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STRUCTURAL CRITERIA FOR METALLOGENIC ZONATIONNORTH OF MARITSA FAULT

Atanas Vulchanov

Sofia, Mladost 1, Block 97

ABSTRACT
The established allochthonous position of the Paleozoic formations in Central Stara Planina turned out to be of essential importance. Central and East Stara Planina are excluded from the proposed metallogenic zonation as far they lack any magmatic and metallogenic occurrences. The trend of the Cambrian volcano-sedimentary arc turns to SE toward Strandzha. Tthree pulses of linear magmatism – diabase, granitoid and quartz porphyries, mark the Balkan-Strandzha deep fault that controlled the magmatic and metallogenic activity from the Cambrian to the Tertiary. This fault separates the Moesian from the Thracian microplate. During the Late Carboniferous, the Turonian and the Lutetian, the Rhodope allochthounous plate, composed of high grade metamorphics and Paleozoic granites, was thrusted over the Thracian plate. During the Late Cretaceous, upon a basement of diverse structure and stratigraphy, powerful magmatic and metallogenic processes developed and modeled the Srednogorie metallogenic zone. In contrast to the Balkan polygenic and polychronous macmatic activity, the Srednogorie metallogenic zone evolved within a relatively narrow time interval – during the Late Cretaceous. The final stages of thrusting, magmatic and metallogenic activity toward the end of the Lutetian shaped the present structural and metallogenic zones which did not changed until now.;

A new insight into any metallogenic zonation requires re-evaluation of some basic structural elements and concepts. The concept of Vulchanov (1971) for the allochthonous position of the Paleozoic formations in Central Stara Planina shed new light on the problem. The main issues are as follows:

- There are no traces of magmatic and metallogenic activity in Central Stara Planina, East Stara Planina and the Fore-Balkan. For this reason they are excluded from the proposed metallogenic zonation.
- The trend of the West Balkan zone and its back-bone – the diabase-phyllitoid complex (DPC) is re-directed not along Central Stara Planina but deviates toward Sveti Ilya Heights and Strandzha.
- The three pulses of linear magmatism along the zone of DPC – the diabase magmatism during the Cambrian, the Stara Planina granitoids and the Permian extrusives evidently trace a deep fault – the Balkan-Strandzha fault (BSF) – Fig. 1. This fault is marked by a first order gravity gradient that intersects the crust and dies out into the upper mantle.
- The allochthonous position of Karandila (K), Tvarditsa (T) and Shipka (SH) tectonic units is not related to gravity phenomena. These units form structural sandwiches in the area of Sliven and Tvarditsa Stara Planina where they mark the stages of thrusting events (Fig. 3).
- The high-grade metamorphic complex and associated Paleozoic granites are not a median massif. They form an allochthonous plate (RAP) – Fig. 4 that, while moving to the north, detached the K, T and SH units from their root zones and thrusted them over Stara Planina (Fig. 5).

According to morphological features, RAP can be divided into several units: Central Srednogorie (CS), Ihtiman (IH), Sakar (SK), Strandzha (ST) and Rhodope (RD) – Fig. 5. During the thrusting events, RAP behaved as a monolithic body. Neither of its units moved independently – they were transported en block.

Valuable information on the deep structure of the crust, where magmatic and metallogenic process are generated, is provided by the geotraverses along the lines Petrich-Kalenik-Dolni Dabnik and Sliven-Galatz as well as by other geophysical methods.

There is no doubt that the consolidated crust on the territory of Bulgaria is of continental type. Fig. 1 shows that the ratio between the “granitic” layer and the heavier “basaltic” layer in the Moesian platform is 1:3-4. To the south, the granitic layer increases in thickness and in the area of Petrich this ratio is 1:1. The larger thickness of the granitic layer may be explained by cascade piling of thrust sheets as a result of compressional stresses. RAP may have been transported to the north along one of the thrust surfaces. Probably for this reason, the crust there is not so dense as compared to the Srednogorie.

Towards the end of the Riphean, during the Cambrian, the territory of Bulgaria began to break-up along the lines of BSF and the Kraishte fault – possible continental rift zones converging into the Carpathian arc. They divided the territory of Bulgaria into three microplates: Moesian, Thracian and Serbo-Macedonian (Fig. 1). Huge amounts of volcanic products were ejected (DPC) along the fault zones.

The DPC is the oldest structural unit and shows a very complex internal structure. It is widely exposed in the West Balkan tectonic zone, from Serbia to Botev Peak. The present shape of the zone is preserved due to the Stara Planina granitoids intruded along the axis of BSF (Figs. 2, 4). The Kazan, Vezhen, Botevgrad and Petrokhan intrusions form a huge “dike”, about 180 km long and 5 to 10 km wide that is locally covered by younger sediments or is not exposed at the present erosional level. The Kazan intrusion may extend to the southeast under RAP, similarly to Tvarditsa pluton, the roots of which are concealed beneath this plate. Between Botev Peak and Stara Zagora, DPC is covered by RAP. Near Stara Zagora and in Sveti Ylya Heights, small outcrops of DPC are exposed

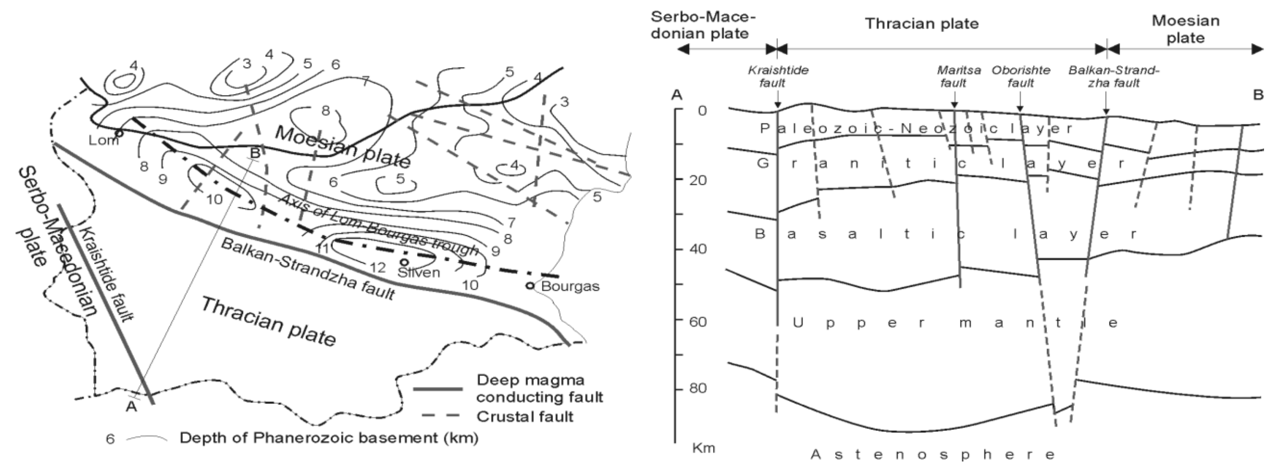

Figure 1. Morphostructural zones in Bulgaria (after Dachev, 1986, midified)

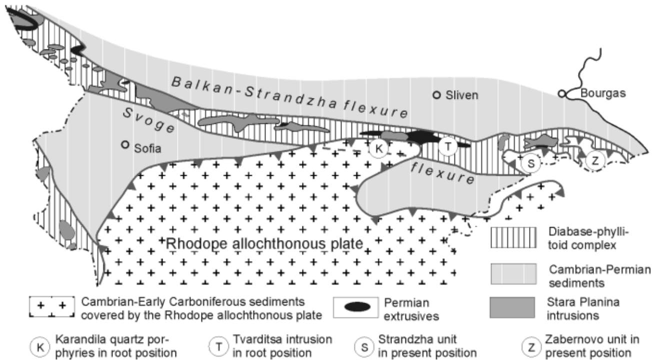

Figure 2. Paleotectonic reconstruction of Bulgaria toward the end of the Permian

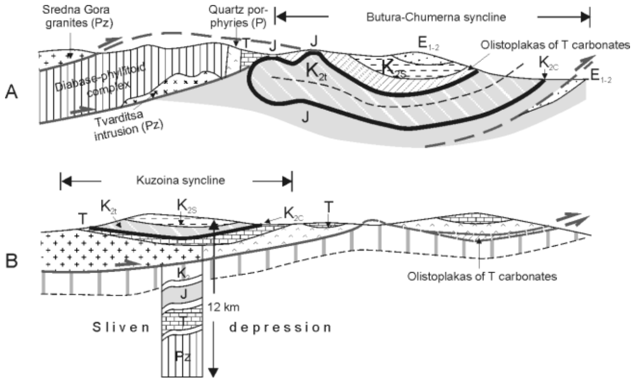

Figure 3. Geological sections across Tvarditsa (A) and Sliven (B) Stara Planina

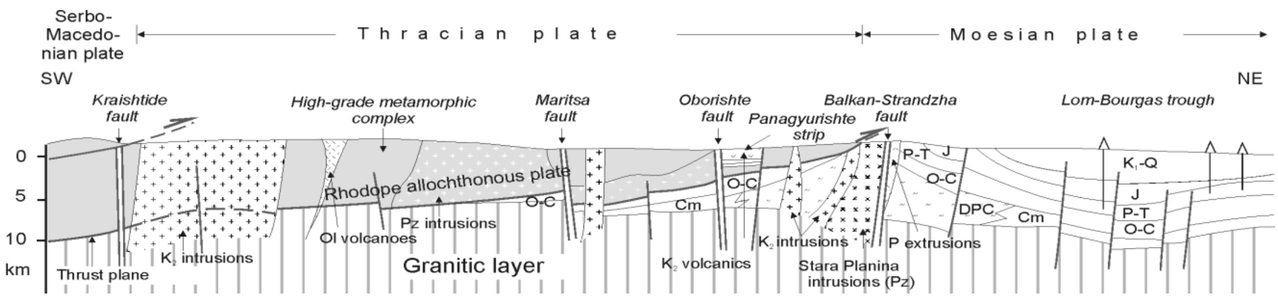

Figure 4. Deep section Petrich-Kalenik-Dolni Dabnik

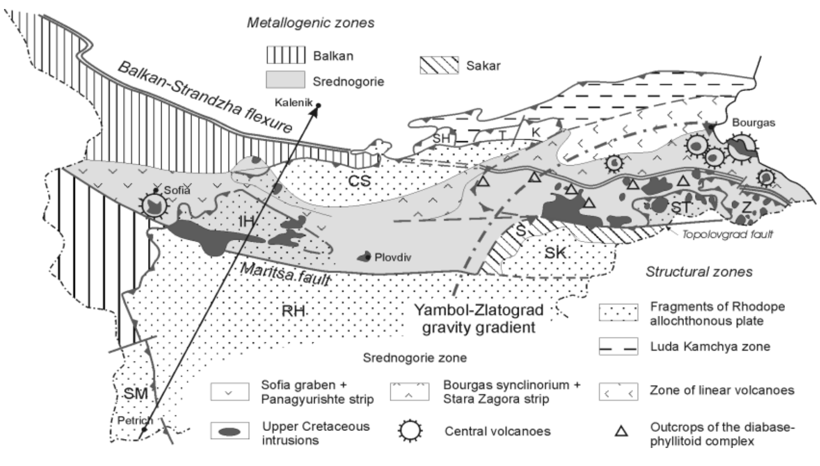

Figure 5. Structural and metallogenic zones north of Maritsa fault

while in Strandzha a minor intrusion of Stara Planina type (Punchevo pluton) is in contact with undivided Paleozoic rocks. So far these small outcrops have not been interpreted as indicating the general trend of a Cambrian volcano-sedimentary arc. This underestimation is related to the incorrect assumption that the West Balkan tectonic zone continues along the ridge of Central Stara Planina forming the autochthonous cores of Alpine anticlines. Those who seek the explanation of Karandila nappe need to know some facts. In the area of Sliven and Sliven Mineral Baths, two 1200 m wells were drilled that terminated in Upper Cretaceous rocks without indications of coastal deposits. It is well known that the area of Sliven is the deepest, about 12 km (Figs. 1, 3) depression on the territory of Bulgaria. There, autochthonous Upper Cretaceous overlies Jurassic and Triassic rocks, the Permian probably buried at a depth of 3 km. Most probably, the roots of Karandila nappe are located about 40 km to the south, in the area of Sveti Ilya Heights and within the zone of BSF.

The Thracian plate – the deformed margin of the Eurasian continent, is bordered by the Balkan-Strandzha and Kraishtide deep faults (Fig. 1). To the southeast it is buried beneath the Aegean Sea and the Sea of Marmora. During the Cambrian-Early Carboniferous the plate developed as a typical platform like the Moesian platform. The northern slope of the Cambrian volcano-sedimentary arc (DPC) was the terrigenous source of the Moesian platform. The lack of clastic components from the high-grade metamorphic complex and related granites in the Cambrian-Lower Carboniferous formations suggests that these complexes were located to the south of the present territory of Bulgaria. There are also no granite intrusions and contact aureoles in these formations. The high-grade metamorphic complex and the Paleozoic granites evidently form an allochthonous unit that was thrusted during the Late Carboniferous – RAP. As a result the realm of the Thracian plate was restructured into three zones: RAP, West Balkan zone and Strandzha zone.

The zone of RAP. In the beginning of the Late Carboniferous, RAP was thrusted over the Cambrian-Lower Carboniferous sediments and possibly related ore mineralizations. RAP was practically sterile in metallogenic respect until the Late Cretaceous. It was the dominating feature in the ancient relief and played the role of a new source of clastic material. It is assumed that the frontal line of RAP was already well outlined during the end of the Permian for the following reasons. A structural assemblage of rocks from DPC, Tvarditsa granitoids and Permian quartz porphyries (K and T units in Fig. 2) is exposed along the northern boundary of RAP within the zone of BSF. This assemblage is transgressively overlain by thick Triassic sediments that mark the front of RAP – parallel to the present boundary of the plate. Uranium polymetallic deposits are related to the contact between the quartz porphyries and the Triassic. During the Cenomanian-Turonian the frontal parts of RAP and the strip from Slivnitsa, Kremikovtsi, Chelopech, Botev Peak and eastward along the northern boundary of Luda Kamcya zone were covered by the Late Cretaceous sea.

Toward the end of the Turonian, RAP experienced a new northward thrusting of about 30-35 km over the Upper Cretaceous sediments. The DPC, Stara Planina granitoids and Permian quartz porphyries were detached from their roots and thrusted over the Luda Kamcya zone – sterile in metallogenic respect. Thus, Karandila (K), Tvarditsa (T) and Shipka (SH) allochthonous units were formed as independent structures both in tectonic and metallogenic respect (Fig. 5).

During the Lutetian RAP was again thrusted to the north by about 5-6 km. The Tvarditsa unit was blocked by the coal-bearing, folded Cenomanian-Turonian sediments in front of the plate. This was the time when the Belene dislocation originated. This fault, interpreted as a deep oblique-slip fault, has been used to invent the so-called "Tvarditsa system". It is well known that there are no independent strike-slip faults in nature. They mark thrusting events. To the west of this fault, RAP was thrusted over the Tvarditsa unit and partially over deformed Cenomanian-Turonian sediments. East of the fault the thrust assemblage and the Kuzoina syncline on top of it were thrusted at a lower level. Practically, the Belene fault is a shear fault along the frontal line of the thrust association and can not be referred to the category of deep faults. Consequently, the "Tvarditsa system" does not exist.

The displacement of the thrust assemblage was accompanied by powerful shocks. Limestone blocks of different size broke off from the Triassic and were deposited into Turonian sediments. Larger plates (olisthoplakas) were also detached and covered a large part of the coal-bearing Cenomanian-Turonian sediments, preserving them from erosion. Olistoplakas were formed also in the area of Karandila and later overthrusted by the quartz porpyries (Fig. 3, sections A and B). This assemblage is preserved today in Sliven and Tvatditsa Stara planina in the form of structural sandwiches that mark the stages of thrusting. This was the time when erosion of RAP commenced and terrigenous material of gneisses and granites participated in the deposition of the "wild flysch". The klippen in Tvarditsa and Shipka Stara Planina and Botev Peak are remnants of the destruction of the frontal part of RAP. The Senonian transgression covered the olistoplakas.

The Sakar and Strandzha allochthonous units, along with the transgressively overlying metamorphosed Triassic rocks, were transported to the north synchronously with RAP (Fig. 2, index S). The Strandzha unit is confined between the Balkan-Strandzha flexure and the Topolovgrad fault – a probable continuation of Oborishte deep fault (Fig. 1).

E. Bonchev (1971) has described two large flexures. The first follows the northern slopes of Strandzha Mts. and Svety Ilya Heights. The second runs along the northern slopes of the West Balkan zone. The same author assumed that the flexure turns from Botev Peak to the east on the basis of the incorrect interpretation of the Paleozoic formations in Central Stara Planina as autochthonous units. In fact, this is a single Balkan-Strandzha flexture that, between Botev Peak and Stara Zagora, was overridden by RAP, the latter covering also the root zones of DPC and the Tvarditsa pluton (Fig. 5).

The Yambol-Zlatograd gravity step of Dachev (1988) is still not well explained (Fig. 5). It divides regions of different Triassic successions – a sedimentary succession to the west, overlying transgressively RAP and the allochthonous units K, T, SH, and a metamorphic Triassic to the east, covering unconformably the Sakar and Strandzha units of RAP (Fig. 5, index S).

Northwest of the Yambol-Zlatograd gravity gradient, the Balkan-Strandzha fault coincides with a 1st order gravity gradient. To the southeast this gradient is not so well expressed and the pre-Creaceous magmatic activity is not so intensive. The same concerns the Maritsa fault.

According to Dachev (1988) the Maritsa fault, as a well expressed deep structure, is buried 8-10 km below RAP. In RAP it is expressed as parallel joint systems forming a graben syncline. After the thrusting of RAP, this syncline was transported by about 35-40 km to the north. This is the present Panagyurishte strip. The real Maritsa fault, covered by RAP, was again ruptured by sub-parallel fractures – the secondary faults on the surface.

Towards the end of the Late Cretaceous the seismic, magmatic and metallogenic processes intensified. Intrusive bodies from Plana to Plovdiv were emplaced along the revived fracture system in the zone of Maritsa fault. The magmatic and metallogenic processes were most intensive in Panagyurishte strip. A minor intrusion (Medet pluton and the associated deposit) perforated the thinned western flank of the Central Crednogorie unit of RAP. The deposits at Chelopech and Elatsite were formed within the zone of the Balkan-Strandzha fault. Most probably, these two deposits were covered by RAP but later erosion exposed them on the surface. The Strandzha unit of RAP was intruded by several minor intrusions. The Sakar unit of RAP has a more specific position. It is confined between Topolovgrad and Maritsa faults and is largely covered on the west by Neogene sediments. The metamorphosed Triassic was metallogenically mobilized and as a result the polymetallic deposit at Ustrem (dated 270-240 Ma, i. e Permian) originated. If these results are correct we have to assume that older Pb, from the period before the thrusting of Sakar unit, was re-mobilized. Re-deposition of Pb was probably related to metamorphic processes. The fact that a minor intrusion was emplaced in the western periphery of the Central Srednogorie unit of RAP is not a reason to include the whole unit in the Srednogorie metallogenic zone. The molybdenum and gold mineralizations localized in this unit are probably related to the Early Paleozoic magmatism. The Central Srednogorie unit may be defined as an independent metallogenic unit but within the confines of the Srednogorie metallogenic zone. The mineral associations, the paragenesis and the age of mineralizations both in Sakar and Central Srednogorie are alien to the Srednogorie metallogenic zone.

The West Balkan zone, prior to Late Cretaceous time, was bordered by the Balkan-Strandzha flexture, the Maritsa fault and the western margin of RAP. During the Late Cretaceous, a volcano-sedimentary association developed south of the line Slivnitsa, Kremikovtsi and Chelopech, covering the southern flank of the West Balkan zone and forming the western flank of the Srednogorie metallogenic zone. This was the time when the West Balkan metallogenic zone was finally shaped. There, directly on the surface, all stratigraphic units are exposed in complex structural position, high-style fold and thrust tectonics and polygenous and polychronous magmatic and metallogenic activity. East of Botev Peak, the zone is covered by RAP.

The Stranzha zone is confined between the Balkan-Strandzha flexure and Topolovgrad fault. This zone remains one of the key problems of Bulgarian geology. Different and controversial interpretations have been proposed – from an autochthonous anticlinorium to allochthonous unit that was detached from East Stara Planina. East of Elhovo Neogene basin, the Strandzha unit of RAP and Zabernovo allochthonous unit are thrusted over the Strandzha autochthon (Figs. 2, 5). Both units cover about 80% of the zone. The situation is similar in the western parts of the zone, buried beneath Zagora and Elhovo Neogene basins. The main question is to what extent the Balkan-Strandzha Cambrian volcanic arc (DPC) is preserved in the structure of the autochthon. Its trend is symbolically shown in Fig. 5. The question is: where are the autochthonous sections of the Ordovician to Upper Cretaceous successions if the oldest autochthonous formations are directly exposed on the surface at 250 m above sea level and the highest parts of the mountain (including the allochthonous units) do not exceed 500 m. Entire stratigraphic units are missing while others are symbolically represented. Evidently, positive vertical displacements prevailed. Destructive processes dominated over accumulative ones. Due to the more erosion-resistant units, the region was not covered by Neogene deposits. If we assume that DPC is symbolically present in the structure of Strandzha zone, this means that the consolidated crust was uplifted close to the surface, which is an absurd. There is no doubt that the Cambrian volcano-sedimentary arc extends to the east of Stara Zagora and forms the autochthonous backbone of Strandzha.

During the Late Cretaceous, the territory between the Balkan-Strandzha and Topolovgrad (Oborishte) faults was a domain of intensive intrusive activity and associated ore deposition. The Zabernovo metasedimentary unit, like Sakar unit before the thrusting, was an area of metallogenic mobilization (Gramatikovo ore deposit). After the thrusting, Zabernovo unit was involved into the Late Cretaceous metallogenic and magmatic cycle and was incorporated into the Srednogorie metallogenic zone. Most probably, the Sakar and Zabernovo units are parts of one depositional, metamorphic and metallogenic cycle that is of wide occurrence beneath the Neogene deposits on the territory of Turkey.

The Moesian plate is surrounded in the form of a horseshoe by the Balkan-Stranzha and the Carparthian zone. From the Cambrian to present it developed as a typical platform of dominantly heavy (basalt-type) crust. This explains the dominating subsidence during the geological history of the platform. The contour lines (Dachev, 1988) trace an axis – Lom-Kalenik-Sliven-Burgas along which the Phanerozoic basement progressively deepens from northwest to southeast along a system of sub-parallel normal faults that roughly parallel BSF. This axis marks a continental rift zone with embryonic volcanism during the Triassic, formation of a flysch trough during the Jurassic and volcanogenic activation during the Late Cretaceous within the Burgas synclinorium (Figs. 1, 4). The depth of the trough axis is about 7 km in the northwest, about 10 km at Kalenik and 12 km in the area of Sliven – the deepest depression on the territory of Bulgaria. The through axis is an indication for lack of oil and gas resources.

In the confines of Burgas synclinorium, parallel and north of the Balkan-Strandzha flexture, central volcanoes formed as sources of metal deposits. North of the line Yambol-Burgas, the volcanoes are linear and sterile. The boundary between central and linear volcanoes is enigmatic. Such is the boundary of the Srednogorie metallogenic zone. The domain of linear volcanoes is excluded from the metallogenic zonation. The boundary between linear volcanoes and Luda Kamchya zone is also conventional since there is a mutual penetration and interfingering between the two facial varieties. Luda Kamchya zone is void of metallogenic indications and for this reason is likewise excluded from the metallogenic zonation. If there were any metallogenic indications in this zone, then it could be included into the Srednogorie metallogenic zone but not in the Balkan one.

In contrast to the polygenic and polychronous Balkan metallogenic zone, the Srednogorie metallogenic zone developed within a narrow time interval – the Late Cretaceous, and is confined to the domain of Late Cretaceous magmatism. The Srednogorie metallogenic zone is superimposed upon a basement of diverse structure and stratigraphy. After the end of the magmatic activity and the thrusting events, i. e. toward the end of the Late Cretaceous and during the Lutetian, the restructuring of the tectonic and metallogenic zones north of Maritsa fault came to an end and they did not change to present days (Fig. 5).

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