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The Iron-Nitrogen-Carbon System at 10 GPa -Implications for deep nitrogen and carbon cycles

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Concentrations of nitrogen, the seventh most abundant element in the solar system, in the different reservoirs of the Earth are intensely debated. Even though Earth's atmosphere consists of about 78% N, it is depleted on Earth by one order of magnitude relative to other volatiles, like carbon, water and most noble gases [1]. Besides the potential sequestration of N into the core and its degassing during accretion processes [2,3], N could also reside in lower mantle reservoirs. According to experimental studies, Earth's mantle is likely to be saturated in metallic iron as a result of the decreasing oxygen fugacity (fO_2) with depth [4,5]. Evidence for Fe-N species in the reduced mantle are inclusions of Fe_2N, Fe_3N, Fe_7C_3 and $Fe_9(N_{0.8}\ C_{0.2})_4$ in deep-mantle diamonds from Rio Soriso, Brazil [6].

In order to understand the deep nitrogen cycle and the formation of deep diamond inclusions, we studied the Fe-N-C-(Ni) system experimentally at 10 GPa and 1000-1400 °C using a walker-type multi-anvil press. We developed a method to measure N and C by electron microprobe analysis (EMPA) using metals, synthesized carbides and nitrides as standards. We aim to compare C/N derived by EMPA with transmission electron microscopy-electron energy loss spectrometry (TEM-EELS) results. Furthermore, we aim to investigate the crystallography of synthesized nitrides by TEM diffraction methods. Preliminary data shows, that subsolidus Fe-nitrides, carbonitrides and carbides are stable under ambient deep mantle fO_2 conditions around the iron-wustite equilibrium. Melting temperatures in the Fe-N-C system at 10 GPa are
<1250 °C and thus significantly lower than the ambient mantle temperatures. This implies that inclusions in deep diamonds were either trapped as melts and recrystallized later, or that they were included as solids and are perhaps related to fluid and N-rich cold subduction processes.

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