Evolution of the Malko Tarnovo plutonism and its significance for the formation of the ore deposits in the region, Bulgaria

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The pluton is situated southward of the town Malko Tarnovo, at the border between Bulgaria and Turkey and a half of it is exposed in the Turkish territory. It covers an area of 12 km^2 in Bulgaria. The pluton is intruded into low grade metamorphosed terrigenous and carbonate rocks of Upper Triassic and Lower Jurassic age. The magmatic intrusion resulted in the formation of magnesian and calcic skarns. Three Cu-Au-base metal vein- and skarn-hosted deposits (Gradishte, Propada and Mladenovo) and one porphyry type Cu-Mo deposit (Bardtze) are located within the Malko Tarnovo pluton area. The Malko Tarnovo pluton is composed of four intrusive phases: I) Basic rocks (pyroxenites, gabbro-pyroxenites, gabbros, monzogabbros); II) Monzonitoids (monzodiorites, quartz-monzodiorites, monzonites and quartz-monzonites); III) Quartz-syenites; and IV) Porphyry rocks (quartz-diorite porphyrites, granodiorite porphyrites, quartz-monzonite porphyrites and quartz-syenite porphyries).

The rocks from the first phase are low-K to high–K. Rocks from the second and third phases are high-K. The rocks of the fourth phase are medium-K to high-K with potassic alkalinity clearly lower than the rocks of the two previous phases. The rocks of the first three phases form an isometric plutonic body. K-Ar dates are in the interval 77-74 Ma (for I and II phases). The rocks of the IV phase are formed in a different stress regime and form subequatorially elongated intrusive porphyritic bodies. The K-Ar age of the porphyritic rocks is 66 Ma.

The magmatic evolution of the first three monzonitoid phases is characterized by decreasing contents of TiO_2, $FeO+Fe_2O_3$, MgO, CaO, V, Cr, Ni, Co and Sr and increasing contents of K_2O, Na_2O, Ba, Zr and Rb. The trends for Al_2O_3, P_2O_5, Cu, Y, Li, Au and Nb are characterized by a maximum during the second monzonitoid phase. The fractionation of Ol, CPx, Mt, and probably Pl is the likely explanation for this peculiarity. Geochemical and textural features of the mafic rocks indicate a cumulative (mainly for Cpx) origin of the pyroxenites and gabbro-pyroxenites.

The complex of the porphyritic intrusive rocks shows the same tendencies for the evolution trends for most of the elements except for K_2O, Zr, Nb, Rb, and Y which are with lower contents.

The Malko Tarnovo magmatism is related to a normal arc tectonic setting. In the diagram Rb vs Y+Nb the samples fall in the fields of VAG and WPG. This peculiarity is due to the fluid factor influence and the increased K-alkalinity. ORG-normalized spiderdiagrams for all magmatic rocks are similar but with lower contents of the less incompatible HFSE for the porphyritic rocks of the IV phase. They have distinct negative Nb and Zr anomalies, typical for VAG. The chondrite-normalized REE patterns show enrichments of LREE and a very slight decrease of the Eu negative anomaly with the magmatic evolution of monzonitoidic magma of the first three phases.

Crystallization temperatures of zircons are 620 to 730^oC for porphyritic rocks and 750 to 900^oC for monzonitoids. The pressure of crystallization of amphiboles according to the geobarometer of Schmidt (1992) is 5.4 to 8.8 kb for monzonitoids and 3.7-5.6 kb for porphyrites.

The chemical composition of monomineral biotite separates allow us to estimate roughly the fO_2 at1-2 units below the Mt-Hm buffer, which corresponds to oxidising conditions during magma crystallization in the Malko Tarnovo pluton, favourable for ore element leaching from the magma by hydrothermal fluids exsolving from the melt.

The initial $^{87}Sr/^{86}Sr$ ratio of the Malko Tarnovo plutonic rocks varies between 0.7044 and 0.7078, indicating different degrees of crustal contamination in the mantle derived magma. This ratio varies with around 0.0003 even in a single phase, suggesting crustal assimilation during the magmatic evolution and crystallization in the intrusive chamber.