Late Cretaceous subduction and magmatism in the Rhodopes: geochronological and isotope-geochemical evidence

Къснокредна субдукция и магматизъм в Родопите: геохроноложки и изотопно-геохимични доказателства

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Introduction

The Rhodopes are a robust area where almost contemporary Jurassic and Late Alpine compressional (HP and UHP) metamorphics and extension-related magmatic or orthometamorphic rocks are outcropped. The extensive geochronological and geochemical study of the magmatic rocks in the adjacent Srednogorie zone revealed subduction-related features and youngling from north to south in the time 92–78 Ma that are explained by oblique northward subduction and slab retreat. It is likely that remnants of the Cretaceous subduction – either as magmatic rocks or as HP metaophiolitic fragments might be exposed further south of the Srednogorie zone – in the Rhodopes. Here we present new data about the occurrences of Late Cretaceous magmatism in the western and eastern Rhodopes. We combine them with evidences for eclogite metamorphism at the end of the Cretaceous in an attempt to better constrain the tectonic evolution of the region.

Late Cretaceous magmatism in the Rhodopes – the status quo

Late Cretaceous granitoids are outcropped in the Western Rhodopes building up the earliest unit of the Rila–West Rhodopes batholith (Kamenov et al., 1999) and intrude the metamorphics E of the batholith (Permian–Triassic and Jurassic metagabbros and granitoids). They are dated in the range 69–72 Ma by U-Pb zircon method (e.g. Peytcheva et al., 2007). We sampled weakly to strongly deformed granitoids NW and SE of the batholith – the Beli Iskur granite (AvQ318) and the granitoids close to Surnitsa village (AvQ277), respectively. “In situ” LA-ICP-MS U-Pb age dating of zircons from Beli Iskar granite gave an age of 72.47 ± 0.62 Ma. The zircons revealed rarely inherited cores, which correspond to the protolithic ages of the surrounding metamorphic rocks (~ 460 Ma, ~ 150 and ~ 250 Ma). Chemically abraded zircons of Surnitsa metagranodiorite yield a concordia ID-TIMS age of 71.71 ± 0.24 Ma. Some grains showed negligible inheritance and define a discordia with Variscan upper intercept age 318 ± 11 Ma. In the Eastern Rhodopes Chuchuliga and Rosino granites are dated at 69–70 Ma (Marchev et al., 2006).

All studied Late Cretaceous granitoids in the Rhodopes are calc-alkaline to HKCA. Trace element spidergrams show typical characteristics of subduction-related magmatic rocks: enrichment in LILE and flat or slightly depleted HFSE; Ta-Nb negative anomaly. These data are in agreement with Hf-zircon and Sr-WR data: age corrected ε-Hf zircon values are in the range +0.8 to +5 and WR initial strontium ratios vary between 0.705–0.707. Compared with the isotope-geochemical characteristics of gabbros and granites of the Srednogorie zone they are more crustal influenced, but still with mantle-dominated magma origin, although basic rock varieties are not established in the Rhodopes.

Late Cretaceous subduction

Numerous ophiolitic slivers and boudins are observed in the metamorphic units of the Rhodopes. In some places they include metamorphosed peridotites, ultramafic cumulates and amphibolitized eclogites. Although these metabasic rocks are usually described as marking the base of the distinguished lithotectonic units/terranes, metaophiolitic slivers are also observed as lenses imbedded in the ortho- and para-gneissic complexes (e.g. the garnet amphibolites of the Chepelare mélange). Protoliths of the HP/UHP overprinted ophiolites differ in their origin (MORB vs. boninite type, e.g. (e.g. Mposkos et al., 1988; Haydoutov et al.,

2004) and in age (Neoproterozoic ~570 Ma to Lower Cretaceous ~ 117 Ma). A wide range is obtained for the time of subduction/burial as HP/UHP metamorphism is dated by zircons at around 300–350, 150, 70, 50 and 42 Ma (e.g. Carrigan et al., 2003; Liati, 2005).

Evidence of Late Cretaceous subduction is reported by Liati et al. (2002) for UHP garnet-rich mafic rocks from the Kimi area, Eastern Rhodopes. There, early Cretaceous magmatic zircons (117.4 ± 1.9 Ma) revealed metamorphic (eclogite facies) rims with an age of 73.5 ± 3.4 Ma. In the Bulgarian part of the Eastern Rhodopes we sampled the metaophiolites of the Bjala Reka mélange. The dated sample (SS10) is previously defined as ophiolitic gabbro that was subjected to HP-L(M)T eclogitic metamorphism (preserved glaucophane in garnet; Kolcheva, Tsoncheva, 1993), overprinted by amphibolite-facies metamorphism. SHRIMP dating of the magmatic zircon cores yield a protolithic age of 566.4 ± 6.3 Ma. Metamorphic rims determine the age of the HP metamorphism at 72.7 ± 3.6 Ma. Isotope Nd characteristics support N-MORB mantle source with εNd values of +6.5 to +8.1.

Discussion and conclusions

The Late Cretaceous magmatism in the Rhodopes infers a continuation of the subduction-related calc-alkaline magmatism to the south of the Srednogorie zone. Comparison of the ages shows a further youngling – from 92 to 78 Ma in the Srednogorie and then to 72–69 Ma in the Rhodopes. The geochemical characteristics of the Late Cretaceous granitoids in the Rhodopes suggest mantle dominated but crustal contaminated origin. The crustal input is particularly visible compared with the latest magma of the Srednogorie. The latter is marked by the most mantle-dominated characteristics in the gabbros of Velichkovo–Boshulya and Capitan Dimitrievo plutons, which are explained with asthenospheric upwelling in the extensional subduction rollback environment. This stage was obviously followed by the (final) accretion of the Rhodope terrane from the south, which modified significantly the geochemical characteristics of the produced magma. After about 69–70 Ma the magmatism ceased and the subduction front moved further to south. It must be mentioned that same time and geochemical constraints are observed in the Timok and Ridanij–Krepolin zones in Serbia but there the Late Alpine tectonics followed other scenario leading to the tectonic erosion of subvolcanic dacites instead of deformed granitoids.

The findings of Upper Cretaceous subduction relicts in the Eastern Rhodopes emphasize the unique evolution of the Rhodope area. Similar to the Alps, the Rhodopes consist of different terranes, which resulted from multiple Alpine subduction and collision and a final Late Alpine extension and erosion.

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