

## **Scientific Drilling at a REE-mineralised Carbonatite**

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Carbonatites host the world's largest and highest grade rare earth element (REE) deposits and are critical for the global transition from fossil fuels to a low-carbon society. Many compositional and structural aspects of these complexes remain poorly understood, such as the relationship between carbonatites and associated alkaline rocks, how carbonatites evolve through magmatic-hydrothermal processes to form economic REE enrichment, how mineralising fluids vary with depth and time, and the importance of local structures for fluid-rock interaction.

Carbonatites are commonly preferentially weathered, and so there are remarkably few global localities where they can be studied in three dimensions. Scientific drilling represents an alternative way to study processes occurring at depth within a mineralised carbonatite complex. In May 2023 we will hold an International Continental Drilling Programme (ICDP)-funded workshop to plan deep drilling that will study the 3D structure of a mineralised carbonatite complex, and the influence of these unusual rocks on groundwater chemistry and deep life. We are targeting the Songwe Hill carbonatite complex in Malawi, currently under exploration by Mkango Resources, which represents an excellent example of a sub-volcanic REE-mineralized alkaline-carbonatite complex, with an extensive catalogue of surface data, existing shallow drilling (to 300 m) and a range of geophysical data to support projections of the carbonatite body to depth.

In this presentation we will summarise discussions at the workshop and outline the geological basis of our plan to drill at Songwe Hill. The current interpretation of Songwe Hill comprises a REE-mineralised carbonatite and phonolite neck emplaced between 1–5 km, enveloped by carbonatite-rich breccias and altered phonolite and passing outwards through a halo of carbonated nepheline syenite into fresh nepheline syenite. Scientific drilling will enable us to understand the relationship between the carbonatite and the alkaline igneous rocks, the structures that have influenced fluid flow over time, and the effect this unusual geology has on modern groundwater resources and deep life. This talk will be presented on behalf of all members of the REEDRILL team, which is far wider than the four listed authors, and we welcome interest from members of the geochemical community as we develop the science plan.