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Nitrides and carbonitrides from the lowermost mantle and their importance in the search for Earth's "lost" nitrogen

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Abstract

The first finds of iron nitrides and carbonitride as inclusions in lower-mantle diamond from Rio Soriso, Brazil, are herein reported. These grains were identified and studied with the use of transmission electron microscopy (TEM), electron diffraction analysis (EDX), and electron energy loss spectra (EELS). Among nitrides, trigonal Fe_3N and orthorhombic Fe_2N are present. Carbonitride is trigonal $Fe_9(N_{0.8}C_{0.2})_4$. These mineral phases associate with iron carbide, Fe_7C_3, silicon carbide, SiC, Cr-Mn-Fe and Mn-Fe oxides; the latter may be termed Mn-rich xieite. Our identified finds demonstrate a wide field of natural compositions from pure carbide to pure nitride, with multiple stoichiometries from $M_5(C,N)_3$ to $M_{23}(C,N)_6$ and with M/(C,N) from 1.65 to 3.98. We conclude that the studied iron nitrides and carbonitrides were formed in the lowermost mantle as the result of the infiltration of liquid metal, containing light elements from the outer core into the D″ layer, with the formation of the association: native Fe^0 + iron nitrides, carbides, and transitional compounds + silicon carbide. They indicated that major reservoirs of nitrogen should be expected in the core and in the lowermost mantle, providing some solution to the problem of nitrogen balance in the Earth.

Keywords: Nitride, carbide, nitrogen, lower mantle