Tertiary domes and depressions in the Rhodope massif

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Regional tectonic position

The Rhodope massif is a fragment of the Morava-Rhodope zone. This zone extends along the southern margin of the European continental plate, NE and N of the Vardar and Intrapontide sutures — traces of Late Cretaceous subduction zones of Tethyan oceanic crust beneath the European continent. The Morava-Rhodope zone is interpreted as a frontal arc in the subduction-related volcanic island-arc system (Dabovski et al., 2002). Towards the end of the Late Cretaceous, collision between fragments of the African and Eurasian plates lead to intense compression, regional metamorphism in eclogite and amphibolite facies and development of large-scale south-verging synmetamorphic thrusts (Ivanov, 2000).

The collision-related thrusts caused considerable thickening of the crust in the confines of the Rhodopes. This led to thermal relaxation and development of a two-layered system — a upper brittle and a lower ductile crust. As a result a series of metamorphic core complexes (domes) formed (Ivanov, 2000). The internal parts of these domes (lower ductile crust) comprise high-grade (migmatized) metamorphic rocks whereas their peripheral parts (upper brittle crust) are composed of diverse gneisses, amphibolites and marbles, accompanied by serpentinized ultrabasic rocks.

The late stage of extension is indicated by exhumation of metamorphic core complexes and development of a system of shallow-dipping detachments and related synthetic and antithetic faults (Ivanov, 2000). Exhumation in the Central Rhodope dome is dated at 37-34,5 Ma (Ovcharova et al., 2003). The time of exhumation of Byala Reka and Kessebir core complexes is 47 and 34 Ma, respectively (Ovcharova et al., 2003).

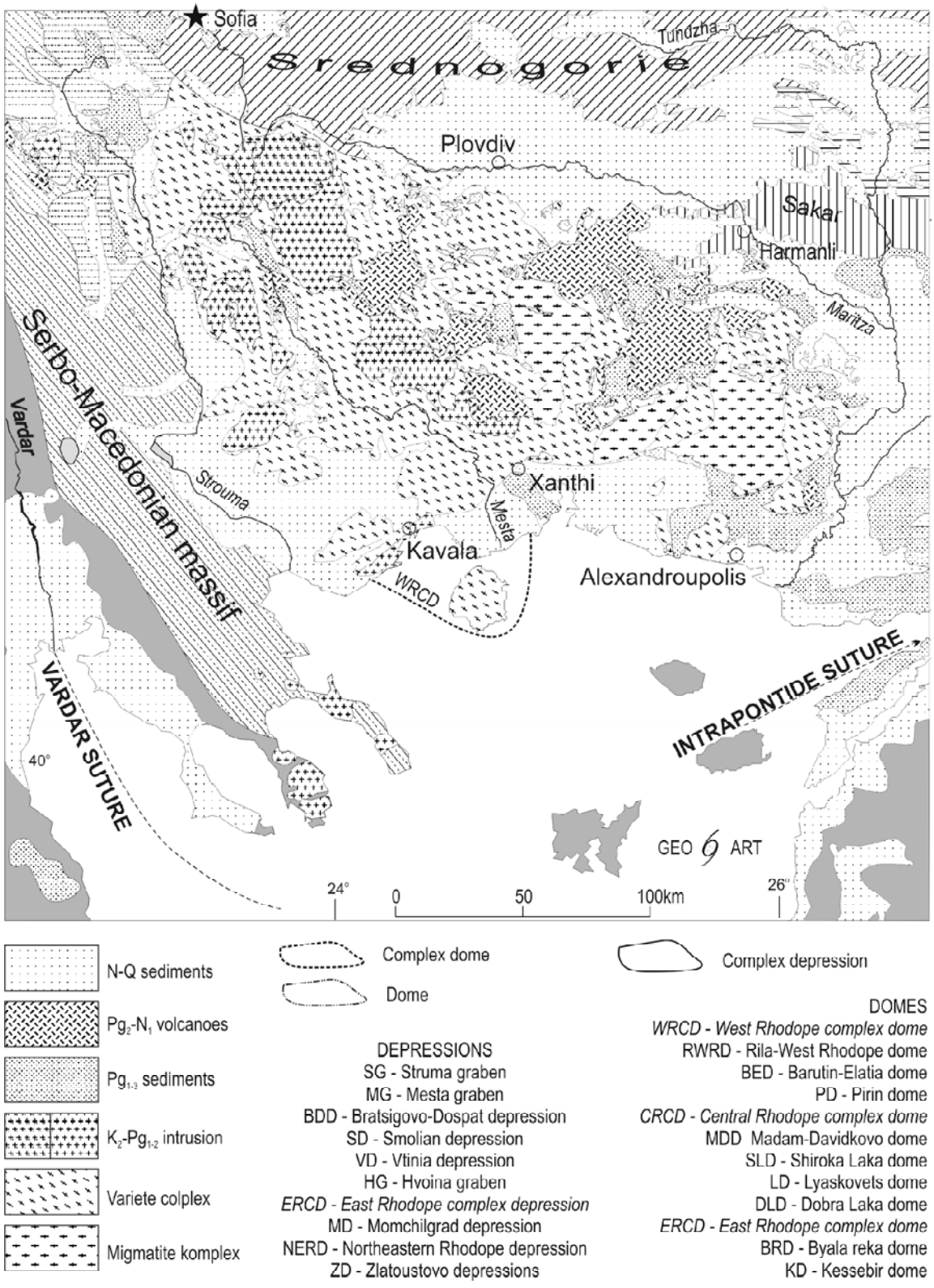
Between the growing domes of metamorphic core complexes, superimposed graben-like depressions developed (Georgiev, 2005). Their initiation began in Paleocene times, before the final exhumation of the core complexes. The depressions were realms of continental to shallow-marine sedimentation (Paleocene-Oligocene) and intense acidic and intermediate volcanic activity (Eocene-Miocene?).

Two types of extension-related magmatism are distinguished (Georgiev, 2005a). The initial stage of post-collisional extension is marked by intrusion of a series of syntectonic and post-tectonic granitoids in the upper brittle crust (Ivanov, 2000). They are most abundant in regions with thick crust (39-52 km) — Rila-West Rhodope and Pirin domes. Some plutons are composed of several intrusive phases. This stage covers the interval Late Cretaceous-Eocene (86-36 Ma, most commonly 54-42 Ma).

The granitoid plutons are two types (Peytcheva et al., 1998; Georgiev, 2005b). The Pirin type is characterized by high $(^{87}Sr/^{86}Sr)_0$ values (0,709-0,715) and is probably a product of mobilization of continental crust in the lower ductile layer (S-type). The Rila-Rhodope type has considerably lower $(^{87}Sr/^{86}Sr)_0$ values (0,705-0,709) and is probably related to mobilization within the lower ductile layer but with considerable influence of fragments from older oceanic crust (I-type).

The magmatic activity during the second stage (Eocene-Oligocene, 40-27 Ma) is dominantly in volcanic facies. Volcanic structures, composed of intermediate to acidic rocks, developed only within the superimposed depressions. In the core complexes outside the depressions, the magmatic rocks of this stage are scarce and form only subvolcanic or intrusive bodies.

The initial strontium ratios $(^{87}Sr/^{86}Sr)I$ in these magmatic rocks vary in a relatively wide range — from 0,700 to 0,708. Remarkable are considerably lower $(^{87}Sr/^{86}Sr)I$ values as compared to granitoids from the early extensional stage. This difference is even larger for acidic phases. These data suggest that the magmatism of the second stage has a dominantly mantle origin. In the process of exhumation of core complexes, the lower ductile layer and the crust as a whole thinned between the individual domes and along the periphery of the Rhodope



Фиг. 1. Тектонска схема на Родопския масив (по непубликувана карта на Хр. Дабовски, с изменения)
Fig. 1. Tectonic sketch of Rhodope massif (after unpublished map by Ch. Dabovski with changes)

massif. These areas were penetrated by upraising mantle material enriched to a deferent extent with crustal components.

Tertiary domes and depressions

Three domes, nominated West, Central and East Rhodope complex domes, can be recognized in the Rhodope massif east of Struma fault (fig. 1). They are defined as complex domes since they comprise second-order domes and synforms (superimposed depressions).

West Rhodope complex dome (including Rila and Pirin Mts.). The western boundary and internal structure of this dome are not very clear for several reasons. Exposures of the lower migmatite complex are lacking and consequently the core of the dome cannot be traced. Furthermore, the central parts of the dome are intruded by abundant granitoids of the early extensional stage that make the interpretation of the core complex even more difficult. The western periphery of the dome is deformed by the younger (Neogene) Struma graben.

The internal structure of the West Rhodope complex dome is complicated by the "crestal" ("apical" after R. Ivanov) Mesta graben. It is filled with Eocene and Oligocene sediments associated with dominantly acidic volcanics. Three domes are located to NE, SE and SW of Mesta graben — Rila-West Rhodope, Barutin-Elatia and Pirin domes, respectively.

Central Rhodope complex dome. The main structure is Madan-Davidkovo dome. It has a core of migmatized gneisses (lower ductile crust) enveloped in the variegated metamorphic complex, (upper brittle crust after Ivanov, 2000). The periphery of the complex dome is deformed by several second-order domes — Shiroka Laka, Lyaskovets and Dobra Laka (in the northern part).

Several depressions formed between these second-order domes. Hvoina graben is situated between Shiroka Laka, Lyaskovets and Dobra Laka domes. It is filled with Oligocene sediments and mainly acidic volcanic rocks.

Bratsigovo-Dospat, Smolian and Vtinia depressions. They separate the West Rhodope from the Central Rhodope complex domes. They are filled with Eocene and Oligocene sediments, rhyolite ignimbrites and in subordinate amount andesites and latites.

East Rhodope complex dome. Its main structure is Byala reka dome. Kessebir dome as a higher-ranking structure is situated further west. The two domes are separated by and embayment of Momchilgrad depression (Ludetina graben).

Momchilgrad depression. It trends NE and separates the Central Rhodope from the East Rhodope complex domes. The basin fill includes Paleocene-Oligocene sediments and Eocene-Oligocene intermediate to acidic volcanic rocks.

Northeastern Rhodope depression. It is situated between the Rhodope massif (located to W and S), Srednogorie zone (to N) and Sakar block (to E). The eastern margin of the depression wedges in between Dobra Laka dome and the northern periphery of Madan-Davidkovo dome. It is filled with Paleocene and Eocene sediments at the base and Eocene-Oligocene intermediate volcanic rocks on top. Borovitsa caldera (Ivanov, 1972) filled with Oligocene acidic volcanics is superimposed upon its western parts.

Zlatoustovo depression. It is located between Byala reka dome and Harmanly block (a fragment of Sakar block). The basin fill comprises Paleocene-Eocene sediments and Eocene-Oligocene intermediate and acidic volcanic rocks.

The Momchilgrad, Northeastern Rhodope and Zlatoustovo depressions merge in Kardzhali region and together form the *East Rhodope complex depression* (East Rhodope Paleogene depression, after Ivanov, 1960).

General trends

The West Rhodope complex dome has the thickest crust (39-52 km, Boykova, 1998). The Central Rhodope complex dome is characterized by less thick (35-40 km) and the East Rhodope complex dome — by the thinnest crust (32-36 km). The thickness of the crust in these structures correlates well with the present-day relief. The area of the West Rhodope complex dome has the highest relief (1500-3000 m). The area of the Central Rhodope complex dome has and intermediate relief (1000-2000 m). The East Rhodope complex dome is characterized by the lowest relief (400-1200 m). The domes are surface expression of lenses which "swim" in the astenosphere (the mantle). Only 5% of their volume is above sea level, resembling to the top of icebergs.

The West Rhodope complex dome (with the thickest crust) is intruded by abundant Late Cretaceous-Eocene granitoids from the early stage of extension, which are considered to be products of mobilization of the lower ductile crust. The East Rhodope Paleogene depression has the thinnest crust. There magmatic rocks of intermediate and acidic composition from the late extensional stage are most abundant. Mantle origin is supposed for them. The other regions of more abundant magmatic activity from the late extensional stage are Bratsigovo-Dospat, Smolian and Vitinia depressions, which separate the West Rhodope from the Central Rhodope complex domes. This magmatism is exclusively acidic.

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Терциерните сводове и депресии в Родопския масив

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Резюме. В резултат на екстензия в Родопския масив възникват поредица от метаморфни ядрени комплекси (куполи). Началният етап на екстензия се бележи от внедряване на гранитоиди в горната крехка кора (K_2—Pg_2). Между отделните куполи и по периферията им се формират депресии. Те са изпълнени с теригенни седименти, рифови варовици (Pg_{1-3}) и вулканити (Pg_2—N_1).

В Родопския масив се отделят Западнородопски (ЗРКК), Централнородопски (ЦРКК) и Източнородопски (ИРКК) комплексни куполи, усложнени от второстепенни куполи и депресии. Вътрешният строеж на ЗРКК (вкл. пл. Рила и Пирин) е усложнен от „билния“ Местенски грабен. На ССИ от Местенския грабен се разполага Рило-Западнородопският купол, на ЮИ — Барутин-Елатийският купол, а на ЮЗ — Пиринският купол. Основна структура в ЦРКК е Маданско-Давидковският купол. Периферията му е деформирана от Широколъшки, Лясковецки и Добралъшки куполи от по-висок ред. Между тях се разполага Хвойненският грабен. Брацигово-Доспатската, Смолянската и Витинската депресии разделят ЗРКК и ЦРКК. Основни структури в ИРКК са Белоречкият и Кесибирският куполи. Момчилградската депресия разделя ЦРКК и ИРКК. Североизточнородопската депресия се разполага между ЦРКК и Сакарския блок. Златоустовската депресия се разполага между ИРКК и Сакарския блок. Тези три депресии заедно образуват Източнородопската комплексна депресия.

В Западнородопския комплексен купол (с най-дебела земна кора) е най-обилно насищането с гранитоиди, които се считат формирани в резултат на мобилизация в долната пластична кора. Източнородопското палеогенско понижение се характеризира с най-тънка земна кора. Тук магматизмът от късния екстензионен етап е най-обилно представен и е със среднокисел и кисел състав. За него се предполага мантиен произход. Други райони с по-значителна изява на магматизма от късния екстензионен етап са Брацигово-Доспатската, Смолянската и Витинската депресии. Тук магматизмът е изключително с кисел състав.

Куполите са повърхностна изява на лещи, които плуват върху астеносферата. От тях над морското ниво се разкриват само около 5%, подобно на връх на айсберг.