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Reconstruction of the primary stratigraphy and correlation of the Precambrian metamorphic complexes in the Rhodope massif

Evgenia Kozhoukharova

Geological Institute, Bulgarian Academy of Sciences, 1113 Sofia; E-mail: evgkozh@geology.bas.bg

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Е. Кожухарова – Реконструкция первичной стратиграфии и корреляция докембрийских метаморфических комплексов в Родопском массиве. Литологический анализ метаморфических пород Родопского массива, с учетом латеральных изменений первичного состава, полиметаморфических эффектов и тектонических деформаций, показывает что верхняя Родопская надгруппа до метаморфизма состоялась только из двух комплексов: нижний вулкано-осадочный и верхний – известковый. Нижний комплекс после метаморфизма состоит из метаоффиолитов (серпентинитов, амфиболитов, метагабброидов, занимающих нижние горизонты), слюдянных сланцев, мраморов, кварцитов, джеспилитов, названый здесь Пестрая свита. Верхний комплекс состоит из мраморов с прослоями сланцев. Различаются два типа Пестрой свиты: а. Западнородопский (Сатовчанский) тип, с преобладающими оффиолитами в нижних горизонтах и б. Центральнородопский (Луковицкий) тип, с преобладанием осадочных пород. Представлена новая схема корреляции литостратиграфических единиц докембрийских блоков в Южной Болгарии.

Abstract. The lithological analysis of the metamorphic rocks in the Rhodope massif, taking into consideration the lateral variability of their primary composition, polymetamorphic effects and tectonic deformations, demonstrates that prior to the metamorphism the upper Rhodopian Supergroup is composed of two complexes: lower volcano-sedimentary and upper calcareous ones. The lower complex after the metamorphism is composed of metaophiolites (serpentinites, amphibolites, metagabbroids) in the lower levels), mica schists, marbles, quartzites, jaspilites, called Variegated Formation. The upper complex is composed of marbles interlayered with schists. There are two types of Variegated Formation: a. Western Rhodopian (Satovcha) type with ophiolites prevailing in lower layers and b. Central Rhodopian (Lukovitsa) type with sedimentary rocks prevailing. A new correlation scheme of the lithostratigraphic units from Precambrian blocks in South Bulgaria is presented.

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Key words: Precambrian; stratigraphy; metamorphism; protoliths; ophiolites; correlation.

Introduction

The stratigraphic column of every metamorphic complex represents superpositions of the lithological units that have been established after metamorphic consolidation of the basement. It usually differs from the primary column of the sedimentary complex. The interregional correlations, based on lithological similarity and stratigraphical sequences, cannot be applied due to the polymetamorphic alteration, tectonic deformations and unreliable age data of the metamorphic formations.

The actual stratigraphic scale of the Rhodope metamorphic basement (Kozhoukharov, 1988), used

in the Geological Map of Bulgaria M 1:100 000, represents also nowadays a real superposition of lithostratigraphic units without pretending to correspond completely to the primary one. The aim of this paper is to make an attempt to reconstruct the initial relationships of the stratigraphical units as well to launch a new point of view for correlation of the Precambrian blocks in South Bulgaria and Northern Greece.

The main factors having control on the features of metamorphosed lithostratigraphical units are: a) primary lateral variation of rock composition, expressed mainly in the volcanogenic-sedimentary formations; b) superimposed polymetamorphic alterations in different facies; c) isoclinal folds and shear zones caused reverse or repeating of sequence. Lithological and petrological analysis and detailed structural mapping were the principal methods for decoding of the stratigraphic and tectonic inversions.

Precambrian complexes in the Rhodope massif

The Precambrian in Bulgaria is subdivided (Вергилов и др., 1963) into two different polymetamorphic complexes and the later investigations confirm their existence.

Prarhodopian Supergroup

The lower *Prarhodopian Supergroup (PRS*) is an ancient infracrustal continental complex, consisting of highly reworked monotonous para-and orthogneisses, granite-gneisses, different migmatites (with porphyroblactic, lenticular, ptygmatic, stromatic, nebular texture), biotite and leptite gneisses. Missing of marbles is a specific feature for this supergroup.

Cadomian, Hercynian and Alpine granitoid magmas and some generations of their aplite-pegmatite vein derivates, penetrate the complex, causing migmatization, granitization, feldspathization and reheating, particularly intense in the deep zones. As a result the whole rock complex has been enriched with components like Si, Al, Na, K, Ba, Rb, Cs and obtained geochemical character of granite-granodiorite. The products of the later superimposed metasomatic processes often are undistinguished from the early Precambrian metamorphites. By this way the chemical alterations as well the deformations in some places changed considerably the features of the protoliths and depreciate the efforts for its recognition only by geochemical methods.

The Prarhodopian Supergroup builds up the core of anticline and dome structures.

Stratigraphy of the Prarhodopian Supergroup. Despite the overgone alterations with different age, a rather clear stratification of the Prarhodopian Supergroup is observed. Strazhevo Group (Кожухаров, 1987) in Belareka dome (Eastern Rhodope block) demonstrates the following sequence from base to top: biotite gneisses (Orlovo Formation), leptite gneisses (Gornoyuroutsi Formation) and porphyroblastic gneisses (Punovo Formation). The porphyroblastic gneisses are base and cover of the variegated materials of Botourche Group – serpentinites, amphibolites, mica schists and thin marble layers, because this group fills up a tight recumbent syncline (Kozhoukharova, 1999, Fig. 1). Therefore Botourche Group is not considered to be part of the Prarhodopian Supergroup as it was assumed in previous years (Боянов и др., 1963; Kozhoukharov, 1988).

Similar interrelations, but not so clearly expressed, are also observed in Tintyava dome.

The same stratigraphic sequence is observed in the Northern Rhodope anticline (Central Rhodope), where these rocks have been described as part of Rhodopian Supergroup. The sequence upward is: biotite gneisses (Boykovo Formation), leptite gneisses (Bachkovo Formation) and porphyroblastic gneisses (as thin irregularly developed layer), covered by the variegated Loukovitsa Formation.

Bogoutevo Formation in Chepelare region (Rhodopian Supergroup), which is composed from highly migmatized biotite and two-mica gneisses and a thin upper level of leptinite gneisses, builds up the core of a reduced southvergent anticline, with broken southern flank. Bogoutevo Formation overlies there the variegated Chepelare Formation and is covered by the variegated Vucha Formation, which is of similar composition. The migmatized gneisses, due to their intensive ductile and brittle deformations, do not show clear stratification. Nevertheless, their rocks composition, geological position and interrelations with the variegated formations, give us ground to consider that Bogoutevo Formation is a correlate of the Boykovo and Bachkovo Formations from the Northern Rhodope anticline, as well is corresponding to Orlovo and Gornoyuroutsi Formations from the Eastern Rhodope block.

The stratigraphic sequence of biotite gneisses, leptite gneisses and porphyryblastic gneisses (the latter are in irregularly developed layered bodies) is observed as well in Gotse Delchev region, Western Rhodope. There the recumbent Debrene syncline (Кожухарова, 1987) again destroys the normal stratigraphic sequence.

The cross-section of the basement in the Sakar block is similar by composition to this in the Eastern Rhodope block. There the porphyroblastic gneisses from Punovo Formation continue in Kostantinovska Metaconglomerate Formation (Кожухаров, 1991).

Most widely spread outcrops of Prarhodopian Supergroup are located in Madan-Davidkovo dome. There due to intensively developed migmatization and granitization processes of variable age and due to the internal isoclinal folding of the gneisses, clear stratification is not observe as it is in Belareka dome. In the eastern periclinal flank of the Madan-Davidkovo dome the highly squeezed and deeply sunk Ardino syncline is located (Kozhoukharova, 1996; Приставова, Кожухарова, 1999), filled with the var-

iegated materials of Chepelare Formation (Rhodopian Supergroup) – amphibolites, serpentinites, schists and marbles. Several isoclinal mesofolds of second order and shear zones complicate the flanks of Ardino syncline causing an alternation between PRS migmatic gneisses and RS amphibolites, schists and marbles. Due to this alternation, giving a wrong impression of normal sequence, is formed the so-called Vishnevo Formation. The latter demonstrates a tectonic style typical for highly migmatized metamorphic terrains where a tectonic mixing of rocks, belonging to different lithostratigraphic units, designated by Загорчев (2003) as amalgamating, is observed.

Thus, the sequence: biotite gneisses, leptites, porphyroblastic gneisses is repeated in the core of the anticline structures in several areas of the Rhodope massif. Although the rock formations as lithostratigraphic units have different names, they are one and same by genesis and composition. The section of Strazhevo Group (Belareka dome) is the most complete and therefore its names will be kept: a. biotite gneisses – Orlovo Formation, with analogs of Boykovo and Bogoutevo Formations, leptite gneisses – Gornoyuroutsi Formation, with analog of Bachkovo Formation and porphyroblastic gneisses – Punovo Formation, with continuation of Konstantinovo Metaconglomerate Formation

Rhodopian Supergroup

The upper *Rhodopian Supergroup (RS),* a new transgressively deposited typical supracrustal variegated complex, is built by metamorphosed volcanogenic-sedimentary rocks (Fig. 1). Its primary rocks were flyschoid pelite-calcareous sediments (Variegated Formation – VF), alternated with ophiolites in the lower stratigraphic levels and ended by limestones (Marble Formation – MF). The sediments were transformed into biotite, muscovite and two-mica schists, marbles, calco-schists, quartzites. The primary ophiolitic rocks of the Precambrian Ophiolite Association in Rhodopes (POAR): serpentinites, gabbros, low potassium-high magnesium tholeiites, tuffs and tuffites have undergone polymetamorphic alteration in different facies and as a result talc-chlorite-actinolite schists, amphibolites, eclogites, pyroxenites, garnet-lherzolites and metasomatic gabbroids were produced. The upper part of the RS is built of thick layered marbles (Dobrostan Formation) with rare schist intercalation in upper levels (Belashtitsa Formation).

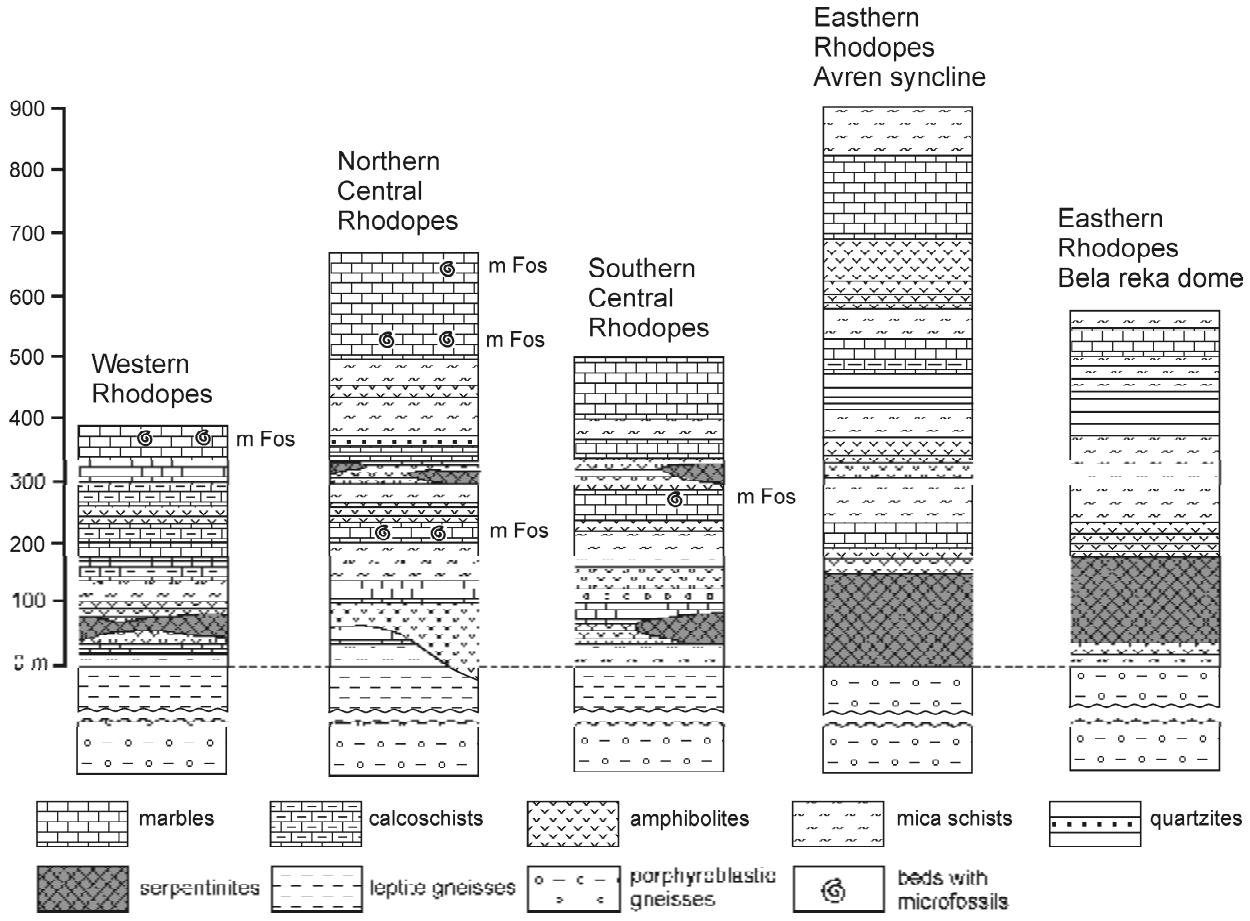

Fig. 1. Columns of the Variegated Formations in the Rhodope Massif

The Variegated Formation with POAR is an important stratigraphic marker for reconstruction of the internal structure of the basement. Everywhere the VF lies on the leptites or porphyroblastic gneisses of the Prarhodopian Supergroup and is covered by marbles of Dobrostan Formation. It is also a good indicator for the pre-metamorphic paleographic situation as well for metamorphic evolution.

Lateral variation is a very specific feature of the metamorphosed lithostratigraphical units in particular clearly expressed in VF. Three main factors are responsible for this: primary composition, metamorphism and tectonic deformations, which influence somewhere is so strongly that delete the original appearance of VF rocks and prevents the interregional correlation.

1. *Variation in the primary composition*. In the areas of abundant basic volcanism the background sedimentation was suppressed and there only very thin rare calcareous or rich of aluminum pelite beds were produced. Amphibolites, amphibole-schists, numerous big and small serpentinite bodies dominate in the lower layers of VF (Fig. 1).

On the same stratigraphic levels in other regions like northern part of Central Rhodope (Northern Rhodope anticline), the calcareous and aluminous pelites (future marbles and kyanite schists) are widely spread. The amphibolites occupy also lower levels, but they build only thin beds, alternating with marbles and schists. The metamorphosed pelites with marble intercalations dominate in the lower part of VF, while the calco-schists and marbles – in the upper ones. The comparative lithological analysis of the outcrops of the variegated formations (Fig. 1) as well the stable features of gneisses from the sole and the cover of marble, are enough convincing facts that the Variegated Formation in the Rhodope massif is the one and the same. It is named as different units depending on its levels in the metamorphic complex.

Two type of VF are distinguished: a. West Rhodopian (Satovcha) type and b. Central Rhodopian (Loukovitsa) type (Fig. 2).

A. West Rhodopian (Satovcha) type of VF represents a rock formation, formed in the region of active volcanism where the volume of basic-ultrabasic orthometamorphites prevailed over the parametamorphites (Fig. 2). It starts usually with ophiolites (serpentinites or amphibolites) lying directly on the gneisses of the Prarhodopian Supergroup. VF continues up-

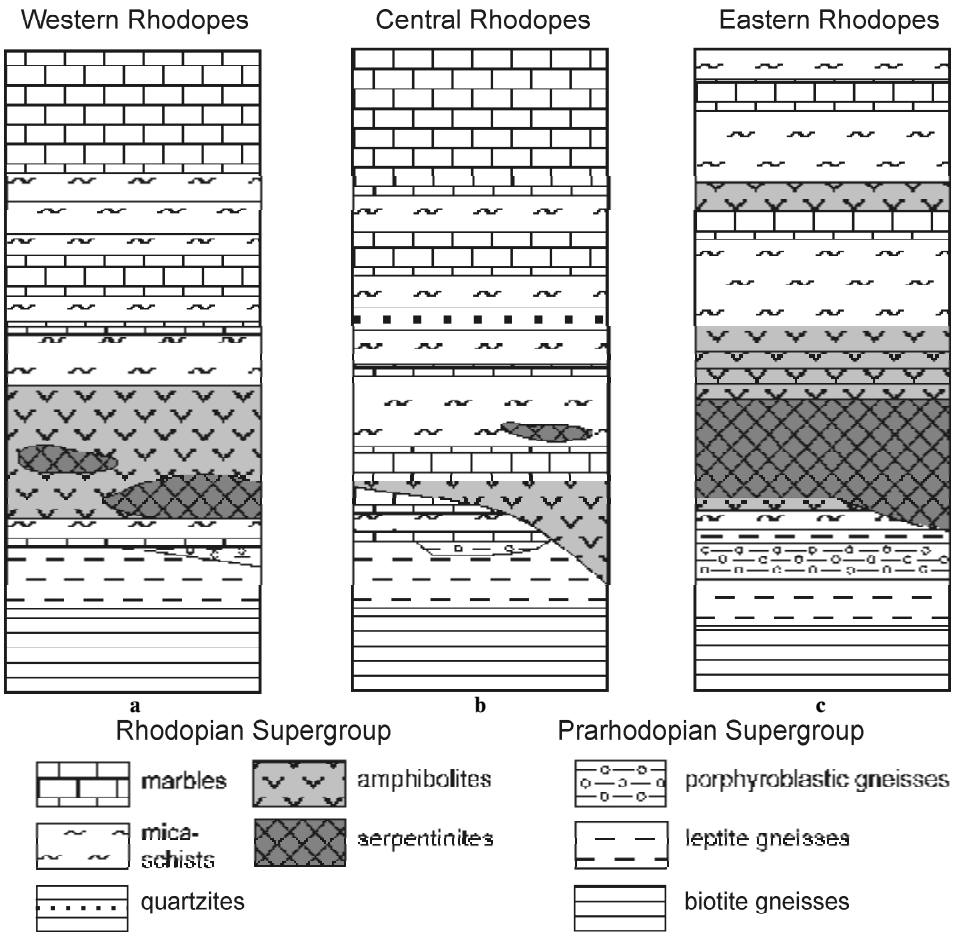

Fig. 2. Main types of the Variegated Formation of in the Rhodope Massif

wards like a thick sequence of layered and massive medium- to coarse-grained amphibolites, amphibole-, actinolite- and actinolite-chlorite schists, interbedded by graphite-bearing garnet quartzites, magnetite-hematite jaspilites and biotite schists. Serpentinite bodies of different dimensions associate with amphibolites. Dykes of fine-grained amphibolites, often enriched of ore minerals, cross the layered amphibolites and serpentinites. Rare small xenoliths of gneisses, with sharp contours from the sole occur among the amphibolites. The chemical composition of amphibolites corresponds to normal, high magnesium tholeiitic and komatiitic basalts.

Two-mica and kyanite bearing biotite schists follow the ophiolite packet. The calcareous layers – marbles and calco-schists appear relatively high in the stratigraphic sequence and when cross-section in the field is short, the marbles often are missing. Sometimes because of this reason, such VF without marbles have been refered to the Prarhodopian Supergroup, f. e. Botourche Group (Боянов и др., 1963; Kozhoukharov, 1988).

Furthermore in the regions of active volcanism on the base levels of VF some beds with different thickness (2–3 to 200–300 m) of porphyroblastic gneisses are found. Its protoliths are believed to have been coarse-grained or fineclastic sands rather than porphyritic granites. They presumably mark an abrupt change in paleoenvironmental setting before the forming of ophiolitic association. Thin layers (2–3 m) from coarse porphyroblastic gneisses are found even among schists on the base of VF just beneath the amphibolites pack, which proves their sedimentary origin. Such outcrops are in the valley of Lozengrad river in Eastern Rhodopes.

Satovcha type of VF is wide spread in Western Rhodope – valley of Mesta river, Satovcha syncline, Yakorouda district, also Vlahina Mts. In the Eastern Rhodopes (Fig. 2) – Belareka dome, Avren syncline, Chakalarovo syncline and Drangovo horst, the composition of VF is similar but the typical basic metavolcanic rocks decrease while the large serpentinite bodies are frequent there.

The location of the most abundant metavolcanites, particularity in the Mesta valley, suggests for a possible initial rifting of the ancient continent.

B. Central Rhodopian (Loukovitsa) type VF is observed in the northern part of the Central Rhodope Mts represented in Loukovitsa Formation. It consist mainly of alternating metapelites transformed into biotite-, muscovite-and two mica schists (some of them kyanite bearing), marbles, calco-schists and few quartzites (Fig. 2). Metapelites predominate in the lower levels of the VF, while marbles and calco-schists – in the upper ones. The amphibolites – products of subvolcanic and volcanic igneous activity built thin beds in lower part of the VF. These in some areas of the Northern Rhodope anticline are connect to subintrusive body, which crosses the leptite gneisses from the base of VF.

The correlation between the variegated formations outcropping in Rhodope Mts. shows identical composition and consistency in the sedimentary package and the difference is only in the amount of basic and ultrabasic orthometamorphites.

2. Variation in the metamorphic facies of VF. The Variegated Formation composition during the regional metamorphism fall into different P/T conditions, crystallizes in respective metamorphic facies and obtains corresponding mineral association, often outlining vertical or lateral zoning. Sometimes the alterations are principal isochemical and by means of petrologic analysis it is possible to recognize the primary sedimentary or magmatic composition of metamorphic rocks. Migmatization provokes some other problem. Usually it causes considerable substantial change as feldspathization and quartzitization of rocks. For example mica-schists are transforming into gneisses, amphibolites – into metasomatic gabbro-diorites, which are difficult to distinguish from the true magmatic rocks. Sometimes such hybrid products are described as magmatic metagabbro and after its nowadays chemical composition the paleodynamic setting was interpreted.

Eclogites and garnet lherzolites, related to ophiolites, are characteristic HP-metamorphic products for the VF. The eclogites are developed as layers parallel to the metamorphic foliation among amphibolites (Kozhoukharova, 1980) and by folding form boudinage structures. The Gr-lherzolites occur in serpentinites like thin bands in shear zones (Kozhoukharova 1966), but always in the stratigraphic level of the ophiolites. The suggestions of some authors (Dercourt, Ricou, 1987; Burg et al., 1990; Dobretsov, 1991; Haydoutov et al. 2004), that eclogites mark zone of subduction, deep thrusts or suture lines were not proved with geological facts from the outcroping sections of the metamorphic basement of the Rhodope massif. The hypothesis that the eclogites are formed in deep zones, uplifted in the upper levels of the crystalline as external bodies is disproved by their stable stratigraphic level in the Variegated Formations. The idea that HP-metamorphism developed within the whole crystalline basement in zones of subduction, followed by later exhumation, is even more unacceptable. The well preserved stratification and linear fold structures exclude deformation in subduction zones. On the other hand the background amphibolite facies of surrounding rocks and presence of big serpentinite bodies (regressive serpentinization among metamorphic complex is impossible) prove that the temperature of the background regional metamorphism does not exceed 580°C. For the moment, the conclusion for locally developed HP-metamorphism in narrow zones of friction on the background of amphibolite facies (Kozhoukharova, 1999; Кожухарова, 2006) corresponds more closely to the real geological situation.

The Phanerozoic dynamometamorphism, which inflicts also different damage on the composition and textures of the rocks are of particular importance. It provokes irregular destructive phenomena and regressive alteration, marked by a new greenschist

parageneses: quartz, sericite, chlorite and albite in the gneisses and amphibolites. For this reason VF in same places was announced as other different formation (for example diaphthoretic Parvenets complex – Иванов et all., 1984) or some mylonitized marbles in Central Rhodope, defined as Mesozoic limestones (Ivanov, 1988).

3. Variation of tectonic characteristic of VF. The rock complex of the Rhodopian Supergroup with the VF had been subjected to synmetamorphic folding at least twice. As a result isoclinal fold structures different in size and morphology were formed, which are typical for the deformed in ductile environment ancient metamorphic complexes. In the general synmetamorphic structural plan, the diapiric raised domes and linear positive structures are observed, whose cores are built of gneisses of the Prarhodopian Supergroup. The synclinal spaces between them contain the compressed deeply sunk subvertical, inclined and recumbent folds, filled by more heavy rocks of the Rhodopian Supergroup. The limbs of main folds are complicated by isoclinal, similar and disharmonious mesofolds. Boudinage and rodding structures are also frequent. By this reason often some lithostratigraphic units repeat in the profile, suggesting the illusion for normal primary sequence. Examples for repeating of the lithostratigraphical units is established in West Rhogopes (Кожухарова. 1987), Eastern Rhodopes (Kozhoukharova, 1996, 1999), Central Rhodopes (Приставова, Кожухарова. 1999). At the boundary between lithological units often is observed also thin bed amalgamation.

In some areas within the migmatized gneisses (for example Bogoutevo Formation in the valley of Chepelare river), bordering with ophiolites from the VF, some rounded rootless bodies of amphibolitized eclogites can be observed. These are cut like thin fragments from the basement of the synclines and formed under the gravity collapse, described by Gorman et al. (1978) for analogical terrains (Fig. 3).

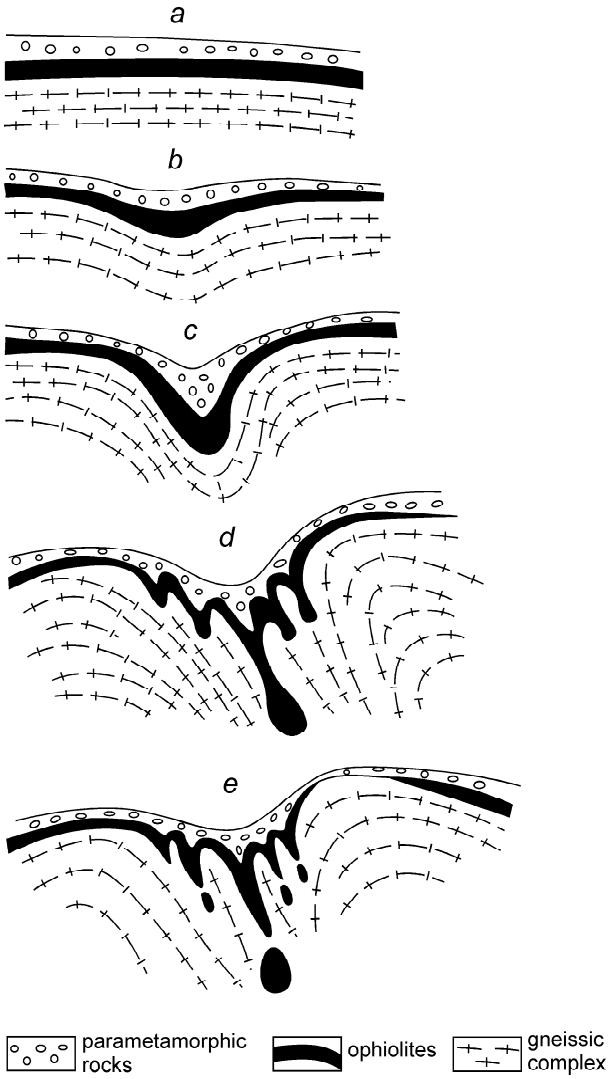

Fig. 3. Scheme of formation the deep synclines in VF with gravity collapse

The lithological and stratigraphical analysis according to all mentioned above facts, points at the following conclusions about VF:

– There was only one Primary Variegated Formation in the Rhodopian Supergroup, but in dependence of its superposition in sequence it has different names like Chepelare, Vucha or Loukovitsa Formation (Fig. 2). It is suggested that the VF should stay with the name Loukovitsa Formation. The arguments for this are: i) for the first time it has been defined and described (Кожухарова, Кожухаров, 1962) in the Northern Rhodope anticline, where later was nominated as Lukovitsa Formation; ii) the same formation demonstrates there the most complete section with base (Bachkovo Formation) and cover (Dobrostan Formation), iii) the VF there is in normal stratigraphic position;

– Zhalty Chal and Gnesdare Formations of Botourche Group, refered to Prarhodopian Supergroup (Боянов и др., 1963; Кожухаров, 1987), are formations of Satovcha type, set in an inclined syncline (Kozhoukharova, 1999) and it is correctly to refer them to Rhodopian Supergroup;

– The POAR is an integral part of VF. Nowhere it is present normally in the Prarhodopian Supergroup. Some serpentinite bodies occur among "gneisses", but during the geological revision it turned out that those "gneisses" are feldspatized mica-schists, often bearing relicts of kyanite;

– The boundary between VF of Rhodopian Supergroup and gneisses of Prarhodopian Supergroup is a transgressive one, consolidated during the regional metamorphism. POAR (with eclogites in it), occupies low stratigraphic levels of VF. It nowhere marks sutures, thrust surfaces, deep faults or subduction zones;

– The POAR is heterogeneous basic-ultrabasic magmatic formation that has originated probably in active marginal continental basins in an island arc system during Neoproterozoic. The serpentinites have

been obduced like fragments of hydrated ocean crust and later have been cut and covered by low K, high Ti and Fe tholeiitic, magmas (Кожухарова, 1984, 1985) in a supra-subduction setting. The geochemical signature of basic protoliths does not lead to a indisputable decision about affinity of metabasic rocks to some geodynamic zone as MORB, IAT or OIB (Kozhoukharova, Daieva, 1990; Закариадзе и др., 1993; Базылев и др., 1999; Haydoutov et al., 2004; Хайдутов и др., 2003) and probably hints their supra-subduction origin in an island arc/back-arc system, with identifiable arc-related and rifting/sea-floor spreading magmatic products (Bonev et al., 2006);

– The basic magmatism is autochthonous one and it is proved by the subintrusive bodies and dykes crossing leptite gneisses of the Prarhodopian Supergroup, as well as by the xenoliths of leptites among the orthoamphibolites;

– The eclogites always are connected with amphibolites of VF. Some small bodies, found in gneisses near the contact between VF and gneisses from the foot, got there as result of gravity collapse or amalgamation;

– The eclogites are crustal metamorphic products and they are displayed along local shear zones of friction among the amphibolites and serpentinites in the same stable stratigraphic level of VF (Kozhoukharova, 1996, 1999). They are not produced within subduction zones.

– The age of VF and MF by fossil data is Rifean (Кожухаров, Тимофеев 1989; Кожухаров, Конзалова, 1990). Corresponding age is defined by the absolute age data for the basic magmatism: Neoproterozoic – 610 Ma in the Central Rhodope (Arkadaskiy et al., 2003) and 572 Ma in the Eastern Rhodope (Carrigan et al. 2003).

The age of the gneisses of the Prarhodopian Supergroup is still under discussion. The Phanerozoic metasomatic processes, related to the influence of the Hercynian and Late Cretaceous/Paleogene granitoid magmatism, have caused strong thermal and substantial impacts. The data of the absolute age of the protoliths and metamorphism cover very wide interval from Precambrian to Paleogene. For the porphyroblastic gneises from Panovo Formation (Belareka dome) there are reported 1700-1800 Ma (Peycheva, v. Quadt, 1995), interpreted as the age of the detrital zircon from sedimentary formations and 305-319 Ma for the intrusive Paleozoic granites. Precambrian age of the ancient sediments – 3230 Ma and 560 Ma (Liati, Gebauer, 1999) and 670–560 Ma (Liati, 2005) is reported for analogous gneisses in Northern Greece.

Correlations of metamorphosed lithostratigraphical units in the Precambrian blocks of South Bulgaria

The generalized stratigraphic column of the primary lithological units (Fig. 4) represents two groups. The lower group – a continental infracrustal com-

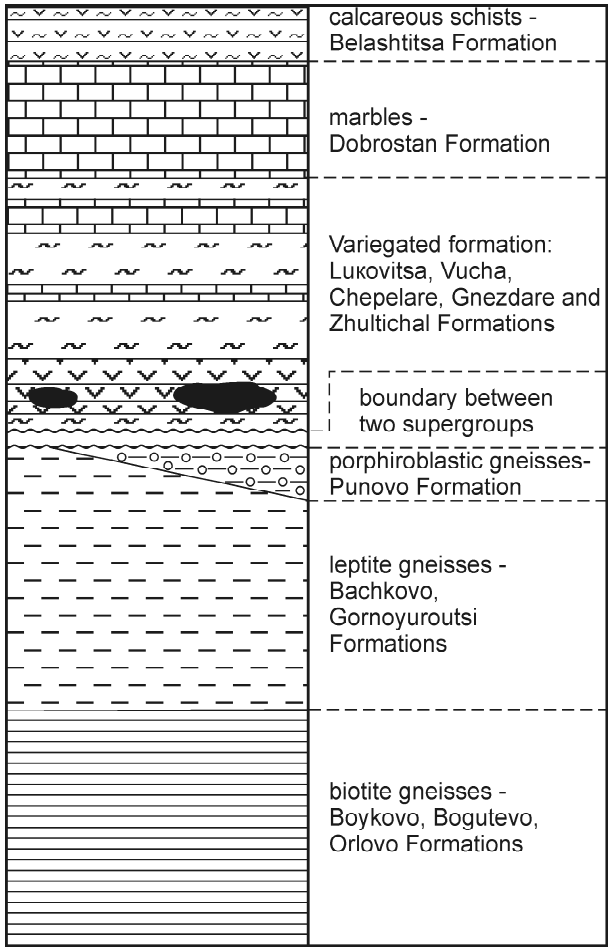

Fig. 4. Generalized lithostratigraphic column of the Precambrian in the Rhodope Massif

plex (PRS) is best represented in Strazhevo Group in Eastern Rhodopes and may be used as an etalon for the stratigraphy of the PRS. It is divided on three subgroups: biotitic gneisses of Orlovo Formation, leptite gneisses of Gornoyuroutsi Formation and porphyroblastic gneisses of Punovo Formation. Orlovo Formation is comparable with Bogutevo and Boykovo Formations and the Gornoyurutsi Formation – with Bachkovo Formation from the Central Rhodopes. Pockets of porphyroblastic gneisses, identical of Punovo Formation, occur on the same stratigraphic level in some places.

Vishnevo Formation consisting of gneisses, micaschists, marbles and amphibolites is a mixed one because of the folding and tectonic amalgamation.

The upper group – a supracrustal complex RS is devided of: i) Variegated Formation with metamorphosed analogs Botourche Group, Chepelare, Vucha and Loukovitsa Formations (Fig. 4) and ii) Marble Subgroup (Dobrostan and Belashtitsa Formations).

The whole metamorphic basement in Sredna Gora Zone was refered to Prarhodopian Supergroup (Вергилов и др., 1963). It includes undivided Arda Group and undivided Botourche Group (Geologi-

cal Map of Bulgaria M 1:100 000: Ihtiman, Panagyurishte, Kazanluk mapsheets). But lithological features of Botourche Group are in line with Variegated Formation – Satovcha type of RS and only gneisses of Ardino Group correspond to PRS (Fig. 5).

The Ograzhdenian Supergroup, outcropping in SW Bulgaria, also is believed to be a correlate to PRS (Zagorchev, 1993, 2001). In our opinion Ograzhdenian Supergroup is composed by migmatite gneisses of PRS and Variegated Formation – Satovcha type of RS. The latter is represented there of chloritoid and kyanite bearing mica-schists, amphibolites, serpentinites. The migmatization and feldspathization in some places is so strong that transforms the mica-schists to enriched of white mica gneisses, where relicts of kyanite have been preserved. Among such "gneisses" lie the serpentinite bodies, cut by pegmatite veins.

Some remarks about correlation of the metamorphites from Rhodope Massif – South Bulgaria and Northern Greece

Irrespectively of different principles for subdivision of metamorphic complexes in Rhodope from South Bulgaria and Northern Greece, it is possible for the moment to make enough satisfactory correlation scheme (Fig. 6).

The Asenitsa group of RS, including Belashtitsa and Dobrostan Marble Formations in Northern Rhodopes corresponds to Menikio and Bos Dag units (Fig. 6) in Northern Greece after fossil and lithostratigraphical data (Zachos, Dimadis, 1983; Zagorchev,1994; Kozhoukharov, 1994a, b).

The marbles from "Upper group of Pangaion unit" (Papanikolaou, Papadopoulos, 1981), and the marble from "upper group of Sidironero units" are correlates of Dobrostan Marble Formation of RS.

The Variegated Formation of RS is correlated with Nimpheas unit (Zagorchev, 1994). Amphibolites and schists from "Lower group of Pangeon units" (Papanikolaou, Papadopoulos, 1981), kyanite and garnet bearing mica schists from "Lower group of Sidironero units", as well as complex Kimi from "Upper tectonic units" in Eastern Rhodopes (Mposkos, 1989) also correspond to the Variegated Formation of RS too.

The porphyroblastic and leptite gneisses (PRS) in Rhodopes are analogs to: augen gneisses and leptites from "Lower group of Pangaion Unit" (Papanikolaou, Papadopoulos, 1981) or Nevrokopi unit – (Zagorchev, 1994). "Lower group of Sidironero unit" as well the leptites from "Lower tectonic units" in Eastern Rhodopes (Mposkos, 1989) also correspond to leptites of PRS.

The three lithological units from Falacron Mts. (Chatzipanagis, 1990): i) upper calcareous units –

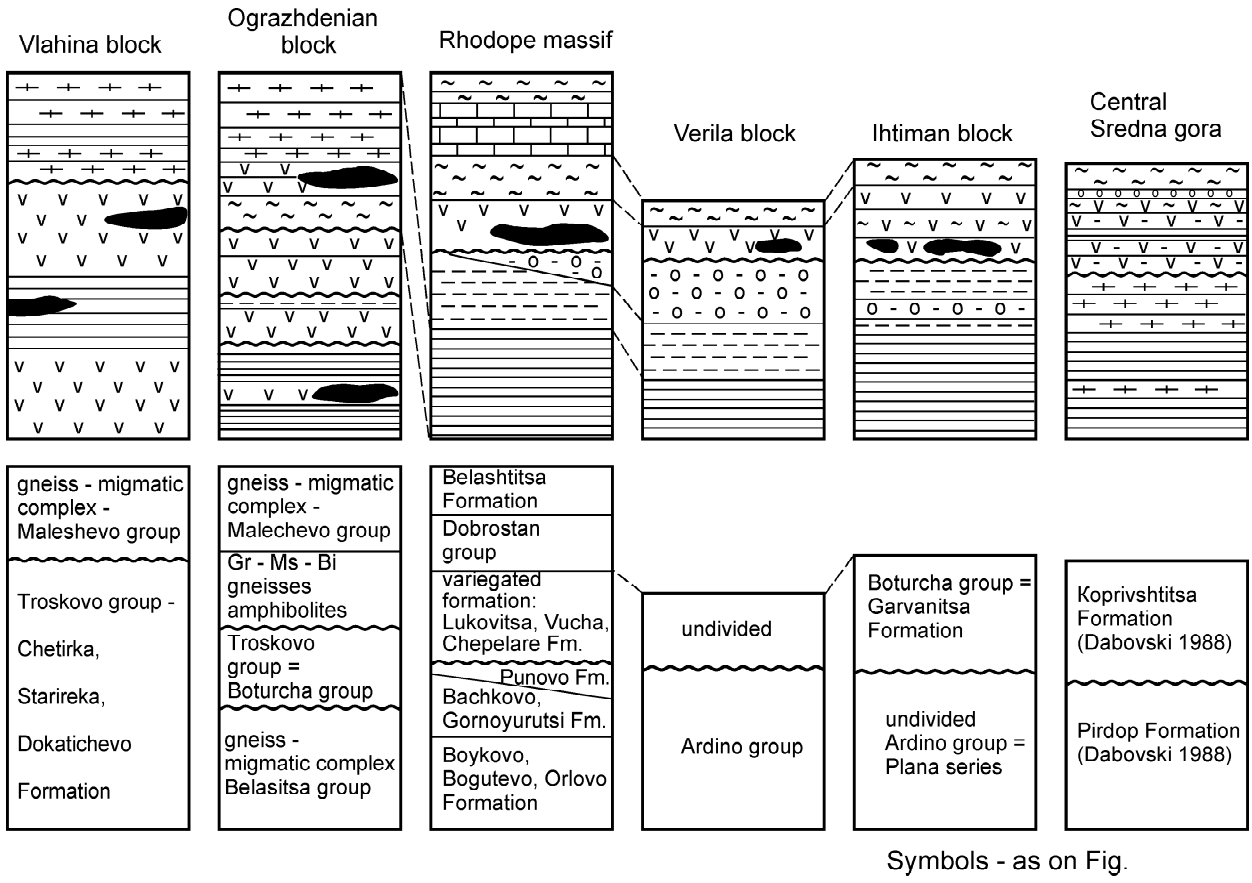

Fig. 5. Correlation lithostratigraphic columns of the Precambrian blocks in South Bulgaria

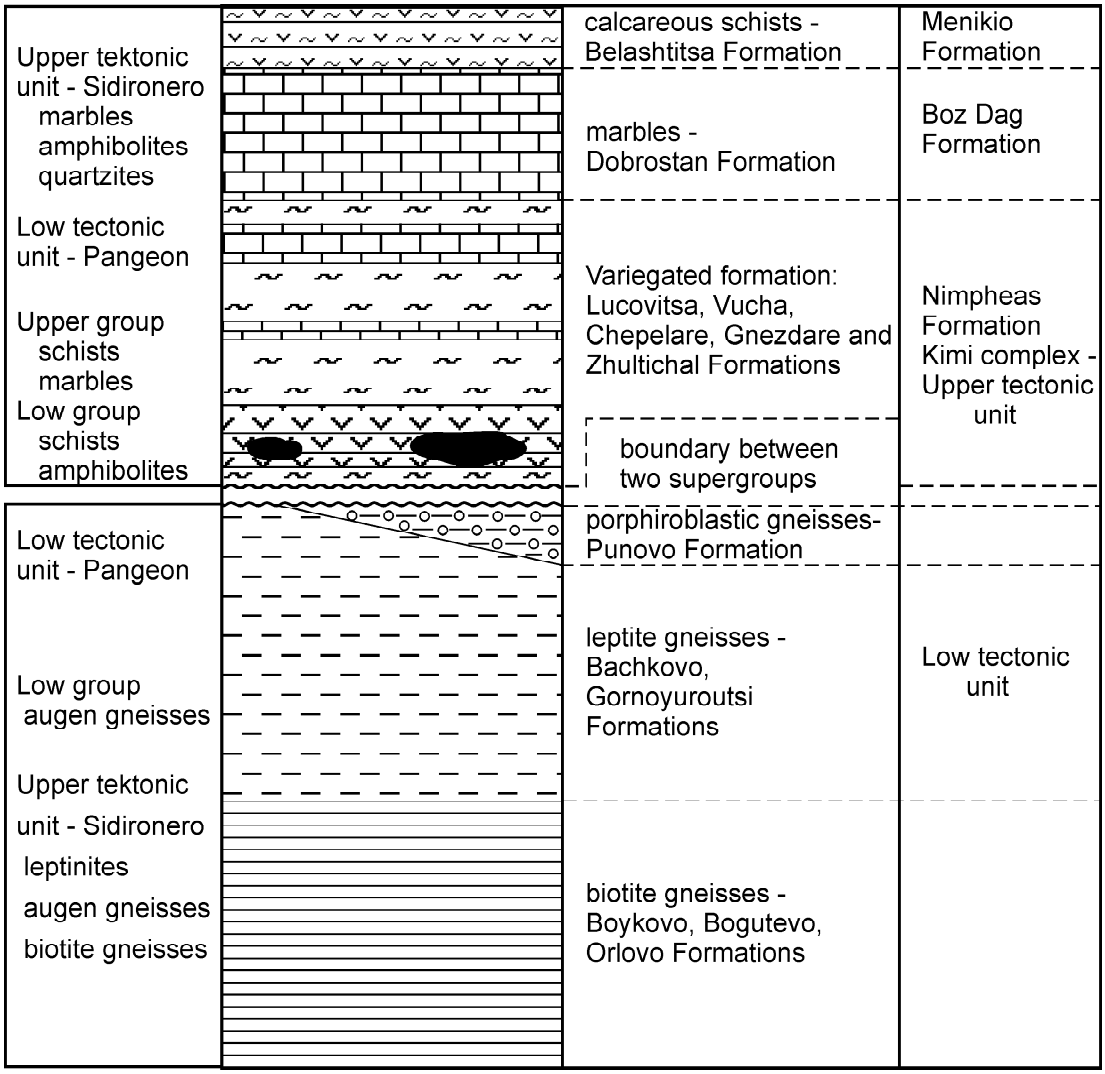

Fig. 6. Correlation lithostratigraphic columns of the Precambrian blocks in the Rhodope Massif and northern Greece

marbles and dolomites; ii) transitional units – schists, marbles, gneisses, amphibolites, eclogites and iii) lower units – monotonous quartz-feldspar muscovite and biotite gneisses, coarse-grained augen gneisses correspond respectively to i) Dobrostan Marble Formation, ii)Variegated Formation of RS and iii) leptites and coarse porphyroblastic gnesses of PRS.

The information about two metamorphic units in the Pelagonian zone (Dumurdzanov and Stojanov, 1988) in Macedonia let a possibility for lithological correlation between Rhodope and Pelagonian massifs. The oldest rocks – 669–713 Ma of Greece (Anders et al., 2005) are a part of the same metamorphic basement.

It is reasonable also to search for a lithological relation between Rhodope Massif and Apuseni Mts. (Romania). After a summary by Krautner (1997) the Precambrian polymetamorphic basement is outcropping in some Pre-Variscan Terranes. In Somes Terrane two-mica schists and leptito-amphibolite formation are assigned. Carpian Terrane, constituted of Baia de Aries Group, consists of mica-schists and carbonate formations, the later is an alternation of calcite and dolomite marbles, amphibolites, mica-schists and quartzites. In Codru Terrane the Codru amphibolite Formation of 524 Ma is outcropping. Nevertheless of complicate nappe system in Apuseni Mts., a lithological similarity between mentioned above formations and Rhodopian Supergroup appears.

Conclusion

1. The actual lithological, petrological and tectonical analysis confirms that the Precambrian metamorphic complexes in Southern Bulgaria are one common lithological system, composed of two metamorphic complexes that are different in lithology and age: Prarhodopian and Rhodopian Supergroups with relatively well preserved stratigraphic sequence.

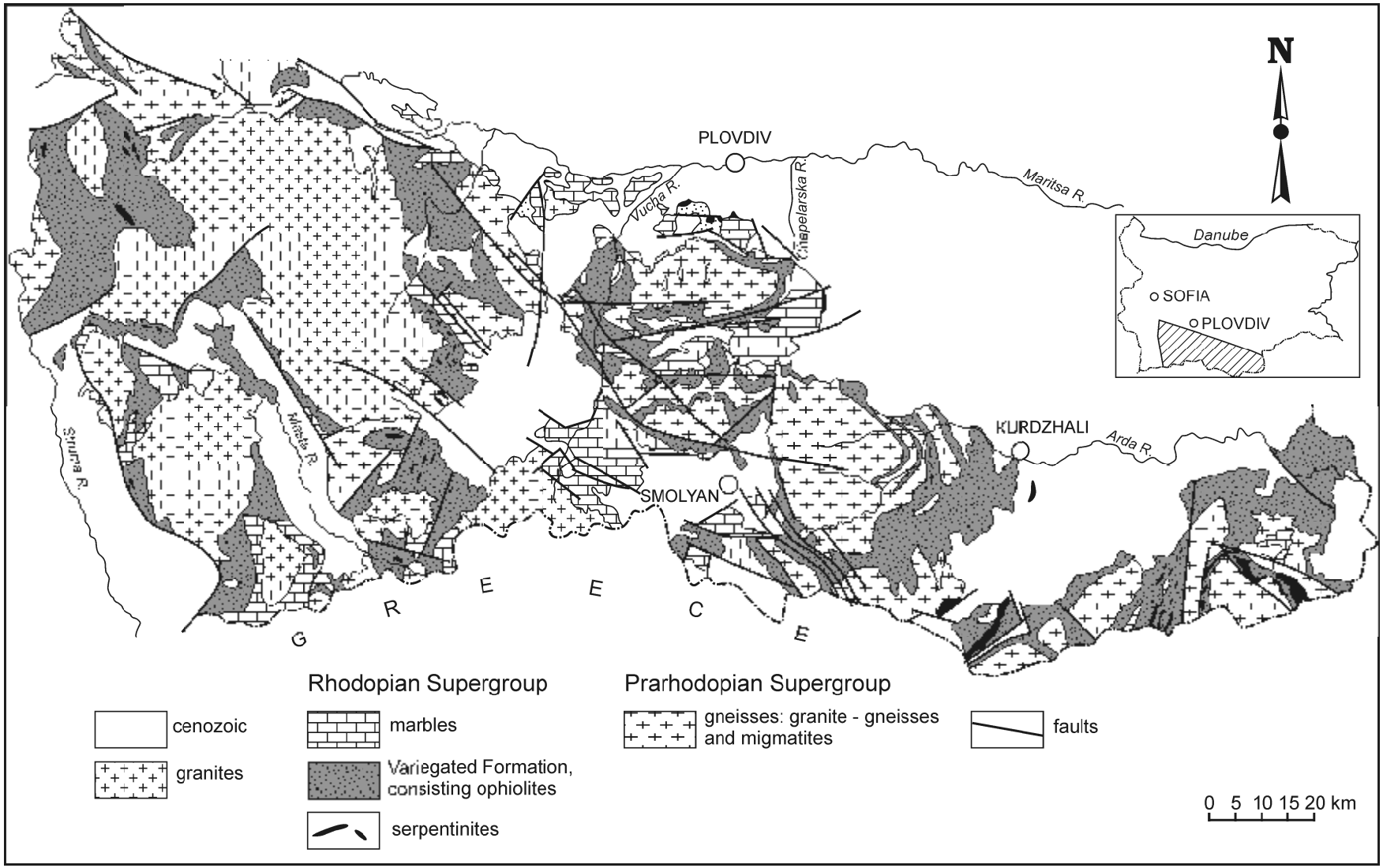

Fig. 7. Map of main lithological formation of the metamorphic complexes in the Rhodope Massif

2. The Prarhodopian Supergroup is an infracrustal gneiss complex from ancient continental crust with the following lithostratigraphic sequence from base to top: biotite gneisses – Orlovo Formation, leptite gneisses – Gornoyuroutsi Formation, porphyroblastic gneisses – Punovo Formation and does not contain variegated formations. Part of the Prarhodopian Supergroup are also the analogous gneiss formations - Boykovo and Bogoutevo Formations (correlates to Orlovo Formation) and Bachkovo Formation (corresponding to Gornoyuroutsi Formation) which are placed in the cores of the anticline structures and have been described earlier as a part of the Rhodopian Supergroup.
3. Transgressively deposited Rhodopian Supergroup is composed mainly of variegated Loukovitsa Formation (with correlates are Vacha and Chepelare Formations) and marble-schists Asenitsa Group with Dobrostan and Belashtitsa Formations.
4. The Ophiolite association is stratigraphically related to the Variegated Formation only.
5. The methamorphic rocks from Sredna Gora zone and Ograzhdenian Supergroup are composite complexes, that contain formations, which lithologically belong either to Prarhodopian or to Rhodopian Supergroup.
6. The main structural plan of the crystalline basement of the Rhodope massif, demonstrated by the distribution of the lithological formation, is characterized by fold structures (Fig. 7).

The correlations between crystalline blocks in Balkan terranes is a main aim for the regional geologists. The realization is difficult because of individual deformation development of every tectonic unit. An effort for reconstruction of the primary composition and stratigraphy of the lithostratigraphical units will be favorable for interregional correlation.

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Е. Кожухарова — Реконструкция на първичната стратиграфия и корелация на докембрийските метаморфни комплекси в Родопския масив. Стратиграфската схема на всеки метаморфен комплекс представя реалните, видими суперпозиционни отношения на литоложките единици, в които са отразени претърпените деформации, но тя почти винаги повече или по-малко се различава от първичната стратиграфска последователност. Достоверността на междурегионалните корелации, затруднени поради тектонските нарушения, неравномерните полиметаморфни изменения и несигурността на изотопните данни за възрастта на скалите, изискват максимално възстановяване на предметаморфния вид на протолитите и техните взаимоотношения. Подобна структурно-петроложка реконструкция е възможна едва след натрупване на необходимата и достатъчна информация чрез специализирани, понякога продължителни разработки.

Актуалната стратиграфска схема на метаморфния комплекс в Родопския масив и съседните области, приложена в Геоложката карта на България (Kozhoukharov, 1988), също така представя днешните суперпозиционни отношения на литостратиграфските единици, без някога да е претендирала за адекватност на първичните. Проведените петроложки изследвания за възстановяване на предметаморфния състав на скалите, уточняването на стратиграфското и структурно положение на офиолитовата асоциация и разшифроването на редица полегнали гънки (Жълтичалска, Авренска, Ардинска, Дебренска синклинала) причиняващи на много места повторения в литоложкия профил, направи възможен този първи опит за реконструкция на първичната стратиграфия и на тази база провеждане на корелация със съседните области.

Резултатите от литоложкия и структурен анализ са обобщени в следните по-важни изводи:

1. Потвърждава се наличието на два различни по литофациес комплекса:

1.1 *Прародопска надгрупа* — долен инфракрустален континентален комплекс, състоящ се от няколкократно преработени монотонни пара и ортогнайси, гранитогнайси, мигмати-

ти, биотитови и лептитови гнайси. Липсват пъстри свити с мрамори и офиолити. Причисляваната към надгрупата Пъстра Богутевска свита от Белоречкото подуване е в тектонско положение, изпълва полегнала синклинала и не принадлежи към Прародопската надгрупа. Комплексът се разкрива в ядрата на големите позитивни структури, известните като Белоречко подуване, Тинтявско подуване, Кесебирска антиклинала, Мадан-Давидковско подуване, Севернородопска, Среднородопска и Южнородопска антиклинали, югозападната част на Западните Родопи и Пирин.

Еталонната стратиграфска последователност на Прародопската надгрупа е представена най-добре в Белоречкото подуване отдолу нагоре: *а. Орловска свита* – преобладаващи биотитови гнайси, с корелати Бойковска и Богутевска свита от Централните, Западни Родопи и Пирин; *б. Горноюрушка свита* – лептитови гнайси с корелат Бачковска свита от Централни, Западни Родопи и Пирин и *в. Пъновска свита* със спорадично развитие в Централните и Западни Родопи, но широко в Сакарския блок, преминаваща в Константиновската метаконгломератна свита;

1.2 *Родопска надгрупа* – горен трансгресивно отложен супракрустален вулканогенно-седиментен комплекс, състоящ се основно от две литофациални единици: а. *Пъстра свита*: толеитови вулканити и туфи, серпентинити, габра (Офиолитова асоциация), пелити, кварцити, варовици, метаморфозирани в амфиболити, пироксенити, еклогити, гранатови лерцолити, слюдени шисти, калкошисти и мрамори, представени в *Луковишката, Въчанската, Чепеларската, Гнездарската и Жълтичалската свита* и б. *Карбонатна свита* – доминирана от калцитови и доломитови варовици, прослояващи се с пелити, метаморфозирани в мрамори и шисти, представени в *Асеновградската група (Добростанска и Белащенска свита.)*

2. Пъстрата свита е развита в два литоложки типа: а. *Западнородопски (Сатовчански)* в райони с активна вулканска дейност, където в ниските стратиграфски нива преобладават вулканити и техните туфи, а нормалната седиментация е сподавена, поради което варовиците и пелитите са редуцирани, а на места дори липсват и б. *Централнородопски (Луковишки)*, преобладават седиментите, а нивата на вулканитите в съвременния профил са маркирани от тънки амфиболитови пластове;

3. Родопската офиолитовата асоциация е хетерогенна базит-ултрабазитова фармация, която има определено стратиграфско положение в ниските нива на Пъстрата свита – Родопска надгрупа. Нейният генезис е свързан с вероятна обдукция на фрагменти от серпентинизирана океанска кора в окрайни континентални басейни в супра-субдукционна обстановка. Серпентинитите са покрити от нискокалиеви толеитови вулканити и техните туфи и туфити. Неопротерозойският базичен вулканизъм е автохтонен, формира субинтрузивни малки тела и дайки, сечащи лептитовите гнайси и включващи ксенолити от тях;

4. Еклогитите и гранатовите лерцолити са корови метаморфни продукти на офиолитите и са образувани “in situ” в тесни зони на триене в обстановка на локално повишени температура налягане при фонов метаморфизъм в амфиболитов фациес. Липсват данни метаморфният комплекс да е попадал в субдукционна зона. Запазената добра стратифицираност на Родопската надгрупа, ненарушените добре очертани линейни гънкови структури и липсата на данни целият комплекс да е преминал през високи T/P условия на кристализация и впоследствие да е претърпел тотална диафтореза, както и невъзможността да е протекла една късна следеклогитизационна серпентинизация на огромните серпентинитови масиви изключва субдукционен етап на метаморфния комплекс.

5. Метаморфните скали от Средногорската зона и Огражденската надгрупа са съставни комплекси от скални формации, съответстващи по литофациес на части от Прародопската и Родопската надгрупа.