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New estimates of global CH_4 and C_2H_6 production in the Precambrian crust

Chelsea N. Sutcliffe (1), Georges Lacrampe-Couloume (1), Chris J. Ballentine (2), and Barbara Sherwood Lollar (1)

(1) Department of Earth Sciences, University of Toronto, Toronto, Canada, (2) Department of Earth Sciences, University of Oxford, Oxford, United Kingdom

Saline fracture fluids found deep within the Precambrian shield possess isotopic and geochemical signatures consistent with prolonged water rock interaction. Noble gas-derived residence times of these fluids, on the order of millions to billions of years, highlight their significance as an ancient deep hydrosphere (Lippmann-Pipke et al., 2011; Holland et al., 2013). With mM concentrations of dissolved gases such as H_2 and hydrocarbons, these fracture fluids are energy rich and capable of sustaining microbial communities of H_2-utilizing methanogens and sulphate reducers (Lin et al., 2006). Globally, Precambrian rocks constitute over 70% of the volume of the continental crust (Goodwin, 1996) and represent a substantial under-investigated source of such dissolved gases. Recent calculations of global H_2 production from these Precambrian Shield rocks, including both hydration reactions and radiolysis, doubles previous estimates to an increased rate of 0.4-2.3 x 10^{11} mol/yr (Sherwood Lollar et al., 2014). This has important consequences for hydrocarbon production, reflected in the high abundance of CH_4 and C_2H_6 in dissolved fracture gases, up to 80 and 10 vol %, respectively. Given the long residence times of these fluids, hydrocarbon production could have persisted on geological timescales. To date, production from this source has not been incorporated into models of evolution of the early atmosphere. Additionally, the quantification of abiotic sources of methane and ethane in the analogous terrestrial Precambrian crust could contribute to our understanding of the origin of the episodic traces of methane recently detected on Mars (Webster et al., 2014). Investigating the origin of these gases has important implications for the global carbon cycle, as well as the distribution of life in the terrestrial deep subsurface and on other planets.

We examine the isotopic evolution of these fracture fluids in the Canadian Shield and provide the first attempts to estimate methane and ethane production potential. We base these calculations on observed dissolved gas abundances in deep fracture fluids within the Canadian Shield combined with the new H_2 production estimates. Together, these previously unrecognized additions of methane and ethane could have important consequences for Archean climate models relating to the Faint Young Sun paradox and contribute, in part, to a missing greenhouse component.

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