Major problems concerning the mineralogy, petrology and geochemistry of the Earth's lower mantle

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Great advances were achieved during the last several decades in our knowledge of the mineralogy, petrology and geochemistry of the Earth's lower mantle [1]. Most geological observations agree and confirm earlier suggestions and conclusions made; however, some disagreements or discrepancies appeared between the various geological and experimental data. One of the first, unexpected occurrences was the presence of free silica in the 'ultramafic' lower-mantle association ("stishovite paradox" [2]). Another unexpected discrepancy is wide variation in the composition of natural periclase-wüstite phase: mg = Mg/(Mg + Fe)$_{at}$ varies from 0.90 to 0.16, while, according to experimental and theoretical data it should, in the pyrolytic system, be with mg at c. 0.90. Iron contents in both ferropericlase and bridgmanite increase with depth, indicating the increasing Fe content in the lower part of the lower mantle. In addition to major lower-mantle minerals (bridgmanite, ferropericlase, CaSi-perovskite and stishovite), some other minerals were identified in association with these, such as Mg–Cr–Fe, Ca–Cr and other orthorhombic oxides, iron carbides and nitrides, and others. In contrast to earlier suggestions on the increase of the oxygen fugacity values in the mantle with depth, the $\Delta \log f_{O2}$ values for the lower mantle, calculated from the compositions of natural ferropericlase inclusions in diamond, are similar to those of the upper mantle: they lie, in general, between the IW and FMQ buffers. In addition to 'ultramafic' and mafic mineral associations, a primary natrocarbonatitic association occurs in the lower mantle. Such and other features observed in lower-mantle samples indicate that the bulk composition of the lower mantle may differ from that of a 'pyrolite model', as well as heterogeneity in the lower mantle being as the result of extensive geodynamic processes occurring in the Deep Earth.

[1] Kaminsky (2017) *The Earth's Lower Mantle: Composition and Structure*. Springer, 331 pp. [2] Litvin (2014) *Doklady Earth Sc.* **455**, 274–278.