LATE ALPINE GEODYNAMICS AND METALLOGENY OF THE MORAVA-RHODOPE ZONE

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Introduction

The Morava-Rhodope zone is located on the southern margin of the European continental plate (Dabovski et al., 2000). On the SW and S it is bordered by the Rhodope and Izmir-Ankara zone and on NE – by the Srednogorie zone. The Morava-Rhodope zone is characterized by extensive outcrops of high-grade metamorphic rocks of controversial protolite age – Precambrian and/or Paleozoic.

During the Late Cretaceous, NE directed subduction of Tethyan oceanic crust along the Vardar and Izmir-Ankara zone generated the Srednogorie island-arc system. The Morava Rhodope zone is believed to be the frontal arc of this system (Dabovski et al., 2002). Toward the end of the Late Cretaceous, collision between the African and European plates resulted in numerous south-vergent thrust sheets and considerable thickening of the crust (Ivanov, 2000) – from 30-35 km in the peripheral parts to 50-52 km in the central parts of the zone (Boykova, 1999).

The considerable thickening of the crust lead to thermal relaxation and formation of a two-layer system – upper brittle and lower ductile crust. Isostatic deformation within the partially melted lower crust initiated extension and development of a series of metamorphic core complexes (domes) (Ivanov, 2000). These domes show similar structure and synchronous development. In the cores of the domes (lower ductile crust) crop out high-grade metamorphic rocks affected by intensive migmatization and anatexis (metagranites, migmatites, migmatitic gneisses, eclogites and eclogitic amphibolites). The periphery of the domes (upper brittle crust, “variegated complex”) is composed of diverse gneisses, amphibolites and marbles, as well as serpentinized ultrabasic rocks. Several large domes can be distinguished in the Rhodope massif (to the east of Strouma fault) – Rila-Rhodope, Pirin, Central Rhodope, Kessebir and Byala reka domes.

Early extensional stage

The initial stage of post-collisional extension is marked by the intrusion of a number of syntectonic and post-tectonic granitoids in the upper brittle crust (Ivanov, 2000). This stage covers the interval late Late Cretaceous – Eocene (86-36 Ma, Soldatos & Christofides 1986; Peytcheva et al., 1998; Kamenov et al. 1999) most commonly 52-42 Ma (Ovcharova et al., 2003).

Some plutons show polyphase character. For instance, three phases are distinguished in the Rila-West Rhodope batholith. The earliest phase (~80 Ma) is assumed to be synmetamorphic and with considerable involvement of mantle material (?). The last two phases (40-35 Ma) are believed to be post-metamorphic and with crustal genesis of the initial substratum (Peytcheva et al., 1998; Kamenov et al., 1999).

As a whole these granitoids show initial strontium ratios ($^{87}Sr/^{86}Sr$) within the interval 0,70727-0,71191, mainly around 0,71 (Zagorchev, Mourbath, 1989; Peytcheva et al., 1998). These data suggest crustal origin of the granite magmas. They resulted probably from melting in the lower ductile crust and subsequent intrusion in the upper brittle crust during the extensional process.

The products of this magmatism are mainly of hypabyssal facies and acid composition. They are located mainly in the internal parts of the core complexes (domes). Such granitoids are most abundant in regions with thickest crust (40-52 km) – the Rila-West Rhodope and Pirin domes where they form large batholiths.

The granitoids of the early extensional stage associate mainly with rare metal (Mo-W) hydrothermal and skarn deposits and occurrences. Two mineral types can be distinguished – quartz-molibdenite and quartz-sheelite. They are located within the granitoid intrusions or their immediate metamorphic framework. The Rila-West Rhodope and Pirin domes include the West Rhodope ore region (Maneva et al., 1994; Maneva, 2002) with Babyak (Mo), Musomishte (W) and Grantsharitsa (W) ore fields. The NW parts of the Central Rhodope dome host the Yugovo-Narechen ore region with Yugovo ore field (Mo). F, Pb-Zn, Ag-Ag, Fe, Cu and U deposits are of secondary importance for this metallogenic stage.

Late extensional stage

During this stage exhumation of migmatites in the core of the domes took place. In the Central Rhodope dome this event is dated at 37-34,5 Ma (Ovcharova et al., 2003). The time of unroofing of Byala reka and Kessebir core complexes is estimated to be 47-34 Ma (Peitcheva, 1997).

Between the domes of the core complexes and around their periphery, superimposed Paleogene depressions developed. Their formation began as early as during the Paleocene, before the final exhumation of the core complexes. The depressions are filled with continental fresh-water terrigenous and shale-terrigenous sediments (Paleocene-Eocene).

The magmatism during this stage (Eocene-Oligocene, 47?-28 Ma) is dominantly in volcanic facies. Volcanic edifices of intermediate and acid composition are localized only within the superimposed depressions. The largest intermediate volcanic edifices are commonly intruded by comagmatic monzonitoid intrusions. In the core complexes, beyond the confines of the depressions, the magmatism of this type is of subvolcanic or intrusive facies.

A longitudinal zoning has been recognized (Harkovska et al., 1989) in the distribution of the magmatic rocks of this stage. In areas with thickest crust (42-52 km), for instance the Rila-Rhodope and Pirin domes, products of this magmatism are practically lacking (Mesta graben is an exception). In WNW and ESE direction of this central region (Strouma and

Central Rhodope volcanic areas), where the thickness of the crust is 35-40 km, the magmatic products are dominantly of acid composition – dacites, rhyodacites and rhyolites to trachydacites, trachyrhyodacites and trachyrhyolites. Intermediate varieties (andesites and latites) are subordinate. In the East Rhodope volcanic area, where the crust is thinnest (30-35 km), the magmatism is bimodal. The intermediate (andesitic basalts, andesites, shoshonites and latites) and acid (dacites, rhyodacites, rhyolites to trachydacites, trachyrhyodacites and trachyrhyolites) are of approximately equal volumes. Though of subordinate importance, basic varieties (basalts and absarokites) may also occur.

In Strouma and Central Rhodope volcanic areas, the magmatic rocks are assigned mainly to the CA and HKCA series of Peccerillo & Taylor (Harkovska et al., 1989) whereas in the East Rhodope volcanic area they belong dominantly to the HKCA and SHO series.

The data on the origin of this magmatism are insufficient and controversial. The results about the type of tectonomagmatic environment are as well contradicting [Nb/Y, Rb/(Y+Nb) and Rb/SiO_2]. The rocks plot both in the fields of syncollisional granites and of volcanic arc and intraplate granites.

The initial Sr ratios ($^{87}Sr/^{86}Sr$) likewise vary in a relatively wide interval – 0,69534?-0,70869 (Marchev, Rogers, 1998; Marchev et al. 2002; Milovanov et al. 2003). Striking are the relatively lower values of the initial strontium ratio ($^{87}Sr/^{86}Sr$) as compared to the granitoids from the early extensional stage. This difference is larger for the acid phases. These data suggest that the magmatism of this period is dominantly of mantle origin and the primary magmas are to a different extent enriched with crustal substratum.

In the process of exhumation of the core complexes, the lower ductile layer and the crust as a whole thinned out between the individual domes and along the periphery of the Rhodope massif. Enriched with core components mantle material penetrated these areas and, as a result of magma differentiation during the ascent from the primary sources, transitional magma chambers both of intermediate and acid composition formed. The products of this magmatism, dominantly of volcanic facies, are localized mainly in the confines of the depressions between the core complexes. Individual monzonitoid intrusions, as well as rhyolite and basic dikes, intrude the neighboring domes (hypabyssal to subvolcanic facies).

A large variety of metallic (Pb-Zn±Au, Au, Sb, Mn) and non-metallic (fluorine, zeolites, bentonite, perlite, alunite, agate) deposits are related to the second extensional stage.

Polymetallic mineralizations are of dominant importance. Two mineral formations are distinguished: quartz-galena-sphalerite and quartz-gold-polymetallic (Dimitrov, 1988).

The quartz-galena-sphalerite mineral formation is related to areas of medium thick crust (35-40 km) where mainly acid magmatic products occur (Strouma and Central Rhodope magmatic areas, Harkovska et al., 1989). The ore mineralizations are localized only in the confines of the metamorphic core complexes. Such are the Osogovo-Blagodat ore region (with Ruen ore field) in the western part and the Central Rhodope ore region (with Madan, Davidkovo, Laki, Byal Izvor and Ardino ore fields -) in the Central Rhodope dome.

The quartz-gold-polymetallic mineral formation is typical of the East Rhodope ore region, which is characterized by thin crust (30-35 km) and bimodal (intermediate and acid) magmatism. In Spakhievo, Madzharovo and Zvezdel-Pcheloyad ore field, located in the confines of the East Rhodope depression, this formation associates spatially and genetically with the largest intermediate volcanoes in the respective depressions – Dragoinovo, Madzharovo and Zvezdel. Popsko and Chernichevo ore fields are located in the metamorphic framework of the East Rhodope depression, between Byala reka and Kessebir dome.

The polymetallic ore mineralizations associate with quartz-sheelite (Ruen ore field in Osogovo ore region) and quartz-molibdenite (Spakhievo and Madzharovo ore field in the East Rhodope ore region) mineralizations. In Chernichevo ore field (East Rhdodope ore region), Ruen ore field (Osogovo ore region) and Ribnovo deposit (Mesta graben area), non-commercial quartz-stibnite mineralizations occur.

The East Rhodope ore region is characterized as well by the quartz-gold-adularia mineral formation (Krumovgrad ore field). The ore mineralizations are localized in sediments, underlying the products of the volcanic activity, but are probably genetically related with it as initial products.

In areas of medium thick crust and dominantly acid magmatism, deposits of fluorine are localized – Mikhalkovo ore field in the Central Rhodope dome and Kozuh in Ograzhden block.

In the East Rhodopes the acid magmatism associates with deposits of zeolites and perlites whereas the intermediate one - with agates. Bentonite clays are also related to intermediate and acid tuffs.

Alunite deposits associate with secondary quartzites in the Eastern and Central Rhodopes.

Conclusion

The Late Alpine extension in the Morava-Rhodope zone generated diverse magmatic products with genetically related diverse mineral deposits. There is a longitudinal zoning both with respect to magmatism and the associated mineral deposits.

In the central part of the zone, where the crust is thickest (40-52 km), only acid intrusive magmatic products from the initial stage of extension are present. This magmatism is of crustal origin and is a result of mobilization of the lower ductile crust. Mainly W and Mo deposits associate with this magmatism.

On both sides of this central domain, magmatism of the late extensional stage dominates. It is of mantle origin but to a different extent enriched with crustal material.

In areas of medium thick crust (35-40 km), the magmatism is dominantly acid in composition. The related ore mineralizations are mainly Pb-Zn. These are the deposits in the Central Rhodope ore region (in the Central Rhodope dome) and the Osogovo ore region.

In the periphery of the East Rhodope region, where the crust is thinnest (30-35 km), the magmatism is bimodal – intermediate and acid. Au-Pb-Zn as well as independent Au deposits dominate. In the NW part of the Morava-Rhodope zone, the Lecen ore region (Macedonia) with characteristic Au-Pb-Zn mineralizations is probably an analogue of the East Rhodope ore region.

In the frontal part of the Morava-Rhodope zone, in the areas of thin crust, Cu-Mo±Au porphyry deposits are localized – Zletovo ore field in Macedonia and the deposits of Skuries and Maronia in Greece.

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