequence of organic matter content (0.84-2.10%), but also to Fe compounds. At least four lithofacies were defined and they are subdivisions of simple complete or amalgamated turbidite beds. The complete turbidite consists of: biosparites and sparite with green schist clasts and bioclasts→ silty micrites with bioclasts→marls→silty shale.

The calcareous turbidites have flute casts on soles and were possible supplied by a shallow shelf or narrow intrabasinal cordillera (or rather uplifted blocks) with green schists basement on which there were conditions for green algae and echinoderms and other shallow water organisms development. The marly interlayers highly bioturbated (*Neonereites*, *Chondrites* etc).

Graded beds of *biosparites and sparite with green schist clasts and bioclasts* (mainly calcareous algae, bivalves, echinoderms and benthonic foraminifers) in a sparitic to micritic cement which previously were described as "allodapic limestone". Internally, their have different features from the base to the top; the algae fragments size and percentage weight decreases.

The lithics are mainly represented by algae fragments, but also by 5-30% "green clasts" (quartzitic schists, quartz-sericite schists, clorite-quartzitic schists). Other grains described are potasic and plagioclase feldspars.

Chemically, they have different carbonate contents (<50% in microconglomerates and

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[6] Based on Grasu et al. (1988)

lithic sandstones) and silica (35-50% for some spiculitic varieties with around 20% spicules).

Silty micrites with bioclasts represent the top part of some previous described graded beds. Their carbonate content is 65-76%, silica 19-29% and alumina up to 3.28%. RX analyses indicate 80% calcite, 10-15% quartz and 5% feldspars.

Microscopically, on a microsparite to micrite background, bioclasts of calcitized spicules, and grains of quartz (<0.1 mm) can be noticed.

Silty marls represent other petrographic type which can be defined in this formation. Chemically, they contain 23-36% carbonates, 52-61% silica and 6.7-6.9% alumina, indicating a clay supply. Although the quartz on thin sections is up to 3%, the RX analyses indicate 35% of it which probably is due to grains of silt and sub-silt sizes.

Clayey siltstones represent the end subdivisions of many graded beds. They macroscopically look like shale interlayers. Chemically they consist of 67-75% of silica, and 8-13% alumina.

One important feature of these lithofacies is the presence of glauconite whose frequence decreases with the drecreasing of the clast's grain size.

Straja Formation (Paleocene-?Eocene)

This lithostratigraphic unit characterizes the mixed and external "lithofacies" of Tarcău Nappe and was established by Joja (1953, 1954). Its stratotype is in Straja village (Neamț district) on the left side of Bistrița River at the confluence point of its tributary Stejaru. In stratotype location, the Straja Formation overlay the Izvor Formation and is around 50 m thick (Fig. 17). The peculiar feature of this formation is its variegated color (green and dark-red; Figs. 18, 19). By petrographic point of view, different lithofacies can be recognized: quartzarenites, gaizes and spongolites (spiculites), siltstones, and green and dark-red clays.

The coarse interlayers are fine turbidites (Tae) with nice flute casts on soles, but also with lot of burrows (vertical, subvertical and horizontal). The source area has to be similar with the previous one (shallow shelf or cordilleras) with the difference in organism abundance – sponges in this case.

Quartzarenites are fine sandstones, greenish, glassy, with sharp fracture which constitute the basal parts of some turbidites. Microscopically, they contain mainly quartz grains and cherts, and subordinately muscovite, feldspars, chloritized biotite, zircon and pyrite, in an overgrow quartz cement; glauconite as cement is also noticed.

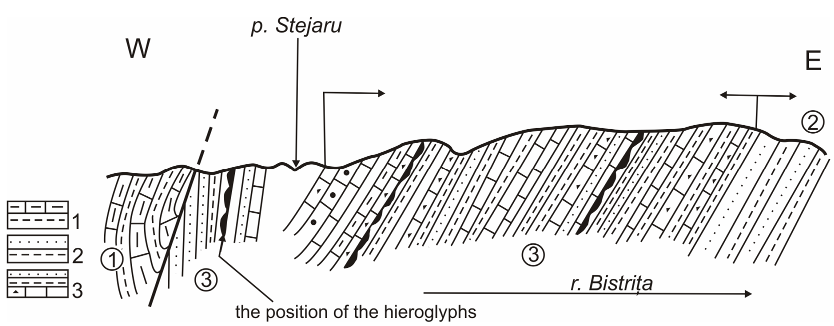

Fig. 17. Paleocene-?Eocene Straja and Izvor Formation of Tarcău Nappe (after Grasu *et al.*, 1988): 1 – Hangu Formation; 2 – Izvor Formation; 3 – Straja Formation.

Fig. 18. Strata Formation stratotype (photo D. S. Baciu)

Fig. 19. Details with variegated shale of Straja Fm. (photo D. S. Baciu)

Gaizes and spongolites (spiculites) constitute either the basal subdivisions of some turbidites or the upper ones in sequences of: calcareous microconglomerates → sandstones (or rather sandy limestone) → gaizes-spongolites.

As basal subdivisions of turbidites, they consist mainly of sponge spicules, partly calcitized, arranged along lamination, and subordinately of echinoid spins, and foraminifers. The detritic component consists of: quartz, sericite, biotite, potasic feldspars and heavy minerals (zircon, tourmaline, rutile, epidote). The cement is chalcedony to microcrystalline quartz and also calcite. Chemically, the content of 22% carbonates, higher than alumina (2.86%), proves they are calcareous gaizes and spongolites.

As upper subdivisions of coarse sequences the gaizes and spongolites consists of spicules in siliceous or sparicalcitic cement. In this case the basal part is a microconglomerate with clasts of quartz-sericite and chloritic schists, metaquartzites, and grains of quartz, and feldspars; the bioclasts consist of echinoid spins, bryozoans, benthic foraminifers in sparitic cement. The transitional part is a sandy limestone (20-30% quartz).

Siltstones may appear as thin interlayers (2-6 cm) in red and green shale or as thicker turbidite beds with parallel to convolute lamination. Both varieties are clayey siltstones. Microscopically, they show a silt-size quartz background with sericite, feldspars, microsparite replacing radiolarians, and rare glauconite. The matrix is clay-sericite or clay-carbonates.

The red color of such siltstones is due to hydrohematite.

Clays represent 62% of the Straja Formation column, and they appear as layers of 0-10 cm and 11-20 cm red or green in color.

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STOP 5. TARCĂU SANDSTONE WITH GIURGIU-GHELINȚA VARIEGATED SHALE (Paleocene-Eocene)[7]

Location: on right side of the road Bicaz-Gheorgheni (DN 12C) about 0.5-1 km upstream of Bicaz Town, on Bicaz River in Hamzoaia Gorges.
Coordinates: N 46°54' E 26°03'; altitude - 462m

This litostratigraphic unit characterizes the internal "Lithofacies" of Tarcău Nappe and was defined and named by Athanasiu (1908). It consists in more than 1500 m sandstones of Paleocene-Eocene age. The sandstones represent more than 80% of unit column in beds of 1-3, 3-5 and >10 m thicknesses (Fig. 20, 21). In the middle part of unit's column a sub-unit of variegated shale (10-20 m) was defined and named Giurgiu-Ghelința Member (Fig. 22). This might be equivalent to Straja Formation (Table 1).

Vinogradov et al (1983) recognized different petrographic types: lithic-feldspathic graywacke and arenites (55%), feldspathic-lithic graywackes and arenites (26%), and lithic arenites and greywacke. All varieties are rich in white micas.

Microscopically, the quartz grains are the most abundant (32-63%), followed by feldspars (12-35%) and lithics (12-55% to 75-80%); the sorting is poor. Generally, the lithic graywackes are coarsest in column, while the feldspathic graywackes are the finest.

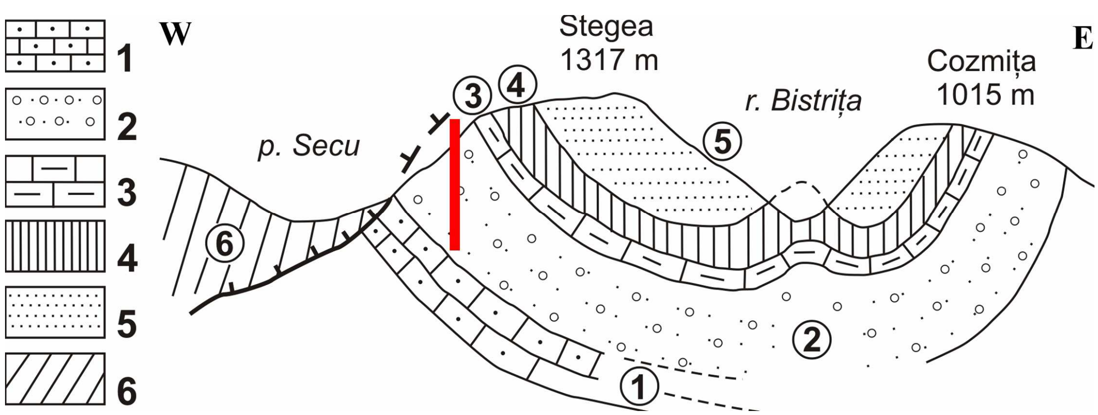

Fig. 20. The position of Tarcău Sandstone (red bar) in Hamzoaia Gorges (after the geological map 1:200 000 of Băncilă, 1958):
1 – Horgazu Formation + Izvor Fm. (Senonian- Pelocene); 2 – Tarcău Sandstone (Eocene); 3 – Podu Secu Formation (Late Eocene); 4 – Undifferentiated Early Oligocene deposits (Ardeluța Fm+Tărcuța Fm+Menilite+Bituminous Marls); 5 – Fusaru Sandstone (Oligocene) ; 6 – Audia Nappe.

[7] Based on Grasu et al. (1988)

Fig. 21. Tarcău Sandstone Formation (photo Crina Miclăuş)

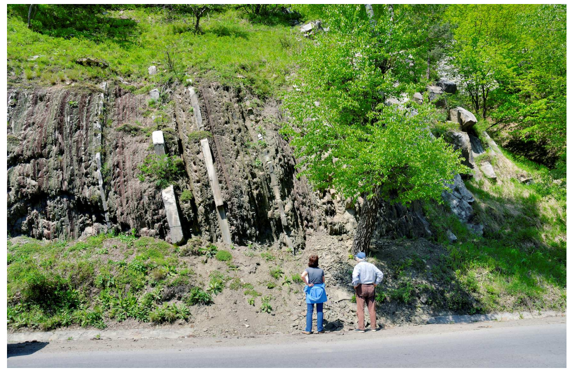

Fig. 22. Giurgiu-Ghelința Member of Tarcău Sandstone Formation (photo D. S. Baciu)

The source area of detritics is considered to be of mezometamorphic type, and corresponding to Carpathian area.

The Giurgiu-Ghelința variegated shales divide the Tarcău Sandstone Fm. in a lower Tarcău Sandstone and an upper one. The sedimentation during this time span was mainly related by "classic" turbiditic currents, while during the sedimentation of Tarcău Sst was mainly of sandy debris flows type or "mixed system" type (in Mutti et al., 2003 terminology). The fine sandstone interlayers in Giurgiu-Ghelința Beds are bioturbated (*Chondrites* and other horizontal and vertical burrows).

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STOP 6. ȚEPEŞENI QUARRY - Middle Member of Sinaia Formation (Ceahlău Nappe of Outer Dacides)[8]

Location: right side of Bicaz-Gheorgheni road (DN 12C), in Bicazu Ardelean Village
Coordinates: N 46°50' E 25°54'; altitude - 600m

The sedimentary rocks which crop out in this point (Țepeseni quarry) belong to Sinaia Formation of Bratocea-Durău Digitation. This formation was divided in three members (Murgeanu *et al.*, 1963; Patrulius, 1969). The sedimentary columns in all Ceahlău Nappe digitations begin with the Sinaia Formation (?Tithonian-Barremian), while after early Barremian each unit is characterized by different deposits (Tables 1, 2), as a consequence

[8] Based on Grasu et al (1996)

of basin paleogeografic configuration with “cordilleras” and trenches (Săndulescu, 1984, 1990) or with horsts and ridges (Grasu *et al.*, 1996).

Table 2. The lithostratigraphic units of the four digitations of Ceahlău nappe (after Grasu *et al.*, 1996; Bădescu, 2005 and Ştefănescu *et al.*, 2006)

Age	CEAHLĂU NAPPE			
	Ciuc Digitation	**Bratocea-Durău Digitation**	**Ticoş-Comarnic Digitation**	**Bodoc Digitation**
ALBIAN	*eroded or unsedimented*	Ceahlău - Ciucaş - Zăganu Conglomerates	*eroded or unsedimented*	Sânmartin-Bodoc Flysch
		Poiana Stănilelor Fm.	Sandy-shaly flysch	
APTIAN	Bistra Fm. (sandy flysch)	Poiana Maicilor Sandstone	Comarnic Formation (calcareous flysch)	
BARREMIAN		Piscu cu Brazi Fm. (sandy-marly flysch)		
BARREMIAN -TITHONIAN	Sinaia Formation			

Lower member (≈200 m). Consists of shale (silty-calcareous claystone, silky sandy-silty claystone), clayey limestone, sandy limestone, and calcareous sandstones. By mineralogical point of view, the sandstones are lithic-feldspatic and feldspatic-lithic sandstones, sub-lithic and arkose sandstones. Based on carbonate:silica ratio they are calcareous sandstones and quartz siltic limestone.

The Azuga “Beds” which were named by Codarcea (1940) and were firstly described by Voiteşti (1935) characterize the lower member and lowermost part of middle member and consist of ophiolite-type rocks (diabases) together with weak metamorphosed rocks (silky schists, green and red argillites, greenish and red jaspers with radiolarians. Based on geochemical analyses they indicate a magmatism corresponding to an intracontinental rifting to thinned crust (Russo-Săndulescu *et al*, 1983).

Middle member (800-12,000 m). Is the most representative subdivision of this formation, cropping out all along the Ceahlău Nappe. The peculiar features of this member are: the obvious “rhytmicity”, the dark-grey color, and the tight folding (Grasu *et al.*, 1996 and references within).

The detailed analyses of this member in Țepeşeni Quarry were done by Grasu et al. (1996). The authors recognized, based on petrographic and chemical analyses, different sandstone types.

Calcareous sublitharenite and litharenite, macroscopically described as calcareous sandstones, calcarenites, lithic calcarenites and sub-calcarenites (Dinu, 1985), represent up to 20% of the middle member column together with transitional rocks. They appear as 1-5 to 10-25 cm thick beds with maximum of 50-60 to 100 cm (Figs. 23, 24). They have usually “hieroglyphs” on sole and graded bedding, representing the lower part of some turbidites.

Microscopically they show: 76-86% mono- and polycrystalline quartz grains, 8-15% lithics (gneisses and micaschists, chloritic schists and cloritic-quartzose schists, sericitic-quartzose schists together with sedimentary lithics such as: micrites, argillites, cherts), and 7-9% potasic and plagioclase feldspars; some muscovite and biotite may also occur as well as pyrite. Some varieties are characterized by up to 44% quartz, 49% lithics and around 7%

feldspars which made them litharenites. The maximum grain-size reaches 0.3-0.7 mm, the regular size being 0.07-0.25 mm. The cement is a sparitic calcite.

Fig. 23. Middle Member of Sinaia Formation in Țepeșeni Quarry (photo D. S. Baciu)

Fig. 24. Detail with slumped calcareous turbidites of Sinaia Formation (photo D. S. Baciu)

Sandy sparites correspond also to some turbidite basal or middle subdivisions. This petrographic type shows a sparitic background which include grains (0.1-0.2 mm) of quartz and metaquartzite (28-56%), micrite grains (22-52%) both of extrabasinal (lithics) and intrabasinal (pellets) types, potasic feldspars (3-16%), gneisses+quartz-sericite schists (3-13%), sericite, muscovite and biotite (2-3%). The carbonate content is 85.4-20.4% and represents the sum between micrite grains and calcite cement.

Quartz-silty sparite and spary quartz-silts represent the transitional subdivisions from calcareous sublitharenite and litharenite or sandy sparites to pelite in top or they may represent interlayers which, macroscopically, look like fine, blackish sandstones, rich in micas in marls or shale, with lens shapes. Microscopically, they show a sparitic background which includes grains (≈0.06 mm) 70-75% quartz and some metaquartzite, 18%, lithics (mainly limestone), and 11% feldspars, mostly potasic; the carbonate:feldspar ratio includes these rocks in calcareous quartz-silts. Other variety is quartz-silty limestone.

All the middle subdivisions of the turbidites show convolute lamination.

Micrite and *clayey micrite* represent the transitional subdivisions of some rhythms, consisting of sandy sparite or quartz-silty sparites→ micrite and clayey micrite→marls or can represent the basal subdivisions of some thin turbidites, when they have flute casts on sole. Macroscopically, they look like dark grey massive marls thick beds (0.3-1 m), whitish on weathered surfaces; on fresh surfaces they are blackish, silky, rich in micas; the internal structures consist of very thin laminae.

The carbonate content (68-75%) includes them in clayey limestone, the clay content being 10-25%.

Microscopically, on a micrite, with tiny veins of calcite, background rare quartz of silt size, sericite and neo-formation feldspars are included; some calcitized radiolarian tests can be also noticed. Pyrite is abundant either disseminated and in clusters which explain the dark color of the rocks together with the organic matter content (0.14-1.86%).

Marls and silty-sandy marls. These petrographic types end some turbidites whose basal and intermediary subdivisions have been described above. Macroscopically, they are dark-grey or even black and contain lens shape laminae of mm-2 cm thicknesses.

Their clay content is 50-55%, while the carbonate content is 20-36%; the coarse fraction is from <10% to 31%, so the rocks are marls or silty-sandy marls.

Microscopically, their residue, after carbonates and clay removing, indicates quartz sericite, cherts, potasic and plagioclase feldspars, and rare glauconite; heavy minerals like tourmaline, zircon and epidote of silt size were also noticed.

Silty-sandy clays. Most of turbidites, whose basal and intermediary subdivisions have been described above, end with blackish or black shale, with silky shine due to their content in sericite. The clay content is 52-63%, coarse fraction is 11-23%, while carbonates are 20-26%.

The coarse fraction consists of silt size grains of quartz, lithics of metamorphics, sericite and muscovite, biotite and rare sponge spicules; some heavy minerals like tourmaline, rutile, zircon and epidote. The organic matter content is 0.76-1.23%.

Upper Member (150-200 m). Is consists also by many different petrographic types such as: sub-litharenite, litharenite, lithic-feldspatic arenite, quartz-lithic siltstone, sandy and silty sparites, biopelsparites and pelsparites, marls, and silty-sandy shale.

The main difference between the middle member and the upper member of Sinaia Formation consists in:

- the better bedding of the last one (average bad thickness is dm) due to thinning of limestone beds;
- increasing of percentage weight of sandstones, marls and clays;
- the presence of breccia and microbreccia interlayers;
- a more obvious rhythmicity of deposit.

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STOP 7. ŞUGĂU GORGES – PANORAMA STOP

Location: in the Massif Munticelu at the entrance point in Bicaz Gorges, confluence of Şugău Brook with Bicaz River
Coordinates: N 46°49' E 25°51'; altitude - 678m

The outcrop where the contact between the decollement Hăşmaş Transylvanian Nappe in outlier (belonging to Transylvanides=Tethyan branch; see the Fig. 2 and geological cross section) and the wildflysch of Bucovinian Nappe is exposed in Surduc Quarry on the right side of Bicaz River (Fig. 25).

The deposits belonging to Transylvanian Nappe are Tithonian-Neocomian in age in Stramberg and Urgonian facies respectively, while those of Bucovinian Nappe are clays with blocks (wildflysch).

Fig. 25. Surduc Quarry seen from Şugău Gorges right side. The white limestone belong to allochtonous Hăşmaş (Transylvanian) Nappe supported by Autochtonous Bucovinian Nappe (photo D. S. Baciu)

STOP 8. "THE NECK OF THE HELL" IN "BIG GORGES"OF BICAZ RIVER[9]

Location. Along the Bicaz-Gheorgheni road, at 31 km apart from Bicaz and 25 km apart of Gheorgheni.
Coordinates: N 46°48' E 25°49'; altitude - 882m

The Bicaz Gorges genesis is related by the Bicaz River evolution. Two stages were recognized in this evolution:

a) an epigenetic one during which the river incised into the post-tectonic conglomerates, covering the limestone;

b) a karstic one during which the Bicaz River and its tributaries (Cupaşul, Lapoşul, Bicăjelul, and Şugăul) were locked in their valleys, then disappeared into the limestone and

[9] Based on Grasu et al (2010)

carved caverns whose hanging roofs collapsed. Important slope breaks and karst towers, like the Altar Stone (Fig. 27), resulted.

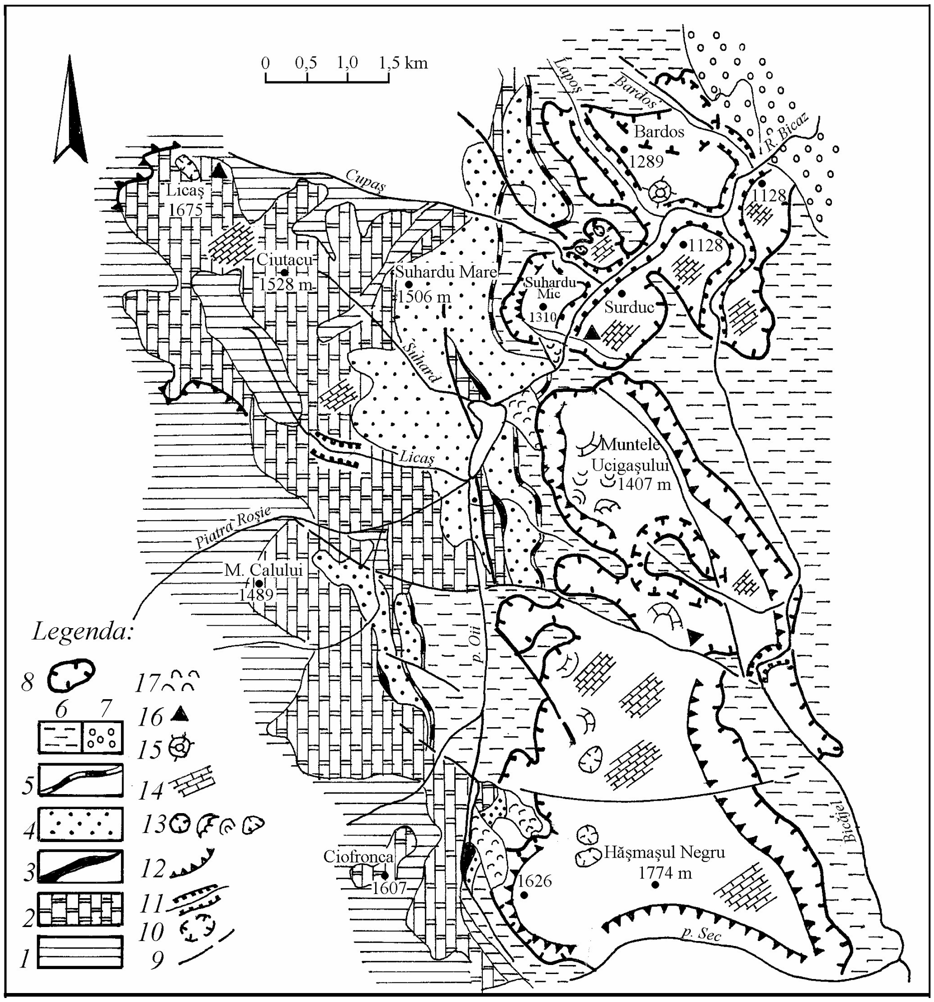

Fig. 26. Geology and Karst in central part of the Hăşmaş Syncline
(after Săndulescu, 1975 and Bojoi, 1971):
1 – Crystalline basement; *2* – Triassic; *3* – Liasic of Hierlatz type and Domerian; *4* – Dogger; *5* – Callovian-Oxfordian (jaspers and radiolarites); *6* – Wildfysch; *7* – Bârnadu Conglomerates; *8* – Hăşmaş (= Hăghimaş) Nappe; *9* – faults; *10* – karst poljes and uvalas; *11* – gorges; *12* – escarpments; *13* – dolines; *14* – lapiés; *15* – karst towers; *16* – active aven; *17* – landslides.

On their 8 km length, the Bicaz Gorges are cut into Bârnadu Conglomerates (4 km Small Gorges) and limestone (4 km Large Gorges) (Fig. 26); in easternmost sector, Bicaz River cross the Surduc-Munticelu limestone ridge. The highest relative altitude of the gorges is > 350 m in the sector known as „The Neck of the Hell" (Fig. 28) at the confluence of Bicăjel River with Bicaz River. The gorges cut by Bicaz River tributaries are short, but spectacular due to their wildness, with length of 350 m on Şugău Creek to about 2 km along the Bicăjel River. The Şugău Gorges are the narrowest, with no more than 3-4 m width on some sectors (Fig. 29). They are epigenetic as it proved both by the talweg potholes and lateral perched ones at about 30 m high. Upstream of confluence of Şugău Brook with Bicaz River there is located the most important area where the calcareous tufa (travertine) are deposited.

At the confluence of Bicăjel with Bicaz River, the Tithonian-Neocomian succession of the Hăşmaş Nappe is exposed (Săndulescu, 1975):

a) the Tithonian is represented by massive light colored neritic limestone which contain gastropods (*Nerinea*), foraminifers (*Trocholina alpina, T. elongata, Kurnubia, Kilianina*, etc.), calcareous algae (*Salpingoporella anulata* as well as *Elipsactinia, Cladocoropsis mirabilis, Clypeina* div. sp., *Actinoporella podolica* etc).

b) the Neocomian is represented by well layered pelagic limestone with *Calpionella elliptica, Tintinopsella carpathica, Calpionellopsis oblonga, Neocomites neocomiensis, Berriassiella privasensis*; Bicăjel River is located on such type of deposits;

c) the Early Barremian (possible whole Barremian) of Urgonian type with white, yellowish and light reddish limestones and calcarenitic breccias containing Pachyodonts (*Requienia* div. sp. *Toucasia carinata*), large foraminifers (*Orbitolina conica*) as well as calcareous algae and briozoarians.

Fig. 27. The karst tower „Altar" Stone shaped in Urgonian limestone (photo D.S. Baciu)

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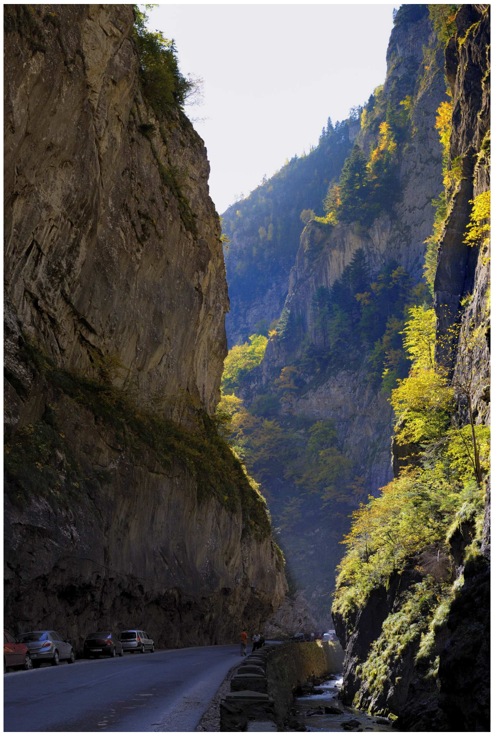

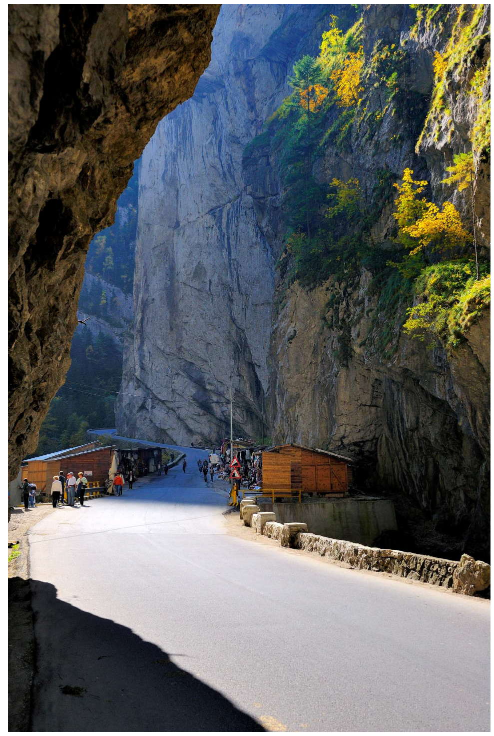

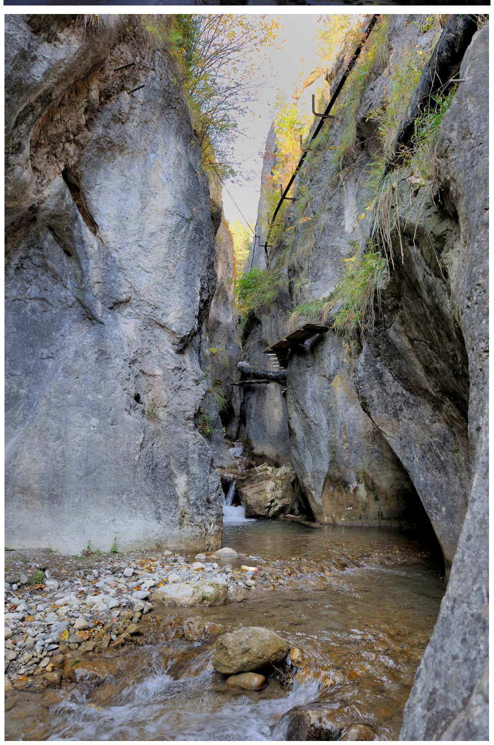

Fig. 28 (above). The Big Gorges sector of Bicaz Gorges at „The Neck of the Hell" cut into Urgonian Limestone of Hăşmaş Nappe (photo D.S. Baciu)

Fig. 29 (left). Şugău Gorges cut into limestone. The narrowest gorges in Bicaz area (3 m wide) (photo D.S. Baciu)

STOP 9. RED LAKE (LACU ROŞU)[10]

Location. In the small tourstic town named Lacu Roşu along the Bicaz-Gheorgheni road at 25 km apart from Bicaz and 31 km apart of Gheorgheni.

Coordinates: N 46°47' E 25°47'; altitude - 991 m

The Red Lake is outlined northward by Suhărzel Massif (1310 m), north-westward by Suhardul Mare (1506 m) and Piciorul Licasului (1343 m), southward by Bâtca lui Cioflec (1179) and south-eastward by Ghilcoş Mountain (1406 m) (Figs 30, 32).

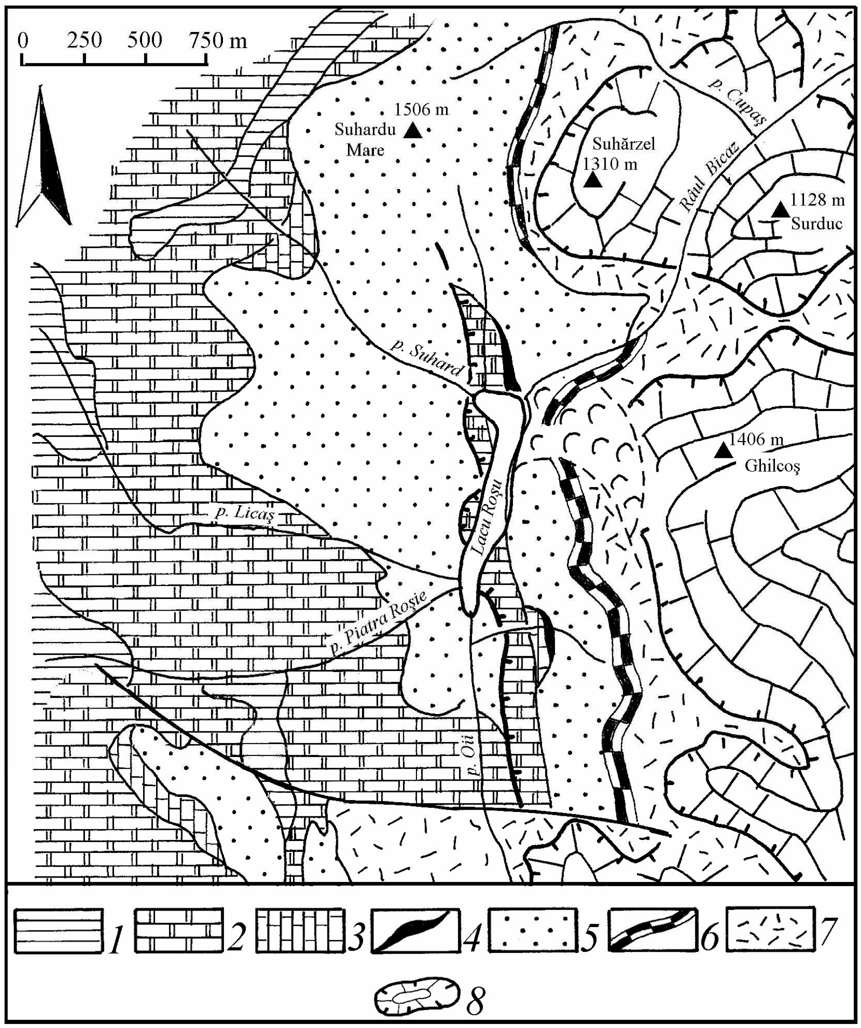

Fig. 30. Geological sketch of Red Lake area (after Geological Map, 1:50 000 Dămuc Sheet): 1 – crystalline basement; 2 – Campilian-Anisian; 3 – Middle-Late Triassic; 4 – Liasic in Hierlatz Facies; 5 – Dogger; 6 – Callovian-Oxfordian (jaspers and radiolarians); 7 – Barremian-Albian (Wildflysch); 8 – Kimmeridgian-Urgonian (Hăşmaş Nappe).

[10] The text and figures are from Grasu *et al* (2010)

It is the largest and the longest lived natural dam lake in Romania. After one opinion it was formed when the Bicaz River valley was dammed by a large landslide moved from the Ghilcoş Mountain side slope (Figs. 31, 33) after a long rainy period in 1837 (Herbich, 1878; Vadasz, 1915; Mihăilescu, 1940; Zaruba & Mencl, 1954). After another opinion it was formed in 1838 after an earthquake which provoked the landslide. In January 1838 it is mentioned an earthquake of 6 on Richter magnitude scale, or VIII on Mercalli intensity scale. Four tributaries of the Bicaz River in this sector also contribute to the lake development, namely: Oii, Piatra Roşie, Licaşul, and Suhardul.

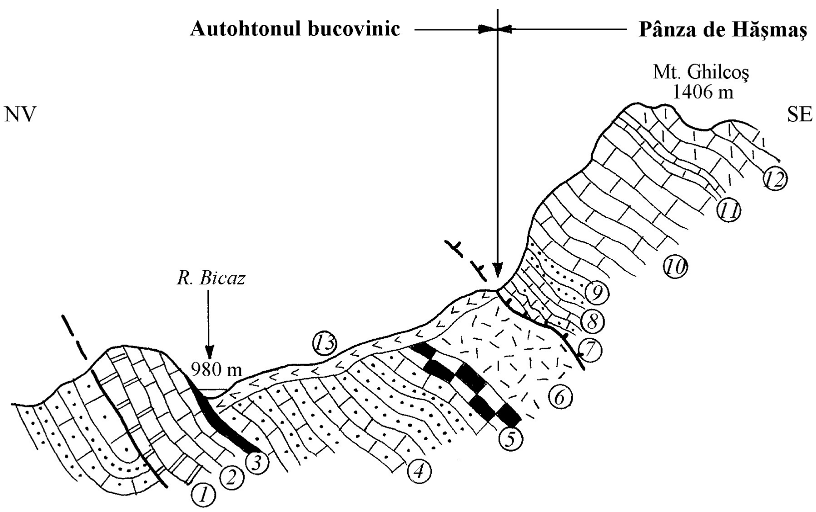

Fig. 31. Geological cross-section through northern slope side of Ghilco; Mountain in natural dam sector of the Red Lake (after Grasu et al., 2010):
Bucovinian Autochtonous: *1* – Campilian-Anisian (dolomite); *2* – Middle-Late Triassic (dolomite and limestone); *3* – Liasic in Hierlatz facies; *4* – Dogger; *5* – Callovian-Oxfordian (jaspers and radiolarites); *6* – Barremian-Albian (wildflysch); **Hăşmaş (Transylvanian) Nappe**; *7* – Kimmeridgian (red nodular limestone); *8* – Kimmeridgian (grey-greenish limestone); *9* – Kimmeridgian (silty-sansy marlstone); *10* – Tithonic (Stramberg Limestone); *11* – Neocomian; *12* – Urgonian; *13* – slumped deposit.

The lake was not discovered until 1857 while the access to it was not possible until 1910 when the road from Gheorgheni to „The Neck of the Hell" was cut.

The initial parameters of the lake were: 2 km length along the Oii branch and 1.6 km along the Suhard branch and 12.5 m maximum depth (Dragoş, 1957).

After 120 years of evolution its parameters changed, the length along Oii branch decreased to 1 km, and along the Suhard branch to 442 m; the maximum depth decreased to 10.5 m (Pişotă &Năstase, 1957). The initial water volume was estimated at 680 000 m^3. After 130 years, the sediment volume filling the lake was around 480 000 m^3 while de water volume reduced with 40%. On Oii branch the sediment thickness reached 5-6 m, the paludal vegetation having an important role to this. On the Oii and Piatra Roşie tributaries there were built dams in order to reduce the sediment supply to the lake but the results were under expectation, since one of them is already overfilled, while the other is almost filled.

Hidrophysical data. The thermal regime of the Red Lake is mixed with a normal thermal stratification during warm season and a reverse thermal stratification during cold season, separated by short isothermal regime intervals. During the winters the lake is covered by a 0.45-0.6 m ice bed which last about 120-130 days, from December to the second part of April. The water transparency is between 0.2 to 3.5 m, with the average value of 2 m and the lowest value during the snow melting.

Fig. 32. The Red Lake with Ghilcoş Mountain in background
(photo D. S. Baciu)

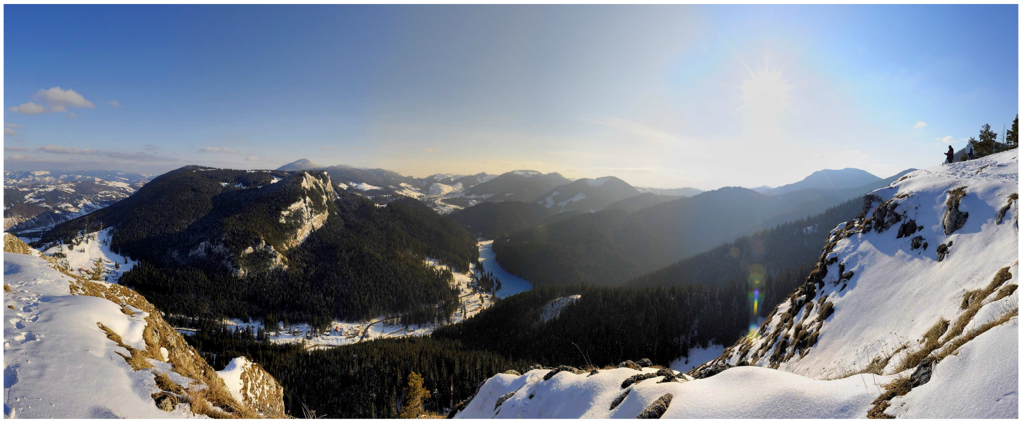

Fig. 33. Ghilcoş Mountain and the Red Lake. View from Suhardul Mic Mountain
(photo D. S. Baciu)

Hidrobiological characterization. Ecologically, from lake's genesis to recent decades, the Red Lake underwent three stages: a) the oligotrophic stage; b) the mesotrophic regime stage when aquatic macrophytes invaded the lake, and c) the mesotrophic-eutrophic stage.

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DAY 2: Lacu Roşu-Gheorgheni-Ditrău-Tulgheş-Tg. Neamţ-Iaşi

STOP 10: THE „TARISZNYÁS MÁRTON" MUSEUM IN GHEORGHENI[11]

Location: center of Gheorgheni city, in the main building of the "Tarisznyás Marton" Museum

Coordinates: N 46°43'13.11" and E 25°36'0.60"; altitude - 800 m

The "Tarisznyás Marton" Museum in Gheorgheni is a private collection, donated by Dr. Jakab Gyula, The museum was opened to the public in 2008. It consists of several rooms and individual collections, such as:

Room 1. Geology of the Ditrău Alkaline Massif:

- a 3D model sc. 1:10,000 of the area geology (Fig. 34 b);
- four structural drilling of various depth (from 650 m to 1400 m) with representative drill-cores;
- representative petrographic and ore minerals samples etc;
- set of pictures taken under the polarizing microscope with the latest minerals found in the Ditrău Massif (Fig. 34 c).

Room 2. Representative fossil for Paleozoic, Mesozoic and Cenozoic

Room 3. Mineralogical and geological equipment and mining tools.

Room 4. Igneous, metamorphic and sedimentary rocks from different parts of Romania and from abroad. Also more than 60 plates of ornamental rocks from different parts of the world are displayed Fig. 34 d).

Room 5. "Mine flowers", i.e. large crystals of various oxides, carbonates, sulphates, sulphides. Minerals arranged according to systematic classification of Strunz (Fig. 34 a), cut gemstones (Fig. 34 e) and fluorescent minerals are displayed.

[11] The text and associated figures are from Gyula (2010).

Fig. 34. The Jakab Gyula private mineralogical collection from the Gheorgheni „Tarisznyás Márton" Museum:

a – showcases presenting a systematic mineralogical classification, b – 3D model sc. 1:10000 of the Ditrău Alkaline Massif geology; c – Display of polarized light microscopic images of minerals and rocks from the Ditrau massif; d – Ornamental rocks from different parts of the world; e – gemstones.

Reference

Gyula, J. (2010): The "Tarisznyás Marton" Museum in Gheorgheni. In Iancu, O. G. & Kovacs, M. (eds.): RO1 - Ore deposits and other classic localities in the Eastern Carpathians: From metamorphics to volcanics. Field trip guide. 20th Meeting of the International Mineralogical Association Budapest. Acta Mineralogica Petrographica. Field Guide Series, vol. 19, pp 1-55.

STOP 11: DOLOMITE QUARRY, IN VOŞLĂBENI[12]

Location: Voşlăbeni dolomite quarry (Fig. 35) is located in the eastern part of Voşlăbeni locality (9 km south of Gheorgheni city), NE of Cocoşul peak (1112 m) in the Giurgeu Mountains (Fig. 36).

Coordinates: N 46°38'2.50" and E 25°38'26.63"; altitude - 890 m

The quarry opens rocks belonging to the Rebra Unit of the Crystalline-Mesozoic Zone. The Rebra metamorphic unit (Balintoni *et. al.,* 2009) from the Rebra terrane was denominated by Kräutner (1968). It could be divided into several sub-units ("formations") named by Kräutner *et al*. (1982) (from bottom to top): Izvorul Roşu, Voşlobeni and Ineu "formations".

Fig. 35. Voşlăbeni Quarry (photo O.G. Iancu)

The *Voşlobeni sub-unit* is represented by a thick pile of carbonatic rocks with intercalations of paragneisses, white and black quartzites. On large areas, at the top and the bottom of the sub-unit amphibolites or thick amphibolitic gneisses can be found.

Voşlăbeni metamorphosed dolomites and dolomitic limestones are exposed on the southwestern side of Cocoşul peak towards Mureş Valley (Fig. 36). They have a grey-white to yellow color, the white being characteristic to freshly exposed dolomite.

Average chemical composition of metamorphosed dolomites is: CaO = 33.10 wt.%;

[12] The text and associated figures are from Şabliovschi V. & Răileanu M. (2010).

MgO = 21.80 wt.%; SiO_2= 1.60 wt.%; Fe_2O_3=0.16 wt.%; Al_2O_3= 0.14 wt.%; Na_2O = = 0.16 wt.%; K_2O = 0.04 wt.%; P.C. = 43.87 wt.% and traces of SO_3 and P_2O_5 (Zsakó & Hints, 1998). Dolomite crystallinity is variable, from fine grained to coarse grained. Large tremolite (5 to 10 cm) may be observed as prismatic crystals and radial fibers. The metamorphosed dolomite is processed by crushing and washing plant belonging to Harghita Mining Company (S.C. Exploatarea Minieră Harghita S.A.). Various granular and powder grades of dolomite are delivered for the following areas: steel industry, chemical industry, road construction, glass production, agricultural amendment, ornamental rocks, ceramics and for roads and railways.

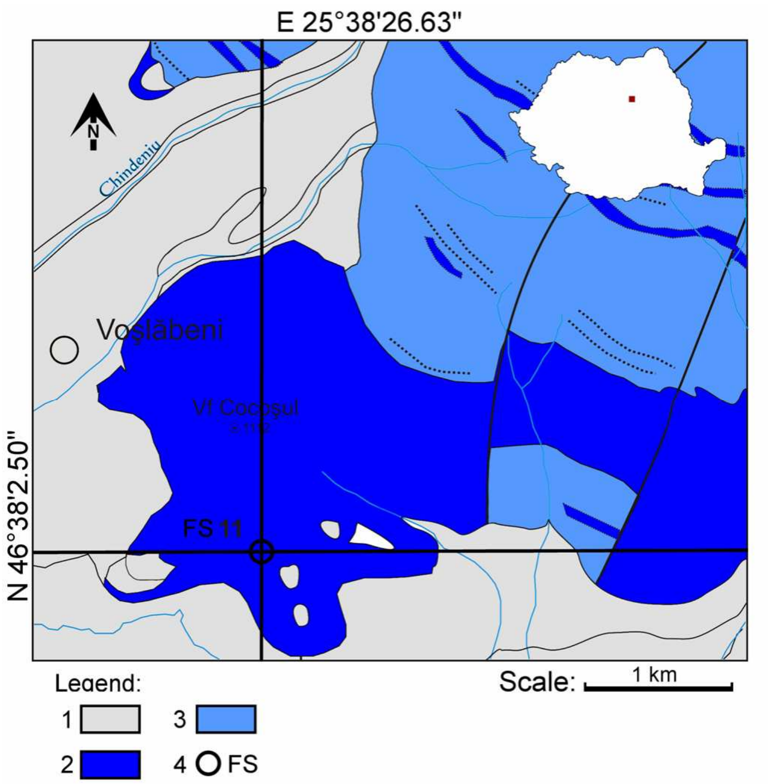

Fig. 36. Geologic sketch of the Voşlăbeni area (modified from the Geological Map of Romania, 1:50.000 – Voşlăbeni, Mureşan *et. al.*, 1986):
1 – Quaternary deposits; 2 – Rebra metamorphic unit (Voşlobeni sub-unit); 3 – Rebra metamorphic unit (Ineu sub-unit); FS 11 – field stop 11.

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STOP 12: OLD NEPHELINE SYENITE QUARRY ON THE DITRĂU VALLEY[13]

Location: Eastern part of the Ditrău Alkaline Massif, Ditrău Valley, at 8 km E of Ditrău village

Coordinates: N 46°50'1.20" and E 25°35'17.70"; altitude - 1030 m.

The nepheline syenite, which may be observed in this abandoned quarry (Fig. 4 and Fig. 37) is the prevailent rock type in the Ditrău massif. The rock is composed of pertithic feldspars, nepheline, biotite, amphibole, pyroxene, cancrinite, sodalite and calcite. This rock type occurs in the central and eastern part of the complex and represents the youngest intrusion of the complex (Fall *et al*., 2007). The commonest variety, with randomly oriented feldspars, is white and coarse- to medium-grained and consists of large (5-10 mm) euhedral perthitic feldspar and nepheline crystals. The mafic components are present in smaller amounts, and include biotite and clinopyroxene, rarely amphibole. Other important phases are calcite, cancrinite, sodalite (Fig. 38) and analcime. Apatite, titanite and zircon are accessory phases.

Fig. 37. The old nepheline syenite quarry, in the Ditrău Valley.

[13] The text and associated figures are from Iancu & Popa (2010).

Nepheline syenite containing sodalite, calcite and cancrinite, actually named foyaite, was referred to as "ditroite" in the alkaline rock nomenclature, a term introduced by Zirkel (1866). At present "ditroite" is not an accepted petrographic term.

According to Fall *et al*. (2007), alteration of nepheline to cancrinite removes additional carbonate, as well as Cl and SO_4 ions. The formation of sodalite by alteration of nepheline (or albite) removes NaCl from the aqueous solution. The alteration of albite to produce sodalite also releases silica to the solution, which is involved in the alteration of nepheline to produce analcime. Late crystallization of the hydrous minerals biotite and amphibole is related to the increasing activity of water in the melt and in the coexisting aqueous phase. This interpretation suggests that the nepheline syenite melt achieved volatile saturation soon after crystallization began, and that an active magmatic hydrothermal system existed during the crystallization history of the nepheline syenites of the Ditrău Alkaline Massif.

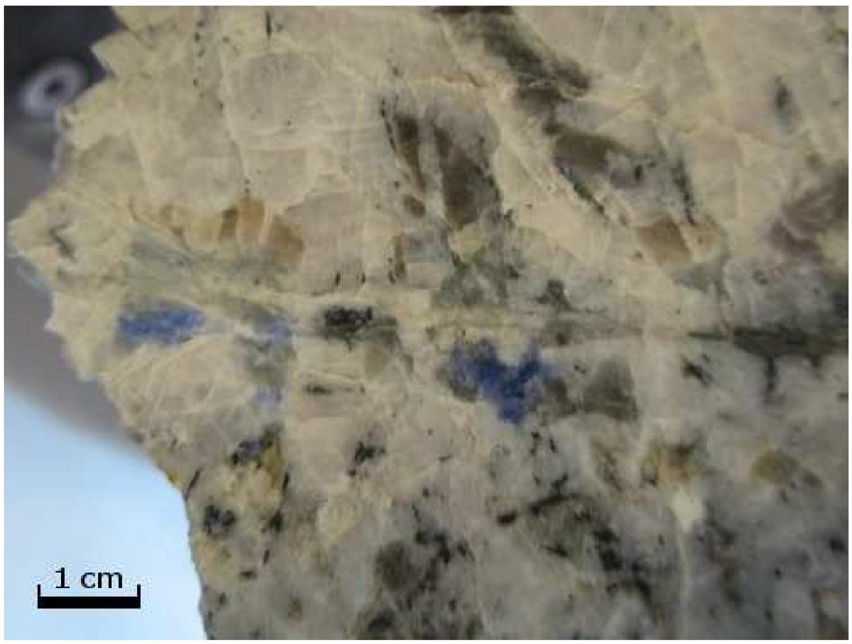

Fig. 38. Detail on sodalite (blue) from a nepheline syenite
(Jakab Gyula's private collection, Gheorgheni)

Reference

Iancu, O. G. & Popa, C. (2010): Abandoned nepheline syenite quarry near Ditrău. In Iancu, O. G. & Kovacs, M. (eds.): RO1 - Ore deposits and other classic localities in the Eastern Carpathians: From metamorphics to volcanics. Field trip guide. 20th Meeting of the International Mineralogical Association Budapest. Acta Mineralogica-Petrographica Field Guide Series, vol. 19, pp 1-55

A SHORT CULTURAL ITINERARY[1]

STOP 13: SECU MONASTERY

Location: Neamț County, Pipirig village
Coordinates: N 47°10' E 26°11'; altitude - 544m

The church of the monastic establishment was founded by the high magistrate Nestor Ureche, the father of the renowned chronicler Grigore Ureche. The construction was completed in 1602. The church is representative of Moldavian architecture at the end of the 16th century and the beginning of the 17th century. It integrates Walachian influences into its Moldavian form. These include the two towers, one above the naos, the other above the pronaos, and the two rows of blind arcades going around the church façades (Fig. 39). The tri-apses architectural plan, as well as the decorative graphically of its façades, are others elements which include this massive construction into the new wave in the architecture of Moldavia which was characteristic of the end of the 16th century.

Before the church was constructed, there existed a skete for nuns on the premises, which was mentioned in the historical document that date from the second half of the 16th century; it was called Zosin's Skete and had a prominent monastic life.

The church was constructed at the end of the 18th century and the diaconikon in the 19th century. The paintings inside the church were completely reconditioned in 1850.

STOP 14: SIHĂSTRIA MONASTERY

Location: Neamț County, in Vânători village at 22 km from Târgu Neamț town
Coordinates: N 47°10' E 26°11'; altitude - 615m

The holy establishment is situated in a Sub Carpathian Valley, on a location that was formerly called "Atanasie's Meadow". The monastery derives its name from the name of an anchorite who constructed a skete around which there were living several other anchorites. The founding of the monastery was Ghedeon, Bishop of Huşi, who completed the construction of church (which was built of wood), a group of monastic cells and a belfry in 1655. In 1734 Ghedeon had a bigger church erected and placed it under the direction of the Secu Monastery. It was also through his preserving efforts that the monastery received a Royal Authorization from Grigore Ghica Voivode, which conferred it certain special privileges and tax-exemptions.

In 1821, the wooden church of Bishop Ghedeon was burnt down during the political unrest caused by the nationalistic Etaireía movement. Dometian, prior of the monasteries of Secu and Neamț, raised a new stone church, dedicated to the Birth of the Holy Virgin, in 1824.

The precinct walls with two towers were built at the same time. The gate tower stands

[1] All information are from *Romanian Monasteries.org* (www.romanianmonasteries.org)

in the middle of the south wall, and a bell tower is in the northeast corner. The monks' cells and a chapel were also built in the yard. These were burnt down in 1941 and soon rebuilt.

Fig. 39. The church of Secu Monastry (left) (photo: http://www.romanianmonasteries.org/other-monasteries/neamt-monasteries/secu)

Fig. 40. The church of Sihăstria Monastry (bellow left) (photo: http://www.romanianmonasteries.org/other-monasteries/neamt-monasteries/sihastria)

Fig. 41. The 14th century church of Neamț Monastry (bellow right) (photo: http://www.romanianmonasteries.org/other-monasteries/neamt-monasteries/neamt)

STOP 15: NEAMȚ MONASTERY

Location: Neamț County, 10 km west of Târgu Neamț
Coordinates: N 47°16' E 26°12'; altitude - 491 m

The monastery was founded by Petru Mușat as convent for monks, in the 14th century. Alexander the Good (Alexandru cel Bun) raised the steeple in the 15th century. Stephen the Great (Ștefan cel Mare) built the big church "….*as a place of commemoration of himself and his wife Maria and his son Bogdan and his others sons, and completed it in the year 7005 (1497), the 41st year of his reign, the 14th day of November*."

The Monastery contains two churches, two chapels, a museum, and a library. Cultural center renowned for its calligraphers, chroniclers and printers (Gavriil Uric – 15th century, Macarie and Eftimie – 17th century) but also for the example of monastic life (Paisie Velicicovschi – 18th century and Saint Ioan Iacob Hozevitul – 20th century). Dedication day: "The Lord's Ascension", 40 days after Easter.