LATE ARCHEAN GAS FROM HYDROGEN BIODEGRADATION OF ORGANIC MATTER

Y. Gao 1, X. Xia 2
1. University of Texas at San Antonio, San Antonio, Texas, USA
2. Apache Corporation, San Antonio, Texas, USA

Introduction

Hydrocarbon-rich gases in Archean rocks were discovered in the Canadian, South African and Scandinavian shields, and they have been regarded as abiotically generated due to their unique isotopic pattern (a broad δD variation accompanied by a narrow δ13C one between alkanes) along with the coexistence of intrusive igneous rocks and serpentinization (Sherwood Lollar et al., 2002, 2008). Because elementary chemical reaction steps accounting for the isotope pattern are unclear, this interpretation is empirical and unconvincing. On the other hand, evidence of microbial activities, such as mRNA and lipids have been discovered in these rocks (Ventura et al., 2007; Edwards et al., 2012). In this work, we provide a new interpretation on the isotope signature of these gases and suggest that they are formed by Archean microbial activities.

Results and discussion

The asynchronous hydrogen and carbon isotopic fractionations in the Archean gases suggest that the hydrogen atoms have two sources with remarkably different δD values. We propose a hydrogen biodegradation reaction to explain this isotopic signature: the alkanes are formed by hydrogenolysis of long C-C chains in organic matter, and Archean microbes could obtain chemical energy in the H2 substrate generated by the reaction. In each produced alkane molecule (CH4 through n-C6H10), two hydrogen atoms are from the serpentinization derived H2 with remarkably depleted deuterium, while the rest hydrogen atoms are inherited from organic matter with normal δD. This mechanism successfully quantifies the isotope variation among the alkanes.

In recent years, more and more microbial organisms have been discovered in deep subsurface biosphere in both marine and continental realms (Edwards et al., 2012). In Oman hyperalkaline peridotite aquifers, abundant aerobic and anaerobic organisms were identified based on 16s rRNA data of DNA extracted from fluid microbial communities (Miller et al., 2016). However, the debate on abiotic or biotic origin of alkanes continued in the past few years (Etiope, 2017; Miller et al., 2017). Our interpretation on isotope data provides direct evidence of biogenic origin, which bridges the gap between microbial activity and the coexistence of alkanes.

Conclusions

Late Archean microbes may have obtained chemical energy stored in hydrogen gas through degradation on organic matter in the oxygen-deficient environment. Analysis on hydrogen isotope data of late Archean gas revealed that the alkane gas is a product from hydrogen biodegradation and bridge the gap between microbial activity and the hydrocarbon products. This is a newly recognized geochemical pathway converting organic matter in sediments to alkane gas, which might be a significant step in the carbon cycle of the late Archean Eon.
References