Evolution of oxygen fugacity with crystallization in the Bjerkreim-Sokndal layered intrusion (Rogaland, Norway)

Jean-Clair DUCHESNE, Bernard CHARLIER & Jacqueline VANDER AUWERA
Department of Geology, University of Liège, Bat. B20, B-4000 Sart Tilman (Belgium)

The Bjerkreim-Sokndal layered intrusion (BKSK) is made up of a Layered Series of cumulates, organized in several macrocyclic units (MCU). MCU IV comprises a complete series of rock types with leucotroctolites as the highest-temperature cumulates in the basal zone, passing upwards to olivine-free norites and gabbronorites. This unit passes to a thin Transition Zone (in which olivine reappears), which is itself topped by mangeritic and quartz mangeritic units forming the acidic massive upper part of the intrusion. Several indicators are used to evaluate the fO_2 evolution during crystallization of BKSK: 1. the $(Eu^{2+}/Eu^{3+})_{plag}$ ratio calculated from REE and Sr distributions between plagioclase and apatite following the method of Philpotts (1970) adapted with the lattice strain model of Blundy &Wood (1994); 2. mineral composition variations allowing application of the QUILF algorithm of Andersen et al. (1993); 3. the partition coefficient of vanadium between coexisting magnetite and ilmenite (Duchesne et al. 2007). The extent of sub-solidus re-equilibration of mineral compositions, with particular focus on the Fe-Ti oxides, is discussed in a variety of well-constrained cases, and primary mineral compositions are reconstructed. $DV_{Mt/Ilm}$ turns out to be much less sensitive to sub-solidus re-equilibration than the Fe-Ti oxide major elements. The $(Eu^{2+}/Eu^{3+})_{plag}$ varies from 26 to 162 in the Layered Series up to the Transition Zone. The QUILF fO_2 calculated from reconstructed primary assemblages in the same succession is FMQ+1.3 in the leucotroctolite (in gross agreement with experimental results). It decreases down to FMQ-0.40 on top of the Transition Zone, and then increases slightly to FMQ-0.25 in the acidic upper part. The $DV_{Mt/Ilm}$ (after correction for sub-solidus re-equilibration) passes from *ca.* 8 in the leucotroctolite horizon at the base of MCU IV to a maximum value of *ca.* 25 in the transition zone, then decreases to lower values in the range of 6 to 14 in olivine quartz mangerites. All these indicators point to a decrease of fO_2 to a minimum value on top of the Transition Zone and to a slight increase in the acidic upper part. The fO_2 decrease is characteristic of a closed-system evolution in MCU IV

and the increase in the upper part possibly corresponds to the arrival of a new influx of magma on top of the cumulate pile. The results are compared to two other layered intrusions: Grader (Havre St Pierre anorthosite, Quebec) and Fedorivka (Korosten Complex, Ukraine). Grader shows $(Eu^{2+}/Eu^{3+})_{plag}$ = 30 to 40, fO_2 around FMQ+1.5, and $DV_{Mt/Ilm}$ *ca.* 1, while in Fedorivka, $(Eu^{2+}/Eu^{3+})_{plag}$ varies from 86 to 216, fO_2 from FMQ +0.7 to -1.4, and $DV_{Mt/Ilm}$ from 6.7 to 27. It is worth noting that while fO_2 varies in a restricted range, $(Eu^{2+}/Eu^{3+})_{plag}$ and $DV_{Mt/Ilm}$ display large variations, suggesting that these parameters could potentially be used as oxy-barometers when experimentally and thermodynamically calibrated.