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The geochemical behavior of Phosphorus and Zirconium in lamproitic magmas: case study the Gataia lamproite, SW Romania

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The Gataia lamproite is a new occurrence located at the southeastern wedge of the Pannonian Basin (Romania). The main petrographical characteristics of the Gataia lamproite are: (1) modal proportions of olivine and leucite are high; (2) relatively abundant are phlogopite, apatite and armalcolite, whereas minor phases include diopside, spinel, sanidine and richterite and (3) Zr-rich glass.

Olivines are zoned with Fo up to 93 in the core and up to 84 in the rim. They have abundant spinel, apatite and melt inclusions suggesting that they are phenocrysts and not xenocrysts and that apatite and olivine crystallized simultaneously. Olivine X-ray maps show that phosphorus forms fine-scale oscillations. Occasionally the core is enriched in phosphorus, providing the highest P concentration (P_2O_5=0.80 wt %). Along the oscillations are growing fine-grained apatites.

The incorporation of phosphorus into silicate minerals is not surprising as from the crystallographic point of view $^{IV}P^{5+}$ can replace $^{IV}Si^{4+}$ due to the small differences in their ionic radii. In our case, the incorporation of phosphorus into olivine took place prior to saturation of the lamproitic magma with a phosphate mineral. In addition, compared to other lamproites worldwide, the Gataia lamproite has the lowest CaO content (CaO=3.43 wt %) and is one of the most rich in P_2O_5 (2.13 wt %). Consequently, the lamproitic magma was oversaturated in P and depleted in Ca preventing the crystallization of apatite and providing the conditions for crystallization of P-rich olivine. The P-oversaturation is continuous up to the groundmass glass generation, which has up to 0.30 wt % P_2O_5 and only 0.07 wt % CaO.

Whole rock contains 1230 ppm Zr that is concentrated in the glass (ZrO_2= 0.26 wt %) explaining the absence of Zr-bearing phases. Zircon has not been observed in lamproites and Zr-bearing minerals as wadeite and/or daylite are recognized as late stage crystallization minerals; their absence in our case suggests a very fast transport to the surface. Such Zr-rich melts can be considered as the metasomatic agent causing anomalous Zr-enrichments in mantle diopsides.

Gataia is located far from the Carpathian subduction system, excluding any relationship to that system. As well, a plume origin for the Gataia lamproite can also be excluded as none of the isotopic compositions shows affinity to HIMU mantle component. The Gataia lamproite appears to be of lithospheric origin related to the extensional processes at the margin of the Pannonian basin.