Two distinct nitrogen sources for microbial activities in the 2.0 Ga Zaonega Formation

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Stepwise combustion method was applied to the samples from 2.0 Ga Zaonega Formation (ZF), NW Russia to understand the compound-specific nitrogen release profiles and nitrogen isotope compositions ($\delta^{15}N$). Bulk rock graywacke and black shale samples were combusted at temperature range from 500 ^oC to 1200 ^oC at 50 ^oC steps, to separate components released at different temperatures. In the graywacke sample, the amounts of released nitrogen and $\delta^{15}N$ values showed bimodal pattern, indicating two nitrogen components with $\delta^{15}N$ values of 0‰ (component N-C1) and +12‰ (component N-C2). The N-C1 correlates with ^{40}Ar released amounts, indicating that the 0‰ nitrogen was hosted in clay minerals, or organic matter having similar combustion profile with caly minerals. On the other hand, the N-C2 had no correlation with ^{40}Ar. This suggests that the N-C2 was not related to the clay minerals, but from other carrier, possibly an organic matter. The $\delta^{15}N$ of +12‰ is among the heaviest value reported from the ZF, indicating that biological nitrogen cycle under oxic condition. Similar nitrogen isotope profiles were also observed in the black shale sample.

The source of nitrogen (ammonium) hosted by the clay minerals is unknown. Although maturing organic matter would release ammonium that can substitute for potassium and be trapped in recrystallizing clay minerals, it appears unlikely that the $\delta^{15}N$ of 0‰ can derived from the +12‰ nitrogen in the organic matter. Regardless the N-C1 source, it had distinctly different from N-C2 source.

Our result suggests the existence of shallow oxic ecosystem during accumulation of the 2.0 Ga ZF. It is possible that other type of ecosystem, which may have utilized a different nutrient source, was presented near the sediment/water interface. Both ecosystems co-existed in the same sedimentary basin. This study further suggests that not only carbon but also nitrogen cycle was more complicated that thought in previous studies for the Paleoproterozoic era.