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Carboniferous peralkalic polyphase intrusions in the Bulgarian segment of the Variscan belt

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In the Eastern Balkan Peninsula, the Balkan orogenic belt developed between the Moesia plate to the N and the Moravian-Rhodopi-Thracian massif to the S. To the Southern margin of the belt (Svoge region), syn-orogenic, peralkalic plutons are intruded at relatively shallow depth (andalusite+biotite in the contact aureole) within Silurian metapelites.

The main body is cut by polyphase intrusions of quartz-syenitic compositions. The main intrusive body, reported as shonkinite or lamproite in the regional literature (Grozdanov, 1965; Stefanova, 1966), has a modal composition consistent with a diopside-sanidine-phlogopite lamproite (Mitchell, 1985), and on the ground of major elements (Foley et al., 1987) and MgO-K_2O-Al_2O_3 ratios (Bergman, 1987) it is consistent with ultrapotassic lamproite compositions.

Early crystallized Fe-rich K-feldspar, diopsidic augite and high-Ti phlogopite accounts for the composition of the main intrusive body. Na-Ca (richterite, winchite) and finally Na-amphiboles (Mg-arfvedsonite, eckermannite, Mg-riebeckite) crystallized cotectic with K-feldspar from residual melts. Diopside-free compositions are characterized by amphibole+phlogopite pseudomorphs after olivine. On the whole, modal variations and crystal zoning support an evolution by fractionation.

Quartz-syenite melts intruded the lamproite body as large masses and dikes. The quartz-syenites strongly vary in composition from primitive to evolved and from leucocratic to melanocratic due to cumulus processes. The more primitive compositions are characterized by early cotectic crystallization of K-feldspar, Na-Ca amphibole and aegirin-augite, followed by K-feldspar with Na-amphibole and aegirine and finally by K-feldspar with aegirine and Na-plagioclase (An_{10-30}). Quartz is an ubiquitous interstitial phase.

In lamproites, REE show fractionated patterns with high Ch-normalized LREE (278-443), low HREE (4.3-7.6) and weak Eu negative anomaly. The Ch-normalized spidergrams evidence high LILE contents with Th positive spike, Nb, Ta, Sr and Ti troughs. In quartz-syenites, fractionated Ch-normalized-REE patterns have high LREE (124-553), low HREE (2.6-11.6) and weak Eu negative anomaly. The Ch-normalized spidergrams evidence high LILE with Nb, Sr and Ti troughs and, in more evolved composition, Th, Zr and Hf positive spike.

In lamproites, diopsidic-augite shows Ch-normalized patterns fractionated for MREE and HREE and core-to-rim increase of the trace elements and ΣREE. Richterite and winchite show low trace elements abundances, except for Nb, Zr, Ti, Sc and V and poorly fractionated patterns for REE. Phlogopite shows a positive anomaly for K, Nb, Ti and V. K-feldspar in lamproitic rocks is homogeneous with slightly LREE and MREE fractionated patterns, with a positive anomaly for K, Ba and Sr.

In quartz-syenites, aegirin-augite shows Ch-normalized HREE- enriched patterns, and poor fractionation for LREE and MREE; the trace elements and REE abundances decrease with core-to-rim trend in aegirin-augite, except for Ba, Nb and Ti. The Mg-arfvedsonite is enriched in HREE and shows positive anomalies for Sr and Ti.

The Svidnya intrusive resulted Mid Carboniferous in age: 337±4 Ma were obtained by $^{40}Ar/^{39}Ar$ dating on amphibole separate and 339.1±1.6 Ma by $^{39}Ar/^{40}Ar$ dating on phlogopite separate. Therefore, the age constrains a Variscan syn-orogenic emplacement.

The $^{143}Nd/^{144}Nd$ ratios, corrected back to 337 Ma and expressed as ε notation, are relatively homogeneous in lamproites and range between –4.87 and –5.88. The negative ε_{Nd} values indicate that these magmas derived from a source relatively enriched in LREE with respect to the bulk Earth. The Nd model ages range between 1.3 and 1.5 Ga. This represents the time required for these lamproites to evolve from initially depleted mantle source, characterized by the ε_{Nd} value of the initial ratio ranging between +4.4 and +5.0, to their observed enriched character. The relatively radiogenic Sr isotopic composition ($^{87}Sr/^{86}Sr$ =0.70694-0.70769) suggests a time-integrated LILE enriched source. Despite the small data set, the lack of a positive correlation of the

$^{87}Sr/^{86}Sr$ with Rb or Sr content make crustal contamination an unlike process to account for the radiogenic character of these magmas. The isotopic data are consistent with an origin of lamproites from a depleted mantle, which has been contaminated by an enriched component, characterized by relatively high Nd/Sm and Rb/Sr ratio.

Among quartz-syenites, one sample is characterized by a ε_{Nd} value of -6.24, similar to that measured in lamproites, suggesting a possible common source; the other sample shows a less-enriched character (ε_{Nd}=-1.24), indicating a different source with the significant role of depleted components. The large variation measured in the $^{87}Sr/^{86}Sr$ (0.70609 – 0.71485) seems to be related to late-stage alteration processes.

The geochemical evidence support hybridization of lamproitic liquids with melts having a more important crustal component to achieve quartz-syenite compositions, rather than mere fractionation from a lamproitic melt. The comparison with literature data evidence an affinity with SiO_2-rich lamproites (Carlier and Lorand, 2003; Mitchell and Edgar, 2002), emplaced in tectonically active crustal segments at destructive plate margins above ocean/continent subduction zones.

The Svidnya P_2O_5 and TiO_2 contents are consistent with those of ultrapotassic collisional rocks (Foley et al., 1987); moreover high Rb/Sr and Rb/Ba are typical of orogenic potassic lavas (Rogers et al., 1987) and ascribed to involvement of subducted sediments. Nb/Zr suggests an origin in partial melting of subduction-modified mantle (Thompson and Fowler, 1986).

The regional pattern including eclogites (Sredna Gora) and ultrafemic rocks within high-grade metapelites, inferred as oceanic lithosphere subducted before the collisional event (406$\pm$40 Ma peak metamorphic age, Amov et al., 1981; 398$\pm$5.2 $^{40}Ar/^{39}Ar$ on Hbl, exhumation age), support the geochemical record.