methane greenhouse?

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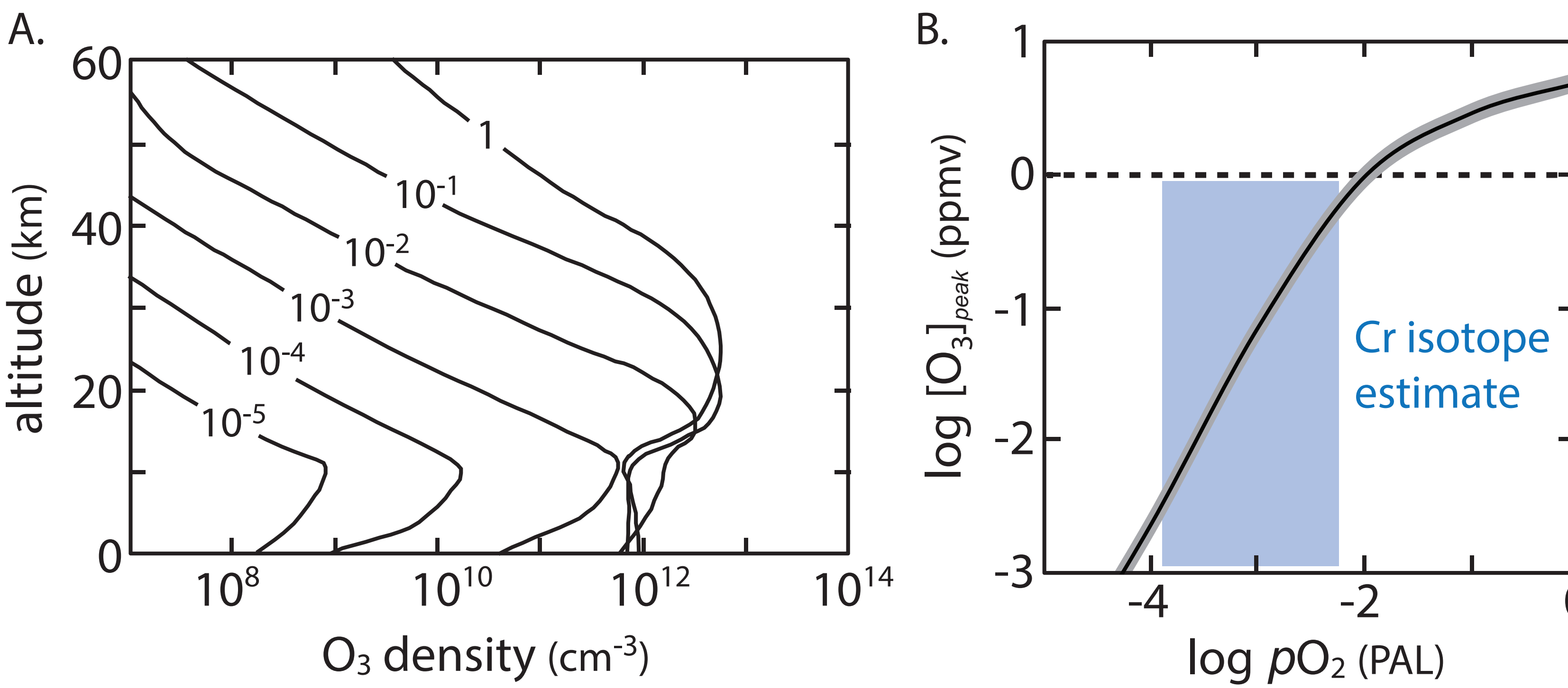
oxygen (O_2) & ozone (O_3)

less O_2 = less O_3

O_3 is abiotically produced from O_2 in the atmosphere

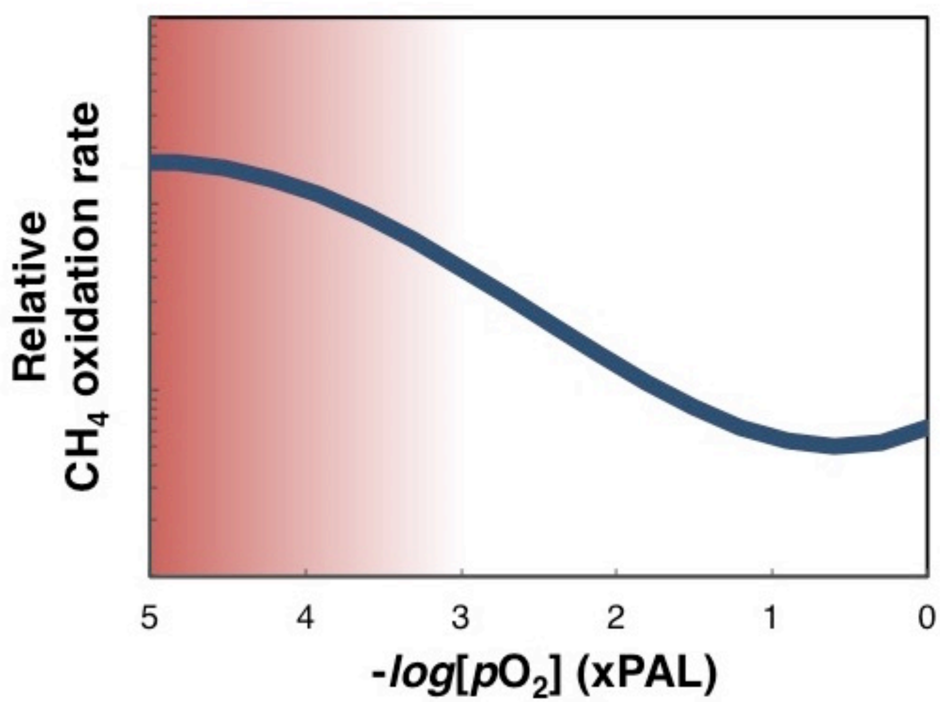


*after Kasting & Donahue [1980]

Reinhard, Olson, Lyons, Kasting [*In prep*]

oxygen (O_2) & methane (CH_4)

Ozone protects CH_4 (and other biosignature gases)



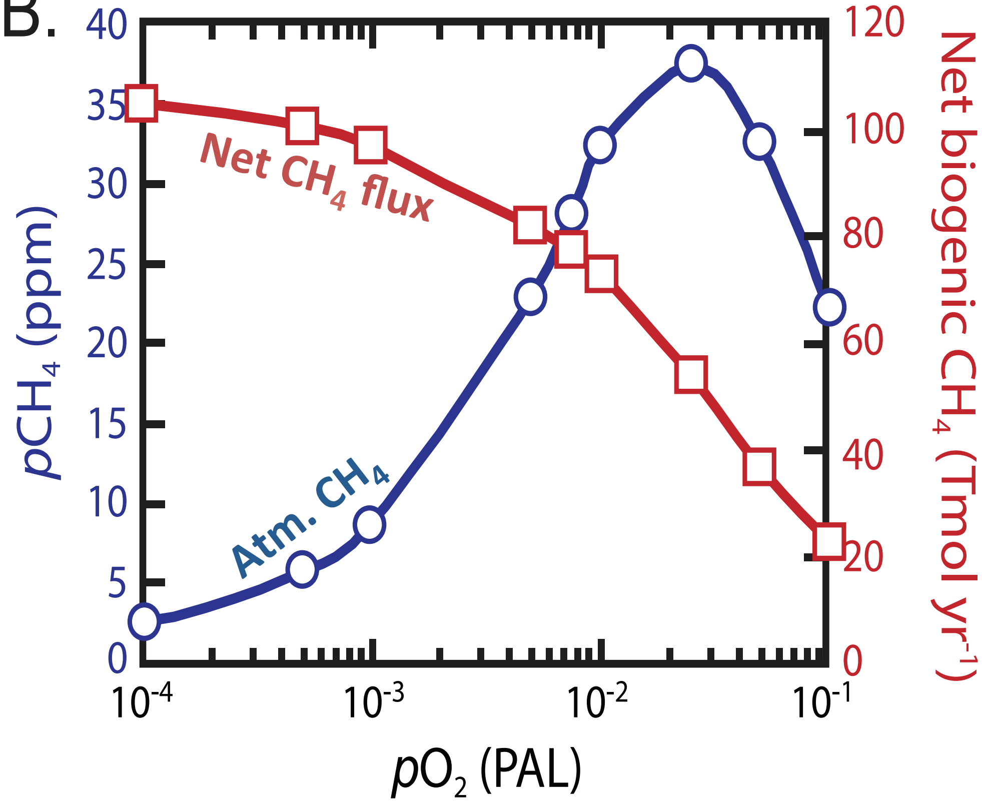
*after Goldblatt et al. [2006]

- CH_4 destruction is muted when O_3 layer is well developed.
- Proterozoic atmosphere was **more oxidizing** toward CH_4 than the present O_2 rich atmosphere

oxygen (O_2) & methane (CH_4)

CH_4 production declines with O_2—but ozone favors CH_4 accumulation

B.

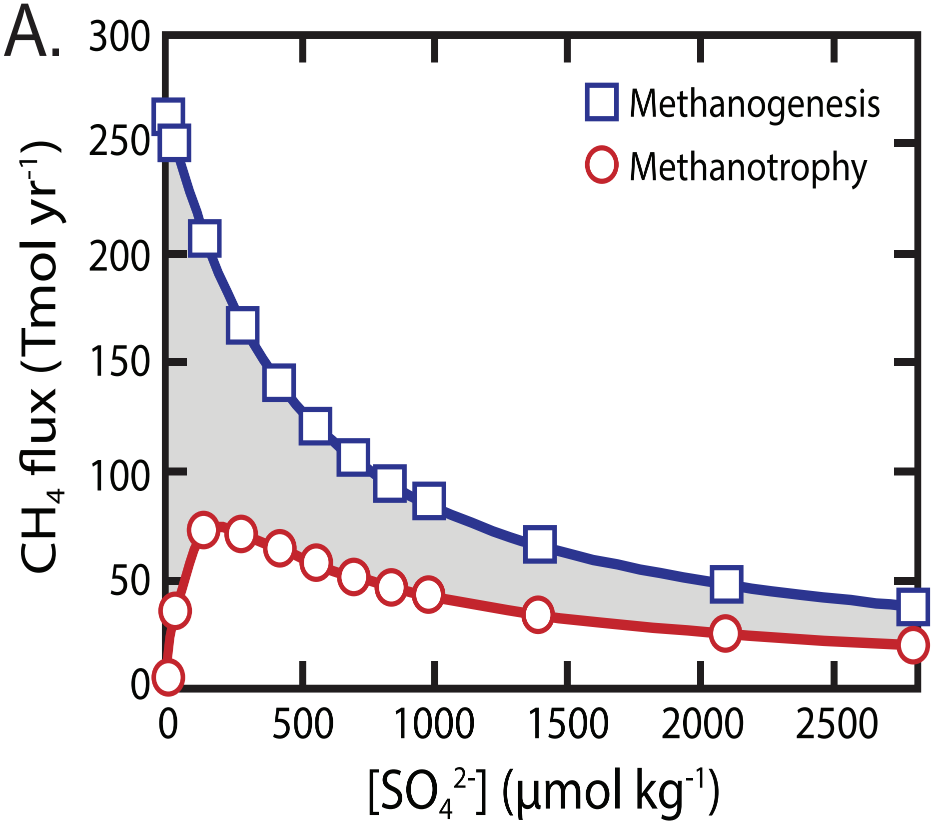


- Maximum pCH_4 occurs for peak preservation—not peak production.
- **Elevated pCH_4 requires relatively high pO_2 (O_3).**

sulfate (SO_4) & methane (CH_4)

Oceanic SO_4 is the primary control on biogenic CH_4 fluxes

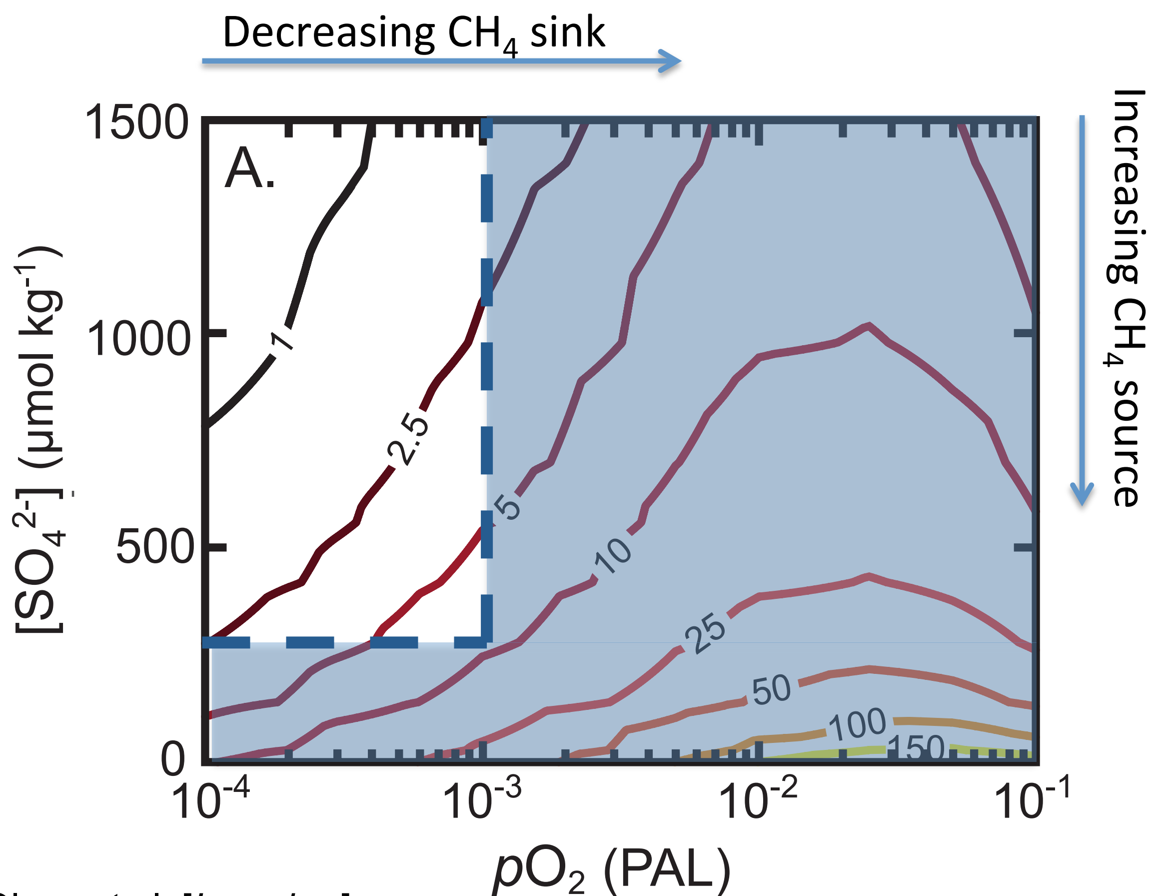
A.



- Both CH_4 production and CH_4 preservation are disfavored by SO_4
- **Substantial CH_4 supply to the atmosphere requires exceptionally low SO_4 concentrations**

methane (CH_4)

mid-Proterozoic *p*CH_4 was probably similar to today

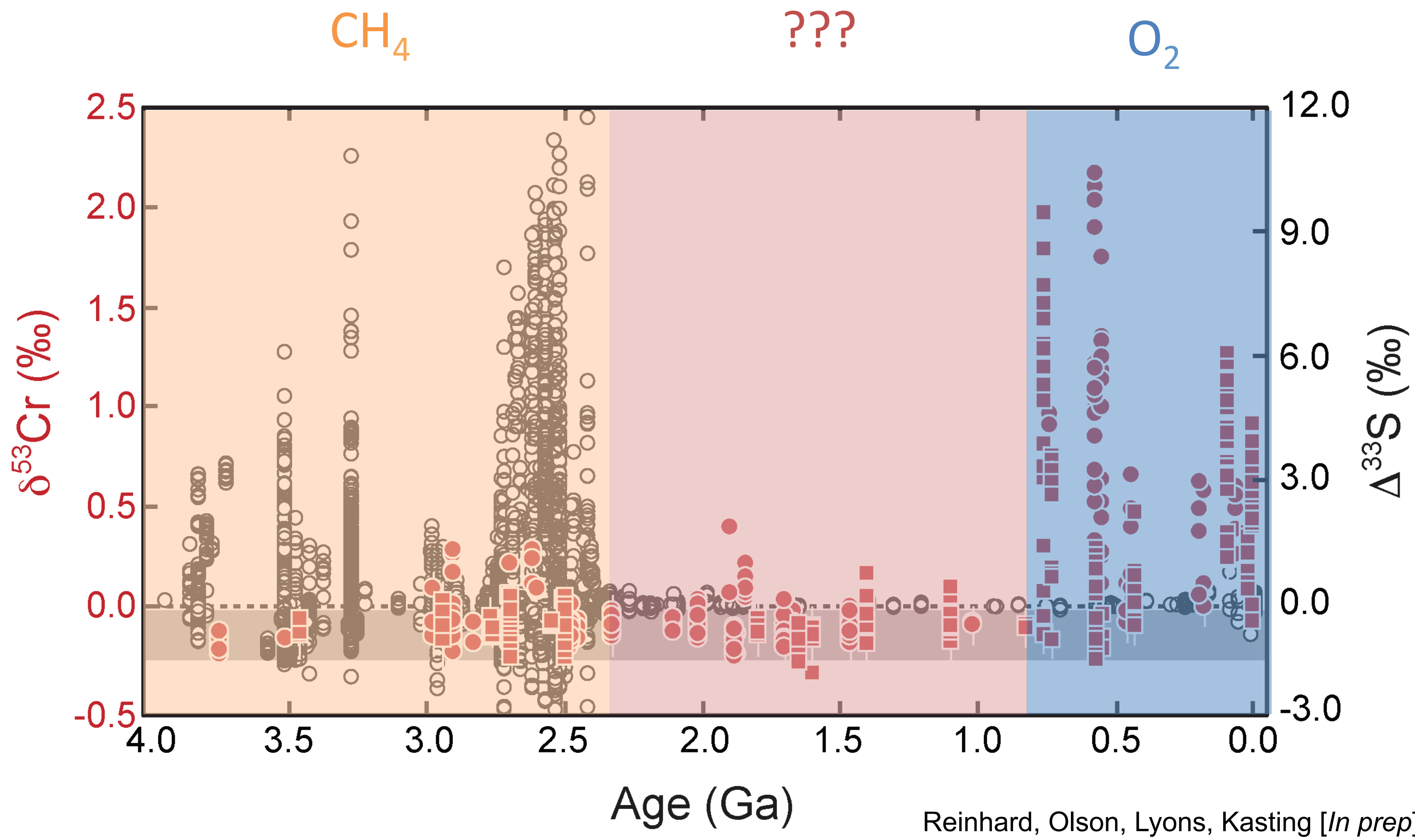


Olson et al. [*In review*]

- The composition of the Proterozoic greenhouse remains unknown.

- **CH_4 is not a viable biosignature for the second half of Earth history**

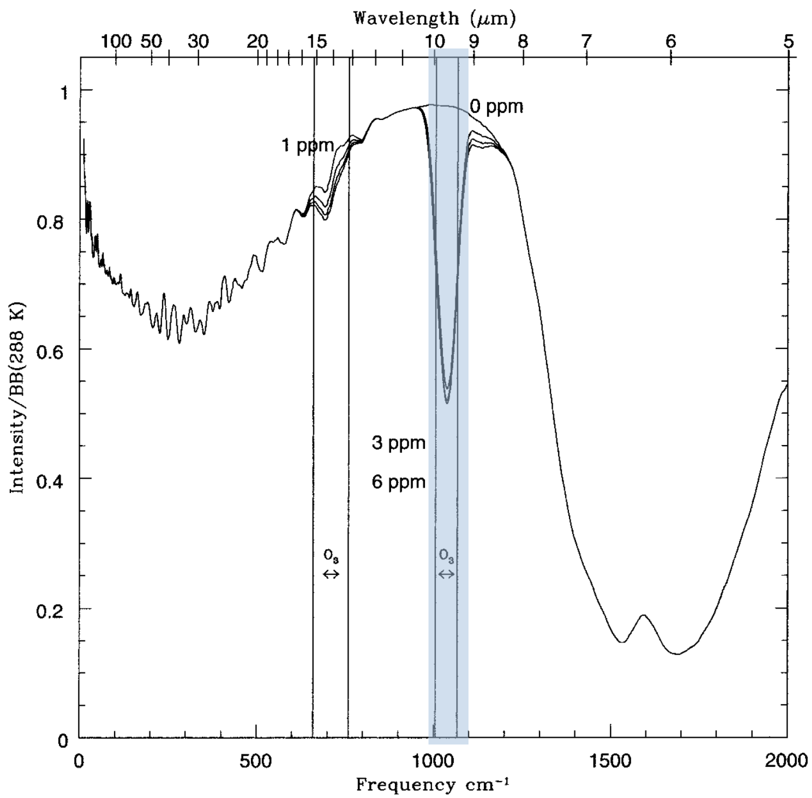
biosignature gases through time



Reinhard, Olson, Lyons, Kasting [*In prep*]

ozone (O_3)

O_3 (abiotic) can be a proxy for trace biogenic O_2



Des Marais et al. [2002]

- O_3 has strong absorption features
- At the upper range of reconstructed mid-Proterozoic pO_2 values detection of O_3 may be possible
- **O_3 (abiotic) vulnerable to false positives**