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Genesis of Subduction-Related Late Cretaceous Mafic-Intermediate Rocks from Pirin Mts (West Rhodopes): Constraints from Isotopic (Sr, Nd, and Hf) Study

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The Srednogorie Late Cretaceous magmatic rocks in Bulgaria comprise the easternmost part of a vast magmatic belt in southeast Europe known as the Apuseni-Banat-Timok-Srednogorie magmatic belt. The Apuseni-Banat-Timok-Srednogorie magmatic belt is considered a continental margin arc, formed as a result of the northward subduction of the Vardar-Izmir branch of Tethyan Ocean beneath the European margin (Serbo-Macedonian and Rhodope Massifs). The major outcrops of Late Cretaceous magmatic rocks are located in the Srednogorie zone, but contemporaneous rocks are also known from the Rhodope Massif and Balkan zone. A southward younging of this magmatism is manifested from 92 Ma in Central Srednogorie to 68 Ma in the Rhodopes, interpreted as a slab retreat of the subducted plate. In contrast to the Srednogorie magmatic rocks, mostly consisting of mafic to intermediate compositions, so far, known Cretaceous plutonic rocks from the Rhodope Massif are mainly felsic. Recently, we found for the first time mafic and intermediate Late Cretaceous (85–71 Ma) rocks near Kremen Village in the northeast Pirin Mountains (western part of the Rhodope Massif). Here we provide petrographic and bulk-rock isotope (Sr, Nd, Hf) data along with zircon Hf isotopes for these rocks and discuss their genesis.

The Kremen mafic-intermediate rocks are represented by two lithologies: plutonic body of coarse-grained gabbro and fine-grained dioritic dikes. The gabbro (SiO_2 = 47–53 wt %) is composed of plagioclase, hornblende, biotite, and magnetite. Important accessory phases are epidote, allanite, and zircon and rare ore minerals (pyrite, chalcopyrite, titanomagnetite, titanite, ilmenite, rutile). Hornblende barometers yielded depth levels from 10 km to more than 20 km, confirmed by the early appearance of epidote in the crystallization sequence. Formation temperatures of ~700° to 900°C were estimated using hornblende, zircon, and allanite thermometers, which are atypically low for a mafic rock and interpreted to reflect derivation from a highly hydrated source.

The Kremen diorite (SiO_2 = 59 wt %) has a similar mineral composition, including hornblende, plagioclase, and magnetite. It appears to be an adakite-like rock, implied by the elevated ratios Sr/Y = 74 and La/Yb = 29. The hornblende started crystallizing a little earlier than plagioclase at upper-crustal depths of 12 to 15 km. Hornblende rims crystallized under significantly lower pressure conditions (3 km), which most likely resulted from rapid ascent of the dioritic magma to a shallower depth.

The Kremen gabbro and diorite are characterized by slightly radiogenic $^{87}Sr/^{86}Sr$ ratios (0.7064 and 0.7058, respectively), coupled with slightly negative εNd_i values of –3.1 in gabbro and –1.9 in the diorite and slightly positive bulk εHf_i values of +0.7 for the gabbro and +0.1 for the diorite. Magmatic zircons from the gabbro and diorite show a wide range of εHf_i values (–0.8 to +15.7), with highest εHf_i values of +14.4 to +15.7, suggesting a depleted MORB-like source. Inherited zircons reveal $\varepsilon Hf_{(71Ma)}$ of –4.2 to +1.8, and their U-Pb age is similar to that of the local metamorphic basement. Therefore, we suggest that the zircon Hf isotopes are preserving the signature of the mantle source. The bulk-rock Sr, Nd, and Hf isotopes have resulted from interaction with the basement rocks.