THE SOUTH CARPATHIANS: TECTONO-METAMORPHIC UNITS RELATED TO VARISCAN AND PAN-AFRICAN INHERITANCE

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Abstract. This overview of the pre-Mesozoic tectono-stratigraphic units from the South Carpathian basement is based on updating the published and unpublished maps with recent age determinations. Updating is focused on pre-Upper Carboniferous metamorphosed sequences and related magmatites, which yielded protoliths ages in the Neoproterozoic to Carboniferous time span. Within the Danubian Domain, the Upper Proterozoic (Pan-African/Cadomian) granitoid massifs are intruded in the metaterrigenous Lainici-Păiuş unit, while Paleozoic (Carboniferous and Lower Permian) granitoids and volcanics are present in both Neoproterozoic units, Lainici-Păiuş and Drăgşan (oceanic type rock assemblages). A Devonian ophiolitic and tectonic paleosuture separating these two units is preserved in the Danubian Domain. In the Getic-Supragetic Domain, Neoproterozoic protoliths are recognised in the Lotru and Ursu units, Cambrian protoliths in the Făgăraș unit, while Lower Paleozoic (Ordovician) metagranitoids are associated to the Cumpăna and Sebeș units. Variscan tectonic lines are cartographically identified based on simple shear zones and syn-tectonic parageneses, contrasting lithologies, structural-metamorphic features and the recognized paleosutures. The main feature of the gneissic units in the Getic-Supragetic basement is the exhumation of the deep seated shear zones and HP mafic-ultramafic rocks with Carboniferous izotopic ages, as well as the widespread metatectic migmatisation and anatexis.

Key words: Getic-Supragetic, Danubian, nappes, regional metamorphism, shear zones, granitoid massifs, ophiolitic complex, eclogite

1. INTRODUCTION

The aim of this paper is to present an overview of the pre-Mesozoic basement units from the South Carpathians, starting with the cartographic data we compiled within research studies in the Geological Institute of Romania - GIR (Iancu and Seghedi, 2000). The cartographic data synthesized are based on published and unpublished geological maps sc. 1: 25.000 and 1:50.000, authored by V. Iancu, T. Berza, I. Balintoni, M. Mărunţiu, I. Gheuca, A. Seghedi, I. Dinică, as well as published geological material (*e.g.* Gheuca, 1988; Gheuca and Dinică, 1986; Stelea 1992, 1994). The maps were electronically processed in OCD program during several years by the first author of this paper.

Some data based on the tectonostratigraphic synthesis in the initial report (Iancu *et al.*, 2000) were published in papers focused on certain middle-high grade gneissic units (Medaris *et al.*, 2003; Axente *et al.*, 2008), as well as on the Paleozoic formations with low to middle grade metamorphism (Iancu *et al.*, 2005b; Seghedi *et al.*, 2005). In the meantime, several specialized articles have been published containing isotopic age determinations on granitic type protoliths (granitoids and granite gneisses) sampled from various types of rocks of the pre-Alpine basement in the South Carpathians (Drăguşanu and Tanaka, 1999; Duchesne *et al.,* 2008; Balica, 2007; Balintoni *et al.*, 2009, 2010, 2014; Săbău and Negulescu, 2012; Plissart *et al*, 2015, 2016). These isotopic age determinations were used to update the cartographic materials presented in this paper, as they are essential for clarifying the geological history of metamorphic and magmatic lithological entities of the Variscan and Pan-African orogens incorporated in the Alpine belt of the South Carpathians. The methods used to attain the proposed goal are diversified and include mapping and field structural data, petrographic-mineralogical and structural observations and analyses focused on pre-Alpine shear zones and the main tectonostratigraphic units.

The contrasting lithological associations, the regional (pure shear) tectono-metamorphic features of the units separated, as well as structural-metamorphic features of the main tectonic boundaries (simple shear zones) were used to map the Variscan nappe stacks involving crustal fragments from exotic terranes of Variscan and Pan-African origin, now preserved within the Carpathian basement. Gondwana-derived crustal microplates (e.g. Avalonia and Armorica, cf. Seghedi *et al.*, 2005; Iancu *et al.*, 2005; Winchester *et al.*, 2006), their Paleozoic covers, exhumed mantle pods and HP markers, as well as newly generated Paleozoic rift and/or oceanic basins can be identified and used for the reconstruction of the pre-Mesozoic tectono-stratigraphic units.

2. ALPINE AND PRE-ALPINE STRUCTURAL BACKGROUND AND GEOLOGICAL HISTORY

2.1. Alpine background

The Carpathians, as a branch of the Alpine-Himalayan fold and thrust belt, mark the mobile areas of the East European and African plates (Burchfiel, 1980). They derived from the mobile parts of the continental microplates (Getic/Rhodope and Danubian microplates), and their allochtonous position is underlined by the oceanic plate remnants preserved as inverted suture zones: Vardar-Mureş (main Tethian suture zone) and Severin-Ceahlău (a Late Jurassic-Early Cretaceous rift developed on the margin of the East European plate), (Săndulescu, 1984; 1994).

The complex nappe structure of the South Carpahians (Murgoci, 1905; Streckeisen, 1935; Codarcea, 1940; Berza *et al.*, 1994; Iancu *et al.*, 2005a and references therein) resulted in Middle-Late Creaceous contractional events (convergence to collision Cretaceous cycle), but the present day position of this mountain belt was defined during the Tertiary continental collision cycle. The Cretaceous-Tertiary nappe stacks of the South Carpathians override to ESE the Moesian Platform, while to the WNW their relationships with the Tethian suture zone are concealed by the Pannonian and Transylvanian extensional basins (Seghedi *et al.*, 2005; Iancu *et al.*, 2005b).

The Cretaceous nappe complexes of the South Carpathians include nappes with basement/cover stratigraphy (Getic-Supragetic and Danubian nappe systems) as well as "cover" napes, including ophiolite and turbidite remnants (Severin-Ceahlău) (Năstăseanu *et al.*, 1981; Berza *et al.*, 1994; Săndulescu, 1994; Seghedi *et al.*, 1995; Balintoni, 1997; Pop *et al.*, 1997; Stanoiu, 2000; Iancu *et al.*, 2005a; Seghedi and Oaie, 1997, 2014).

2.2. Pre-Alpine context

The pre-Mesozoic basement of the South Carpathians (Fig. 1) is represented by crustal fragments of metamorphic-magmatic complexes of Paleozoic and Proterozoic age (Streckeisen, 1935) preserved inside the Getic-Supragetic and Danubian nappe complexes.

It is documented that the tectono-metamorphic evolution of the Paleozoic-Proterozoic Getic-Supragetic gneissic composite basement (Berza *et al*, 1994; Iancu and Mărunţiu, 1994b; Iancu *et al.*, 1998) is related to the Variscan orogenic cycle (Dallmeyer *et al.*, 1984, 1986, 1998; Ledru *et al.*, 1997; Drăguşanu and Tanaka, 1999; Medaris *et al.*, 2003), involving Armorica type-crust and newly generated sedimentary successions and magmatic protoliths (Iancu *et al.*, 2005b; Winchester *et al.*, 2006; Balintoni *et al.*, 2011). By contrast, the Danubian Proterozoic basement shows Pan-African affinities and distinct tectono-stratigraphic composition and metamorphic-magmatic history (Berza *et al.*, 1994; Liégeois *et al.*, 1996), while the Paleozoic evolution can be assigned to both pre-Variscan and Variscan events (or Eo-Variscan contraction to Neo-Variscan collision), involving also a late Neoproterozoic inverted rift and Avalonian derived terrannes (Mărunţiu *et al.*, 1997; Seghedi *et al.*, 2005; Iancu *et al.*, 2005b; Winchester *et al.*, 2006; Balintoni *et al.*, 2014).

3. PRE-MESOZOIC BASEMENT: PROTEROZOIC AND PALEOZOIC METAMORPHOSED SEQUENCES AND RELATED MAGMATITES

The main types of deposits and lithological associations forming the pre-Mesozoic basement of the South Carpathians are presented in Figure 2. They include: medium-high grade metamorphic rock assemblages of pre-Upper Carboniferous age, Paleozoic sedimentary and volcano-sedimentary rock sequences affected by low-grade, prograde Variscan metamorphism, Pre-orogenic, Paleozoic basic-ultrabasic and bimodal basic-felsic magmatic rocks with prograde Variscan metamorphism, Paleozoic (pre-Upper Carboniferous) orogenic granitoid massifs and Upper Carboniferous-Permian sedimentary and volcano-sedimentary deposits of mollase type.

3.1. Medium-high grade metamorphic rock assemblages of pre-Upper Carboniferous age

Pre-Upper Carboniferous rocks with a medium to high grade metamorphism form the largest areas of the South Carpathian basement and are spatially associated with large granitoid suites and anatectic granitoids or migmatites (Fig. 3). They display complex and diversified polymetamorphic (poly-stage or poly-orogenic) history, as well as contrasting features of metamorphic deformation style and nappe stacking events. The structural building and tectono-metamorphic histories of the Danubian gneisses are documented as Neoproterozoic, Pan-African (Berza *et al.*, 1994; Liégeois *et al.*, 1996), with a low grade Variscan imprint (Berza and Iancu, 1994) and late Variscan granitoid intrusions (as dated by Balica, 2007; Balintoni *et al.*, 2014 and references therein; Plissart *et al.*, 2012).

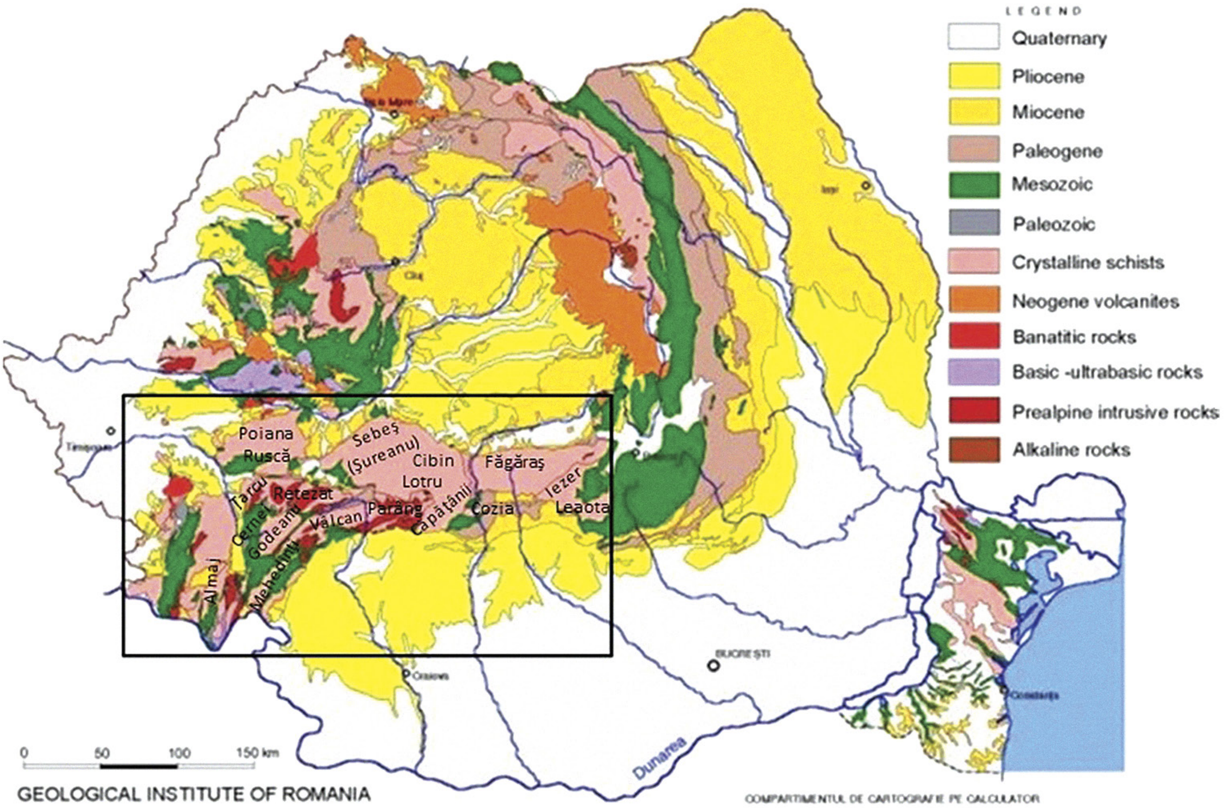

Fig. 1. Location of the South Carpathians on the geological map of Romania, sc. 1:1,000,000 (simplified after Săndulescu *et al.*, 1978).

In contrast, the Neoproterozoic-Paleozoic gneisses of the Getic-Supragetic basement (Figs. 2, 3) display a more complex history, as some crustal fragments were reactivated in HP and/or HT conditions. Some units (e.g. Lotru and Ursu units) show deformation and paragenetic evidence for prograde medium-high grade conditions with contrasting thermal regimes (HP, Lotru; HT, Ursu, cf. Medaris *et al.*, 2003; Hann *et al.*, 1988; Săbău, 1994), while Făgăraş lacks evidence for high-grade metamorphism (Stelea, 1992). In the Central-Eastern South Carpathians, the known HP metamorphic ages of the Cumpăna and Sebeş units (Fig. 3) are documented to be Neo-Variscan in age (Drăguşanu and Tanaka, 1999; Medaris *et al.*, 2003; Axente *et al.*, 2008). Also, exhumation related parageneses and deformations are different from one unit to the other, as the Variscan nappe stacks are in some cases of a deep seated crustal level (medium grade mylonites), while others were formed at higher crustal levels (low-grade mylonites).

Medium grade metamorphic rocks in the Danubian nappes

Two types of pre-Ordovician metamorphic suites, with contrasting protholiths and metamorphic history, form two distinct Variscan units, involved in a pre-Permian nappe structure: the Lainici-Păiuş Group, dominated by HT-LP metasediments, and the Drăgşan Group, dominated by MT-MP metabasites (Berza, 1978; Berza and Seghedi, 1983). The Variscan thrust, emplacing Drăgşan on top of Lainici-Păiuş Group, is sealed by Permian-Mesozoic sedimentary sucessions (Berza and Seghedi, 1983; Berza and Iancu, 1994; Berza *et al.*, 1994).

The Lainici-Păiuş Group includes a lower "Carbonate-Graphitic Formation", consisting of marble, graphite mica gneiss, amphibolite and calc-silicate gneiss, and an upper "Quartzitic and Biotite Gneiss Formation", dominated by quartzies and biotite gneisses, with minor marble, graphite mica gneiss, (para) amphibolite and calc-silicate gneiss (Berza, 1978; Berza *et al.*, 1994). This succession is pervasively migmatized, typically with leucogranite veins made of black K-feldspar, muscovite and garnet. The high temperature, medium pressure assemblages with sillimanite, andalusite and cordierite are partly overprinted by low-temperature minerals, due to Variscan and Alpine deformation. The Drăgşan Group includes the lower Făgeţel Augen gneiss Formation, the dominant Straja Amphibolitic Formation (including kilometre-size ultramafic cumulates) and the upper, Dobrota Micagneiss Formation (Berza and Seghedi, 1983; Kräutner *et al.*, 1988). Mineral assemblages indicate medium pressure, medium temperature metamorphic conditions (Berza, Seghedi, 1975, 1983; Berza *et al.*, 1994). In the Upper Danubian basement from the Banat area, the gneissic rock assemblages of Drăgşan and Lainici-Păiuş units are tectonically separated by Paleozoic low-grade metamorphic units and an important

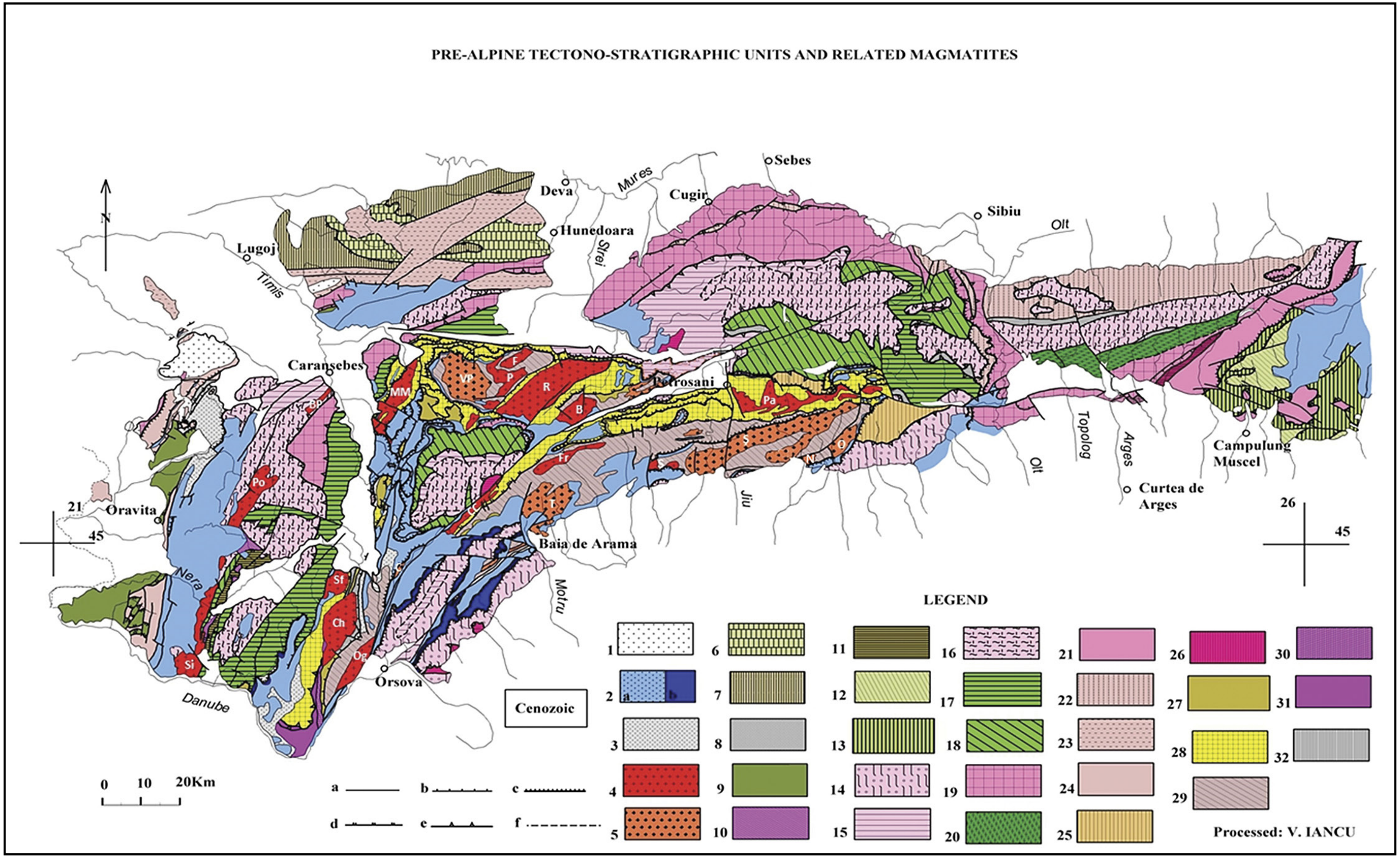

Fig. 2. Pre-Alpine tectono-stratigraphic units, metamorphic terranes and related magmatites in the South Carpathians. Authors: V. Iancu, T. Berza, I. Balintoni, M. Mărunțiu, A. Seghedi, I. Dinică. Structural elements: **a**: fault, **b**: reverse fault, **c**: alpine thrust, **d**: pre-Alpine thrust boundary, **e**: pre-Alpine, deep-seated shear zone, **f**: lithological/formation boundary. *Abbreviations*: Si – Sichevița, Po – Poniasca, BP – Buchin-Poiana, Og – Ogradena, Ch – Cherbelezu, Sf – Sfârdinu, MM – Muntele Mic, VP – Vârful Pietrii, P – Petreanu, F – Furcătura, R – Retezat, B – Buta, C – Cerna, CC – Culmea Cernei, T – Tismana, Fr – Frumosu, S – Suseni, Ş – Şuşița, P – Parâng, N – Novaci, O – Olteț.

suture zone (Iancu *et al.*, 1990, Iancu *et al.*, 2005 b) with obducted ophiolites, all involved in a Carboniferous nappe stack and crosscut by Late Variscan granitoids.

Getic-Supragetic gneissic units

A regional scale image of the pre-Alpine tectono-stratigraphic units and related shear zones in the Getic-Supragetic gneissic basement was presented by Iancu and Mărunţiu (1994a, b), but they were also recognised locally in various areas (e.g. Iancu *et al.*, 1988; Stelea, 1992, 1994; Săbău, 1994). Medium-to high-grade mylonites are closely related to the main tectonic contacts of Variscan age. Their syn-tectonic mineral phases are controlled by protolith petrography and chemistry, as well as by the physical conditions (PT) of the dynamic metamorphism.

The exhumed HP rocks from the Getic-Supragetic basement are related to different lithologic assemblages, as well as to some tectonic boundaries underlined by regional simple shear zones and tectonic mélanges, all together involved in the Variscan nappe stacks (Fig. 3) (Iancu *et al.*, 1998).

Two types of HP assemblages could be observed. One includes eclogite, granulite, garnet-amphibolite and garnet peridotite assemblages, located inside the superposed Sebeş, Lotru and Cumpăna tectonostratigraphic units, showing distinct petrographic and geochemical features (Mărunţiu, 1987; Medaris *et al.*, 2003), or along medium grade (amphibolite facies) shear zones separating medium-high pressure gneiss units. The other includes eclogites and coronitic metagranite (mucronite type) occurrences, cropping out in Iezer-Leaota Mountains and preserved as exhumed boudins and lenses in a tectonic mélange separating the epidote-amphibolite facies sedimentary and volcano-sedimentary Lereşti Formation (correlated with Caraş-Locva Formation) from the underlying Cumpăna-type gneisses (Iancu, 1998).

There are two different regional paleosutures, suggested by the distribution and geotectonic position of the HP rocks of basic and ultrabasic markers: a cryptic, deep seated paleosuture whose HP markers crop out on the southern border of the Variscan nappe stack (Mehedinţi-Căpăţâna Mountains, cf. Iancu *et al.*, 1987, then described as a Proterozoic event) and a HP tectonic mélange, cropping out in the Iezer-Leaota Mountains, on the oposite side of the fan-like nappe stack. A short description of the tectono-stratigraphic units will be presented according to Iancu (1998).

The Sebeş unit is typically developed in the Sebeş Mountains and can be correlated with similar lithologies (with different local names) from the entire area of the Getic-Supragetic basement. This large unit includes some widespread, lithologically contrasting tectonostratigraphic sub-units and formations.

Sebeş 1, exposed in Mehedinţi and Căpăţâna Mountains, is a dominantly metasedimentary rock sequence in which mica gneiss, quartzite, and quartz-feldspar para- and ortho-gneisses develop as metric to decametric alternating bands with a strongly penetrative S_2 foliation. Amphibolite and marble bands are subordinate. Widespread eclogite, felsic HP granulite and retrograde garnet peridotite are present as lens-shaped bodies (decametric to hundreds of meters long), that lack any apparent stratigraphic control. The regional metamorphism has a complex history. The oldest event (of barrovian type facies series) is recognized based on frequent relics of kyanite-staurolite-garnet assemblages in country rocks. A second metamorphism, of "intermediate" low-pressure type, is correlated with a quiet, narrow metamorphic zonation in Godeanu (Bercia, 1975), Mehedinţi (Hârtopanu, 1986) and Căpăţâna Mountains (Săbău *et al.*, 1987). HP rocks are well preserved even if polystage deformation (S_1 coexist with the main S_2 foliation) is strongly penetrative and metatectic migmatisation, or "in situ" anatectic granite formation, are frequent (Iancu, 1995).

*Sebeş 2***,** typically developed in the southwestern part of the Sebeş Mountains, is a volcano-sedimentary formation, including a good lithological marker of intimately associated bimodal mafic (amphibole rich) and felsic (quartz-feldspar rich) orthogneiss, as well as harzburgitic metaultramafites. The upper stratigraphic (lithologic) limit of the Sebeş 2 with Sebeş 3 formation is marked by the lithological contrast, even when a strong S_2-controlled transposition makes it difficult to

◂ LEGEND

1. Upper Cretaceous granitoids (banatites)
2. Mesozoic cover and volcanics (a), Sinaia Formation and Obârşia Ophiolite complex
3. Upper Carboniferous-Permian cover and volcanics
4. Paleozoic granitoids
5. Neoproterozoic granitoids

METAMORPHIC ASSEMBLAGES OF PALEOZOIC AND NEOPROTEROZOIC AGE GETIC-SUPRAGETIC BASEMENT

6. Hunedoara-Luncani Fm.
7. Padeş Fm.
8. Moniom Fm.
9. Caraş-Locva Fm.
10. Buceava Fm.
11. Miniş Fm.
12. Căluşu Fm.
13. Lereşti Fm.

SEBEŞ GROUP

14. Sebeş 1 (Topolniţa, Vaideeni Fm.
15. Sebeş 2 (Sebeş leptino-amphibolitic Delineşti Fm.)
16. Sebeş 3 (Nera, Negovanu, Măgura Câinenilor, Moaşa Fm.)

LOTRU GRUP

17. Lotru (Păscoaia, Ravensca Fm.)
18. Lotru 2 (Steaza-Cataracte, Gugu Fm.)

CUMPĂNA GRUP

19. Cumpăna 1 (Cumpăna-Cozia, Cugir, Brebu Fm.)
20. Cumpăna 2 (Topolog, leptino-amphibolitic, Bolovanu Metagabbro)
21. Cumpăna 3 (Iezer, Voineşti Fm.)

FĂGĂRAŞ GROUP

22. Suru Formation
23. Rusca Formation
24. Bocsiţa-Drimoxa Fm.
25. Ursu complex
26. Jidoştiţa, Jigureasa Fm.

DANUBIAN BASEMENT

PALEOZOIC (undifferentiated)

27. Drencova- Râul Rece, Râul Alb, Sevastru, Brustur, Valea de Brazi, Valea Izvorului, Coarnele, Nijudimu, Ieselniţa Formations

NEOPROTEROZOIC

28. Drăgşan Group
29. Lainici-Păiuş Group

TISOVIŢA-IUŢI OPHIOLITE COMPLEX

30. Plavişeviţa metagabbro
31. Basic-ultrabasic complex Iuţi, Tisoviţa and Eibental)
32. Pre-Mesozoic mylonites-blastomylonites

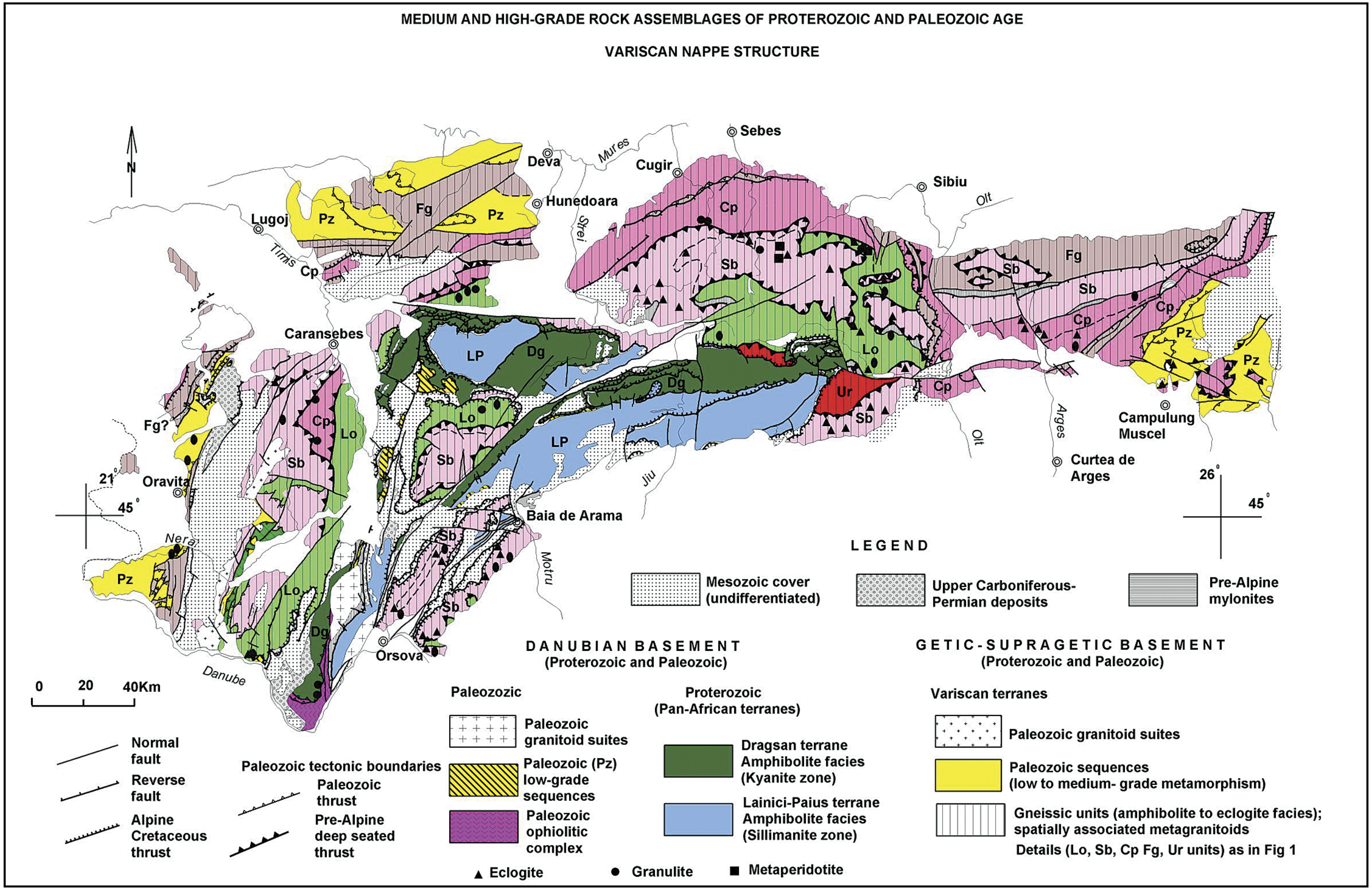

Fig. 3. Variscan structural units of the Danubian and Getic-Supragetic basement: medium and high-grade rocks. Authors: V. Iancu, and M. Mărunțiu. *Abbreviations*: Sb – Sebeş, Lo – Lotru, Cp – Cumpăna, Fg – Făgăraş, Ur – Ursu, Dg – Drăgşan, LP – Lainici-Păiuş, PZ – Paleozoic.

recognize. The lower limit of this formation is everywhere tectonic, and the "bimodal" or "leptino-amphibolitic" level (Ledru *et al.*, 1997) is locally preserved. Some of the lithological boundaries are similar with those mapped by Stelea (1992, 1994) and Săbău (1992), even if a different succession was considered. Abundant mafic garnet amphibolite and granulite, as well as retrogressed eclogites, are located at different stratigraphic levels, inside of the bimodal (mafic-felsic) gneiss bands, or in the paragneiss and micaschist matrix. Spectacular, cm-sized garnet-kyanite-rutile bearing micashists contain large porphyroblastic garnets with a complex growth and overgrowth pattern including kyanite.

Sebeş 3 is a monotonous metasedimentary sequence in which micaschist and paragneiss are intimately associated; characteristic manganiferous (tephroite to spessartin bearing) rocks are transposed as bands and lenses in the S_2 foliation plane (Hîrtopanu and Hîrtopanu, 1981). Scarce boudins of mafic rocks (garnet amphibolite or granulite) are present, sometimes with the appearance of retrogressed eclogites. Metaultramafic rocks generally occur as spinel- bearing lherzolite, but a large body (hundreds of meters in size) of garnet-peridotite (garnet-lherzolite?) is preserved in the Foltea peak.

In the Sebeş 2-3 tectonic unit, the continental type protoliths are dominant, represented by mica rich, quartz-feldspar meta-sedimentary rocks. Extensional type, rift-related, bimodal mafic-felsic magmatites and ocean floor, alumina- and manganese-rich sediments, characterize both Sebeş 2 and Sebeş 3 formations. The regional metamorphism of the Sebeş 2-3 unit is characterized by staurolite and kyanite-garnet mineral association and abundant pegmatite related to both M_1 and M_2 regional events. Late muscovite and sillimanite are developed in the extensional (post-S_2) foliation and shear bands.

The Lotru unit crops out in the Lotru Mountains and Lotru valley basin and was cartographically separated in respect with the tectonically uppermost Sebeş unit (Iancu and Mărunţiu, 1994a, b) inside of the so called Sebeş-Lotru series (on the 1:50.000 scale geological maps of Romania and in Savu, 1978), or Lotru suite (cf. Săbău, 1992, sensu Streckeisen, 1935). Lithologically, the Lotru unit consists of two main contrasting formations.

Lotru 1, a dominantly volcano-sedimentary formation, includes large amounts of amphibolite and biotite-plagioclase gneiss, associated with dismembered bodies of eclogite and layered gabbro-peridotite oceanic-type magmatites. The rocks of the dismembered mafic magmatic complex are strongly affected by a prograde, medium to high-pressure metamorphism and dynamic metamorphism (producing flasser-type fabrics). Modal and grain size composition of magmatic protoliths indicates layered gabbros (olivine gabbro, gabbro-norite) and cumulate type ultramafite (lherzolite, harzburgite, dunite and plagioclase wehrlite), which are sometimes preserved in larger bodies (Mărunţiu *et al.*, 1997). Partly metamorphosed gabbros and peridotites preserve prograde type corona and pseudomorph reactions (e.g. prograde reaction at the ortho/clinopyroxene and plagioclase contact in coronitic metaggabro, Mărunţiu *et al.*, 1995), or olivine-plagioclase reactions in ultramafite (Medaris *et al.*, 2003). The interlayered country rocks of the Lotru 1 formation are micaschists and biotite or mica-rich paragneiss, containing frequent, M_1 related sillimanite-garnet, and M_2 related kyanite-garnet mineral associations.

Lotru 2 is mainly a metasedimentary formation of sillimanite-garnet micaschist and paragneiss, containing scarce bands of white quartzite and amphibolite. Poly-stage pegmatite bodies are widespread in both Lotru 1 and Lotru 2 formations. Detailed lithological maps from the Lotru basin are known from Gheuca (1996, unpublished report).

The Cumpăna unit typically crops out in the Făgăraş and Iezer-Leaota Mountains (Dimitrescu *et al.*, 1985; Balintoni *et al.*, 1986; Gheuca, 1988) and was recognized in the northern part of the Sebeş Mountains and in Banat area as Cumpăna Group lithologies (Iancu and Mărunţiu, 1994 a, b).

As a large "group" or "terrane", the Cumpăna unit includes some distinct subunits and formations, consisting of metasedimentary and volcano-sedimentary rock successions, mainly represented by micaschist, biotite paragneiss and quartz-feldspar gneiss in Cumpăna 1 and Cumpăna 3 Formations, while amphibolite and felsic quartz-feldspar gneiss are intimately associated in Cumpăna 2 Formation (the "Topolog leptino-amphibolite Formation" of Dimitrescu *et al.*, 1985). Associated metamorphosed magmatic protoliths are both mafic and felsic rocks. Large layered gabbro complexes and associated granulite-eclogite bodies (e.g. Cumpăna valley complex) and scarce bodies of metaultramafites (e.g. plagioclase bearing olivine-rich websterite with cumulus texture present at the springs of Dâmboviţa valley). The mafic and ultramafic magmatites are located in the Cumpăna 1 and Cumpăna 2 sub-units cropping out on the southern slope of the Făgăraş Mountains.

Porphyritic metagranites (Cozia type K-feldspar augen gneiss and related linear gneiss) are present in all lithological subunits, as kilometer size to decametric size bodies of circular, dome-type, oval or lens-shaped bodies.

At regional scale, the rocks of the Cumpăna unit show an amphibolite to garnet-granulite facies metamorphism, while eclogite facies is usually related to sheared metagabbro bodies (Făgăraş Mountains), or to mafic-felsic garnet amphibolite and granulite (Northern Sebeş Mountains).

The Făgăraş unit is well developed in the northern Făgăraş Mountains and was correlated with similar rock assemblages from the Poiana Ruscă Mountains (Balintoni and Iancu, 1986) and possibly from Banat area. This unit is typically composed of metasedimentary rock sequences (Balintoni and Pană, 1993), dominated by quartz-feldspar-mica gneisses, carbonate and amphibolite sequences, with a medium grade regional metamorphism and reactivated in greenschist facies conditions.

The Ursu unit is represented by metapsamitic and mafic-ultramafic rocks (garnet mica-gneisses, amfibolites, ultramafites), which crop out in the Căpățâna Mountains (Săbău, 1987; Hann *et al.*, 1988) and display particular metamorphic features. HTLP mineral parageneses contain sillimanite-cordierite-K feldspar and andalusite associated with garnet-biotite, and are successively deformed and retrogressed prior to nappe stacking (Iancu *et al.*, 1998).

The Bughea unit is a shear zone related complex. The pre-Alpine Bughea shear zone and related tectonic mélange, including eclogite and coronitic metagranites, was for the first time defined by Iancu and Mărunțiu (1994a, b). The deep seated, now exhumed mélange is tectonically interlayered between the Paleozoic Căluşu-Lereşti successions (in upper geometric position) and the Cumpăna type polymetamorphic rocks of the underlying basement, represented by the Voineşti formation. The Căluşu-Lereşti successions represent obducted metamorphic complexes showing a low-grade (greenschist to epidote-amphibolite facies) metamorphism.

A complex, subduction-collision type geotectonic evolution can be presumed based on the lithological heterogeneity and polystage nappe piling in the Făgăraş and Iezer-Leaota Mountains (Iancu, 1998).

Lithologically, the Bughea tectonic level (or complex) displays a dominant green colored, epidote-amphibolite to garnet-amphibolite mylonitic matrix, where white mica-rich rocks are phengite-epidote-amphibole-garnet-rutile schists or muscovite-garnet-albite micaschists. Discontinuous, biotite-garnet rich and garnet-quartz-feldspar rich gneisses are abundant in the lower part of the level, while albite/-garnet porphiroblast-bearing schists of Lereşti type are frequent at the upper part of the complex. The exhumed HP rocks in the Bughea complex and shear zone are eclogites of different mineral compositions and PT conditions (Medaris *et al.*, 2003; Săbău and Negulescu, 2015 and references therein). Coronitic metagranites (garnet-kyanite-phengite bearing) and coarse grained garnet amphibolite with flasser type texture (metagabbros) are also strongly shared and recrystallised (Negulescu, 2006). This level, about 40-80 meters thick, was mapped over a large area by Gheuca and Dinică (1986).

Structurally, the Bughea complex can be identified as a major deep seated, exhumed shear zone, with dominant simple shear S-C-C' type fabric, both in the matrix rocks and borders of the anisofacial boudins and lenses which preserve older fabrics of the magmatic protoliths (gabbro, granite), or of the HP stages (eclogite, coronitic metagranites). Advanced mineral re-equilibration in rocks with SIIC mylonitic foliation is suggested by metamorphic differentiation and bending of different compositions. Some eclogite boudins preserve initial HP related S-C type fabric, highlighted by progressive re-crystallization of omphacite-kyanite or zoisite and phengite, but the outer parts of the same boudins show clear effects of retrogression. The metamorphic degree of the main syn-tectonic matrix is equilibrated in epidote-albite-amphibolite facies conditions, corresponding to an upper structural level related to exhumation-thrusting processes, as the upper, Lereşti unit shows similar mineral assemblages and physical conditions.

3.2. Paleozoic sedimentary and volcano-sedimentary rock sequences affected by low-grade, prograde Variscan metamorphism

Lithological features of these sequences were synthetically described by Năstăseanu *et al.* (1981), Kräutner *et al.* (1981) and Iancu *et al.* (2005b and references therein). Based on paleontological and palynological data, these lithological successions are dated as Cambrian-Ordovician-Silurian and Devonian-Lower Carboniferous in age. The main rock-sequences are cartographically separated in the Danubian realm (Valea Izvorului, Coarnele, Valea de Brazi, Poiana Mică, Nijudimu, Brustur, Râul Rece and Sevastru formations) and Getic-Supragetic basement units (Buceava, Caraş, Moniom Groups and Miniş, Lereşti, Căluşu Formations) (Fig. 2). The detailed description of these formations is found in our unpublished reports and some published papers (Iancu *et al.*, 2005b and references therein).

3.3. Pre-orogenic, Paleozoic basic-ultrabasic and bimodal basic-felsic magmatic rocks

The internal part of the Danubian (Figs. 2, 3) preserves a key-zone plate boundary and remnants of an inverted rift and accretionary wedge of Paleozoic age, as a result of a new cycle of rifting and oceanic spreading affecting the older, Neoproterozoic terranes of the Gondwana supercontinent (Iancu *et al.*, 2005b). The Tisovita-Iuți ophiolitic type complex (Mărunțiu *et al.*, 1997; Plissart *et al.*, 2012 and references therein) is tectonically sandwiched in a crustal nappe complex (Fig. 4). This Devonian paleosuture (Plissart *et al.*, 2012), together with discontinuously preserved metasediments (Iancu *et al.*, 2005b), are good markers for a paleozoic plate boundary, later involved in a Variscan magmatic arc (Stan, 1985; Iancu *et al.*, 1997). The ophiolitic +paleosuture is exposed in the Danube Gorges (Romania and Eastern Serbia) and represented by Late Neoproterozoic-Lower Paleozoic ophiolites (Mărunțiu *et al.*, 1997). In the Western Balkans, a 563±3 Ma zircon age on Tcherni Vrah ophiolite (von Quadt *et al.*, 1997) indicates a Late Pan-African rift in the northern (Cadomian) part of Gondwana (Haydutov and Yanev, 1997). Oceanic type and volcano-sedimentary successions of Lower Paleozoic age (Iancu and Visarion, 1988), as well as coarse grained, clastic successions reworking the mentioned rock-assemblages are exposed about 80 km North of Danube Gorges (Iancu *et al.*, 1990, 2005b). The subduction of the rift and basin successions was followed by tectonic inversion, nappe stacking and magmatic arc activity during a Variscan collisional stage (documented by K/Ar and Rb/Sr ages).

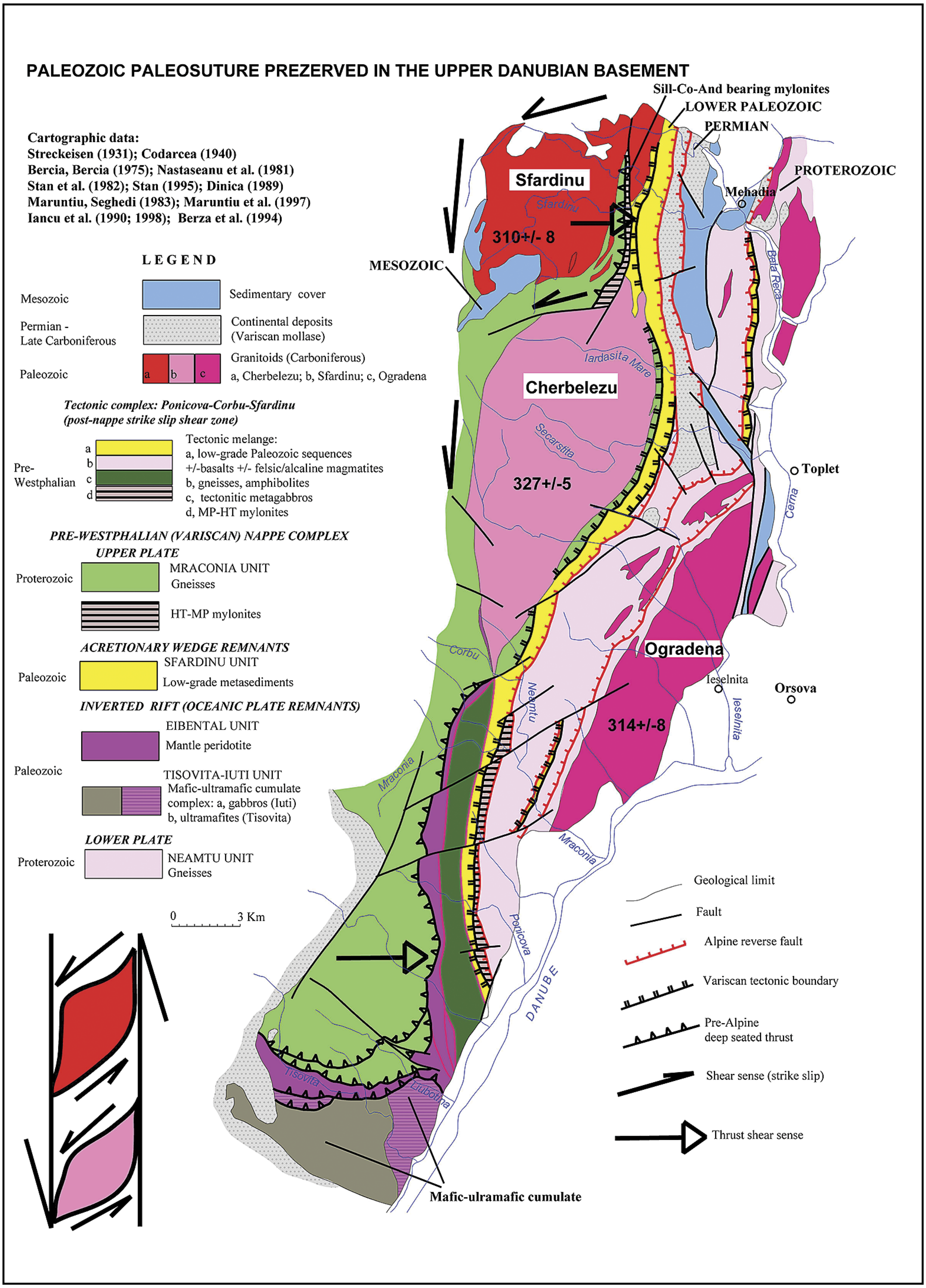

Fig. 4. Neoproterozoic – Lower Paleozoic basement in the South Carpathians and Variscan imprint. Abbreviations as in Fig. 3

In the Getic-Supragetic basement, basic-felsic (bimodal) and basic-ultrabasic (rift related) remnants are present in the exhumed Variscan nappe piles and are preserved in some other areas (e.g., Bozovici-Danube, Caraş-Locva). In the Iezer-Leaota zone, basic-ultrabasic HP rocks are exhumed within a tectonic mélange squeezed between Variscan crustal nappes (Iancu, 1998; Negulescu, 2006; Săbău and Negulescu, 2015, 2016). Mafic and ultramafic bodies of mantle and lower crust origin are recognized as HP remnants markin deep seated, criptic paleosutures (Iancu *et al.*, 1988), as a characteristic of the Getic-Supragetic gneissic basement (Iancu *et al.*, 1987; Medaris *et al.*, 2003; Săbău and Massone, 2003).

3.4. Paleozoic (pre-Upper Carboniferous) orogenic granitoids

Paleozoic orogenic granitoids of pre-Upper Carboniferous age and various geotectonic signatures (contraction to collisional and post-colisional) are present as large intrusions in the Danubian (as a dominant feature) and in the Getic-Supragetic basement units (Figs. 2, 5). In the Danubian units, these granitoids are represented by Ogradena, Sfârdinu, Cherbelezu massifs, in Almaj Mountains, by Cerna or Culmea Cernei massifs in Cerna Mountains, by Muntele Mic, Furcătura, Retezat and Buta massifs in Retezat Mountains, by Frumosu and Suseni in Vâlcan Mountains and by Parâng massif in Parâng Mountains. In the Almaj Mountains, the Getic-Supragetic basement hosts three Variscan granite massifs, Sicheviţa, Poniasca and Buchin-Poiana.

3.5. Upper Carboniferous-Permian sedimentary and volcano-sedimentary deposits of mollase type

These clastics and volcano-sedimentary successions are sometimes associated with basic and acid magmatic volcanics related to crustal extension during the collapse of the Variscan orogeny (Fig. 2).

4. GRANITOIDS EMPLACED INTO THE SOUTH CARPATHIANS BASEMENT

4.1. Granitoids in the Danubian basement

The spatial distribution of the granitoid plutons cropping out in the Danubian basement is cartographically represented in Fig. 2, based on 1: 50.000 scale geological maps of the Geological Institute of Romania and the published papers of the mentioned authors (see figure explanation). Some special contributions focused on the Proterozoic and Paleozoic granitoids and their relationships with the country rocks in the South Carpathians are known from published papers and PhD theses (Berza, 1978; Iancu, 1998 and references therein).

We revised the important geochronological data published in the last decades, which are focused on isotopic age determinations by different methods and authors (Liégeois *et al.*, 1996; Balica, 2007; Balintoni and Balica, 2013; Plissart *et al.*, 2012; Stremţan *et al.*, 2013; Balintoni *et al.*, 2014; Duchesne *et al.*, 2017). The integrated izotopic data of the granitoid ages, as well as those of some gneissic protoliths of the country rocks (tables in the Duchesne *et al.*, 2017 and Balintoni *et al.*, 2010, 2014) are shown in Fig. 5.

Proterozoic granitoid intrusions

The Proterozoic granitoids are spatially and genetically related to the Lainici-Păiuş unit (terrane). These granitoid massifs yielded ages of 567 Ma (Tismana, Liégeois *et al.*, 1996), 570-586 Ma (Vârful Pietrii) and 587-592 Ma (Şuşiţa, Novaci, Olteţ, Balintoni *et al.*, 2014). Few ages are known for the Drăgşan (803, 777 Ma) and Lainici-Păiuş protoliths (582 Ma) (Liégeois *et al.*, 1996). Their tectono-metamorphic evolution is the result of the pan-African orogeny (Liégeois *et al.*, 1996). A Proterozoic, polystage barrovian type regional metamorphism is well expressed in the rocks of the Drăgşan group and a regional influence of a higher thermal regime (low-pressure facies series) in the Lainici-Păiuş Group is related to the syn-metamorphic Proterozoic granitoid intrusions (596-567 Ma, Liégeois *et al.*, 1996); the HT thermal imprint related to the post-metamorphic granitoids is present in both Drăgşan and Lainici-Păiuş groups.

Paleozoic granitoid intrusions

The Paleozoic granitoids are present in both Drăgşan and Lainici-Păiuş units, as well as on the Danube (Almaj Mountains). Their ages range between 327-303 Ma (Upper Carboniferous) and 292-286 Ma (Permian), consistent with a late Variscan geotectonic evolution (nappe stacking), followed by emplacement of post-collisional granitoids, molasse type sedimentation and volcanic activity (Seghedi *et al.*, 2001; Seghedi, 2010).

LEGEND ▸

1. Upper Cretaceous granitoids (banatites)
2. Mesozoic cover and volcanics (a), Sinaia Formation and Obârşia Ophiolite complex
3. Upper Carboniferous-Permian cover and volcanics
4. Paleozoic granitoids
5. Neoproterozoic granitoids

METAMORPHIC ASSEMBLAGES OF PALEOZOIC AND NEO-PROTEROZOIC AGE
GETIC-SUPRAGETIC BASEMENT

6. Hunedoara-Luncani Fm.
7. Padeş Fm.
8. Moniom Fm.
9. Caraş-Locva Fm.
10. Buceava Fm.
11. Miniş Fm.
12. Căluşu Fm.
13. Lereşti Fm.Gneissic units

GNEISSIC UNITS

14. Sebeş
15. Lotru
16. Cumpăna
17. Făgăraş
18. Bocsiţa-Drimoxa
19. Ursu
20. Jidoştiţa – Jigureasa

DANUBIAN BASEMENT

21. Paleozoic (undifferentiated)

NEOPROTEROZOIC

22. Drăgşan Group
23. Lainici-Păiuş Group

TISOVIŢA-IUŢI OPHIOLITE COMPLEX

24. Plavişeviţa metagabbro
25. Basic-ultrabasic complex Iuţi, Tisoviţa and Eibental)
26. Pre-Mesozoic mylonites-blastomylonites

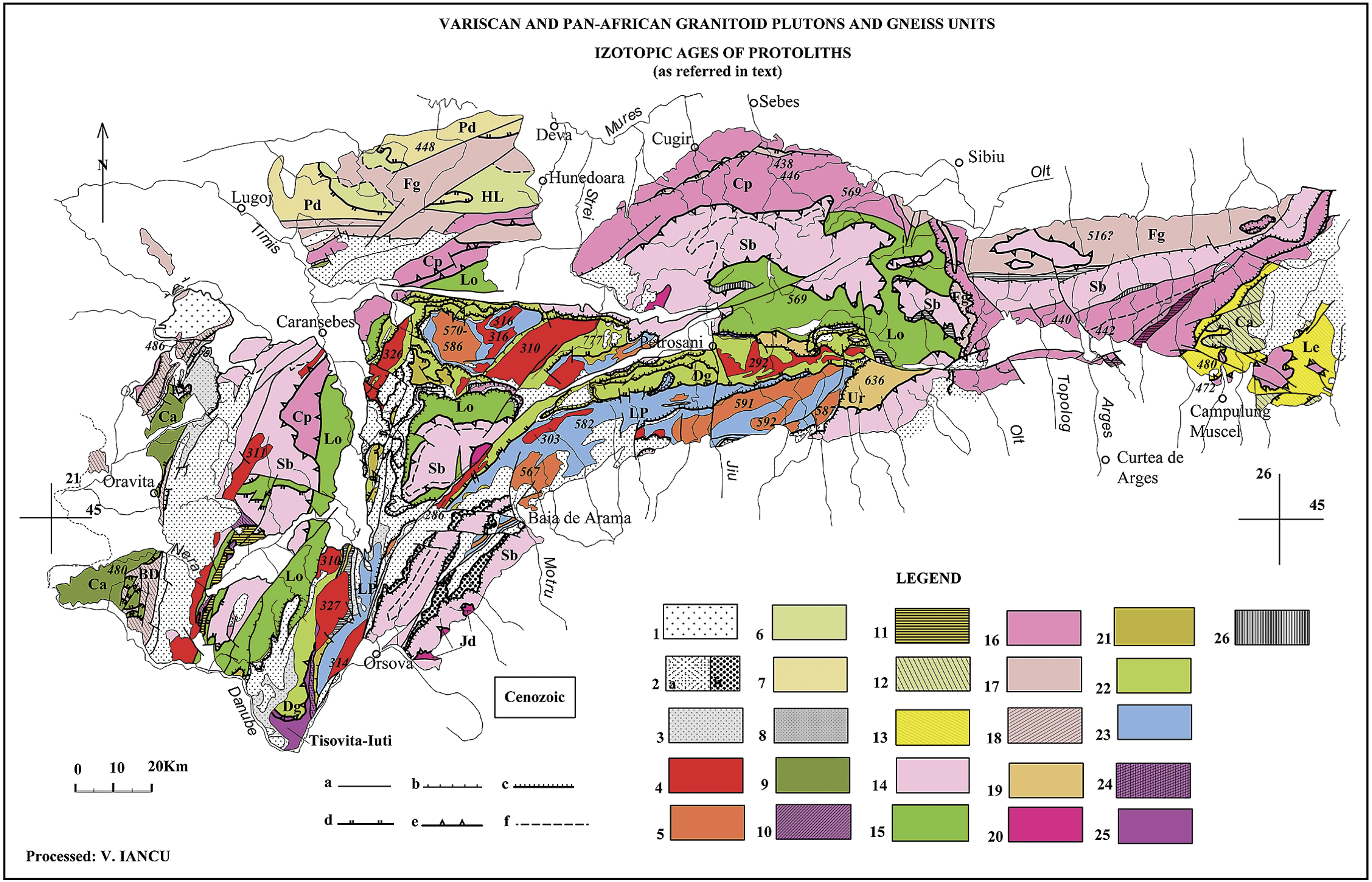

Fig. 5. Pre-Alpine units and tectonic boundaries, variscan and cadomian granitoid plutons in the South Carpathians. Authors: V. Iancu, T. Berza, I. Balintoni, M. Mărunțiu, A. Seghedi, I. Dinică. Structural elements: **a**: fault, **b**: reverse fault, **c**: alpine thrust, **d**: pre-Alpine thrust boundary, **e**: pre-Alpine, deep-seated shear zone, **f**: lithological/formation boundary. *Abbreviations*: HL – Hunedoara-Luncani, Sb – Sebeş, Lo – Lotru, Cp – Cumpăna, Fg – Făgăraş, Ur – Ursu, Jd – Jidostița, Pd – Padeş, Lo – Locva, BD – Bocşița-Drimoxa, Dg – Drăgşan, LP – Lainici-Păiuş.

A special geotectonic significance is indicated by the geochemical, geophysical and structural features of the granitoids from the Danube area (the Almaj Suture zone) (Plissart *et al.*, 2012). Their syn-tectonic emplacement in a plate boundary-ophiolitic suture zone is suggested by the contrasting petrology and composition of the superposed units of the nappe pile (Fig. 4). A major fault system (transcurrent shear zone) cutting the Carboniferous nappe pile (Mărunțiu and Seghedi, 1983) is connected with the syn-tectonic emplacement of the Cherbelezu and Sfârdinu granitoids (327 and 310 Ma respectively) (Fig. 4). A narrow and inverted HTLP metamorphic zonation is preserved at the eastern border of the Sfârdinu massif (Iancu *et al.*, 1997), as well as closed to the Cherbelezu granitoid (Mărunțiu and Seghedi, 1983). The preserved ofiolitic (basic-ultrabasic) suture is recently documented to be Devonian in age (Plissart *et al.*, 2017, in press).

The intrusion of Paleozoic continental arc granitoids of 338, 329 and 320 Ma (Ogradena, Cherbelezu and Sfârdinu) dated by U/Pb zircon ages (Balica, 2007, and oral communication) is documented by magmatic flow fabrics (K feldspar and biotite foliation), direct transition into a deep seated shear zone and related arteritic/metasomatic migmatization, LP-HT shear zone-related metamorphism, which can be connected to the high thermal gradients of the magmatic arc environment (Iancu *et al.*, 1997), S-C′-C″ myllonitic fabrics marking a major thrust fault at the eastern border of the Sfârdinu granitoid massif, and syn-tectonic blastesis of sillimanite-Kfeldspar/cordierite-garnet/andalusite-garnet parageneses in the "thermal" contact zone. Unconformable Upper Carboniferous-Permian sedimentary cover seals the entire nappe stack, granitoid bodies and their associated HT-LP mylonites.

4.2. Granitoids in the Getic-Supragetic basement

Few granitoid plutons of Variscan age are emplaced in the Getic-Supragetic basement (Iancu, 1998 and references therein). These plutons crop out in Banat area, along transcrustal fault zones, cutting a Variscan nappe pile sealed by Permian sedimentary deposits (Iancu *et al.*, 1988). The uppermost nappes are built by gneissic rock assemblages, correlated with the Sebeş (mostly micaschists and paragneisses) and Lotru (amphibolitic and quartz-feldspar gneisses) tectonostratigraphic units, overlying other nappes containing low-grade volcanics (basic tuffs and basalts) and terrigenous rocks (quartz, biotite and stilpnomelane bearing schists), (Iancu and Mărunțiu, 1989).

Variscan plutons

Both Sichevița and Poniasca massifs are composed of two types of successive suites (Iancu, 1998): Sichevița 1 and Poniasca 1 (tonalites-granodiorites) and Sichevița 2 and Poniasca 2 (granites-monzogranites). Their emplecement age is documented as Upper Carboniferous (311+/-2Ma) and petrological-geochemical features point out for a post-collisional environement (Duchesne *et al.*, 2008), in agreement with field data (post-nappe stacking of the gneissic and low-grade Paleozoic rocks, Iancu *et al.*, 2005b). Arteritic migmatization and thermal contact aureoles are widespread, as sillimanite-Kfeldspar to garnet-biotite zones are not related to regional structural elements.

U-Pb geochronology on zircons from two small bodies of Buchin and Slatina-Timiş granites yielded 320-214 Ma on the rims of strongly zoned zircon crystals with inherited cores (Dobrescu *et al.*, 2010), consistent with a Late Variscan, post-collisional magmatic event.

Anatectic granitoids and migmatitic veins

Both anatectic granitoid bodies and migmatites are widespread in the gneissic units of the Getic-Supragetic basement, especially in the Lotru, Sebeş and Cumpăna units (Balintoni**,** 1975; Iancu, 1998; Stelea, 2000 and related references). Some of them are recently documented to be of Ordovician age (Balintoni *et al.*, 2010, 2014 and references therein). Our tectono-stratigraphic map corelates the gneissic unit of Cumpăna type (Southern Făgăraş) with the lower complex of the Sebeş-Lotru suite (sensu Stelea, 2000), containg the Kfeldspar augen gneisses (Fig. 3) and are consistent with the Ordovician ages of the related granitoids (Balintoni *et al.*, 2009).

The gneissic units of the Getic-Supragetic basement, especially the Lotru, Sebeş and Cumpăna units, host widespread anatectic granitoids and migmatitic veins (Balintoni, 1975; Iancu, 1998; Stelea, 2000 and related references). Some of them are recently documented to be of Ordovician age (Balintoni *et al.*, 2010, 2014 and references therein). Our tectono-stratigraphic map correlates the gneissic unit of Cumpăna type (Southern Făgăraş) with the lower complex of the Sebeş-Lotru suite (sensu Stelea, 2000), containg K feldspar augen gneisses (Fig. 1) and are consistent with the Ordovician ages of the related granitoids (Balintoni *et al.*, 2009).

5. VARISCAN TECTONO-STRATIGRAPHIC UNITS AND TECTONIC BOUNDARIES IN THE GETIC-SUPRAGETIC BASEMENT

5.1. Pre-Alpine tectonic and metamorphic events

In the Getic-Supragetic basement, pre-Alpine events were identified based on geological and isotopic data, as well as on structural relationships. They are related to the Variscan convergent-collision cycle and can be correlated with the coeval metamorphic terrains from the clasical Variscan belt outside of the Alpine front (Iancu *et al.*, 2005b). The Variscan tectono-metamorphic events in medium to high pressure rocks are documented by isotopic ages (Sm-Nd, Pb-Pb and U-Pb methods), as seen in Fig. 6 (Drăguşanu and Tanaka, 1999; Medaris *et al.*, 2003; Balintoni *et al.*, 2009, 2014).

Based on maping and petrological data, the effects of two types of metamorphic regime characterising the Paleozoic metamorphic units and terrane provenance were distinguished. One is a dynamo-thermal (regional) Paleozoic metamorphism, older than the Upper Carboniferous-Permian, which can be attributed to the Variscan orogeny and

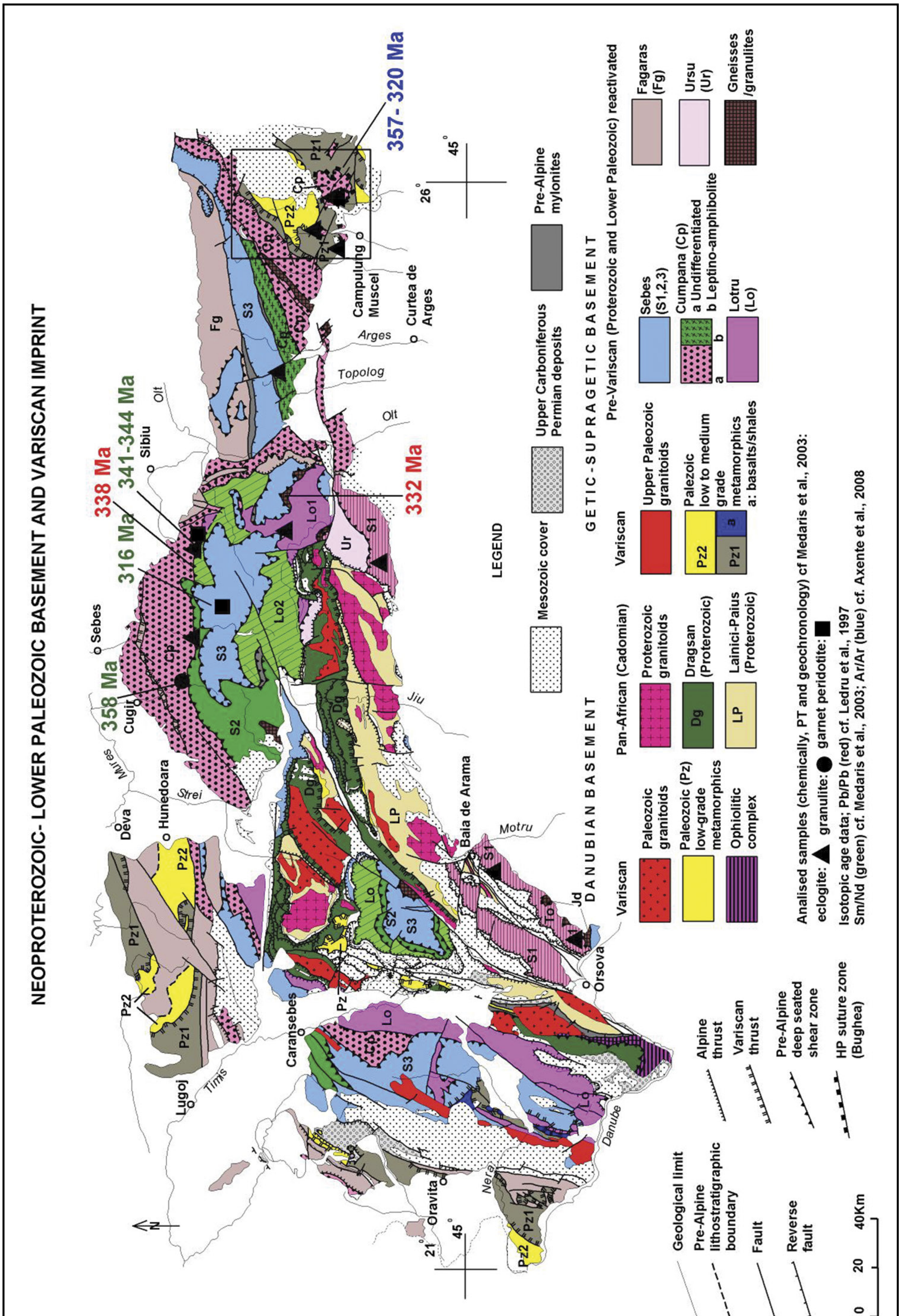

Fig. 6. Paleozoic paleosuture preserved in the Upper Danubian basement north of Danube (Almaj Mountains).

corresponds to the deposition of the discordant, sedimentary, molasse type deposits. Recent isotopic geochronological data from the Getic-Supragetic basement support this timing, as 40Ar/39Ar cooling ages range between 309-320 Ma (Dallmeyer *et al.*, 1996), while older ages are of 354-346 Ma (Maluski, in Iancu *et al.*, 1997). The other type is a dynamic, shear zone related metamorphism of Paleozoic age, spatially associated to the main tectonic contacts separating the pre-Alpine litho-tectonic units.

Some isotopically dated occurrences of mylonitic rocks and syn-tectonic pegmatites yielded Paleozoic, Variscan ages: 346-331 Ma (40Ar/39Ar, cf. Maluski, in Iancu *et al.*, 1997) and respectively, 338-332 Ma (Pb/Pb, single crystal zircon ages, Cocherie, in Ledru *et al.*, 1997). The dated minerals derived from blastomylonites and syn-tectonic pegmatites characterising the tectonic boundaries between the main litho-tectonic units of the Getic-Supragetic basement (Iancu *et al.*, 1998).

5.2. Variscan tectono-metamorphic events

Two types of Variscan tectono-metamorphic events were recognized in the Getic-Supragetic basement rocks: a regional, dynamo-thermal metamorphism and a shear-zone related, dynamic metamorphism.

Regional, dynamo-thermal metamorphism

The Variscan tectono-metamorphic history of the Getic-Supragetic basement is better documented for the Early Carboniferous (Neo-Variscan) collisional event, but recent U/Pb zircon ages on different granitoids, migmatites and gneisses (Balintoni *et al.*, 2004; Dobrescu *et al.*, 2010) suggest effects of older tectono-thermal activities during the Middle-Lower Paleozoic times.

As the result of subduction- and contraction-related tectono-metamorphic events of Pre-Westphalian age, low-grade (subgreenschist to green schist and epidote amphibolite facies) and medium/high grade (amphibolite and eclogite-granulite facies) rock assemblages were involved in complex nape stacking, tectono-metamorphic inversion and exhumation processes. Individual tectono-stratigraphic units display contrasting metamorphic and deformation features (S_1-S_2 foliations and B_1, B_2 fold systems), as a consequence of contrasting lithologies and metamorphic conditions. Regional deformation gradients inside the “gneissic units” can be observed on the structural maps of the Central-South Carpathians (Ledru *et al.*, 1997 and unpublished reports).

Apparent transitions from one unit to another are induced by the shear zone-related metamorphism, sometimes syn-metamorphic, at amphibolite facies level in the internal, gneissic areas (Lotru-Cibin, Semenic Mountains), while epidote-amphibolite bearing mylonites (including tectonic lenses of eclogites) crop out in external areas (Leaota-Iezer Mountains). Extension-related foliations (post-S_2, or post-nappe stacking) are also present and give a false impression of continuity all over the “crystalline” basement.

Based on existing isotopic geochronological data, the tectono-metamorphic events in the Getic-Supragetivc basement can be attributed to the Variscan orogeny based on as 358-341 Ma, Sm/Nd (Medaris *et al.*, 2003), 357-331 Ma, 40Ar/39Ar (Axente *et al.*, 2008), 354-319 Ma, Sm/Nd, 342 Ma, Rb/Sr and 348-328 Ma, 40Ar/39Ar (Drăguşanu and Tanaka, 1999), 329-323 Ma (Dallmeyer *et al.*, 1996). Isotopic data of and 320-309 Ma 40Ar/39Ar (Dallmeyer *et al.*, 1996) and K/Ar ages (Grünenfelder *et al.*, 1983) represent cooling ages related to the Variscan extension and collapse. Paleozoic tectono-stratigraphic units (Iancu *et al.*, 2005b) are characterized by distinct tectono-thermal histories (Medaris *et al.*, 2003) and are separated by major tectonic contacts.

Shear zone related dynamic metamorphism

Paleozoic dynamic metamorphism related to shear-zones is spatially associated to the main tectonic contacts separating the pre-Westphalian litho-tectonic units. Thrust-related, strike-slip- and extension-related fault zones are well preserved on the entire outcrop area of the Getic-Supragetic nappes and the syn-tectonic blastesis covers large PT fields, from greenschists to amphibolite and eclogite facies conditions.

Some isotopically dated occurrences of mylonitic rocks and syn-tectonic pegmatites yielded Paleozoic, Variscan ages as 342-341 and 332-331 Ma (reinterpreted from Axente *et al.*, 2008) and 338-332 Ma (Pb/Pb, single crystal zircon ages, Cocherie, in Ledru *et al.*, 1997). The dated minerals were derived from blastomylonitic rocks (Iezer-Leaota) and syn-tectonic pegmatites (Cibin and Lotru) characterizing the tectonic boundaries between the main litho-tectonic units preserved in the Getic-Supragetic basement (Iancu *et al.*, 1998).

6. DISCUSSION AND CONCLUSIONS

The current image of the South Carpathians is based on geological maps at scale 1:50.000 and detailed petrological studies of the pre-Mesozoic basements of the main domains, Danubian and Getic-Supragetic. The synthesis and correlation of the geological formations started with the knowledge base existing previous to 2000-2005, updated with new geochronological data. The new data refer to protolith ages of granitoid rocks associated to pre-Alpine events, as well as the ages of metasedimentary and metavolcanic rock assemblages. Accordingly, an updated, unitary vision on the geology of gneissic units and associated migmatites from the pre-Permian basement rocks is presented. The main conclusions refer to the ages and nature of protoliths of the sedimentary and metamorphosed magmatic sequences, the pre-Alpine structural units and tectonometamorphic events associated to Pan-African and Variscan cycles and to tectonic and ophiolitic paleosutures, sometimes accompanied by tectonic mélanges.

The protoliths of the sedimentary and volcano-sedimentary successions are exposed on large areas in the Danubian realm, in Lainici-Păiuş si Drăgşan tectonostratigraphic units, while in the Getic-Supragetic domain they are documented only in Lotru and Ursu units. In other tectonostratigraphic units, the ages of such successions were interpreted as Proterozoic on the 1:50.000 scale maps of the GIR, based on existing data at the time of map elaboration. The intimate association of the Ordovician metamagmatites within the Cumpăna unit makes mapping of host rocks difficult, as they could be assigned to the upper Proterozoic – Lower Paleozoic (Cambrian-Ordovician) interval, reactivated during the Upper Proterozoic.

The upper Proterozoic granitoids (Liégeois *et al.*, 1996) are spatially associated to the Lainici-Păiuş unit, as they are coeval to the Pan-African/Cadomian orogenic magmatism. An important landmark in the Lainici-Păiuş unit is the Valea Izvorului Formation, a discordant, detrital sequence containing Silurian macrofauna (Iancu *et al.*, 2005 and references therein).

Magmatic rocks emplaced during the Lower Paleozoic – Ordovician were dated in the last decade (Balica, 2007; Balintoni *et al.*, 2014 and references therein). Such metagranitoids from Cumpăna unit (Getic-Supragetic domain) have been ascribed to a continental arc magmatic activity, specific to the Carpathian area. Coeval metagranitoids are known in the basement rocks of the West Carpathians (Putiš *et al.*, 2008), based on U-Pb (SHRIMP) analyses of zircon crystals with oscillatory zoning.

Associations of bimodal volcanics occur within some formations of the Sebeş and Cumpăna gneissic units, as well as in the external, Caraş-Lereşti unit, suggesting that extension occured in continental margin areas during the Lower Paleozoic (Iancu *et al.*, 2005b).

Carboniferous granitoid magmatites occur both in the Drăgşan and Lainici-Păiuş units (Balica, 2007; Plissart, 2012; Balintoni *et al.*, 2014), associated to the Variscan orogeny (Neo-Variscan, according to Iancu *et al.*, 2005b). The relationships of Variscan, allochtonous granitoids, with their country rocks are diversified, as they are associated with thermal aureoles or arteritic migmatisation zones. The midle-upper Carboniferous granitoids exposed in the Tisoviţa-Iuţi paleosuture from the Upper Danubian reveal an emplacement in post-nappe tectonic regime (strike-slip fault system), accompanied by syntectonic low pressure-high temperature metamorphism (blastomylonites with sillimanite-K feldspar-cordierite-andalusite). Geochemical features of Carboniferous granitoids cross-cutting the Variscan nappe pile in the Getic-Supragetic domain (Bozovici-Sicheviţa area) indicate post-collisional geotectonic setting (Duchesne *et al.*, 2008).

The Permian magmatic activity is represented by granitoid massifs (Culmea Cernei, Frumosu) and by acid and basic volcanics in the Danubian domain, coeval with the sedimentation of the continental Variscan molasse.

The maps presented show the location and areal extent of the tectonostratigraphic units and the tectonic contacts separating them, the latter marked by simple-shear zones accompanied by syn-tectonic blastesis (dynamic metamorphism, blastomylonites). Deep seated shear zones with medium grade blastesis have been identified, along with shear zones at upper crustal levels showing low-grade metamorphic recrystallization. The physical conditions of the regional metamorphism, as well as time and space evolution differ from one unit to the other, sometimes being contrasting and empasized by tectono-metamorphic inversion due to nappe stacking. The regional metamorphism in the Danubian units are Neoproterozoic (pre-Silurian) in the Lainici-Păiuş unit and Neoproterozoic with mid-Paleozoic reactivation (Neo-Variscan) in the Drăgşan unit. A distinct and more complex history is reflected by the tectonostratigraphic units of the Getic-Supragetic basement, where isotopic dating reveals Paleozoic ages (Middle Carboniferous) both for the regional metamorphism of metamagmatic rocks (eclogites, Ordovician granitoids) and the blastomylonitic zones and syn-tectonic pegmatites (Ledru *et al.*, 1988; Medaris *et al.*, 2003; Axente *et al.*, 2008).

Tectonic and ophiolitic paleosutures, sometimes accompanied by tectonic mélanges, are preserved both in the Danubian and the Getic-Supragetic basements. In the Danubian basement, oceanic crust rocks mark the collision between the Lainici-Păiuş and Drăgşan-type units. In the Getic-Supragetic basement, two types of paleosutures can be distinguished. A cryptic paleosuture, marked by eclogites-granulites and garnet metaperidotites preserved along the eastern border of the Getic basement (Mehedinţi-Căpăţâna Mountains) and a paleosuture accompanied by eclogites, metagabbros and metagranites (the Bughea complex), situated on the opposite margin of the Variscan nappe stack (Lereşti unit, correlated with the Caraş-Locva unit, representing Supragetic basement extending westward to the Serbo-Macedonean basement.

The petrologic features and ages of Variscan events of the Getic-Supragetic basement enable correlation with similar units from the west Carpathians, as well as with units of the Variscan belt from the Bohemian Massif and the French Massif Central. Recognizing the tectono-stratigraphic units and Proterozoic granitoids both in the Danubian and Getic basement types enables their correlation with terranes derived from the marginal zone of Gondwana supercontinent, divided in microplates separated by oceanic basins (e.g. Eastern Rheic Ocean) during their entire Paleozoic geological history.

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