

Understanding rare-earth element enrichment in the Ninakri complex, Côte d'Ivoire

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Rare-earth elements (REEs) are critical metals necessary for a range of green energy transition technologies that will be crucial for reaching net zero targets. As such, exploration for these metals is increasing across the globe. One area that is gaining burgeoning interest is the Precambrian geology of West Africa, known as the West African Craton (WAC). While exploration in this region has primarily been focused on sub-alkaline magmatism, alkaline centres have also been identified with potential for REE-enrichment.

In this study, we integrate fieldwork, geochemistry and phase equilibria modelling to explore the major and trace element evolution of the Ninakri complex in Côte d'Ivoire. This complex is notable for containing both silica-undersaturated nepheline syenite alongside silica-oversaturated quartz syenite, with REE enrichment greater in the former [1]. A range of intermediate assemblages are also present, including aegirine-, riebeckite- and/or melanite garnet-bearing syenites. By using new thermodynamic models for alkaline and sub-alkaline systems [2], we constrain the major element history of the different units within the complex. Integrating these models with mineral-melt partition coefficients, we are also able to quantify the trace element budgets of the syenites, allowing us to identify the controls on the varying REE concentrations across the complex.

Our results provide a method to quantify and test the various proposed mechanism for REE-enrichment in natural systems, which will inform future exploration for REEs in the WAC and elsewhere. The results also showcase the importance of poorly constrained parameters such as crystallisation pressure and oxidation state on the fate of potential ore deposits, highlighting the utility of integrating phase equilibria modelling into economic geology workflows.

References:

[1] Morel & Alinat (1993) *Journal of African Earth Sciences* 17, 213-233.

[2] Weller, Holland, Soderman, Green, Powell, Beard & Riel (2024) *Journal of Petrology* 65, egae098.