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Ammonia synthesis in serpentinization on the early Earth

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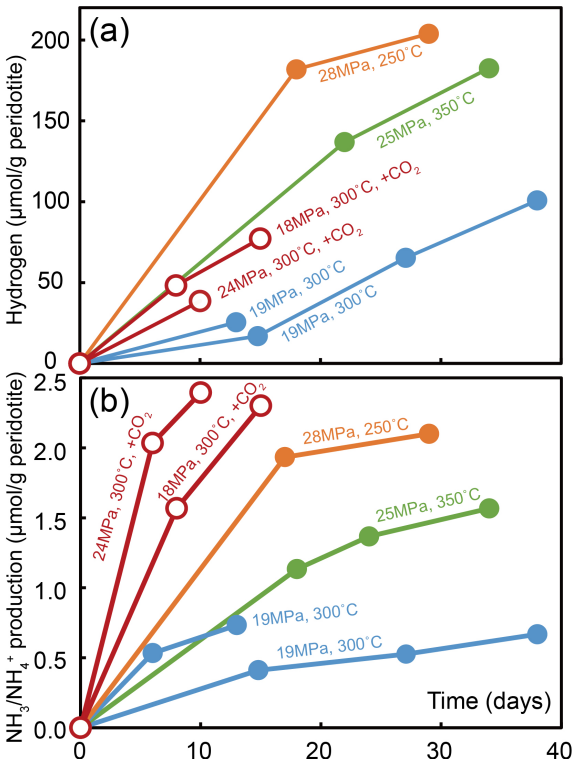

Nitrogen is an indispensable element for life. The atmosphere and mantle are two of the most essential N budgets since early Earth. However, due to the inert chemical properties of atmospheric N_2, N cannot be easily converted to other N-species, such as NH_3, through abiotic reactions. Thus, prebiotic reactions like Miller-Urey experiments lack available N on early Earth(Miller, 1953). Here, we use hydrothermal experiments on the "peridotite-H_2O-N_2(-CO_2)" system to prove N reduction and NH_3 formation in serpentinization, which may provide sufficient NH_3 as fuel for the origin of life(Shang et al., 2023). Serpentinization widely occurs between Fe-containing minerals and H_2O, which produces H_2 by oxidizing Fe^{2+}. Then, H_2 reacts with N_2 under hydrothermal conditions to synthesize NH_3(Figure 1). The addition of CO_2 accelerates serpentinization rates and NH_3 yields. Our experiment indicates that atmospheric N_2 can be fixated as NH_3 through serpentinization in a CO_2-N_2 atmosphere, and its N fixation efficiency is at least 3 orders of magnitude faster than other known pathways. Due to its powerful N fixation potential, NH_3 formation in serpentinization may drive the N cycle on early Earth, such as synthesizing N-organic matters, atmospheric evolution, and deep N cycle.

References

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