The role of carbonate-fluoride melt immiscibility in shallow REE deposit evolution: New evidence from the Lugiin Gol high grade REE deposit, Mongolia

Jindrich Kynicky1,2, Martin P. Smith3, Wenlei Song1,2, Anton R. Chakhmouradian4, Cheng Xu5, Radka Fryzova1, Antonin Kopriva2 and Martin Brtnicky2

1Mendel University in Brno, Zemedelska 1, 613 00 Brno, Czech Republic

2Central European Institute of Technology, Brno University of Technology, Technicka 3058/10, 616 00 Brno, Czech Republic

3University of Brighton, Brighton, BN2 4GJ, United Kingdom

4University of Manitoba, Winnipeg, Manitoba, Canada

5Peking University, Beijing 100871, China

**ABSTRACT**

The Lugiin Gol deposit, Mongolia, is hosted by a range of carbonatite dikes mineralized in rare-earth elements (REE). Both these dikes, and composite nepheline syenite-fluorite-calcite veinlets, are host to a previously unreported macroscale texture involving pseudo-graphic intergrowths of fluorite and calcite. The inclusions within calcite occur as either pure fluorite, with associated REE minerals within the surrounding calcite, or as mixed calcite-fluorite inclusions, with associated Zr minerals. Consideration of the nature of the texture, and the proportions of fluorite and calcite present (~29and 71mole %, respectively), indicates that these textures formed through either cotectic crystallization of the immiscible separation of carbonate and fluoride melts. Pure fluorite inclusions are depleted in REE relative to the calcite. A model is proposed, in which a carbonate-fluoride melt phase enriched in Zr and the REE, separated from a phonolitic melt, and then either unmixed or underwent cotectic crystallization to generate an REE-rich carbonate melt and an REE-poor fluoride phase. The separation of the fluoride phase (either solid or melt) may have contributed to the enrichment of the carbonate melt in REE, and ultimately its saturation with REE minerals. Previous data have suggested that dry carbonate melts separated from silicate melts are relatively depleted in the REE, and thus melt immiscibility cannot result in the formation of REE-enriched carbonatites. The observations presented here provide a mechanism by which this could occur, as under either model the textures imply initial separation of a mixed carbonate-fluoride melt from silicate magma. Multistage silicate-carbonate-fluoride melt immiscibility may be a previously unrecognized, but important process in the generation of REE-mineralized carbonatites.