Angolan carbonatites and mineralogical constraints to development of low waste, optimised REE recovery methodologies

Project Highlights:

- Opportunity to work on newly discovered, economically significant carbonatite-hosted REE mineralisation in Angola, adjacent to a deposit now being developed for production.
- Focus on developing advance fieldwork and laboratory skills to produce a new geological model and evaluate the potential to develop a possible economic deposit.
- Work closely with the industry partner (Pensana) to further develop professional exploration and evaluation applied geoscience skills.

Overview:

As the world faces the threat of climate change, huge effort is being expended to move from carbon-emitting forms of energy generation to greener, sustainable methods. Underpinning this transition are the manufacture of components which include high strength magnets (wind turbine, electric vehicles) that require metals (REEs) that require extraction. Carbonatites (igneous rocks with >50% carbonate minerals) and alkaline (igneous rocks with elevated sodium and potassium) rocks are host to largest and highest grade REE deposits. UK-based Pensana Plc is developing one of the world's largest REE deposits at Longonjo in Angola and it holds the exploration rights to the Coola and Sulima West deposits in an adjacent district. The supervisors are based at the NHM and University of Exeter and both institutions' teams have extensive experience in investigating a range of REE deposits and carbonatites more generally.

The carbonatites at Coola and Sulima West have been identified as significant targets for exploration as they contain between 0.6 and 4.9% total REE-oxides which are hosted in bastnaesite. There are additional potential resources including fluorine and phosphorous. This project will focus on further validation of the mineralogy of these deposits along with investigations into the potential for on-site beneficiation of these resources which can make the most advantage of a future processing plant to be developed close to the Longonjo carbonatite, 40 km to the South of Coola.

Key research questions:

This project aims to answer the following key research questions:

1) Understand the geological setting of the carbonatite systems of interest in the context of the total mineralised system in Angola

2) Define the mineralogical composition and mineral chemistry of the mineralised bodies, evaluating possible suitable processing strategies based on project findings in consultation with company geoscientists

3) Develop geological models for the deposit system that are relevant to discovery and recovery of further economic and sustainable REE resources and potential by-product minerals.

Methodology:

Initial studies to date have included soil and rock sampling, trenching, pitting, geophysical surveys and mineralogical investigations all confirming rare earth element, fluorite and phosphate mineralisation. Further studies will include field mapping and sampling, petrological studies and mineral identification/classification in the laboratories of the Natural History Museum and Camborne School of Mines (University of Exeter). The initial focus will be to understand the composition of the host rocks and the potential host phases for economic components like REE, F and P. Techniques to be applied will include SEM, EMPA, XRD, ICP-MS and LA-ICP-MS, techniques all available in the laboratories of the two host institutions. This study will provide valuable information to the company developing a potential extension to their already defined resource at Longonjo, which will have a priority to make the best use of these important resources whilst minimising costs of recovery and environmental impact of any operations. Advanced studies are likely to include appropriate stable and radiogenic isotopic studies (yet to be defined and fully open to development by the incoming student) that can further unravel the mineralised system. The student will also have access to industry standard state of the art exploration technologies which will provide further data to help in the interpretation of the deposits and training for the student in modern exploration and evaluation techniques. There will be the clear opportunity for the student to refine and refocus the objectives of the PhD after the initial findings of work in Year 1.

Possible timeline:

Year 1: Literature research and initial one week training in the CDT programme. Further bespoke training including fieldwork skills and laboratory techniques. Two to three weeks of fieldwork in Angola to collect material for laboratory studies. Submission of a stable and/or radiogenic isotope proposal to NERC facilities. Laboratory work largely in NHM London but short visit(s) to Camborne School of Mines. Presentation skills training. Preparation of a poster on work completed to date and possible attendance at SEG Namibia meeting.

Year 2: Second fieldwork campaign (2 weeks) Laboratory studies largely NHM but short visits to Camborne. Detailed preparation of samples for extended geochemical and isotopic analysis. One week CDT cohort training. Revision of presentation skills training. Presentation of oral paper to MDSG or similar UK meeting.

Year 3: Continued laboratory studies and short secondment to industry partner. Preparation of manuscript for submission to an international meeting and journal. Technology transfer workshop with industry partner and local Angolan geoscientists. Thesis write-up and submission in Year 3.5

Training and skills:

Anticipated training includes three, annual one week cohort-wide training programmes.

In addition, for this studentship:

In **Year 1** there will be NHM-based training in electron beam and xray techniques, aspects of wet chemical and LA-ICPMS analysis. Introduction to isotopic techniques. A 4-day exploration fieldwork skills course is anticipated.

In **Year 2** training will include advanced presentation skills and various in-house courses at Camborne and NHM to include time management, EDI and unconscious bias, museum studies and access to other bespoke in-house courses. The student will be mentored in preparation of manuscripts for publication.

In **Year 3** training will include exploration strategy and field studies, introduction to mineral economics and mineral processing, ESG to include biodiversity impacts and metrics, and social risks, aspects of mine life cycle and LCA analysis.

The student will be expected to attend the annual MDSG meeting, presenting, in Year 1/2, a poster and, in Year 2/3, an oral presentation. Additionally, the student will be encouraged to attend at least one international meeting with an oral or poster presentation and will be expected to work on at least one manuscript for an international journal.

Partners and collaboration (including CASE):

The student will be mostly based at the lead institution (NHM) but will spend significant time with the second partner and university host at the Camborne School of Mines (University of Exeter). The project is CASE-funded so the student will also spend significant time with the industry partner (Pensana Plc), mostly at their field sites in Angola but also with the UK-based technical team. The project is anticipated to have a short secondment to the mining company to work alongside company exploration staff. This work will be further supported by the company in terms of logistical support etc.

Requirements: Applicants should ideally have a BSc degree (or higher) in geology/geosciences, graded at 2:1 or above, with an interest in geology, mineralogy and geochemistry.