# Heterogeneity in nitrogen source for microbial activity recorded in 2.0 Ga Zaonega Formation, NW Russia

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We performed stepwise combustion method on the samples from 2.0 Ga Zaonega Formation (ZF), NW Russia to understand the heterogeneity in nitrogen in the sedimentary rocks via nitrogen release profiles and nitrogen isotope compositions ( $\delta^{15}$N). Bulk rocks of graywacke and black shale samples, representing shallow and deep sedimentary environments, were chosen for the analysis, and were combusted at temperature range from 500 °C to 800 °C at 50 °C steps, and 1200°C, to separate components released at different temperatures. As a result, both samples showed similar trend. 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 1) and +12‰ (component 2). Nitrogen release amounts of component 1 correlated with $^{40}$Ar released amounts, indicating that the 0‰ nitrogen was hosted in clay minerals, or organic matter having similar combustion profile with clay mineral. On the other hand, the component 2 had no correlation with $^{40}$Ar. This suggests that the component 2 was not related to the clay minerals, but from other carrier, possibly an organic matter. The $\delta^{15}$N of +12‰ is one of the heaviest values reported from the ZF, indicating that biological nitrogen cycle under oxic condition.
The origin of ammonium-nitrogen, hosted by the clay minerals, is unknown. Although maturation of organic matter would release ammonium ion that can substitute for potassium and be trapped in clay minerals, it is unlikely that the $\delta^{15}$N of 0‰ could produce from the +12‰ nitrogen in the organic matter. Thus, regardless the nitrogen source of component 1, it was distinctly different from that of component 2. Our result suggests that the shallow oxic ecosystem was existed during accumulation of the 2.0 Ga ZF, while 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, which is consistent with those of predicted by the previous study in the same core sample. This study further suggests that not only carbon but also nitrogen cycle was more complicated that thought in previous studies for the Paleoproterozoic era.

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