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MORPHOSTRUCTURES IN MOMCHILGRAD DEPRESSION (Eastern Rhodopes)

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ABSTRACT. The Late Alpine Momchilgrad Depression is located between the Central Rhodopes and the Byala Reka metamorphic core complexes (domes) in the eastern periphery of the Rhodopes massif. Several volcanic edifices of intermediate composition and many acid extrusions have been mapped in the confines of the Depression. These relatively young structures are directly reflected in the modern morphostructural plan and can be easily detected on aerial photographs and space images. Morphostructural and morphometric studies and the GIS potentialities of the relief outline the domes of the metamorphic core complexes as positive arch morphostructures. Between them, the Momchilgrad Depression forms a negative structure contoured by well-manifested morpholineaments. The Paleogene volcanic cones and extrusions are registered as second-order positive morphostructures in the Depression. These features are very well expressed on space images and are interpreted as photoanomalies of linear, arch, or circular pattern.
Key words: morphostructures, Momchilgrad Depression, Eastern Rhodopes, remote sensing, GIS.

МОРФОСТРУКТУРИ В МОМЧИЛГРАДСКАТА ДЕПРЕСИЯ (Източни Родопи)

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РЕЗЮМЕ. Късноалпийската Момчилградска депресия се разполага между Централнородопския и Белоречкия ядрени комплекси (куполи) в източния фланг на Родопския масив. В нея са локализирани няколко среднокисели вулкански постройки и редица кисели екструзии. Тези сравнително млади структури намират пряко отражение в съвременния морфоструктурен план и се дешифрират по аерофото снимки. Въз основа на морфоструктурни и морфометрични изследвания в релефа добре се очертават куполите на ядрените комплекси като положителни сводови морфоструктури. Между тях като отрицателна структура се очертава Момчилградската депресия, отделена с много добре изразени морфолинеаменти. В пределите на депресията, като положителни морфоструктури от втори ранг, изпъкват палеогенските вулкански конуси и екструзии.

Geological setting

The Momchilgrad Depression is located between the Central Rhodopes (to NW), the Byala Reka and the Kessibir (to SE) metamorphic core complexes (domes) of the Rhodope massif, and the Kurdzhali block to the north (Georgiev, 2004).

The basement and framework of the Depression comprise pre-Paleogene metamorphic rocks (various gneisses, marbles, amphibolites, serpentinized ultrabasites).

The Kurdzhali block, occupying an intermediate hypsometric level between the core complexes and the Momchilgrad Depression, is composed mainly of Eocene sediments and Lower Oligocene acid pyroclastic rocks.

The basal parts of the Depression are build up of Paleocene-Oligocene terrigenous sediments and reefal limestones.

In the end of the Priabonian and during the Oligocene formed the Iran Tepe, Sveti Iliya, Bivolyane, Dambaluk, and Zvezdel volcanoes (Fig.1). They are composed of the materials of the Putochara intermediate subgroup and the Zdravets acid subgroup pertaining to the Dambala magmatic group. The Nanovitsa caldera, located between them, is filled with products of the Sveti Iliya trachyrhyodacite and the Ravena rhyolite complex.

Extrusives from the Perperek trachyrhyolite and the Ustren rhyolite complex are exposed along the northern and western periphery of the Depression and its framework (Georgiev, Milovanov, 2003).

Trachyrhyodacite to trachyrhyolite and latite dikes from the Pcheloyad dike complex occur in the southern part of the Depression and its frame.

Methods

To highlight the morphostructure of the Momchilgrad Depression and its framework, aerial photographs and space images (LandSat TM) in scale 1:20,000 and 1:100,000 were deciphered and an aerophototectonic map was compiled (Fig.2). A morphostructural map of the tectonoisohypses was constructed, too (Fig. 3).

In the process of deciphering of aerial photographs and space images, both direct and indirect methods for interpretation of lineaments and ring structures were used. Nowadays, the quick development of computer engineering and the integration of data bases into GIS enables to use interactive methods in georeferencing, processing, deciphering, and interpretation of modern remote sensing data, as well as to use this data in complex with ground-based data. The spatial juxtaposing of complex data allows to separate surface and in-depth lineament manifestations (Кац Я. и др. 1988).

The generalized outlook of the Momchilgrad Depression, its constituent higher-order morphostructures, and its metamorphic framework are reflected on the tectonoisohypse map. The area structures manifested directly in the modern relief are fixed by the circular form of the tectonoisohypses outlining positive morphostructures. Furthermore, the modern dynamics of these morphostructures is outlined by the centrifugal configuration of the river-gorge network. The linear tectonic elements (morpholineaments) are manifested either by congestion of the rectilinear tectonoisohypses or by their knee-likebendings. The morpholineaments are also outlined by the rectilinear segments of the river valleys.

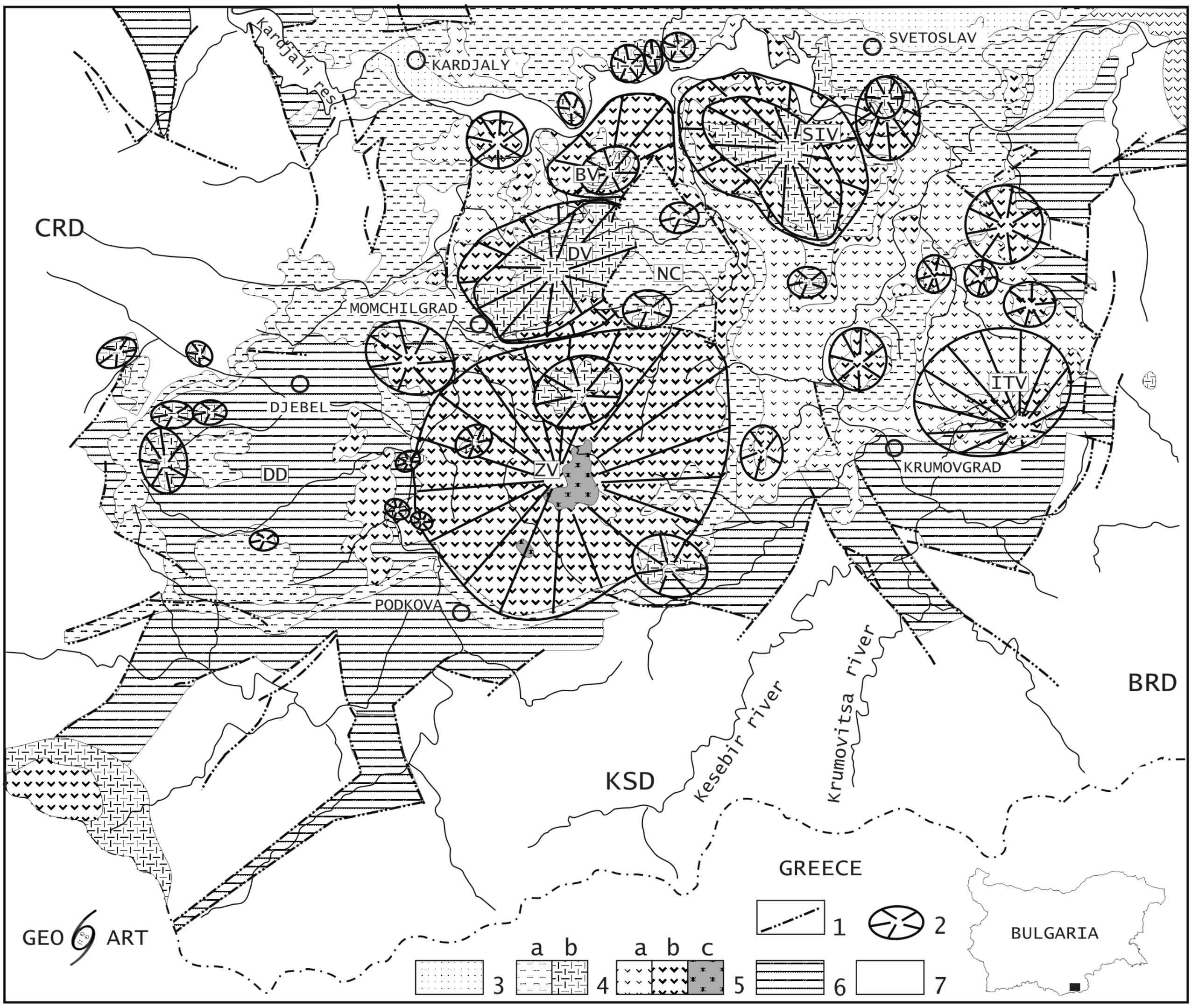

Fig. 1. Geologic-structural map of the Momchilgrad Depression. 1– fault; 2 – volcanic cone or extrusive; 3 – Neogene-Quaternary deposits; 4 – acid tuffs (a) and effusives (b); 5 – intermediate tuffs (a), effusives (b) and intrusions (c); 6 – Paleogene sediments; 7 – pre-Paleogene basement; ZV- Zvezdel volcano; DV- Dambaluk volcano; BV- Bibolyane volcano; SIV- Svety Iliya; ITV- Iran Tepe volcano; CRD- Central Rhodopes dome; BRD- Byala Reka dome;KSD- Kessibir dome

Morphostructures of the metamorphic framework

In the beginning of Paleogene, the factor accounting for relief formation was arch formation, related with the formation of core metamorphic complexes in connection with extension processes (Ivanov, 2000). On the modern morphostructural plan, the first-order tectonic structures are well manifested – the Central Rhodopes, the Byala Reka, and the Kessibir core complexes (domes). These form morphoarches, which feature a high and strongly segmented relief. To the north of the Byala Reka morphoarch, a second-order positive morphostructure is identified which may be regarded as an element of the Surt arch (Вапцаров, Дилинска, 1980). The crestal parts of these first-order morphodomes feature a hypsometric level of over 900 m. Their low peripheral parts around the border with the Momchilgrad Depression feature a hypsometric level of 500-600 m.

The inner structure of these first-order positive morphostructures is complicated by a number of second-order morpholineaments. Extensional stresses in the crestal and peripheral parts of the domes produced superimposed negative structures that are filled with continental and marine sediments.

Along the border between the arch-block morphostructures, Neogene-Quaternary valley extensions are formed, often featuring asymmetric structure.

Boundary morphostructures

In most cases, the boundary between Momchilgrad Depression and the surrounding Central Rhodepes, Kessibir, Byala Reka, and Popovo morphostructures is traced by well-pronounced first-order morpholineaments. The eastern margin of the Depression is well outlined by a system of NNE morpholineaments inheriting the Avren-Madzharovo fault bundle. The southern margin is marked by a system of ENE, less commonly WNW first-order morpholineaments along which the valleys of the Kessibir river, the upper part of the Vurbitsa river and other valleys are formed. The western margin of the Depression is also well outlined by fault systems of different orientation. The northern boundary of the Momchilgrad Depression with its relatively slightly elevated Kurdzhali block is traced by morpholineaments of WNW and ENE trend. Along these, the valley of the Arda river is formed.

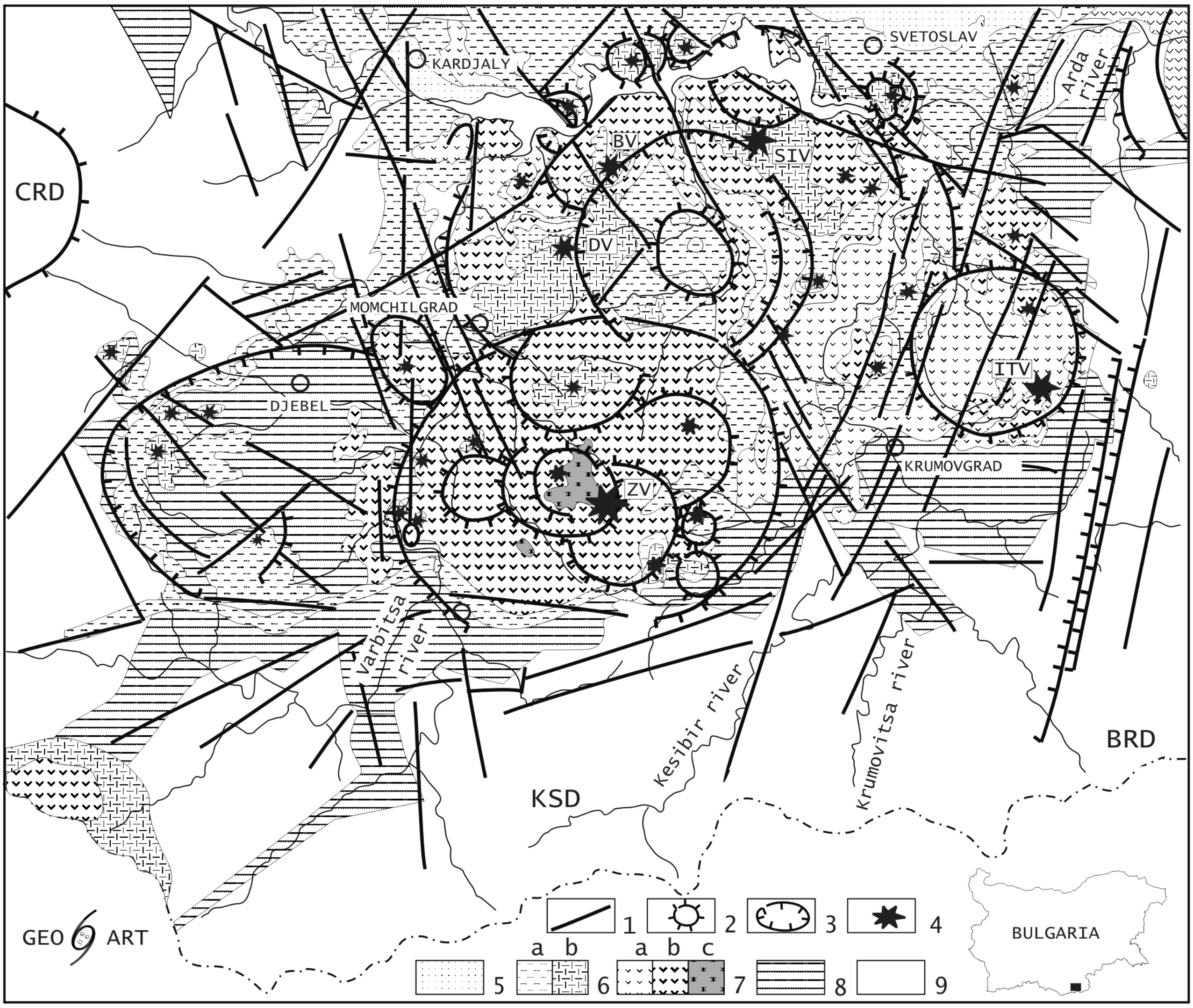

Fig. 2. Aerophototectonic map. 1 – lineaments; positive (2) and negative (3) ring structures; 4 – neck; 5-9 – same as in Fig .1

When the geologic boundary between the Depression and the surrounding arches is not determined by faults, but by transgressions, the morphostructural boundary is marked by knee-like bendings of the tectonoisohypses and by abrupt change in their values. In this way, the western boundary of the Depression SW of the town of Kurdzhali is outlined.

Morphostructures of the Momchilgrad Depression

The Momchilgrad Depression is well outlined as a first-order negative morphostructure against the surrounding morphoarches featuring a high and strongly segmented relief. The areas, which are built-up of Paleogene sediments and pyroclastic rocks, show a relatively smooth and less-segmented low relief (400-600 m). Such is the situation within the area of the Dzhebel depression constituting a second-order negative structure within the Momchilgrad Depression. The northern margin of the Depression, the Kurdhali block, features a similar pattern.

There are also a number of higher-order positive morphostructures in the Depression, which inherit various paleo-volcanic structures. The volcanic forms imprinted in the relief show up as strongly elevated inverse forms against the background of the structural depressions filled with Paleogene, Neogene, and Plio-Pleistocene sediments.

On aerial photographs and on the tectonoisohypse map, volcanic cones are usually well marked in the relief as positive ring morphostructures. Of the volcanic cones from the Dambala group, the relatively isolated volcanic edifices of Zvezdel and the Iran Tepe volcanoes are best outlined. They form positive, relatively isometric morphostructures marked by the ring form of the tectonoisohypses and the centrifugal configuration of the river-gorge network. The periphery of their volcanic cones is well marked also by the arch-like configuration of the Vurbitsa and Krumovitsa rivers and by a part of their tributaries.

The Iran Tepe stratovolcano is imprinted in the relief as an asymmetric ring morphostructure with steep eastern and southern slopes and with longer and more shallow-dipping western and northern slopes. Along its periphery, some parasitic volcanoes project as truncated dome-like peaks.

The Zvezdel volcano features a complex orographic plan. A central cone-like core shows up in the relief around the Strumni Rid peak as well as a peripheral frame, built-up of long, arcuate asymmetric hills. It is morphologically emphasized by the radially developed river-gorge network, too. According to Vaptsarov (1983), it constitutes an inner caldera edifice, which was formed during the final development stages of the Zvezdel caldera. In the geological context, no data pointing to an existing caldera structure within the Zvezdel volcano are available. The peripheral arch-like hill is a result of fault deformations of the Zvezdel volcano, however preserving some fragments from the periphery of its volcanic cone.

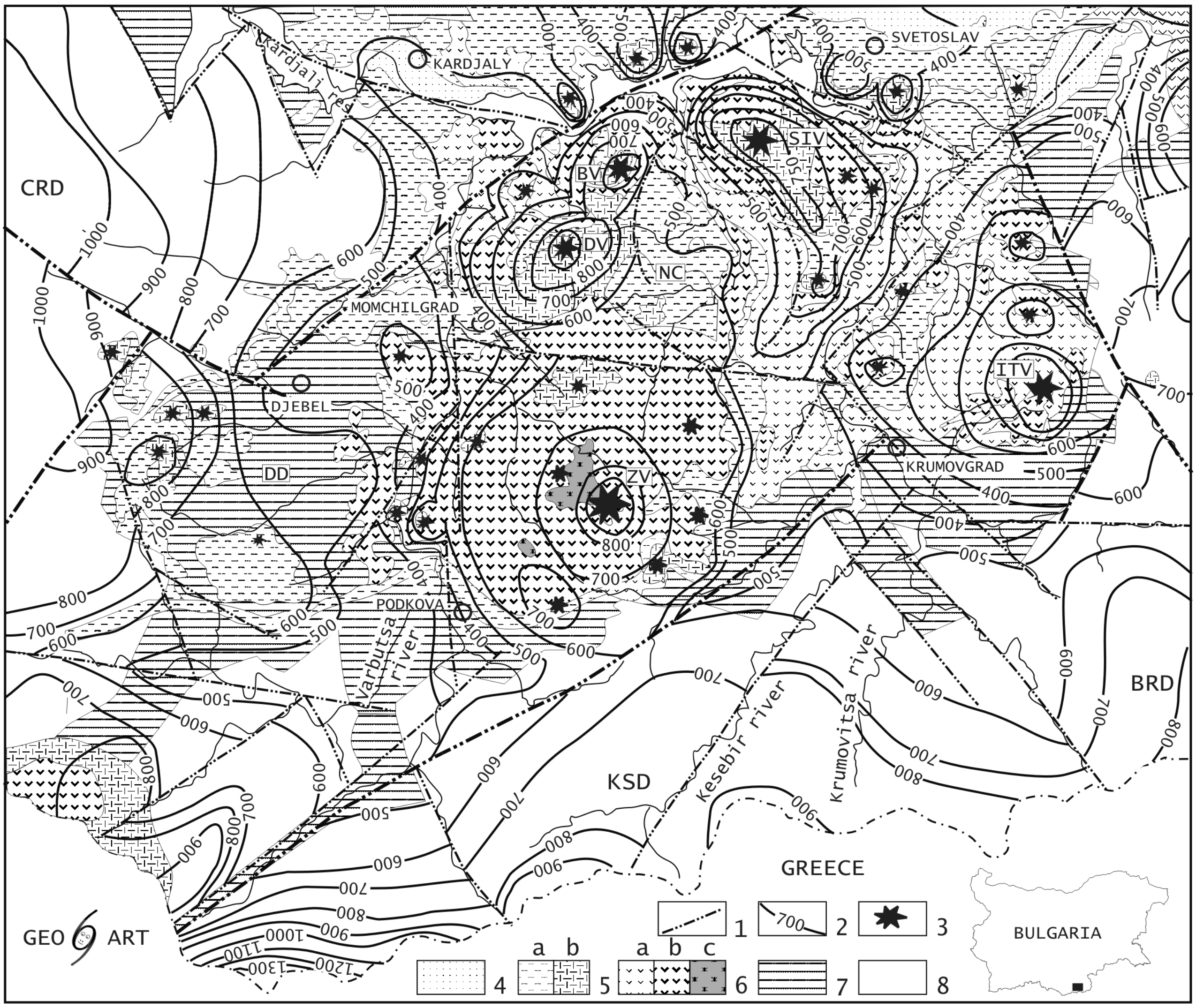

Fig. 3. Morphostructural map. 1 – morpholineaments; 2 – tectonoisohypses; 3 – neck; 4-8 – same as in Fig.1

In the confines of the Zvezdel volcano, some second-order ring structures can be also deciphered, which in most cases coincide with parasitic volcanic cones, confirmed as well by geologic data. The most typical one is the parasitic volcanic cone along the northern slope of Zvezdel volcano, built-up by the Momchilgrad trachydacite complex.

The Dambaluk, Bivolyane, and Sveti Iliya volcano form a joint first-order positive ring morphostructure (the Ravena one). In its confines, only individual fragments of the volcanic cones of the near-by volcanoes constituting it have been deciphered. However, their centers are well marked by their late acid phases which are characterized by light phototone and high relief. The southern part of this first-order structure is deformed by the Zvezdel volcano. Along its northern periphery, the extrusions of the Perperek trachyrhyolite complex are emplaced mainly along the Hissarya magma-conducting zone.

In the inner parts of this first-order positive morphostructure, a negative ring morphostructure is outlined. Spatially, it coincides with the Nanovitsa caldera, nevertheless featuring much greater dimensions while nearly touching the tops of the surrounding volcanic cones. This negative structure should be considered as an erosion caldera (Vaptsarov, 1983).

The actuate peripheral ridge is built-up of acid lavas and pyroclastics, forming imprinted in the relief volcanic vents and lava flows. They form well-expressed lava plateaus with steep to vertical slopes. The inner caldera depression has circular form. It is drained by the valley of the Bouyukdere river (which forms an epigenetic defile crossing the caldera's actuate ridge) and its radial tributaries. In the inner parts of the erosion caldera, the genuine Nanovitsa caldera with its modern dimensions is deciphered as an inverse higher-order positive ring morphostructure.

In the southwestern part of the Depression, the Dzhebel negative form is well outlined, which is filled with Oligocene sediments.

In the NE part of the studied area, part of the positive morphostructure of the Madzharovo volcano is deciphered.

Transform morphostructures

Several inner or transit morpholineaments are observed. Along the lower part of the Vurbitsa river, a first-order lineament with meridional orientation can be traced. It separates the Dzhebel depression and the NE fragment of the Central Rhodopes dome (to the east) from the volcanic edifices (to the west). In the eastern part of the studied region, an area of ENE oriented morpholineaments is outlined. They can be identified in both the Kessibir morphoarch, as well as in the inner part of the Momchilgrad Depression, including the positive morphostructure of the Iran Tepe volcano. Another morpholineament system can be traced from the Kurdzhali block and the Ravena morphostructure in the NW part of the studied area up to the Byala Reka dome to the SE. In the SE periphery of the Momchilgrad Depression, these lineaments mark the Loudetino graben, wedged in-between the Kessibir and the Byala Reka dome.

Conclusions

1. The first-order tectonic structures of the metamorphic basement (Central Rhodopes, Byala Reka, and Kessibir core complexes) are well expressed on the modern morphostructural plan. They form morphoarches which feature a high and strongly segmented relief.
2. The Momchilgrad Depression is outlined as a first-order negative morphostructure against the background of the surrounding morphoarches. The regions built-up of Paleogene sediments and pyroclastic rocks feature a relatively smooth and less segmented low relief.
3. The boundary between the Momchilgrad Depression and the surrounding morphoarches is marked in most cases by well manifested first-order morpholineaments.
4. Volcanic structures are usually well expressed in the modern relief as higher-order morphostructures. They are reflected on both the aerophototectonic and the morphostructural map. Two types of ring volcanic morphostructures are outlined:
   - ❖ Positive, relatively isometric morphostructures with centrifugal orientation of the river-gorge network, which inherit volcanic cones and extrusives. The larger volcanic cones are also well marked by the arcuate configuration of the river beds along their periphery.
   - ❖ Negative, relatively isometric morphostructures with centrifugal orientation of the river-gorge network, which mark caldera edifices.
5. The use of remote sensing methods and the potentialities of modern technologies provide for more detailed deciphering and more correct interpretation of the boundaries of the individual morphostructures and their spatial relationships.

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