

## **The nature of REE mineralization in the Ashram deposit, Eldor Carbonatite Complex, Québec**

**CMJ Béland, AE Williams-Jones**

Department of Earth and Planetary Sciences, McGill University, Montréal, QC, Canada

Until recently, carbonatite-hosted REE mineralization has been considered to be magmatic in origin. A growing number of studies, however, suggests that (carbo)hydrothermal fluids play an important role in the formation of these ore deposits. Understanding the processes that control the transport and deposition of REE to exploitable levels is key to the development of effective methods for their exploration. The Eldor Carbonatite Complex and its Ashram deposit provide an ideal natural laboratory in which to determine REE mineral paragenesis, identify the dominant controls (magmatic and hydrothermal) on the deposition of REE minerals, and develop vectors to potentially economic carbonatite-hosted REE mineralization. Textural evidence from ore zone samples at Ashram indicates that REE minerals precipitated from hydrothermal fluids, although this does not rule out the possibility of magmatic pre-concentration. The rare earth ore minerals, such as monazite-(Ce) ( $\text{REEPO}_4$ ), bastnäsite-(Ce) ( $\text{REECO}_3\text{F}$ ), xenotime-(Y) ( $\text{YPO}_4$ ), and minor aeschynite-(Y) ( $(\text{Y,Ca,Fe})(\text{Ti,Nb})_2(\text{O,OH})_6$ ) occur as disseminations in breccia matrices, in veins, and as vug fillings. Monazite-(Ce) was the earliest mineral to form, followed by xenotime-(Y) and bastnäsite-(Ce). The mineralogy varies appreciably in different parts of the deposit; For example, xenotime-(Y) and aeschynite-(Y) are enriched in the MHREO zone and bastnäsite-(Ce) is enriched in the BD zone. The compositions of the main REE minerals also vary with location in the deposit, particularly in respect to their Nd and Th contents, which may indicate a magmatic pre-concentration stage and/or multiple hydrothermal stages of mineralization. The occurrence of monazite-(Ce) adjacent to and within apatite suggests that it replaced apatite by substituting REE for Ca. A similar conclusion can be drawn for xenotime-(Y). By contrast, textures and mineral chemistry indicate that bastnäsite-(Ce) (BD zone) developed as a replacement of monazite-(Ce) through ligand exchange ( $\text{F}^-$ ,  $\text{CO}_3^{2-}$  for  $\text{PO}_4^{3-}$ ), while preserving the original REE chemistry. These observations suggest that Ashram had a long-lived history in which the combination of magmatic zone-refinement and hydrothermal mobilization contributed to the formation of a carbonatite-hosted deposit, with considerable potential for the exploitation of highly sought after REE such as neodymium and dysprosium.