EPRI and the Lamellibrancid Worm

Jesse H. Ausubel

EPRI Board of Directors Meeting, Dallas TX

19 November 2009

My title this morning is EPRI and the Lamellibrancid Worm, a title that I am sure electric power executives realize leads to the subject of natural gas. I think natural gas is the burning heart of the next 50 years of the electric power industry. During 30 years of involvement with the industry, I have wondered why gas almost always, especially in the US, is obscured by mountains of reports and rhetoric about coal, nuclear, and renewables, including in the programs of EPRI.

Because words are famously cheap, wisdom reminds us to look at what people do as well as what they say. Between 2000 and 2008, more than 75% of new global electricity demand was met with gas-fired power plants.[1] So, fortunately, your instincts if not your words are for gas.

In 2005, Lee Raymond, the combative CEO of Exxon Mobil, solemnly declared that "gas production has peaked in North America."[2] Notwithstanding Raymond's privileged insider position, recent estimates of gas resources – both in the US and globally – show gargantuan potential.

For the US, estimates of the Potential Gas Committee, a non-profit organization spanning experts from academia, the energy sector, and government, are probably the most respected. On June 18, 2009, the committee's biennial report estimated US gas resources at over 2,000 Tcf – the highest resource evaluation in the committee's 44-year history.[3] That 2,000 Tcf

[1] IEA, "Natural Gas Market Review 2009," 109.
[2] Reuters, "Exxon says N. America gas production has peaked," June 21, 2005. Available: http://www.reuters.com/article/Utilities/idUSN2163310420050621
[3] Potential Gas Committee, "Potential Gas Committee Reports Unprecedented Increase In Magnitude Of US Natural Gas Resource Base," June 18, 2009. Available:

of gas equals the energy of more than 350 billion barrels of crude oil, roughly the combined known oil reserves of Saudi Arabia and Venezuela. The 2009 estimate by the Potential Gas Committee rose an astonishing 35% over its 2007 estimate.

This month (November) the International Energy Agency (IEA) released its World Energy Outlook 2009, which estimated recoverable global gas resources at more than 27,000 Tcf.[4] At current global rates of consumption that volume of gas will last 260 years.[5]

One big reason estimates of abundance are rising is reconsideration of shale gas. I need not spend precious minutes speaking with you about the Barnett and Marcellus shales and counterpart formations in Europe and elsewhere. Browsers of the Wall Street Journal or Bloomberg News are well acquainted with the astounding numbers associated with the shale reserves and resources.

I do want to spend a couple of minutes offshore, even though the rise in the IEA numbers comes largely from potential on land. All of you know that I am an oceans guy as well as an energy guy and have devoted a lot of time the past decade to helping explore the margins where the continents slope down from about 200 meters below the sea surface to the abyssal plains that average about 4000 meters deep, the dark gray areas extending around ALL the continents in Slide 1. We have been exploring for marine animals on the margins, and an interesting fact is that the life on the margins, which needs energy sources to survive, also turns out to be a guide to hydrocarbons seeping or even gushing out of the continental margins.

For vivid illustration, let's watch a 90-second video of a Lamellibrancid tube worm filmed during a Census of Marine Life expedition in September 2009 on the

---

http://www.mines.edu/Potential-Gas-Committee-reports-unprecedented-increase-in-magnitude-of-US-natural-gas-resource-base

[4] IEA unpublished report, Chapter 11, 1. Note that this report uses cubic meters as a metric. It estimates total recoverable global gas resources (conventional and unconventional) at 780 trillion cubic meters. One cubic meter equals 35.3 cubic feet.

[5] Global gas consumption is about 3 trillion cubic meters per year. See BP Statistical Review of World Energy 2009. Available: bp.com

continental margin in the Gulf of Mexico, south of Louisiana. The worm will feature in a Census of Marine Life press release 23 November about forms of life that do not care about sunlight. Marine biologists are calling the worm the Wildcat Worm and you will see why. The worm feeds on oil.

Now mostly what Census researchers have been finding on the margins is not oil but methane, with long ribbons of life indicating vast potential, sometimes in water 3000 meters deep. Companies such as Petrobras are starting to exploit the deep offshore formations. My point is that the combination of shale gas and gas accessible on the continental margins makes methane a resource whose ubiquity and abundance resemble coal. Methane is the new coal.

Let me make a further point. All that methane may not come from Jurassic parks. For decades some researchers have argued that the term fossil fuel may be misleading and that a lot of hydrocarbons may have an abiotic origin, that is, they may arise from carbon upwelling from deep in Earth rather than surface carbon that was folded under in early epochs. A growing literature supports this view, and in July the journal *Nature Geoscience* published an article by a US-Swedish-Russian team that showed definitively that methane, ethane, and other hydrocarbons could be synthesized from upwelling carbon encountering hydrogen and other elements in the conditions of the upper mantle.[6] Slide 2 extracts some of that article. It leads to a picture of oil and gas where the gusher starts not 1500 meters deep, the depth of an average drill hole today, but 10,000 or, as in Slide 3, 100,000 meters deep. If Earth continuously synthesizes methane in large quantities, methane qualifies as much as wood as a renewable resource.

This very deep carbon has fascinated me, and together with colleagues in about ten other countries and generous initial support from the Sloan Foundation we announced on 1 July 2009 the launch of an International Deep Carbon

---

[6] Kolesnikov, A, Kutcherov, V.G., and Goncharov A.F., Methane-derived hydrocarbons produced under upper-mantle conditions, *Nature Geoscience* 2, 566 – 570 (2009), 26 July 2009 | doi:10.1038/ngeo591.

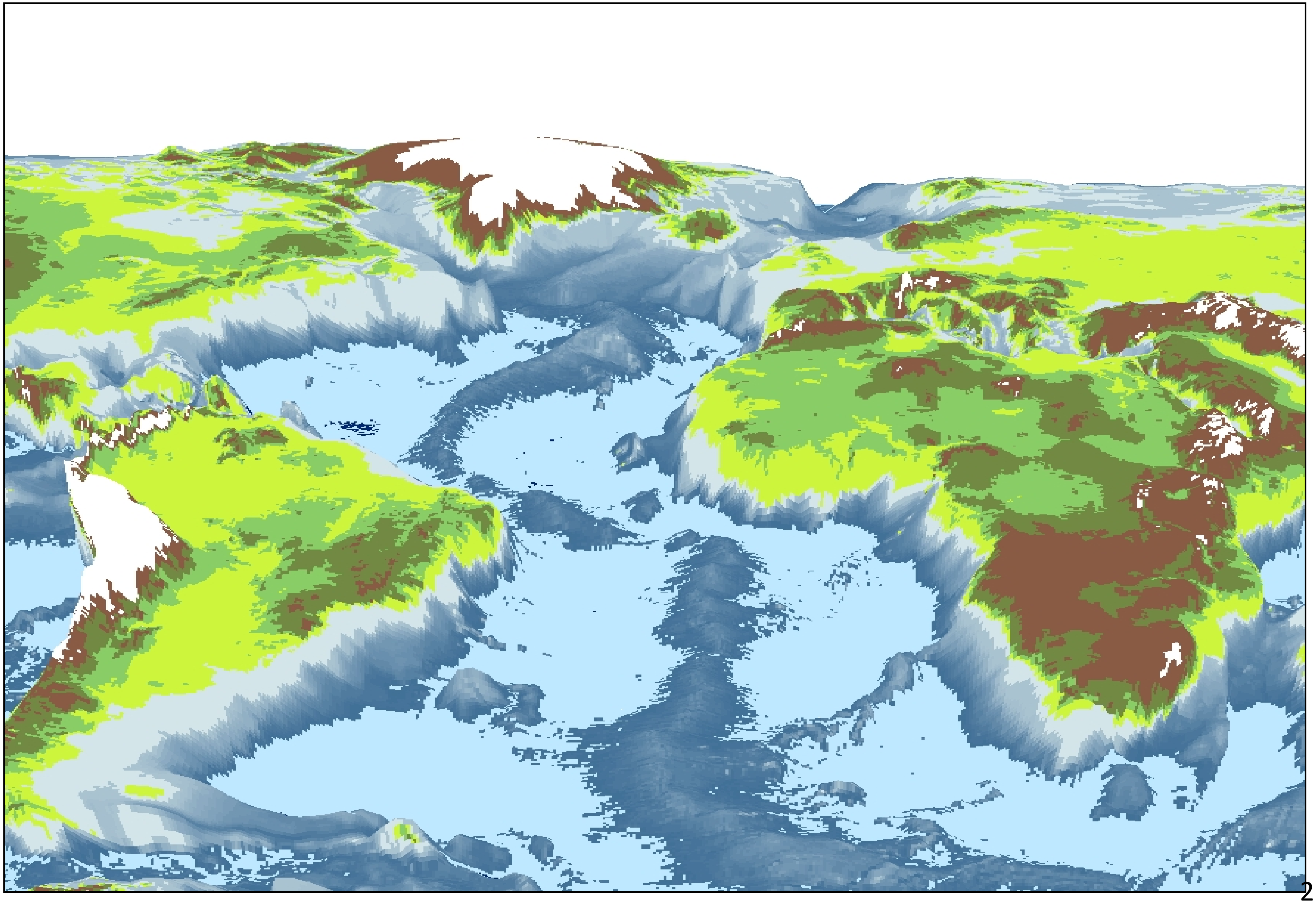
Observatory (http://www.ciw.edu/news/carnegie_wins_grant_probe_earth_s_deep_carbon). The Deep Carbon Observatory (DCO) aims for a vast improvement in the knowledge of deep reservoirs and fluxes of carbon and how hydrocarbons are synthesized (http://www.gl.ciw.edu/deep_carbon_project) . Along the way, we may discover the origins of life, which may have begun deep in the crust at high temperatures and pressures that stimulate chemistry and then biochemistry.

The headquarters of the project, which expects to raise and spend about $600 m over ten years, are at the Carnegie Institution of Washington, whose exceptionally able director, Richard Meserve, many of you know. Nations participating include China, Japan, France, Germany, UK, South Africa, and Brazil. The DCO team is of course engaging with DOE, Interior, and NSF in the US. Some major oil and gas companies are participating. I hope EPRI and some utilities will consider participating, too. The majority of the kilowatts of the 21st century may well come from cleanly used unconventional and deep methane. (Slide 4) This shift in expectations implies changes in the R&D program and the infrastructure and operations of the electric power industry. President Specker's mention of EPRI's new interest in pre-combustion capture of carbon in methane power plants fits perfectly. Emulating life on the continental margins, EPRI should help lead the way toward a superb energy system defined by methane abundance.

EPRI and the Lamellibrancid Worm

Jesse Ausubel
EPRI Board of Directors Meeting
Dallas, Texas
19 November 2009

Gas-rich margins (dark gray) girdle all continents

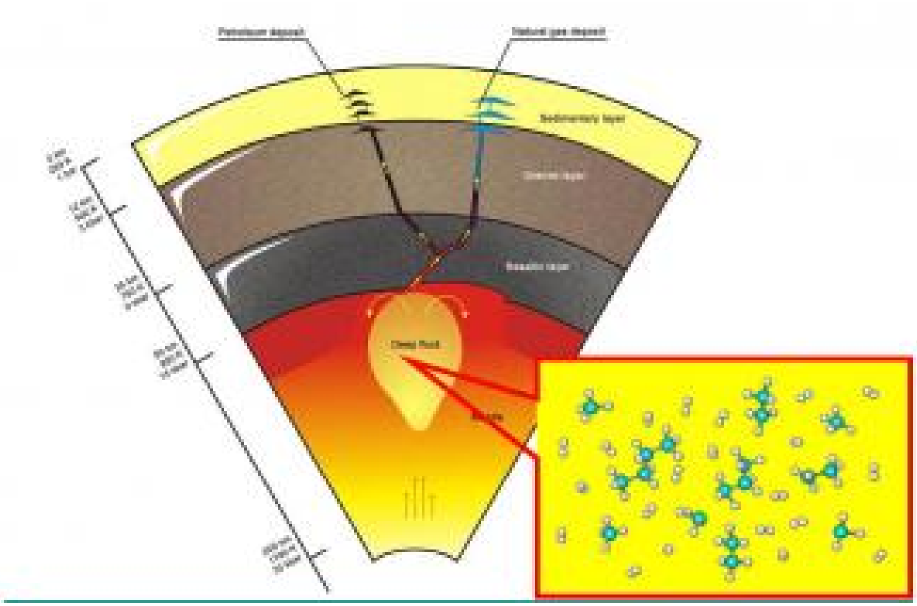


Source: Census of Marine Life Continental Margins project, exaggerated bathymetry

Hydrocarbons in Deep Earth?

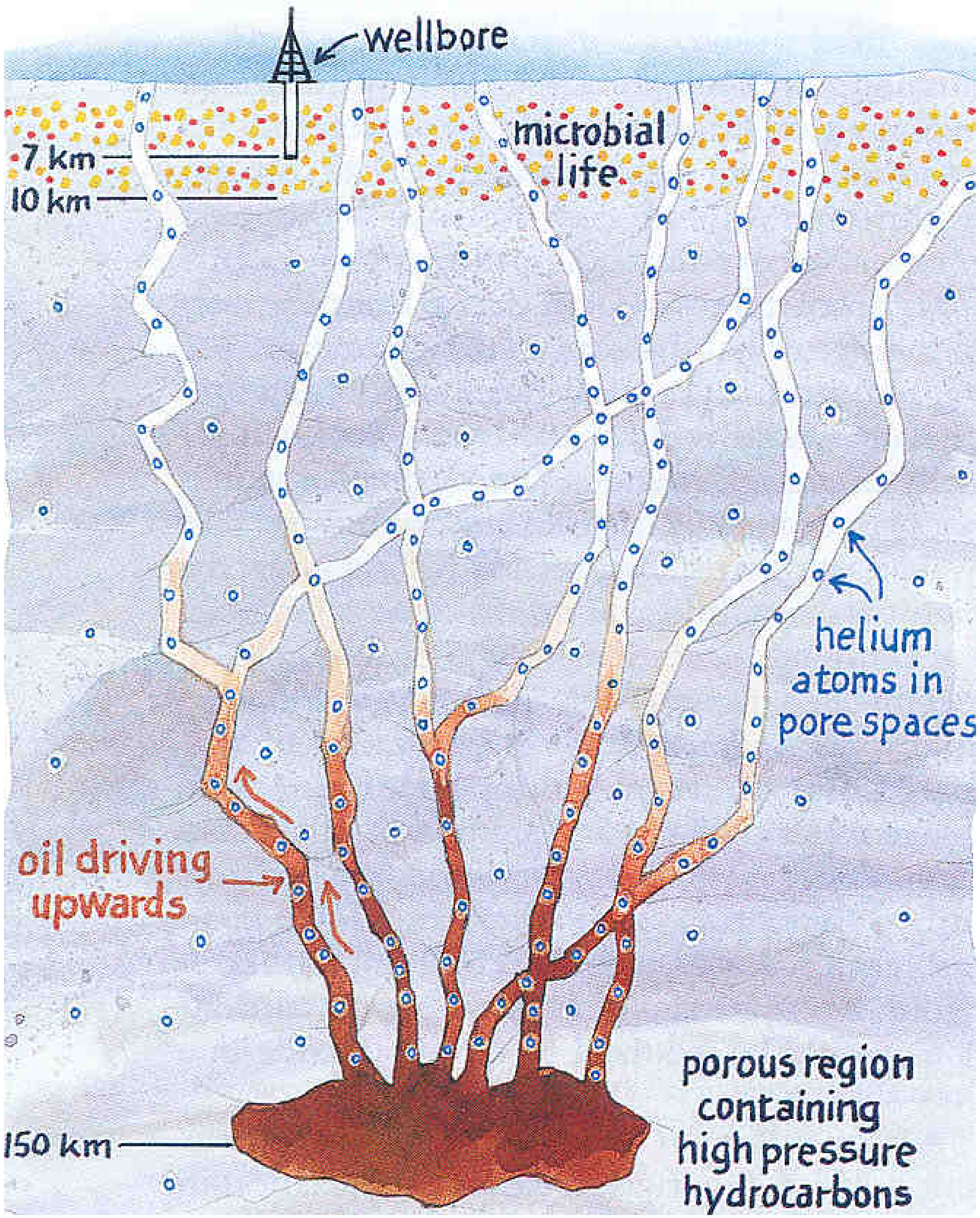
Monday, July 27, 2009

Nature Geoscience



…for the first time, scientists have found that ethane and heavier hydrocarbons can be synthesized under the pressure-temperature conditions of the upper mantle —the layer of Earth under the crust and on top of the core….Using a diamond anvil cell and a laser heat source, the scientists first subjected methane to pressures …mimic[king] those found 40 to 95 miles deep inside the Earth. The methane reacted and formed ethane, propane, butane, molecular hydrogen, and graphite. The scientists then subjected ethane to the same conditions and it produced methane…

Maybe complex hydrocarbons
(oils & gases)
are synthesized at extreme
pressures & temperatures,
and then seek to escape,
outgassing
where they can, e.g.,
in the fracture zones
along continental margins.
Rising to the surface,
they pick up traces of life
from the deep biosphere
of microbes
that feed on oil and gas.



Maybe prevailing views about Earth's fossil fuels are wrong… Maybe abundant methane maintains the historic march of decarbonization…

Image of endless sea of methane on surface of Titan, a moon of Saturn, derived from data of probe Huygens, 14 Jan 2005 (ESA). See also "The Lakes of Titan," 4 Jan 2007, *Nature*, Stofan et al.