STRUCTURAL UNITS IN THE PRE–ALPINE BASEMENT OF THE EASTERN CARPATHIANS

H. G. KRÄUTNER[1] and G. BINDEA[2]

[1] *Isarstr. 2E, D – 83026 Rosenheim, Germany; hg.kraeutner@t–online.de*

[2] *Institutul Geologic al României, Str.Caransebeş 1, 78344 Bucureşti, Romania; bindea@ns.igr.ro*

Abstract: Pre-Alpine lithologic and structural units in the metamorphic basement of the Eastern Carpathians are presented in a new geological map (scale 1:200 000), based on detailed mapping, extensive mining and drilling performed during the last thirty years.

Key words: Eastern Carpathians, Pre-Alpine basement, metamorphics

Paleostructural setting. The metamorphic basement of the Eastern Carpathians derived from the Bucovino-Getic microplate, which during Jurassic was separated from the south European continental margin by the Civcin-Severin rifting and spreading system. This rift evolved to a narrow oceanic basin, which was closed during the Upper Jurassic – Lower Cretaceous and filled with calcareous flysch (Sinaia flysch) (Săndulescu 1984, Kräutner 1996). In the Meso-Cretaceous compressional stages the Bucovino-Getic microplate was sheared and staked to a thick nappe pile described as Median Dacides, which include the Bucovinian, Subbucovinian and Infrabucovinian nappe systems (Săndulescu 1984). During this crustal shortening the Bucovinian elements were covered by obducted slabs of Tethyan oceanic crust (Transylvanides) and have been overthrusted altogether on the Sinaia flysch of the Civcin-Severin trough (Outer/External Dacides). In Middle Cretaceous, as well as by Late Cretaceous reactivation, the Outer Dacides were thrust over the deformed European margin (Peri-Moldovian rise, Marginal Dacides, Danubian units in the Southern Carpathians), which at its turn overrides the younger Moldavide flysch nappes.

During the Miocene escape tectonics of the Alpine collisional stage, the Dacidic units of the Eastern Carpathians have been displaced eastwards over more than 100 km, due to the push of the clockwise rotating Apuseni-Tisia block and the interposed Thetyan element. Concomitantly the outer flysch zone was uprooted, deformed and thrust over the East European platform (Moldavides).

The Bucovino-Getic microplate included in its Pre-Mesozoic basement Variscan structures which continued from Central Europe into the area south of the Alpine front. The wide of the Bucovino-Getic microplate is estimated roughly at about 300 km, whereas its length was more than 700 km, when the Southern Carpathians are included (without their 50% stretch). In the Eastern Carpathians a 300 km long segment was preserved, in which the shortening transversal to the Alpine chain was at least 60%. The Bucovinian nappe is exposed on the whole length of the Eastern Carpathians. The Subbucovinian basement can by observed only in the northern part, over about 150 km, whereas the Infrabucovinian units are known exclusively from isolated Alpine tectonic windows, among which the largest is the Rodna halfwindow of 20x20 km. Thus, any attempt to reconstruct the Pre-Alpine lithologic and structural framework of the Bucovino-Getic microplate can be only restrictive and highly speculative.

Variscan nappe structure. In the Pre-Alpine basement of the Central East Carpathians Variscan napping is proved by Permian-Triassic sediments transgressively covering metamorphics of different tectonic basement units, as well as by the 232 and 160 Ma biphasic Ditrău intrusive massif, welding in its thermal contact aureole at least five superposed tectonic sheets. The nappe emplacement is constraint to Middle-Upper Carboniferous by 310-280 Ma old Variscan metamorphics on Paleozoic and older educts, involved in the tectonic deformation. A westward vergencis, opposite to the Alpine napping, was suggested (Săndulescu 1984). In the Infrabucovinian units this is consistent with the western vergencis of the Variscan synmetamorphic deformation (Kräutner 1991). The Variscan basement units form a pile of flat nappes, which were involved in Alpine large normal folds together with the Mesozoic sedimentary cover. In the axial zones of Alpine anticline structures (e.g. Rusaia, Iacobeni, Barnar) both, the Alpine and Variscan nappes were stretched or partly razed by intensive shearing. It is suggested that also at larger scale Variscan shear planes were partly reactivated during the Alpine compressional stages, so that in some cases no accurate distinction is possible between preserved Variscan nappe contacts and further Alpine scaling of Variscan tectonic and lithologic units.

A model reconstruction of the Pre-Alpine structure in the East Carpathian Bucovino-Getic basement (Fig. 1) suggests a pile of six main Variscan nappes, which locally are more complicated by local scaling. Only in the Infrabucovinian realm both, Pre-Variscan basement and Paleozoic cover sequences were preserved in their primary superposition. Most of the nappes have a lithologic constitution restricted to a single lithostratigraphic unit (Balintoni 1984). This suggests that Variscan napping was highly intensive, giving thin skinned tectonic sheets, derived from a composite crust. The higher Variscan units mostly form the basement of lower Alpine (Infrabucovinian) nappes, whereas units from the lower part of the Variscan nappe pile prevailing form the basement of upper Alpine (Bucovinian, Subbucovinian) nappes. This is consistent with the suggested westward vergencis of Variscan napping, opposite to the eastward Alpine vergencis (Fig. 1). The parts of the Variscan nappe pile preserved in each of the main Alpine nappes are shown schematically in Fig. 2. The surface distribution of these Variscan units in the basement of the Bucovinian and Subbucovinian nappes are given in Figs. 3, 4. From the top towards the base of the nappe pile, the following sequence of Variscan units is suggested:

Hăghimaş-Granitoid nappe. Formerly Hăghimaş-Granitoids were considered as a part of the Rarău nappe, but their flat position and tectonic contacts towards the underlying Bretila lithology, including greenschist facies mylonites covered by Triassic sediments, rather suggest a discrete Variscan granitoid nappe.

Rarău nappe. In Bucovinian and Infrabucovinian position the Rarău nappe consists of Bretila type MT/MP gneisses, separated from underlying tectonic units by a retrogressive greenschist facies zone, grading into mylonites and phyllonites. In the Infrabucovinian units of the Rodna and Maramureş Mts., Bretila metamorphics are conformable covered by Variscan LT/LP metamorphics on Silurian – Lower Carboniferous sedimentary and magmatic educts (Rusaia, Repedea and Cimpoiasa Groups). Thus the Bretila gneisses are assigned to a Precambrian basement, intensively overprinted by the Variscan metamorphism, which in the Paleozoic sedimentary cover developed progressively in greenschist facies conditions.

Chiril nappe and Balaj mylonite zone. In the north eastern part of the Bucovinian unit, below the Rarău nappe occurs a lithostratigraphically well defined sequence of unknown age (Chiril Formation). It was affected by Variscan greenschist facies metamorphism ("biotite in" zone) and is separated from overlying and underlying metamorphics by mylonite and phyllonite

zones. In the south, at the tectonostratigraphic position of the Chiril nappe, occurs only a 100-200 m thick sheet of blasto-mylonites and phyllonites (Balaj mylonitic zone, Bindea 1998).

Putna, Sândominic, Bălan nappes and Liţu scale. These tectonic units include the LT/MP Variscan metamorphics of the Tulgheş Group, derived from Ordovician sediments and volcanics (Vaida 1998), formerly assigned to the Cambrian. This sequence records an early siliciclastic platform stage (Formation Tg1), followed by an initial basinal phase (Formation Tg2) and a period of extensional intracontinental breakdown and collapse, associated with bimodal magmatism (Formation Tg3). Syngenetic manganese (Iacobeni, Oiţa, Dadu, Dealul Rusului) and barite (Holdiţa-Broşteni) ores formed in the Tg2 basinal stage, whereas to the prevailing rhyolitic Tg3-volcanism VHMS deposits are related (Baia Borşa, Fundul Moldovei, Leşul Ursului, Bălan). The final stage was a rifting basin, partly filled with flysch-like deposits and local interlayers of basic volcanics (Formation Tg4). Detailed lithostratigraphic mapping, as well as intensive and extensive drilling and mining, show that the Tulgheş Group was involved in a complicated Variscan nappe system, that is interposed between units of older and higher-grade metamorphics (Figs.1, 2, 3, 4). Thus in the Bucovinian basement the Bălan, Putna - Baratu Mare and Sândominic nappes were distinguished, each of them with specific lithologic characteristics. In the Subbucovinian nappe the main unit is considered coeval to the Putna nappe, whereas the lower unit (Valea Stânei) could have an Infrabucovinian equivalent in the albite porphyroblast schists drilled in the core of the Barnar tectonic window. Some relict mineral phases of coarse-grained Tg4-sediments, like blue magmatic quartz with rutile needles, prevailing plagioclase feldspar, high quartz content, could suggest that partly the Tg4 deposits were fed from Rebra and Pietrosul lithologies, which form the lower Variscan nappes.

Pietrosul Porphyroid nappe. Between the piles of Tulgheş and Rebra metamorphics, Pietrosul Porphyroids (meta-dacites, meta- porphyric granodiorites with metamorphic biotite in their matrix) occur as tectonic lenses with lengths ranging from some metres up to more than 50 km. They are intensively overprinted by Variscan and Alpine greenschist facies mylonitization. Unaffected rocks were preserved only in central parts of thick lenses.

Rodna, Rusca-Dârmoxa and Negrişoara nappes. This nappe system includes the lowermost Variscan units exposed in the Eastern Carpathians. They are constituted of Rebra-type metamorphics assigned to the Precambrian. It is considered that these units represent Variscan nappes rather than a Variscan autochthonous, as their equivalent in the Supragetic units of the Southern Carpathians (Făgăraş Group) overthrusted the Poiana Ruscă Paleozoic metamorphics with a vergencis that is conformable with the Variscan vergencis. In the Rusca-Dârmoxa unit a Pre-Variscan polymetamorphic evolution was documented by successive MT/MP and MT/LP stages (Balintoni, Geucă 1977). The Rebra lithology records a carbonatic platform stage (Formation Rb2), in which carbonatic hosted Mississippi-Valley type Zn-Pb deposits formed (Valea Blaznei, Guşet). The platform stage was followed by a basinal stage which flysch-like deposits (Formation Rb3). We suggest that the sequence described as Negrişoara formation (Balintoni, Gheuca 1977), occurring in tectonic position below the Putna nappe in Bucovinian position, in fact represents a lithology equivalent to the Rb3 formation. Only the Negrişoara sequence exposed in the southern East Carpathians below the Sândominic nappe, shows distinct lithologic characters. These could by consistent with a distal flysch development, coeval with the Rb3 flysch.

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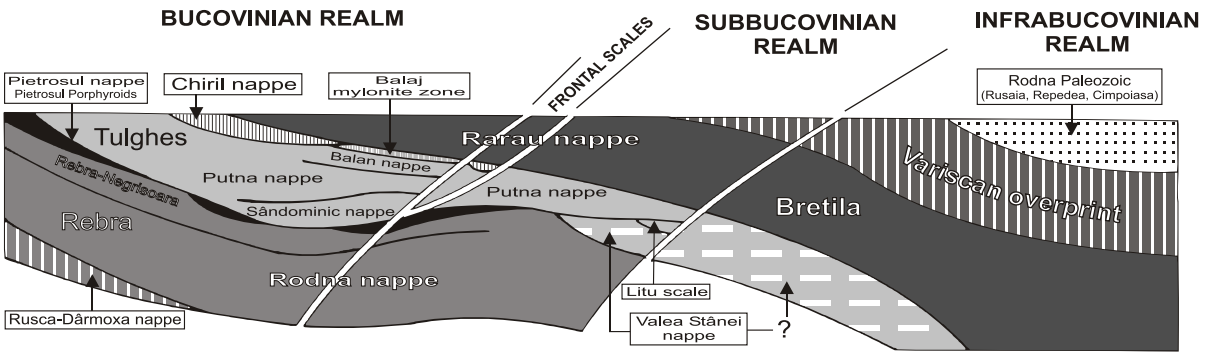
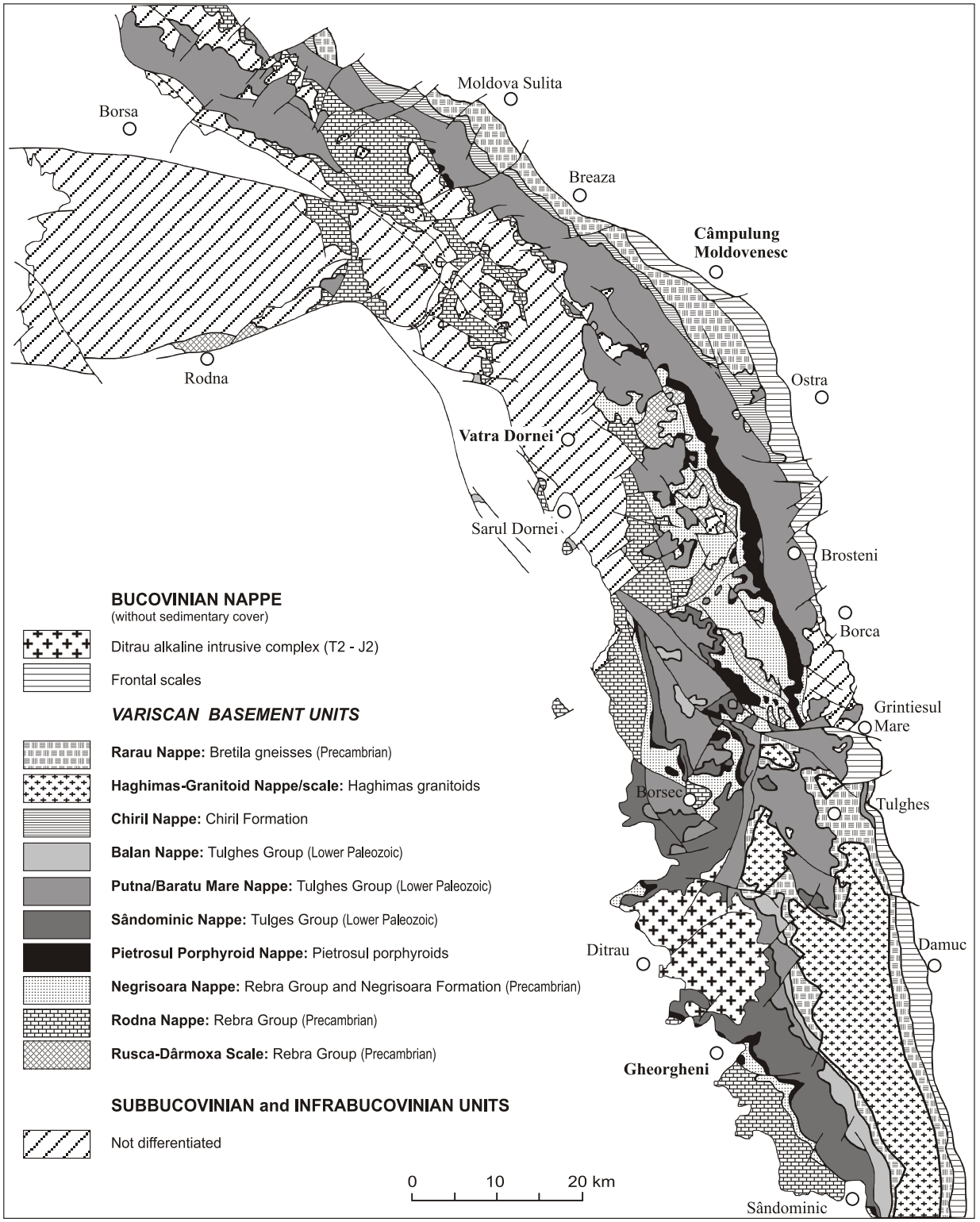
Fig.1 Model of the Variscan nappe structure in the Bucovino-Getic basement prior to the Alpine napping.

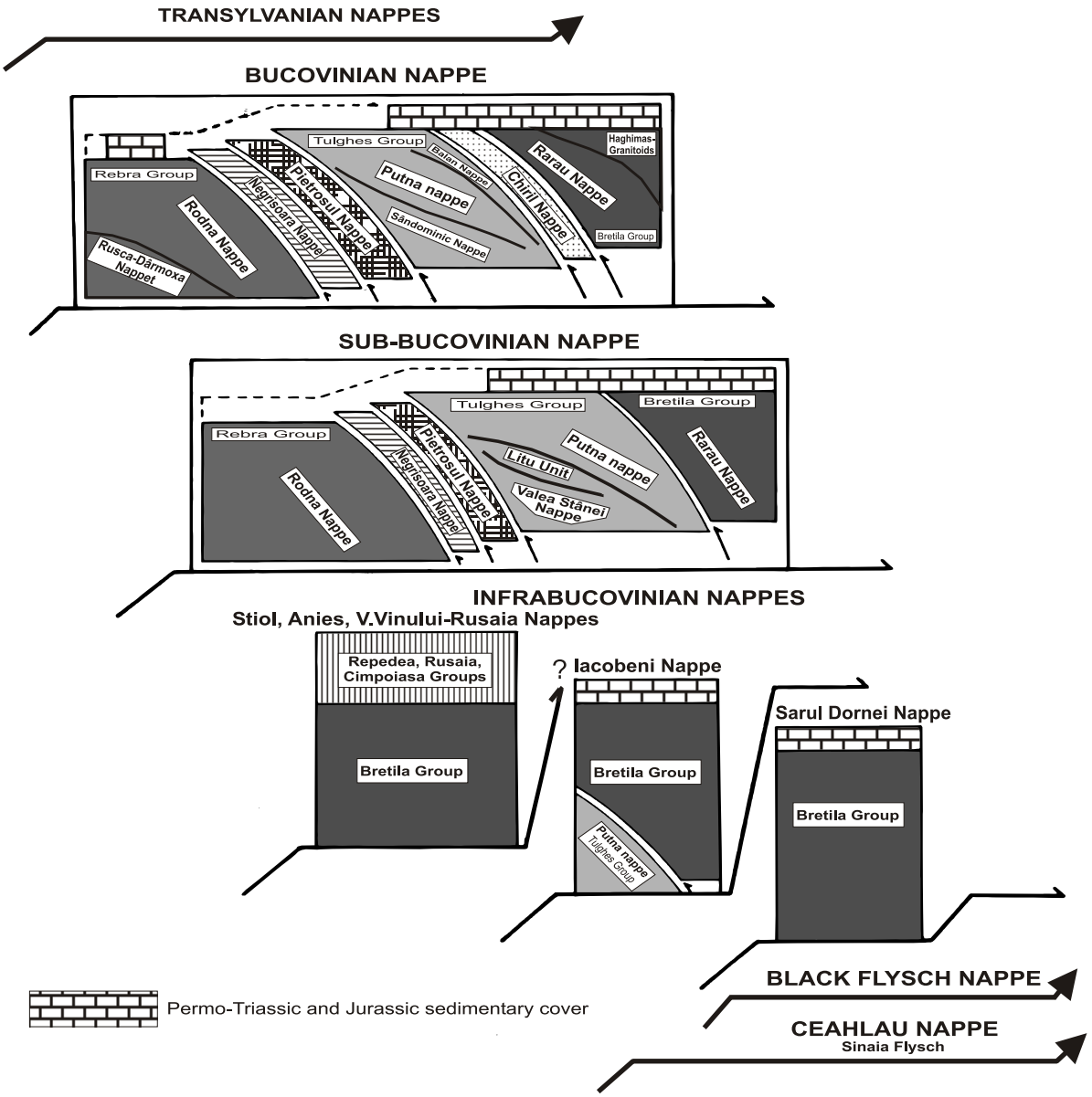
Fig. 2 Structural model of the main Alpine and Pre-Alpine tectonic units of the Eastern Carpathians.

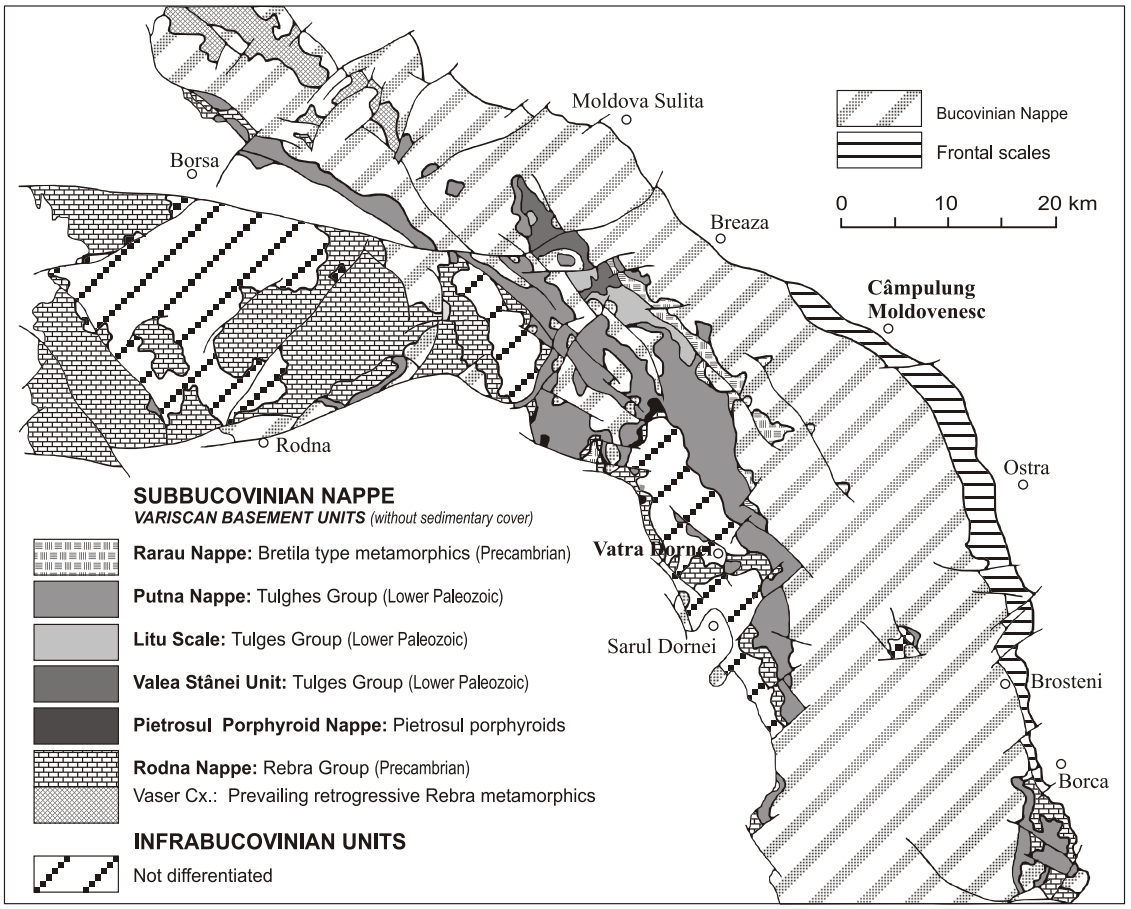
Fig. 3 Variscan tectonic and lithostratigraphic units in the Pre-Alpine basement of the Bucovinian nappe.

Fig. 4 Variscan tectonic and lithostratigraphic units in the Pre-Alpine basement of the Subbucovinian nappe.


BUCOVINIAN REALM
SUBBUCOVINIAN REALM
INFRABUCOVINIAN REALM
FRONTAL SCALES
Pietrosul nappe
Pietrosul Porphyroids
Chiril nappe
Balaj mylonite zone
Rodna Paleozoic
(Rusaia, Repedea, Cimpoiasa)
Tulghes
Rebra-Negrisoara
Rebra
Putna nappe
Balan nappe
Sândominic nappe
Rarau nappe
Putna nappe
Bretila
Variscan overprint
Rodna nappe
Litu scale
Valea Stânei nappe
?
Rusca-Dârmoxa nappe


Moldova Sulita
Borsa
Breaza
Câmpulung
Moldovenesc
Rodna
Ostra
Vatra Dornei
Sarul Dornei
Brosteni
Borca
Grintiesul
Mare
Borsec
Tulghes
Ditrau
Damuc
Gheorgheni
Sândominic
BUCOVINIAN NAPPE
(without sedimentary cover)
Ditrau alkaline intrusive complex (T2 - J2)
Frontal scales
VARISCAN BASEMENT UNITS
Rarau Nappe: Bretila gneisses (Precambrian)
Haghimas-Granitoid Nappe/scale: Haghimas granitoids
Chiril Nappe: Chiril Formation
Balan Nappe: Tulghes Group (Lower Paleozoic)
Putna/Baratu Mare Nappe: Tulghes Group (Lower Paleozoic)
Sândominic Nappe: Tulges Group (Lower Paleozoic)
Pietrosul Porphyroid Nappe: Pietrosul porphyroids
Negrisoara Nappe: Rebra Group and Negrisoara Formation (Precambrian)
Rodna Nappe: Rebra Group (Precambrian)
Rusca-Dârmoxa Scale: Rebra Group (Precambrian)
SUBBUCOVINIAN and INFRABUCOVINIAN UNITS
Not differentiated
0
10
20 km


TRANSYLVANIAN NAPPES
BUCOVINIAN NAPPE
Tulghes Group
Balan Nappe
Haghimas-Granitoids
Rebra Group
Putna nappe
Chiriș Nappe
Rarau Nappe
Rodna Nappe
Pietrosul Nappe
Negrișoara Nappe
Sândominic Nappe
Bretila Group
Rusca-Dârmoxa Nappet
SUB-BUCOVINIAN NAPPE
Tulghes Group
Bretila Group
Rebra Group
Pietrosul Nappe
Negrișoara Nappe
Putna nappe
Litu Unit
Rarau Nappe
Rodna Nappe
Valea Stânei Nappe
INFRABUCOVINIAN NAPPES
Stiol, Anies, V.Vinului-Rusaia Nappes
Repedea, Rusaia, Cimpoiasa Groups
? Iacobeni Nappe
Sarul Dornei Nappe
Bretila Group
Bretila Group
Bretila Group
Putna nappe
Tulghes Group
BLACK FLYSCH NAPPE
CEAHLAU NAPPE
Sinaia Flysch
Permo-Triassic and Jurassic sedimentary cover


Moldova Sulita
Borsa
Breaza
Câmpulung
Moldovenesc
Rodna
Ostra
Vatra Dornei
Sarul Dornei
Brosteni
Borca
Bucovinian Nappe
Frontal scales
0
10
20 km
SUBBUCOVINIAN NAPPE
VARISCAN BASEMENT UNITS (without sedimentary cover)
Rarau Nappe: Bretila type metamorphics (Precambrian)
Putna Nappe: Tulghes Group (Lower Paleozoic)
Litu Scale: Tulges Group (Lower Paleozoic)
Valea Stânei Unit: Tulges Group (Lower Paleozoic)
Pietrosul Porphyroid Nappe: Pietrosul porphyroids
Rodna Nappe: Rebra Group (Precambrian)
Vaser Cx.: Prevailing retrogressive Rebra metamorphics
INFRABUCOVINIAN UNITS
Not differentiated