# Palaeogene igneous evolution of the Rhodopes

# Палеогенска магмена еволюция на Родопите

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The modern approach to the late Alpine igneous evolution of the Rhodopes region is related to the recognition and establishment with viable arguments of the presence of widespread intrusive activity throughout the Palaeogene Period together with the well-known Priabonian and Oligocene volcanism.

Several major problems are under discussion in the flow of abundant publications rich in new evidence. They are related to **(1)** exact timing of the igneous events; **(2)** petrological features and position of the Palaeogene igneous products: intrusive bodies and suites, lava centers and volcanic edifices and flows; **(3)** sources of the magmas that gave rise to the intrusive and volcanic products; **(4)** relations between the igneous activity and the metamorphic rocks and complexes; **(5)** mechanisms of formation of the magma foci, and of magma dynamics leading to movement to crustal chambers, and finally, to the Earth’s surface as lavas.

We have performed LA-ICP-MS U-Pb studies on zircons from several granitoid plutons, some of them already studied by other scientists. The results obtained are as follows:

**Spanchevo pluton** (Pirin-Pangaion unit; host rocks from Bogutevo Formation): coarse-grained or porphyric granite to granodiorite, with numerous sill-like apophyses and pegmatite and aplite dykes, numerous granitised xenoliths from the host gneisses; metaluminous to peraluminous; ages of 55.05 ± 0.59 and 57.23 ± 0.58 Ma have been determined on two samples, and they correspond with the 56.0 ± 0.5 Ma age reported by Jahn-Awe et al. (2010).

**Kalin pluton** (West Rila unit, at the boundary between Bogutevo Formation or the Ograzhdenian complex, with the Chepelare Formation): lens-like body built up of coarse-grained biotite granite, locally with plagioclase or microcline endoblasts, locally leucogranite; peraluminous granites; very low K content in comparison with the other Palaeocene–Ypressian granites; age determined 57.90 ± 0.76 Ma.

**Dolno Dryanovo pluton** (West Rhodopes unit; host rocks from the Bachkovo-Boykovo complex): coarse-grained to porphyric granites, and leucogranites, with numerous sill-like apophyses and pegmatite dykes, numerous granitised xenoliths; peraluminous; age obtained 55.27 ± 0.52 Ma similar to 55.0 ± 0.4 Ma reported by Jahn-Awe et al. (2010).

The chemical analyses of granites from the three plutons show considerable differences in the contents of K, Mg and Fe as well as of the MALI (Modified Alkali-Lime Index) index. The figurative points of each of the 3 plutons occupy a distinctive field on the corresponding diagrams.

We have analysed also samples from migmatites of the Bogutevo Fm and a cross-cutting granite dyke, from the Vacha valley in the Central Rhodopes unit. The ages obtained are as follow: 61.03 ± 0.92 Ma (**granite dyke**) and 55.0 ± 1.6 Ma (**leucosome in migmatite**).

**Yugovo granites** (Central Rhodopes unit): small bodies within the Lukovitsa and Dobrostan Formation; biotite granite to leucomonzonite, metaluminous to (rarely) peraluminous; age 44.70 ± 0.86 Ma similar to the 42.29 ± 0.87 Ma reported by Ovtcharova et al. (2003) and Kaiser-Rohmeier et al. (2013) both for the Yugovo and Smilyan granites.

Compared also with previous numerous results obtained on young granites from the Bulgarian and Greek Rhodopes (see Marchev et al., 2013; Perugini et al., 2004), three distinct age groups of Palaeogene granites may be distinguished: **Palaeocene to Early Ypressian** (Spanchevo, Kalin and Dolno Dryanovo granites; numerous small bodies and dykes in the Bogutevo Fm and the Prerhodopian complex in the

Central Rhodopes; ca. 61 to 52 Ma); **Late Ypressian to Lutetian** (Yugovo and Smilyan granites; 45 to 42 Ma); **Priabonian to Rupelian** (main volcano-plutonic association in the Rhodopes, with typical crustal magmas in the thickest crust parts of the Pirin-Pangaion unit and the Rhodopes s.s., and mixing of magmas of two different sources, crustal and mantle, near and along the southern edge in Greece – Vrondou, Xanthi and Maronia; see Perugini et al., 2004). Symptomatically, no volcanic manifestations are known within the first two age groups (the Lutetian Kraishte and Visoka Elha volcanics pointed at by Marchev et al., 2013 belong to entirely different tectonic and geodynamic settings).

Each of the three age groups possesses distinctive petrochemical features displayed on petrochemical diagrammes. The diagrammes $K_2O$ vs. $SiO_2$, MgO vs. $SiO_2$, MgO vs. $FeO_{tot}$ and alk vs. $SiO_2$ are particularly demonstrative. Alkalis show a higher level of the Palaeocene–Ypressian, and a lower level, of the Lutetian granitoids in respect to the Priabonian–Oligocene ones, whereas the latter have higher potassium levels. MgO has a pronounced higher level at the Priabonian–Oligocene intrusive bodies, and they are distinctive also by the split in all diagrammes for values of $SiO_2$ between 62 and 65%, with a clear change in the general trends for the basic (gabbro to monzonite) and acid rocks; that is symptomatic for the suggested (see Perugini et al., 2004) mixig of mantle-derived and crustal anatectic magmas in this age group.

## Conclusions

The Palaeocene–Early Ypressian granitoids formed within the areas with the thickest continental crust of the Rhodopes region, in close relations to granitisation and migmatization processes due to beginning extension, uplift and decompression. A second igneous (intrusive) Lutetian phase possibly involved also deeper levels with mantle(?) or lower crust input. The most intensive third Palaeogene phase of Priabonian–Oligocene magmatism (Macedonian-Rhodopes volcano-plutonic belt, association or province; see Harkovska et al., 1989) was bimodal, and most probably due to involvement of deep asthenospheric sources during subduction slab break and intense geothermal, magmatic and fluid upflow. Several foci have been formed in the mantle and the crust, and magma mixing, hybridization and contamination occurred in magma chambers at different crustal levels. The granitoids of this phase are restricted to deeper levels (Pirin-Pangaion unit) of the Rhodopes edifice while the volcanic products crop at shallower levels or at the surface, as vast lava sheets of Mesta, Bratsigovo-Dospat and the East Rhodopes lava fields.

The partitioning of the three generations gives indirect indications for the thrusting events and a related intermediate mid-Eocene crustal thickening in the Rhodopes s.l. The thickening corresponded to the thrusting over the Pirin-Pangaion unit by Rhodopes (SW-ward along the Nestos shear zone), and by the Serbo-Macedonian Massif (NE-ward along the Strymon Thrust), and moved Pirin-Pangaion to a deeper position in the crust. The unroofing of the Pirin plutons occurred (Zagorčev, 1992) as late as in (Late) Pontian times.

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