



# **Methane on Mars: Arctic Methanogenesis Analogs**

**Measurement Challenges:  
Sub-surface aquifers**

**Methanogenesis/Methanotrophy metabolites**

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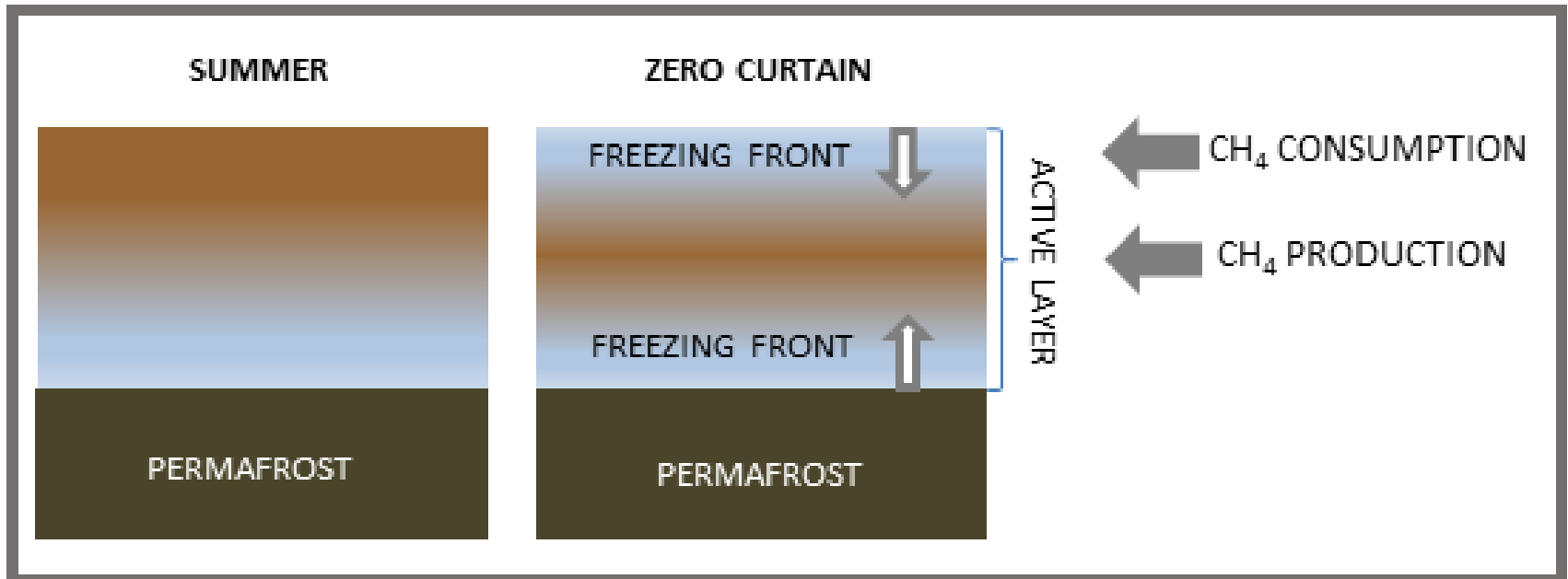


# Year-round Measurements of CH<sub>4</sub> Fluxes On North Slope Alaska



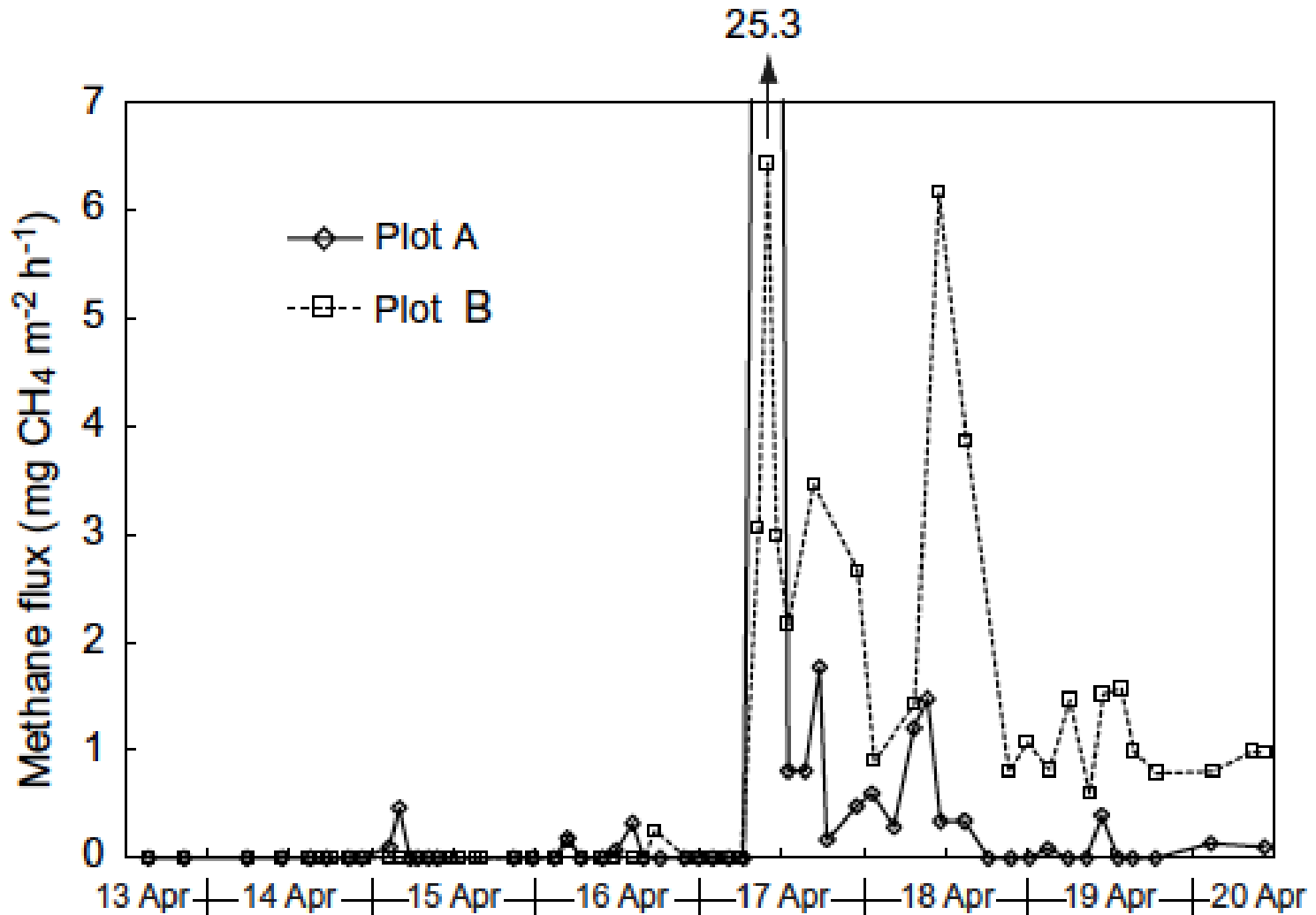
Oechel et al. JGR 2014

# Approximately 50% of North Slope Alaska Methane Emissions Occur During the Cold Season



- Methanogenesis persists well into the cold season as long as unfrozen water is available
- The 'zero curtain' period is as long or longer than the growing season

# Arctic Spring CH<sub>4</sub> Bursts Occur with Surface Thaw



*Tokida et al., Chemosphere (2007)*

- At the very moment the surface ice cover thawed, a large CH<sub>4</sub> flush was observed, similar in magnitude to that observed in the high summer

# Microbial characterization of a subzero, hypersaline methane seep in the Canadian High Arctic

**Niederberger et al., ISME 4, 1326 (2010)**

- Microbiological characterization of a terrestrial methane seep in a an Arctic hypersaline (~24% salinity), subzero (-5 C), perennial spring, arising through thick permafrost in an area with an average annual air temperature of -15 C
- This hypersaline, subzero environment supports a viable microbial community capable of activity at in situ temperature and where methane may behave as an energy and carbon source for sustaining anaerobic oxidation of methane-based microbial metabolism.
- This site also provides a model of how a methane seep can form in a cryoenvironment as well as a mechanism for the hypothesized Martian methane plumes.

# Permafrost Microbiology

Rivkina

- Biogenic methane is performed by a specific group of strictly anaerobic methanogenic archaea (FEMS 2007)
- Number of organisms in permafrost –
  - Total population = up to  $10^8$  cells/g,
  - Viable cells =  $10^2$  –  $10^6$  cells/g
- Methane formation may occur in frozen Holocene deposits down to -16.5 C (FEMS 2007)
- Microorganisms can carry out redox reactions after thousands to millions of years existence in permafrost (Adv Space Sci, 2004)

Price & Sowers (PNAS 2004):

- There is no evidence of a minimum temperature for metabolism (down to -40 C).
- Microbes in ice and permafrost have metabolic rates similar to those in water, soil, and sediment at the same temperature. This finding supports the view that, far below the freezing point, liquid water inside ice and permafrost is available for metabolism.

# 5 Stages of Alaska Cold Season

*Olsson et al., Arctic Appl Res 35, 74 (2003)*

- Early Snow & Early Cold
  - Soils remain warm, unfrozen water present, highest rates of cold season methanogenesis and respiration
- Deep Cold & Late Cold
  - Frozen active alyer & decreasing soil temperatures
- Thaw
  - Determines the length of the growing season, resumption of