Origin of Alkaline-Carbonatite Rocks and Related Mineral Deposits at the NW Margin of the West African Craton: Inferences from Field and Petro-Geochemistry

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The pericratonic terrains of the Reguibat shield in the NW part of the West African Craton host several occurrences of carbonatites, whose mineral potential deserves consideration due to the growing global demand for critical mineral resources. In the present work, we report a comprehensive field inspection and a petrographic and geochemical study of three annular structures in the western Oulad Dlim massif (southern Morocco), namely Twihinate, Lamlaga, and Lahjayra. These structures are partially to completely covered by silica breccia and ferruginous crusts. The carbonatites are Cretaceous sövites, evolving from primary magmatic paragenesis to hydrothermally reworked facies hosting REE- and Nb-bearing phases, mainly REE-fluorcarbonate and pyrochlore. These occurrences were previously thought to be isolated carbonatite structures, lacking coeval silicate alkaline rocks. However, our study revealed the existence of silicate alkaline rocks with ultrapotassic affinity, mainly composed of K-feldspars and characterized by high K/Na ratios. The occurrence of such rocks in close association with the calciocarbonatites suggests the derivation of the igneous complexes from a parental carbonated silicate melt, probably formed by low-degree partial melting of a phlogopite-bearing mantle source.

The iron oxide cap rocks host the highest concentrations of REE-Nb and igneous phosphates and locally preserve relics of primary carbonatite paragenesis. They exhibit normalized REE and multi-trace element patterns consistent with those of associated carbonatites, indicating that their geochemical signatures are primarily inherited from their carbonatitic protoliths. Similarly, the siliceous breccia facies show a trace-element signature comparable to that of the carbonatites. However, they have locally preserved the same sedimentary stratification as observed in the sandstone and quartzite country rocks. Their trace-element signature is attributed to intense hydrothermal activity during the carbonatite's emplacement. In light of these results, the studied structures are considered suitable sites for better understanding of the genesis of carbonatite-related mineral deposits through hydrothermal/supergene enrichment processes.