Prospective Mapping of Carbonatite-associated Iron Oxide Mineralization in the Western Oulad Dlim Massif: Remote Sensing, Field, and Geochemical Investigations

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Over the past decade, the growing need for critical metals for the energy transition has resulted in a sharp increase in exploration programs focused on carbonatite complexes. Carbonatite/alkaline intrusive complexes and their associated deposits are known to host concentrations of this type of elements, in particular rare earth elements (REE). Additionally, post-emplacement processes often lead to secondary enrichment of several mineral resources, including REE, niobium and phosphates. In this study, we investigate the metallogenic potential of the western Oulad Dlim massif, in the northwestern margin of the West African Craton (south Morocco), where new carbonatite complexes have been recognized. The adopted approach is based on the application of multispectral data for the remote detection of carbonatite-related occurrences potentially enriched in REE and Nb. The areas of interest are validated by field inspections using in-situ portable X-Ray fluorescence analysis. In addition, further laboratory analyses are carried out, involving petrographic analysis, major- and trace-element characterization of rocks and ore mineral phases. Results reveal that the fusion of processed data of ASTER and Sentienl-2A sensors is reliable to delineate iron rich-zones within the carbonatite complexes. Remote sensing results are consistent with field observations, where 90% of validated occurrences are concentrated in only 10% of the total investigated area. Additionally, petrographic, mineralogical, and geochemical characterization confirms the presence of significant concentrations of REE, Nb and phosphate (up to 3.6 wt.%, 1.8 wt.% and 9 wt.%, respectively). These concentrations are associated with the presence of monazite, pyrochlore and apatite mineralization concentrated in the mapped iron ore formations. Our study has highlighted the existence of several high potential zones with great similarities in terms of mineralization in several annular structures of the western Oulad Dlim massif. Further exploration should be pursued in this area as it is a promising district for critical metal deposits.