Deep Earth Academy
CONSORTIUM FOR OCEAN LEADERSHIP

Like a Bolt from the Blue

This poster was designed specifically for upper level high school and early undergraduate Earth systems, chemistry and/or environmental science students. While the gas law problems may not be appropriate for younger audiences, some of the demonstrations and activities presented in "Don't Try This At Home" may be adaptable for middle or early high school groups. *The text and activities address most, if not all of the National Science Education Standards for grades 9-12, but we have chosen to focus upon: Content Standard A: Science as Inquiry, Content Standard B: Physical Science, and Content Standard D: Earth and Space Science.*

Image Descriptions and Discussion

1. **Gas hydrate or methane hydrate** – what, exactly, is the structure pictured here? Both names are correct. Methane hydrates, also known as gas hydrates, are frozen crystalline solids composed of rigid cages (clathrate structures) of water molecules enclosing methane and other low molecular weight gases. The maximum amount of methane trapped in the hydrate is fixed by the clathrate geometry: 1 m^3 of hydrate in situ (below the seafloor) yields 164 m^3 of methane at standard ambient temperature and pressure (25°C and 1 atm) in a ratio of 1 mole CH_4: 5.75 moles H_2O. *Use Charles' Law to find the new volume of 164 m^3 of methane when conditions are changed from standard ambient temperature and pressure to STP (0°C and 1 atm).*[1]
2. **From methane to methane hydrate** – how does it happen? Methane is produced when anaerobic bacteria decompose organic matter through a series of energy—producing reactions called methanogenesis: $CH_20 \Leftrightarrow CH_4 + CO_2$. Methanogenesis takes place everywhere from landfills to lake bottoms to the ocean floor – any time and any place that decomposition occurs in the absence of oxygen, sulfate or nitrate sources. Methanogenesis may also support communities of animals like the ice worms pictured here. *We're familiar with methane and its uses: generating electricity, home heating, a substitute for gasoline in buses, trucks and trains. Identify at least three other sources of methane in the environment. Out of the sources you've identified, which ones do humans contribute to? List at least three other uses for methane.*[2]
3. **Burning ice** – is it really possible? No, this photo is deceptive. Instead, the image depicts burning methane. The "ice" is actually methane hydrate, unstable at ambient classroom or laboratory temperatures and pressures. But, how was the methane trapped in the ice? Methane molecules "seed" the formation of cage-like hydrate structures when temperatures are very low and/or pressures are very high, like the conditions in arctic tundra or the deep seafloor. Don't try this at home. You couldn't, even if you wanted to. *What other ice-like substance sublimates from a solid to a gas?*[3]
4. **Methane hydrate discovery** - past, present and future. The Ocean Drilling Program, using the drillship *JOIDES Resolution* (pictured here), conducted the first scientific drilling expedition dedicated entirely to methane hydrate research, Leg 164, east of the Carolina coast in 1995. Still a fairly new field, exploration and study will continue through the Integrated Ocean Drilling Program (IODP) and other organizations. See *http://iodp.tamu.edu/scienceops/expeditions/exp311.html* for daily and weekly reports from a more recent hydrate expedition, IODP Expedition 311. *Study the methane hydrate drill site map. What do all the sites have in common? What conclusions can you draw about the formation and location of methane hydrates?*[4]
5. **Methane hydrates** – like a bolt from the blue. On Leg 208, in 2003, the Ocean Drilling Program conducted research on ancient climate change at the Walvis Ridge in the south Atlantic. Findings from the expedition suggest that the Paleocene-Eocene thermal maximum (PETM), a period of peak global warming that occurred 55 million years ago, is attributable to the rapid release of a large mass of methane from gas hydrates in the ocean. *Knowing the greenhouse capability of methane, what does this information about the PETM suggest about our future and the pace of global climate change?*[5]

Global Distribution of Methane Hydrates