Oxidation potential in the Earth's lower mantle

F. KAMINSKY[1*], I. RYABCHIKOV[2], C. MCCAMMON[3], M. LONGO[3], A. ABAKUMOV[4], S. TURNER[4] AND H. HEIDARI[4]

[1]KM Diamond Exploration Ltd., West Vancouver, V7S3J1 Canada (*correspondence: felixvkaminsky@aol.com)
[2]Institute of the Geology of Ore Deposits RAN, Moscow, 109017 Russia (ryabchikov@igem.ru)
[3]Universität Bayreuth, Bayreuth, D-95440 Germany (catherine.mccammon@uni-bayreuth.de)
[4]EMAT, University of Antwerp, B-2020 Antwerp, Belgium (artem.abakumov@uantwerpen.be)

Earlier the estimates of oxygen fugacity in the Deep Earth were suggested to be around the IW equilibrium. Direct measurements of lower-mantle redox conditions, performed in ferropericlase (fPer) from Brazil and Guinea, gave $\Delta\log f_{O_2}$ (IW) values from 2.6 to 4.3. The recent calculations estimated the variation of log f_{O_2} values in the lower mantle within a wide range from -1.5 log units below to +5 log units above the IW buffer.

Four samples of fPer inclusions from lower-mantle diamonds from the Juina area, Brazil were analysed with TEM, EELS and the flank method. The presence of exsolved non-stoichiometric Fe^{3+}-enriched nanometre-sized clusters, comprising ~ 3.64 vol. % of fPer was established. The calculated oxidation conditions vary over a wide range: $\Delta\log fo_2$ (IW) from 1.58 to 7.76, reaching the FMQ buffer position. This agrees with the identification of carbonates and free silica among inclusions within lower-mantle Juina diamonds. On the other hand, at the base of the lower mantle $\Delta\log fo_2$ values may lie at and below the IW buffer. The variations of $\Delta\log fo_2$ values within the entire sequence of the lower mantle may reach ten logarithmic units, varying from the IW buffer to the FMQ buffer values.

The similarity between lower- and upper-mantle redox conditions implies the whole mantle convection. The mechanisms responsible for redox differentiation in the lower mantle may include subduction of oxidized crustal material, mechanical separation of metallic phase(s) and silicate–oxide mineral assemblage enriched in ferric ions, as well as transfer of fused silicate-oxide material presumably enriched in Fe^{3+} through the mantle.