

# **Gas Hydrate as Part of the Petroleum System of Mars\***

**Art Johnson<sup>1</sup>, Michael Max<sup>1</sup>, and Stephen Clifford<sup>2</sup>**

Search and Discovery Article #40990 (2012)\*\*

Posted August 13, 2012

\*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

\*\*AAPG©2012 Serial rights given by author. For all other rights contact author directly.

<sup>1</sup>Hydrate Energy Int'l, Kenner, LA ([artjohnson51@hotmail.com](mailto:artjohnson51@hotmail.com))

<sup>2</sup>Lunar and Planetary Institute, Houston, TX

## **Abstract**

The recent detection of plumes of seasonal methane venting into the Martian atmosphere indicates the likely presence of a significant subjacent gas resource. The venting of methane requires a deep, long-term source that, whether originating from biogenic or abiogenic processes, appears to require the existence of an aqueous environment at depth. This methane may reside within and beneath the Martian cryosphere as natural gas hydrate within the hydrate stability zone. Shallower deposits may be easily accessible from the surface. An accessible natural gas hydrate resource would provide the basis for the production of high-density liquid fuels and serve as a chemical industry feedstock for constructing facilities and products from local Martian resources. A resource-rich Mars, based on indigenous methane hydrate, water, CO<sub>2</sub>, and minable minerals, would make Mars and its moons an ideal base for the exploration of the outer solar system.

## **Selected Reference**

Clifford, S.M., J. Lasue, E. Heggy, J. Boisson, P. McGovern, and M.D. Max, 2009, Depth of the Martian cyrosphere: Revised estimates and implications for the existence and detection of subpermafrost groundwater: *Journal of Geophysical Research*, v. 115, E7, 17 p.

# Gas Hydrate as Part of the Petroleum System of Mars

Art Johnson, Michael Max  
Hydrate Energy International

Stephen Clifford  
Lunar and Planetary Institute

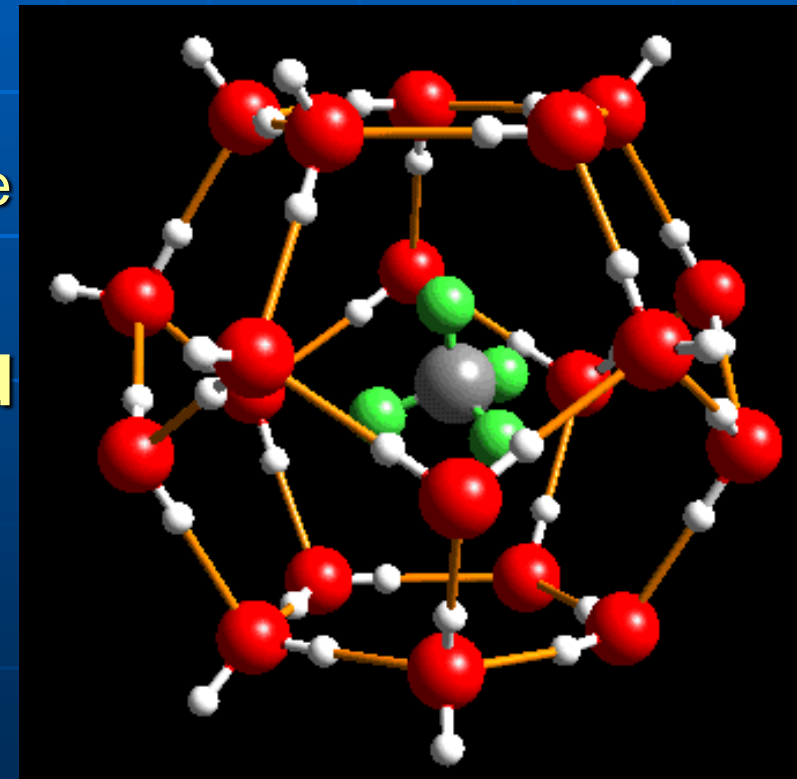
AAPG ACE 2012

[www.hydrate-energy.com](http://www.hydrate-energy.com)

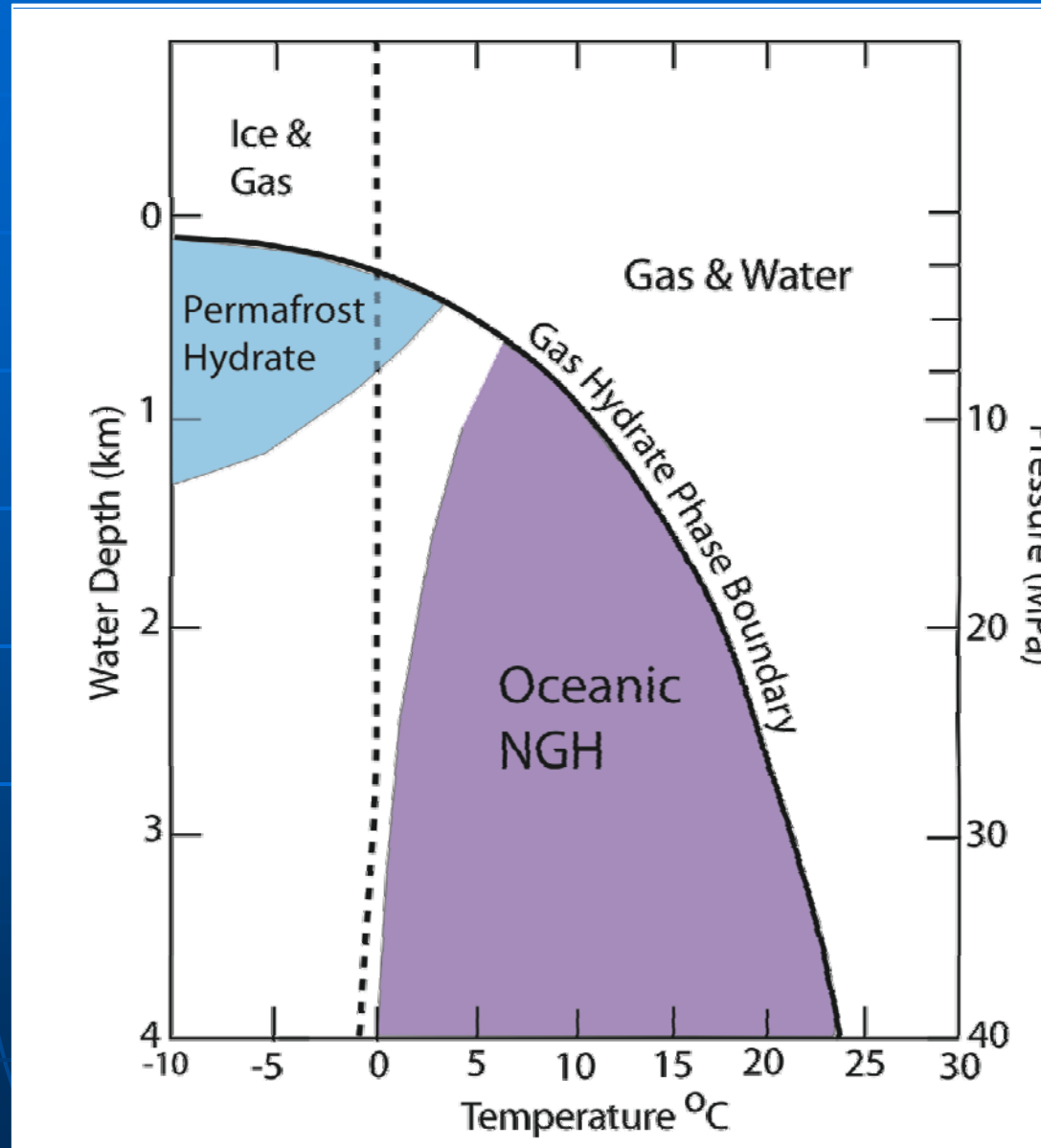
*HEI*

# What is a Gas Hydrate?

- **Crystalline solid consisting of gas molecules, usually methane, each surrounded by a cage of water molecules**
  - One volume hydrate typically equivalent to 160 volumes methane gas
- **Stable at low Temperature and high Pressure**
- **Occur abundantly on Earth**
  - Arctic regions and in marine sediments



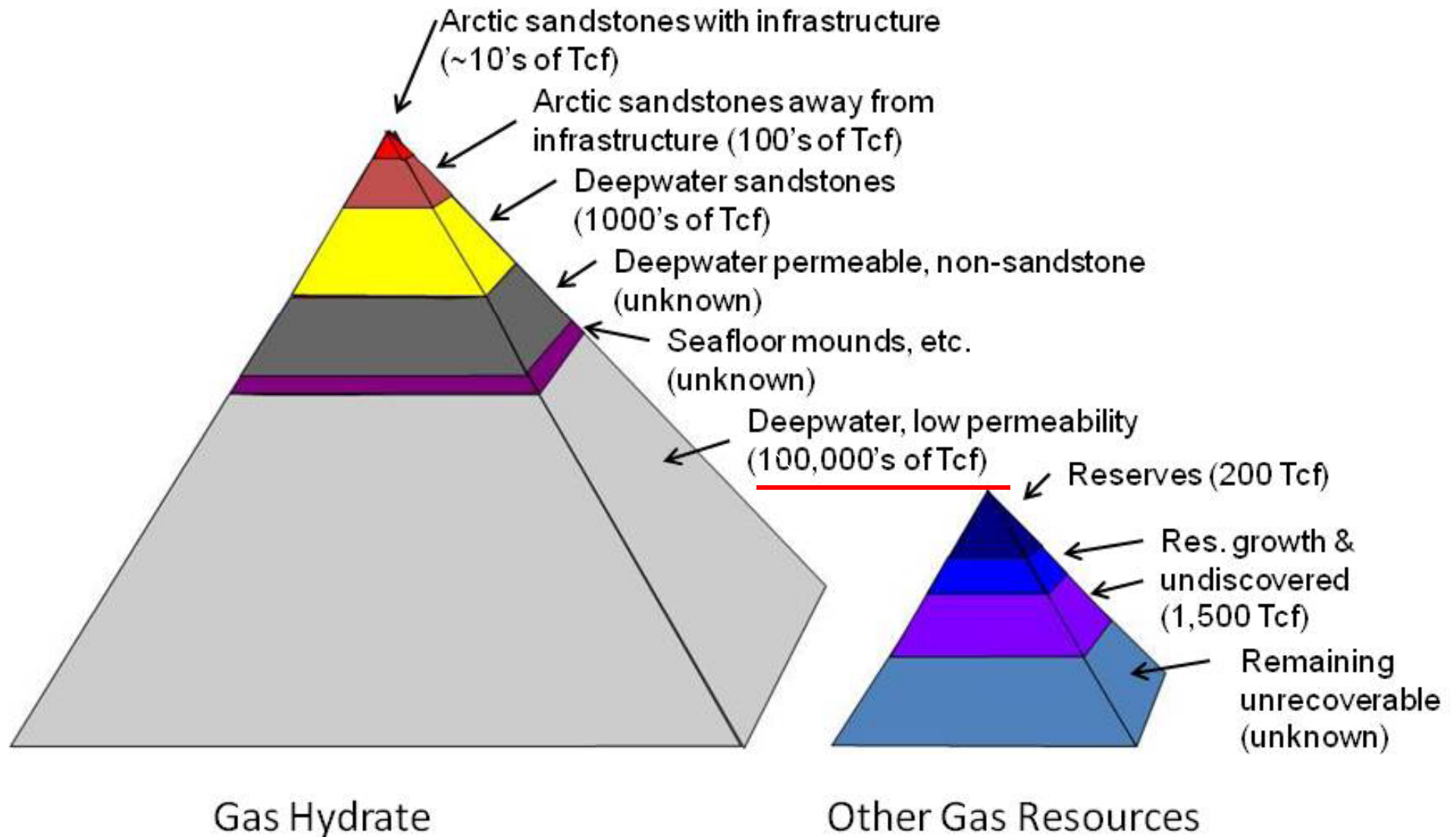
# Methane Hydrate Stability



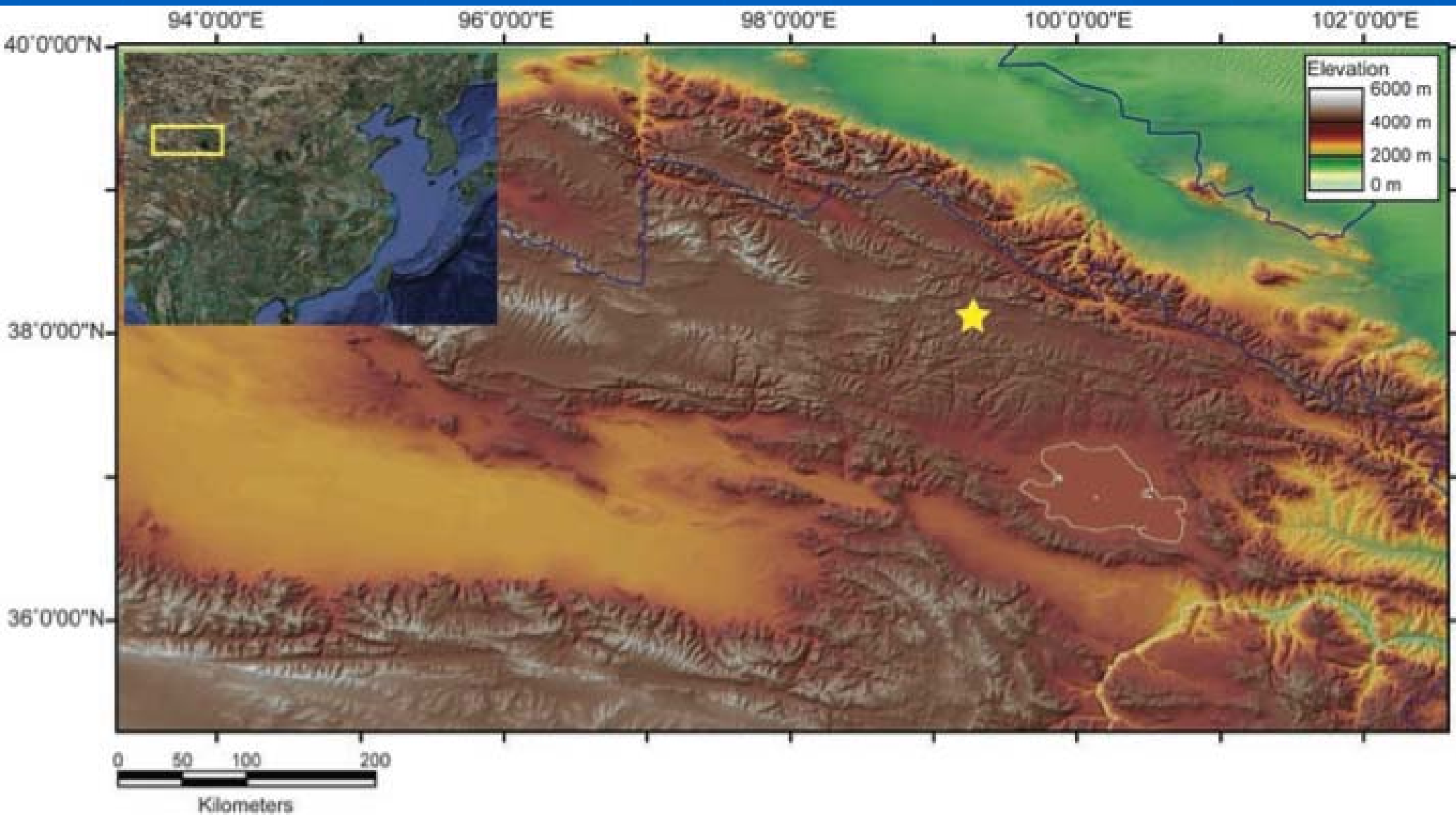
The same phase relationship occurs throughout the Solar System



# U.S. Gas Resource Base



# Tibet





# Key Points from Earth

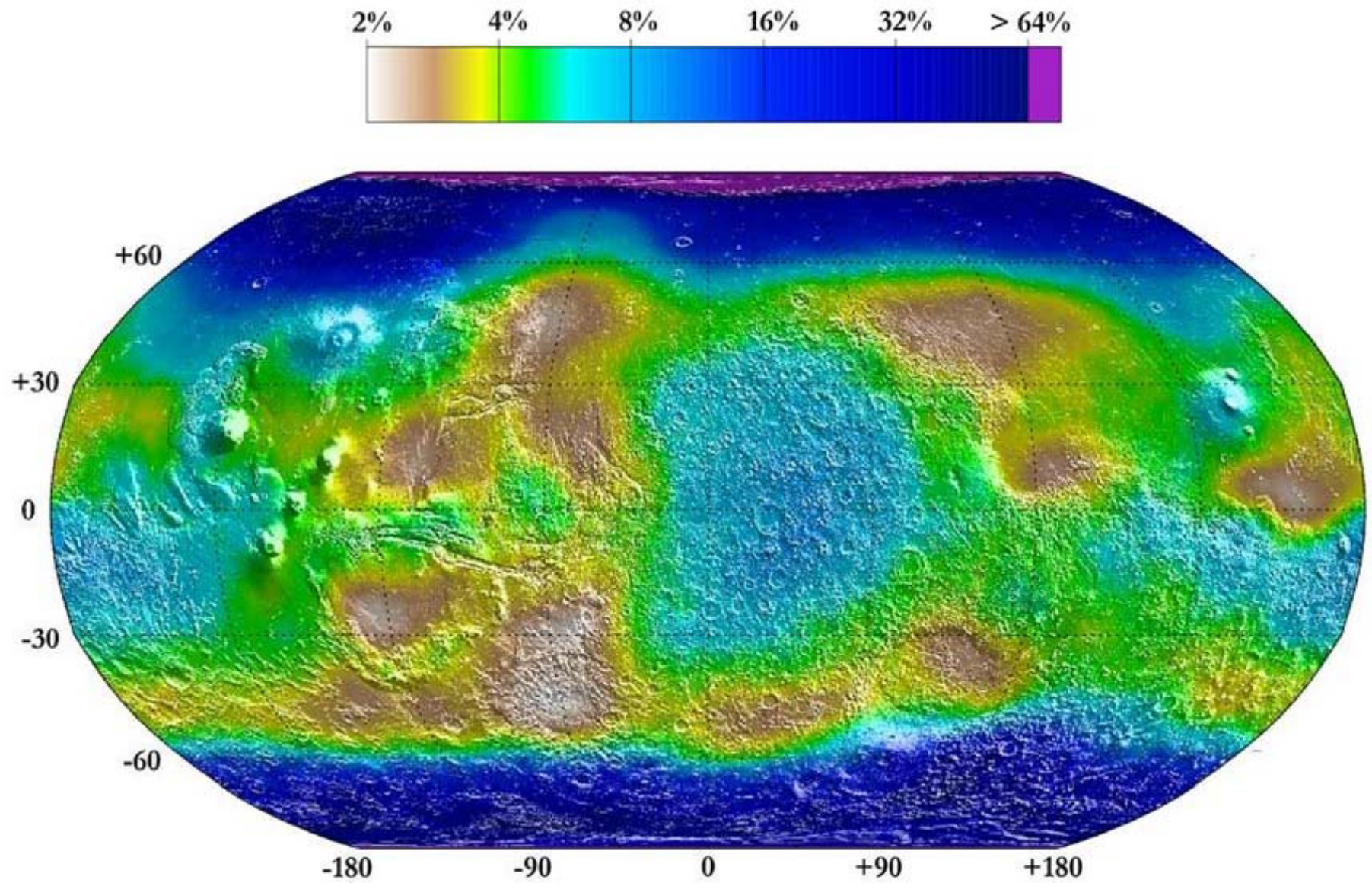
- At appropriate temperatures and pressures, hydrate will form if methane and water are present
- There is a lot of hydrate in shallow sediments (deep water and permafrost)
- Veins hold large amounts of hydrate, even though sands are the commercial target

# Can There Be Hydrate on Mars

- Water?
- Methane?
- Pressure/Temperature?

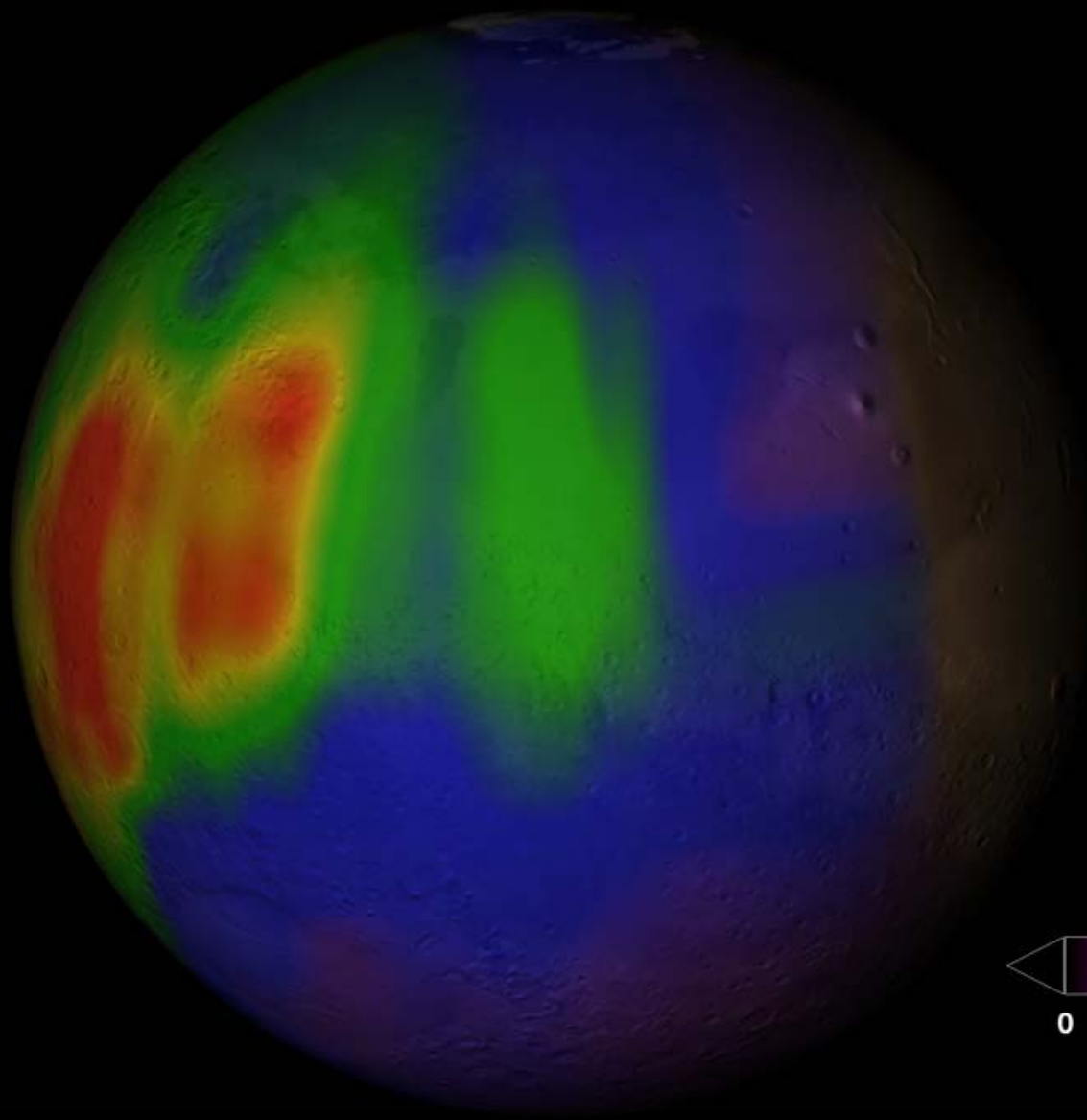


## Lower-Limit of Water Mass Fraction on Mars



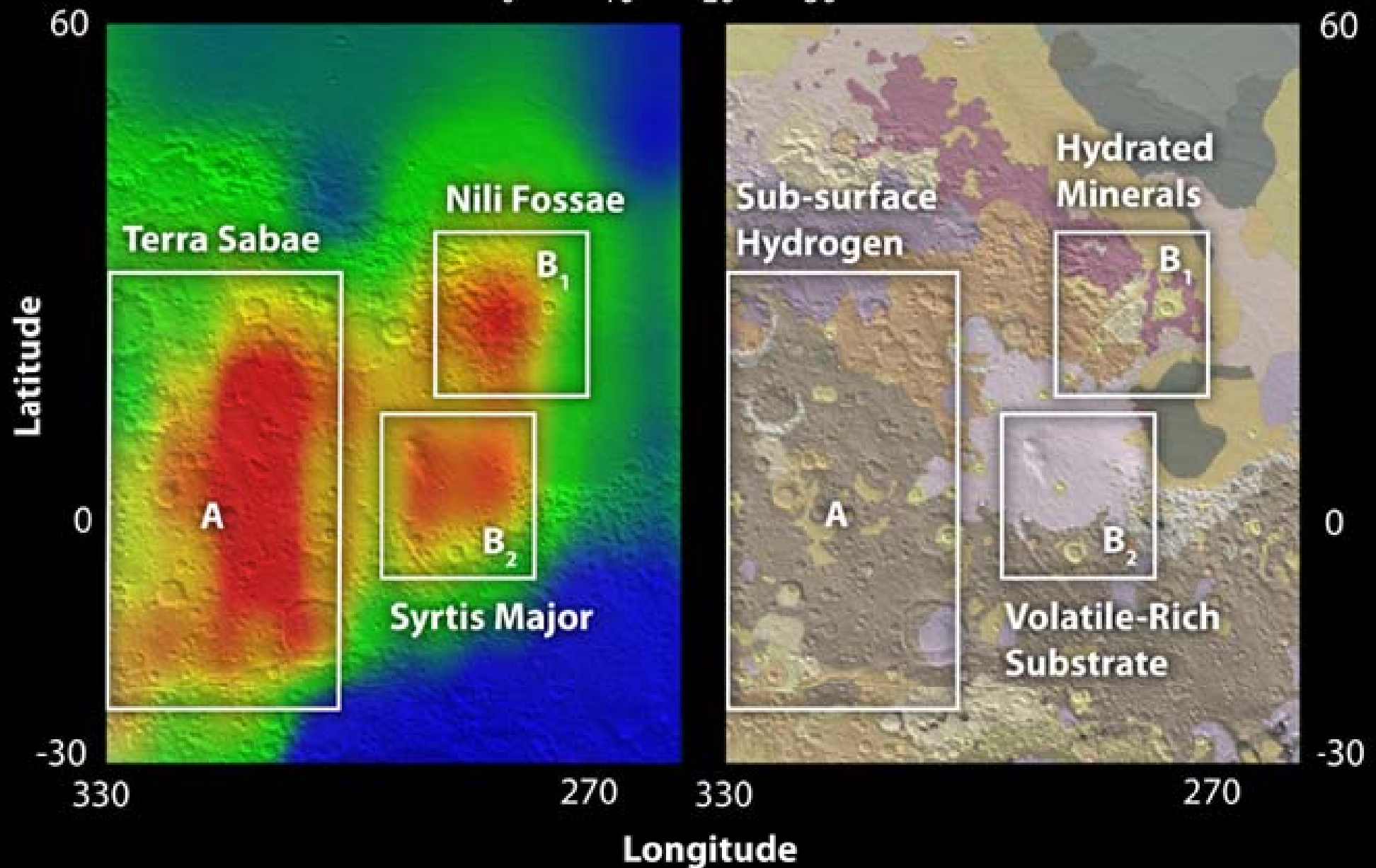
From 2001 Mars Odyssey – Gamma Ray Spectrometer Suite

## Methane release: Northern summer



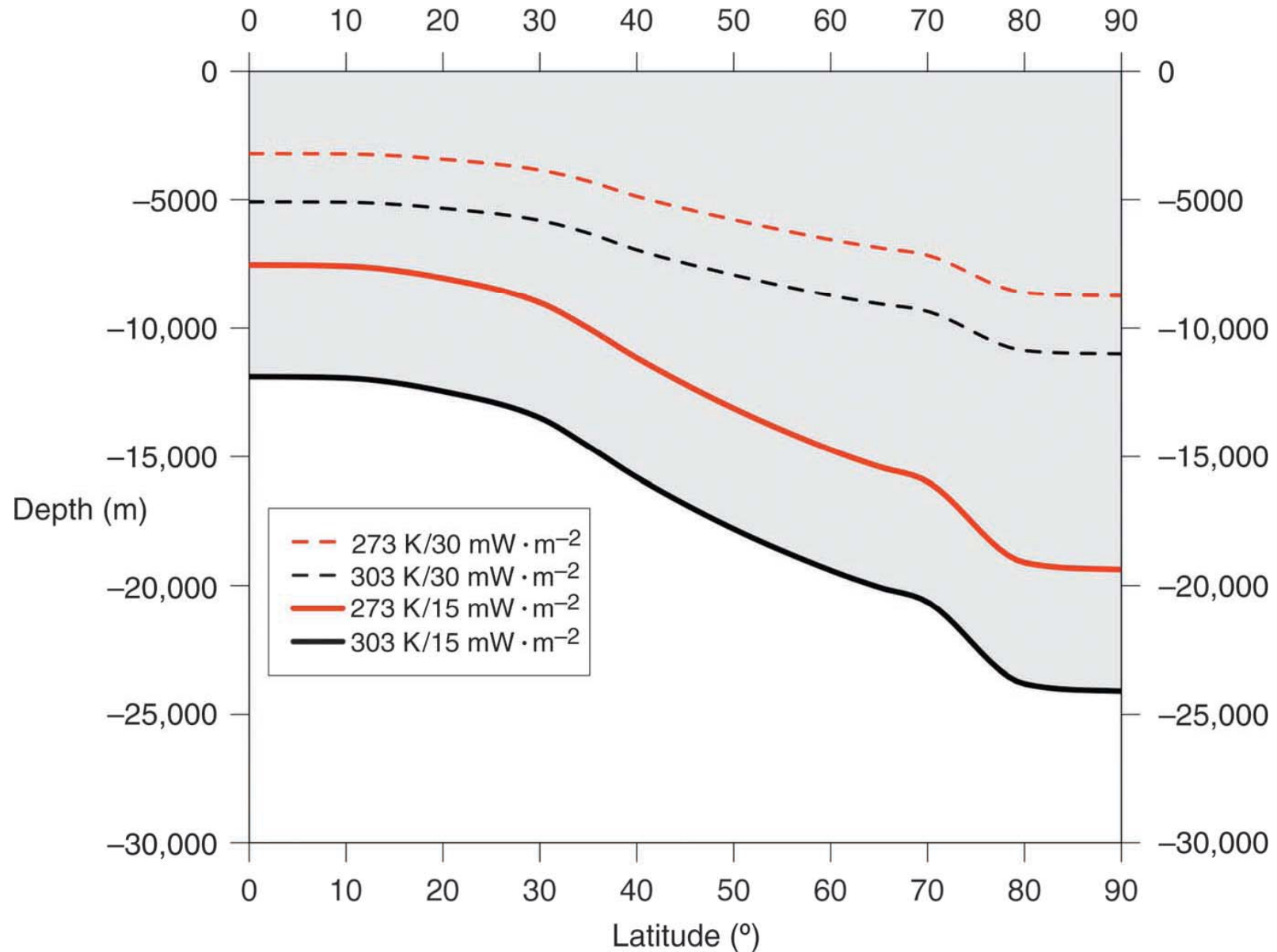
- From high-dispersion infrared spectrometers at three ground-based telescopes
- The principal plume contained ~19,000 metric tons of methane, and the estimated source strength ( $\geq 0.6$  kilogram per second) was comparable to that of the massive hydrocarbon seep at Coal Oil Point in Santa Barbara, California.

Methane abundance [ppb]





# Martian Cryosphere and Hydrate Stability Zone



Red Lines: water-ice cryosphere (e.g. Permafrost)

Black lines: gas hydrate stability zone From Clifford et al. (2009)

# Depth of Hydrate

- Upper boundary of hydrate stability is 15 to 30 meters beneath the Martian surface
- The base of the hydrate stability zone is 5 – 24 kilometers beneath the Martian surface

# A Key points

- Free methane from depth would have to migrate through at least 5 kilometers of section within the hydrate stability zone.
- If any water is present, hydrate will form.

# Is the Observed Methane Venting from Hydrate?

- Released during warmer seasons
- Released from discrete regions
- Hydrate release is a distinct possibility

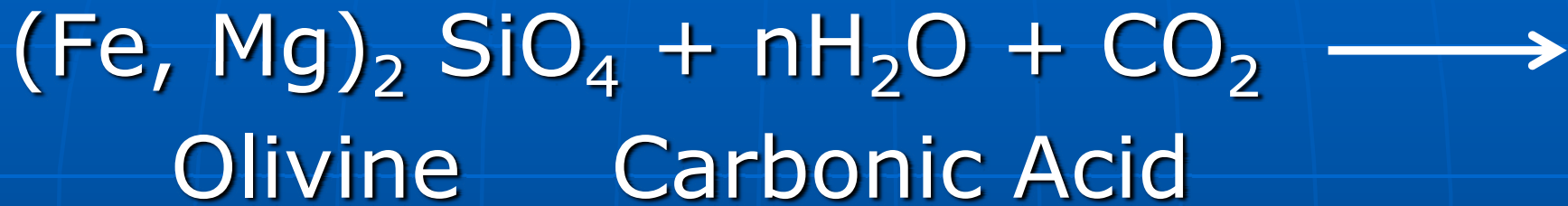
# What is the Origin of the Methane?

- Primordial?
  - Not according to any model

# What is the Origin of the Methane?

- Primordial?
  - Not according to any model
- Inorganic?

# Serpentinization



# Serpentinization

Balancing the Equation:



A lot of olivine to make one molecule of Methane



# What is the Origin of the Methane?

- Primordial?
  - Not according to any model
- Inorganic?
- Organic?

# What is the Origin of the Methane?

- Primordial?
  - Not according to any model
- Inorganic?
- Organic?

A real game changer

# Implications

## ■ Exploration

- Methane hydrate deposits may be easily accessible from the surface by shallow drilling.
- Utilizing the natural resources of Mars makes occupation of Mars logistically possible and will inevitably result in lower costs for supporting human exploration there than if we had to rely on transporting those same resources from Earth.

# Implications

## ■ Exploration

- Methane hydrate deposits may be easily accessible from the surface by shallow drilling.
- Utilizing the natural resources of Mars makes occupation of Mars logistically possible and will inevitably result in lower costs for supporting human exploration there than if we had to rely on transporting those same resources from Earth.

## ■ You wouldn't have to bring everything with you

# Implications

## ■ Launching Pad

- The availability of Martian natural resources may prove to be the critical enabling factor for the continued human exploration of the solar system.

# Implications for Organic Methane

Philosophically, there are two  
fundamental questions for humanity:  
**Where did we come from?**

# Implications for Organic Methane

Philosophically, there are two fundamental questions for humanity:

Where did we come from?

Are we alone?

# Implications for Organic Methane

Philosophically, there are two fundamental questions for humanity:

Where did we come from?

Are we alone?

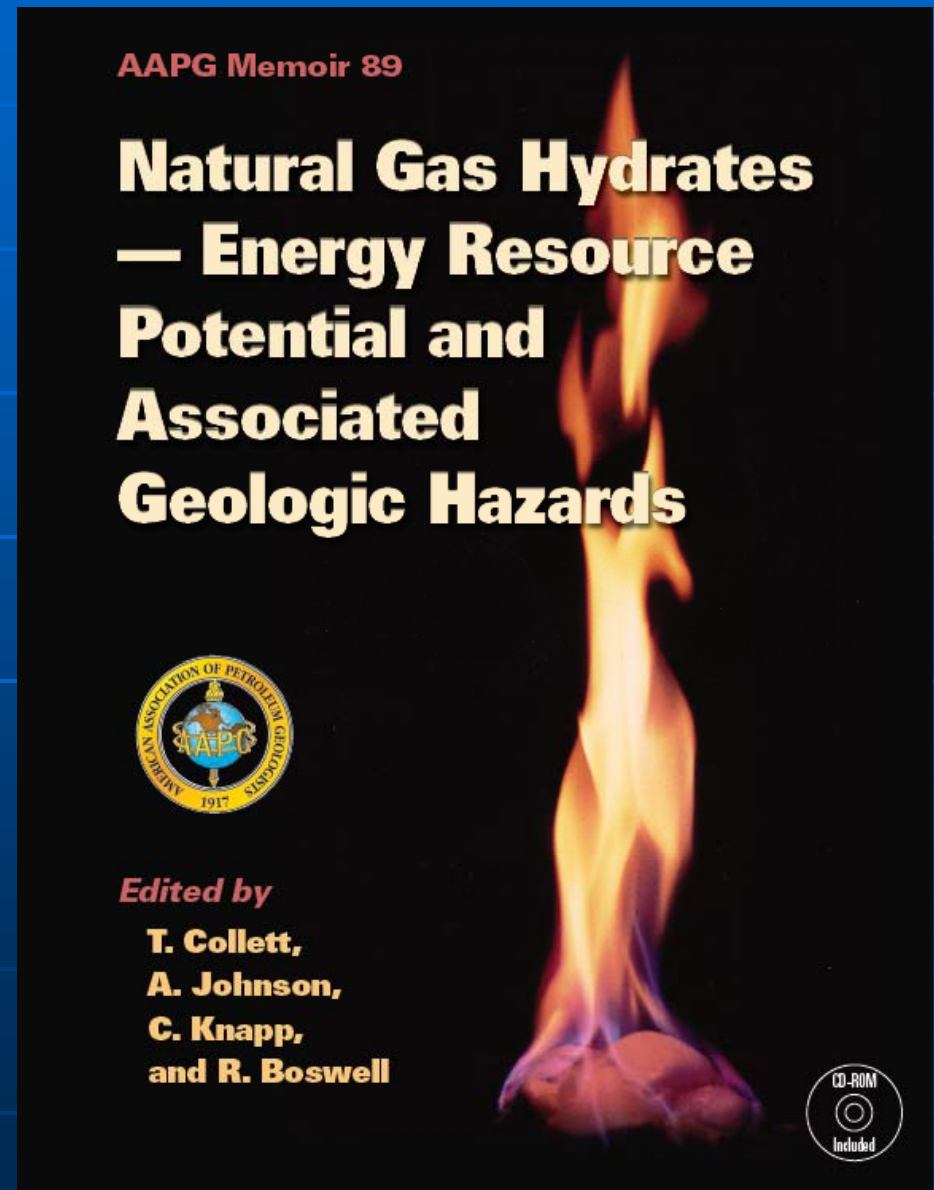
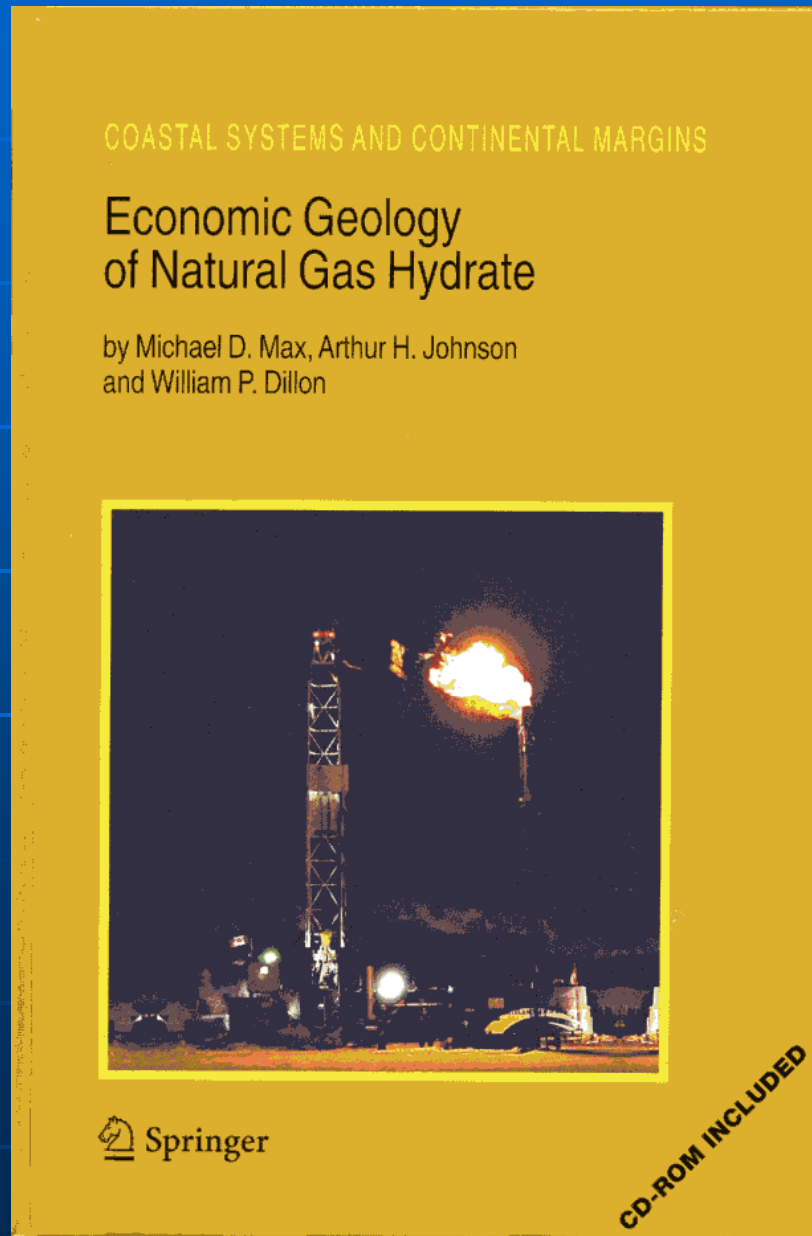
It is worth finding out







# For more information



# Coming Soon

Energy resources for human settlement in the solar system and earth's future in space

AAPG Memoir 101

W. A. Ambrose, J. F. Reilly II, and D. E. Peters, eds.

Includes: Max, M. D., S. M. Clifford, and A. H. Johnson,  
"Hydrocarbon system analysis for methane hydrate  
exploration on Mars"

Thank You

[www.hydrate-energy.com](http://www.hydrate-energy.com)