

## A Genetic Model for the Heavy REE Deposit at Lofdal, Namibia

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Economic rare earth element (REE) deposits are invariably light REE-enriched, and those hosted by or spatially associated with carbonatites have particularly low contents of heavy REE. It is therefore highly anomalous that the Lofdal deposit, which is the most enriched in heavy REE among the 58 REE deposits at an advanced exploration stage, is carbonatite-associated [1]. The deposit has a reserve of 1.7 million tons grading 0.59 wt.% REE, of which the HREE proportion is 85% [1]. It was initially described as being carbonatite-hosted, with the principal REE mineral, xenotime-(Y), occurring as an accessory mineral in calcite and ankerite-rich carbonatite dykes [2]. However, textural relationships observed in outcrop, drill core, and microscopically indicate that the xenotime-(Y) is hosted by biotite-carbonate veinlets within brecciated albitite, and that the latter subsequently underwent hydrothermal carbonate alteration. This interpretation is supported by  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  values that are consistent with a hydrothermal rather than magmatic origin for the carbonate minerals.

Both the host rocks and the REE mineralization are interpreted to be hydrothermal in origin. However, it is likely that the source of the fluids was a carbonatite magma, albeit one unusually enriched in HREE. A model is presented, in which LREE-dominated hydrothermal fluids rose through basement faults, initially albitising the host gneisses and later brecciating the albitites, and precipitated biotite and calcite in veins. Owing to the high stability of the aqueous LREE species relative to the HREE species [3], the LREE were mobilised above the present erosional level leaving the HREE to precipitate as xenotime-(Y) in veins with the biotite and calcite. Hydrothermal activity terminated with the saturation of calcite that flooded the brecciated rocks and largely replaced the albitite, leaving behind a rock that could easily be mistaken for carbonatite, particularly in narrow ridge-like outcrops reminiscent of dykes.

[1] <http://www.techmetalsresearch.com>. [2] Wall *et al.* (2008) *CanMin* **46**, 861-877. [3] Migdisov *et al.* (2009) *GCA* **73**, 7087-7109.