Trace element and isotopic constraints on the genesis of the cumulitic xenoliths from the alkaline basalts in the eastern Rhodope metamorphic core complexes

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Oligocene within-plate alkaline basalts, intruded in the Eastern Rhodope metamorphic core complexes Kesebir and Biala Reka, carry ultramafic and mafic xenoliths, consisting of clinopyroxenites, websterites, orthopyroxenites, 2-pyroxene- and clinopyroxene gabbros. The xenoliths are interpreted as samples of layered intrusions formed at upper mantle-lower crustal depths as the results of mafic magma underplating. This process might be an attractive potential source for the heat required for thermal modification and extension of the lower and middle crust in the metamorphic core complexes.

We present LA ICP-MS trace element analyses of minerals from the xenoliths, along with limited whole rock ICP and Sr and Nd isotope analyses. All ultramafic clinopyroxenites, except high-Fe varieties, exhibit convex-upwards C-normalized REE patterns, similar to those of clinopyroxene mega/phenocrysts of the host alkaline basalts. Calculated parental liquids from the trace element analyses of clinopyroxene indicate that clinopyroxenites may have formed from melts with clear Nb and Ta positive anomalies, similar to composition of the host alkaline basalts. The clinopyroxene REE profiles of the orthopyroxenite and olivine websterite suggest that they also might have crystallized from an alkali-basaltic melt, but the slight Eu anomalies suggest either plagioclase fractionation or contamination by a crustal component. The most Mg-poor websterites, which have flat to "W"-shape REE profiles, are the result of strong differentiation, producing depletion in the MREE, flat negative slope and slight positive Eu anomaly. Gabbros and high-Fe clinopyroxenites and their melt inclusions indicate that these rocks appear to be the most differentiated product of the same parent. Their calculated parental liquids are more enriched in REE, with pronounced negative Eu, Nb-Ta and Ti anomalies and positive Pb anomaly on their Primitive-mantle normalized diagrams, as commonly observed for typical subduction-related rocks. This transition from within-plate to subduction-related signature can be related to fractionation of amphibole and other Ti-bearing phases. In addition, evolved websterites and gabbros have slightly higher Sr and almost identical Nd isotopic ratios compared to those of the host basanites. The most reasonable explanation for the isotopic offset of the cumulates is interaction of alkaline basaltic magma with lower/middle crustal wall-rocks.

In the light of our new data, the most mafic xenoliths are interpreted as cumulates originated from melts of alkaline magma, whereas the progressive change of the mineral and isotopic compositions in more evolved lithologies is consistent with extensive transformation through fractionation and a small percentage of assimilation of lower crustal material.

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Application of regionalized variable theory in analysis of morphological phenomena of the Herzegovina karst

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This paper presents an interpretation of results of a long-lasting scientific investigation of the Herzegovina karst using the methods of Regionalized Variable Theory, i.e.