An appetite for apatite: Investigating apatite geochemistry as an exploration tool for carbonatite rare earth element deposits

Orlova, K.[1], Mavrogenes, J.A.[2], Chandler, R.B.[3], Wei, C.[4] and Gao, Y.[5]

1. Honours Student, ARC Training Centre in Critical Resources for the Future, Research School of Earth Sciences, Australian National University, Acton ACT 2601. Email: katya.orlova@anu.edu.au.
2. Economic Geology Professor and Chief Investigator, ARC Training Centre in Critical Resources for the Future, Research School of Earth Sciences, Australian National University, Acton ACT 2601. Email: john.mavrogenes@anu.edu.au.
3. Postdoctoral Researcher, Research School of Earth Sciences, Australian National University, Acton ACT 2601. Email: ross.chandler@anu.edu.au.
4. Postdoctoral Researcher, Research School of Earth Sciences, Australian National University, Acton ACT 2601. Email: chunwan.wei@anu.edu.au.
5. Postdoctoral Researcher, Research School of Earth Sciences, Australian National University, Acton ACT 2601. Email: yajie.gao@anu.edu.au.

Keywords: rare earth elements (REEs), critical metals, carbonatites, mineral exploration, indicator minerals, apatite geochemistry, Yin Complex, West Arunta

ABSTRACT

Rare earth elements (REEs) are “critical metals” needed for emerging technologies, yet their supply is limited and under geopolitical threat. A unique class of igneous rocks called carbonatites are the primary host of economically significant REE deposits. However, a key challenge in mineral exploration is that mineralised and barren carbonatite systems are often indistinguishable using conventional geophysical and remote sensing techniques. This uncertainty limits effective exploration targeting and the discovery of new resources needed for a sustainable transition towards clean energy. This project addresses this issue by testing the idea that apatite – a common accessory mineral in carbonatites – can act as a reliable geochemical indicator of REE mineralisation due to its ability to preserve signatures of geological and ore-forming processes. To evaluate this, elemental and isotopic geochemical data will be compared between apatites from two REE-bearing carbonatite systems in Western Australia: the Yin Complex and the West Arunta region. The study aims to better understand how these systems formed, evolved and were influenced by fluids during mineralisation. By integrating multiple geochemical datasets, the project has identified consistent differences in apatite geochemistry that distinguish the Yin Complex from the West Arunta with statistical significance. Ultimately, these findings will be integrated with a much larger global apatite dataset, which includes both fertile and barren carbonatite systems and has been compiled by researchers at the ARC Training Centre for Critical Resources for the Future. This combined dataset will be used to assess whether apatite can serve as a robust indicator mineral for identifying REE enriched carbonatites in mineral exploration.