

# Experience the Phenomenon: Making Observations

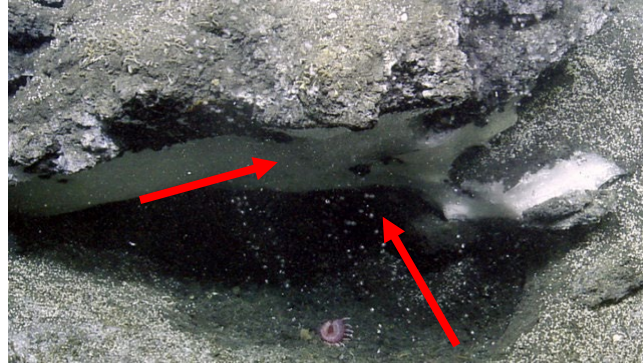


0:25 -0:50 min no sound Source: <https://www.youtube.com/watch?v=OazBJKRIAmA&t=1s>

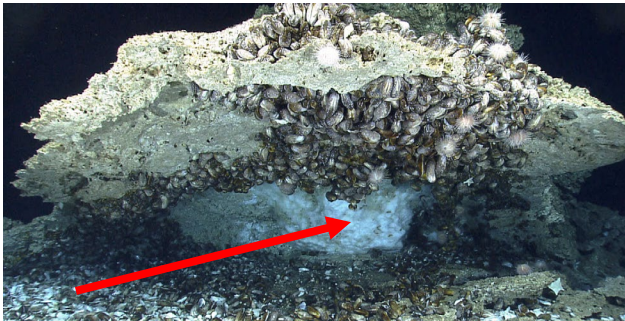
# What do you see? What questions do you have?



<https://oceanexplorer.noaa.gov/explorations/deepeast01/logs/sep27/media/hydrateoverhang.html>



<https://www.pmel.noaa.gov/eoi/Cascadia-margin.html>



<https://oceanexplorer.noaa.gov/oceanos/explorations/ex1402/logs/apr12/apr12.html>



<https://oceanexplorer.noaa.gov/oceanos/explorations/ex1304/dailyupdates/dailyupdates.html#cbpi=july11.html>



# Background: Cold Seeps

## Cold Seeps

- places where hydrogen sulfide, methane, and other hydrocarbon-rich fluids and/or gases escape from cracks in the ocean floor

## Methane Cold Seep

- characterized by methane and hydrogen sulfide bubbles coming out of the seafloor
- chemicals provide energy for chemosynthetic ecosystems

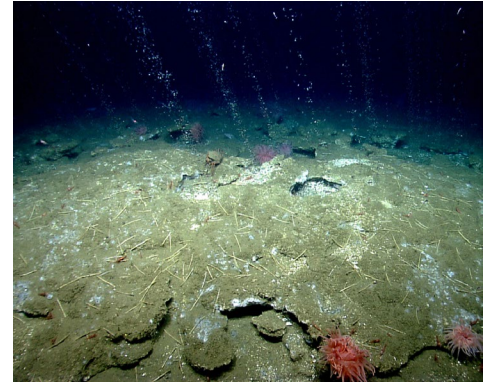


Image courtesy of NOAA Ocean Exploration;  
<https://oceanexplorer.noaa.gov/oceanos/explorations/ex1903/background/seeps/welcome.html>

# What is a Methane Hydrate?

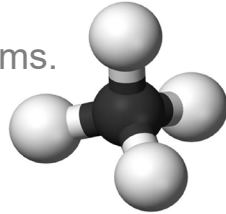
## Methane Structure

**Methane hydrates are ice-like crystal structures made of water and methane gas.**

- Methane gas is produced by biological activity in sediments conducted by microorganisms.

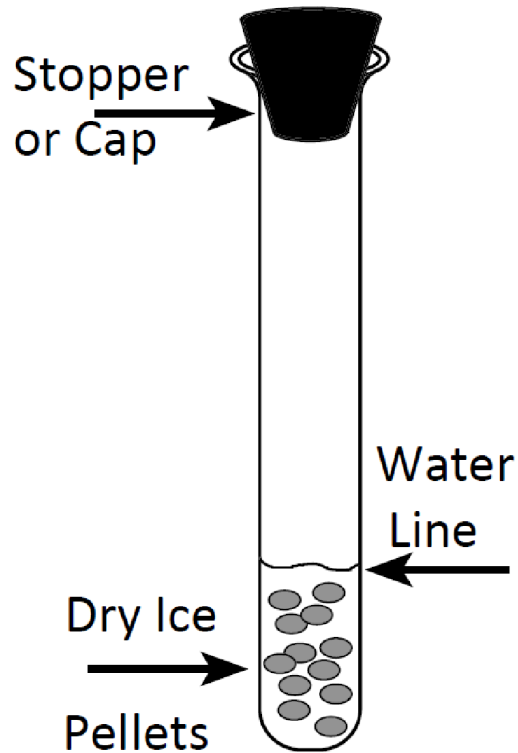
## Why are they important?

- May contain 2X the carbon contained in all reserves of coal, oil, & conventional natural gas combined, making them a potentially valuable energy resource.
- Their decomposition can release large amounts of methane, which is a greenhouse gas that could impact Earth's climate.
- Can be associated with unusual and possibly unique biological communities that use hydrocarbons or hydrogen sulfide for carbon & energy, via chemosynthesis.



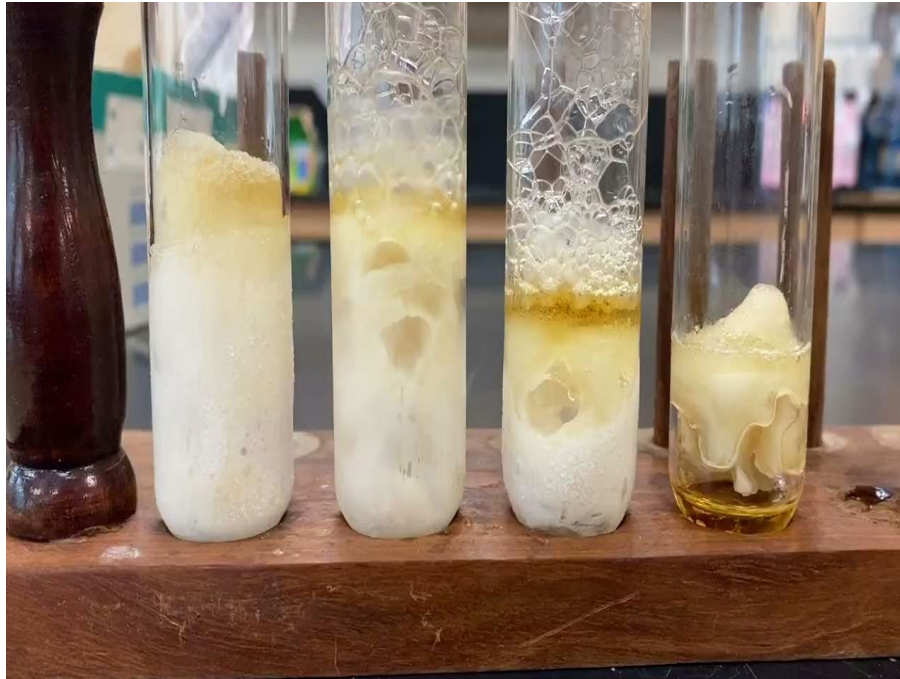
*But how does methane hydrate form on and below the ocean seafloor?*

# Investigate: Diagram of Lab Set-up





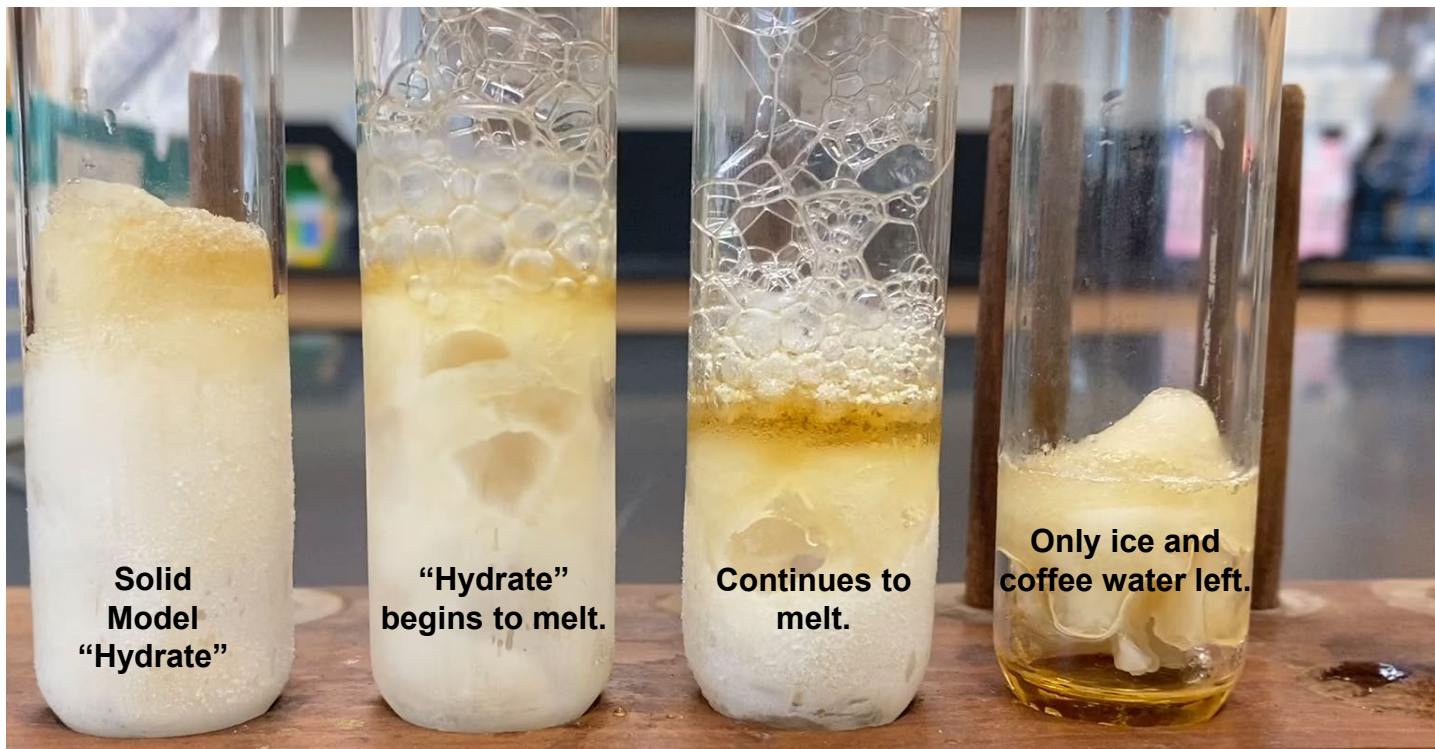
# Investigate: Methane Hydrate Lab Video



Source: <https://oceanexplorer.noaa.gov/edu/materials/methane-hydrate-formation-demonstration.mp4>



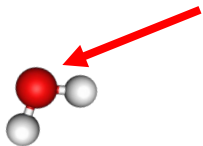
## Investigate: Methane Hydrate Lab Images



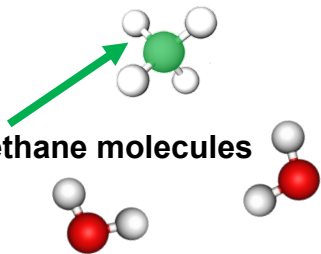


# Investigate: Chemical Structures

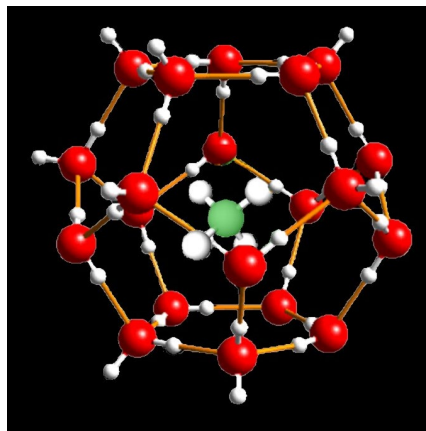
water molecules



methane molecules

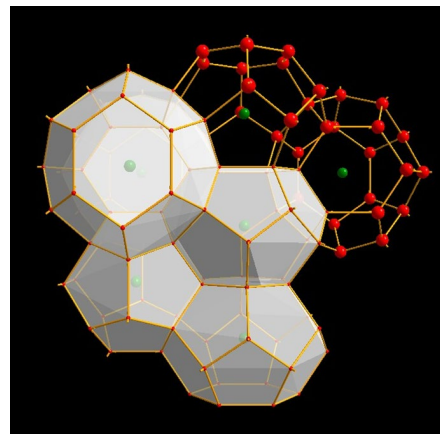


Individual water and methane molecules.



**Methane hydrate crystal structure.** Water molecules (1 red oxygen and 2 white hydrogens) around a methane molecule (1 green carbon and 4 white hydrogens).

<https://www.usgs.gov/media/images/hydrate-molecule>



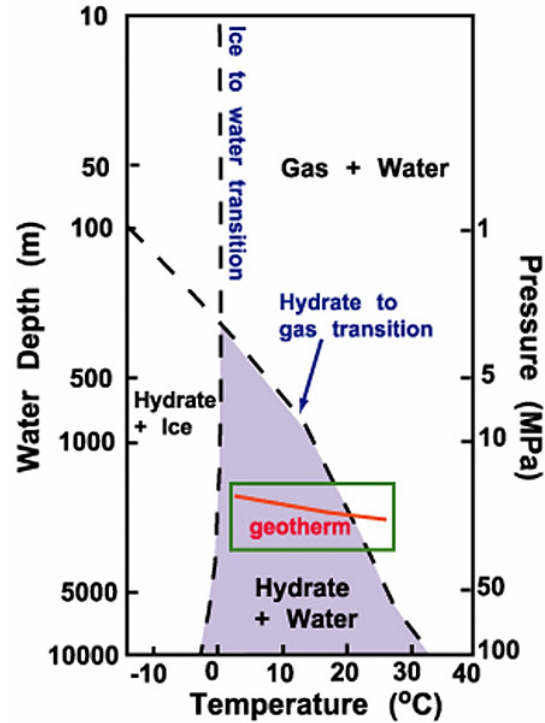
**Methane hydrate repeating crystal structure.** Water molecules (red spheres) form a pentagonal dodecahedron around a methane molecule (green spheres).

Author: Andrzej Falenty

[https://commons.wikimedia.org/wiki/File:CH4\\_hydrate\\_sl.jpg](https://commons.wikimedia.org/wiki/File:CH4_hydrate_sl.jpg)



# Investigate: Phase Change Diagrams



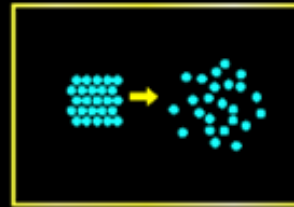
Adapted from [https://oceanexplorer.noaa.gov/explorations/03windows/background/hydrates/media/fig1\\_phase\\_diagram.html](https://oceanexplorer.noaa.gov/explorations/03windows/background/hydrates/media/fig1_phase_diagram.html)

# Phase Change Simulation: *Optional*

## States of Matter: Basics



States



Phase Changes

PHET

[https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics\\_en.html](https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html)

# Put the Pieces Together: Cold Seeps and Methane Hydrates



0:30 – 3:17 min Source: <https://www.youtube.com/watch?v=ahmjHLyF9GM>