Fracking 101

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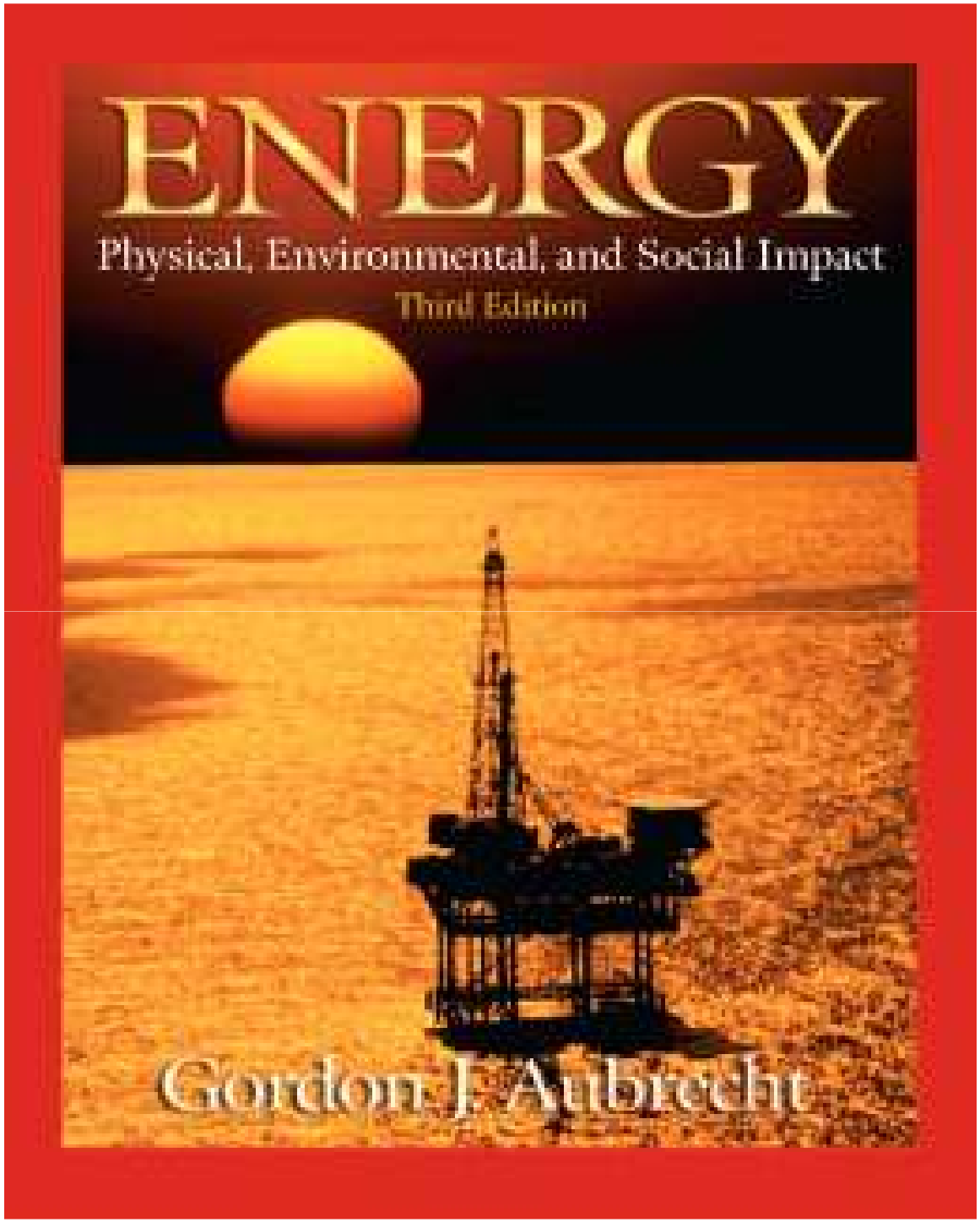
THE OHIO STATE UNIVERSITY

Physics Education Research Group

Sustainable Delaware, Earth Day, 22 April 2012


ENERGY
Physical, Environmental, and Social Impact
Third Edition
Gordon J. Aubrecht

What is fracking?

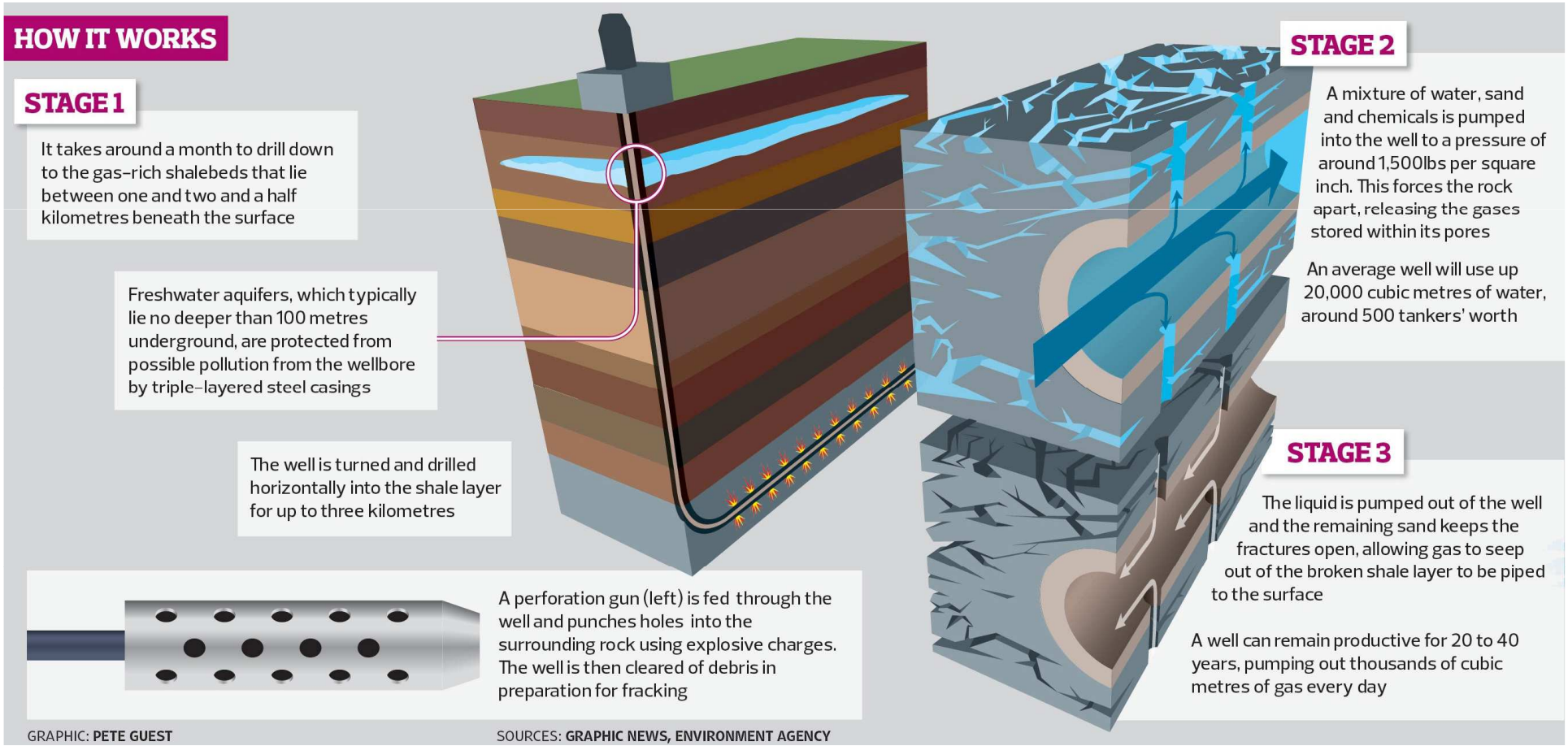
This is short for "hydrofracturing." This is an old technique for increasing oil production from worked-out oil wells, but a new technique for obtaining methane (natural gas).

What is fracking?

Hydraulic fracturing was first employed experimentally in 1947 in the Hugoton oilfield in Kansas. (Maybe it's a "senior citizen" of oil recovery methods?)

Fracking—hydraulic fracturing

Water laced with chemicals is pumped down to fracture the shale and releases the gas, which can be pumped up.



Fossil fuels

Coal—essentially $CH_{0.8}$

The most carbon per unit of energy.

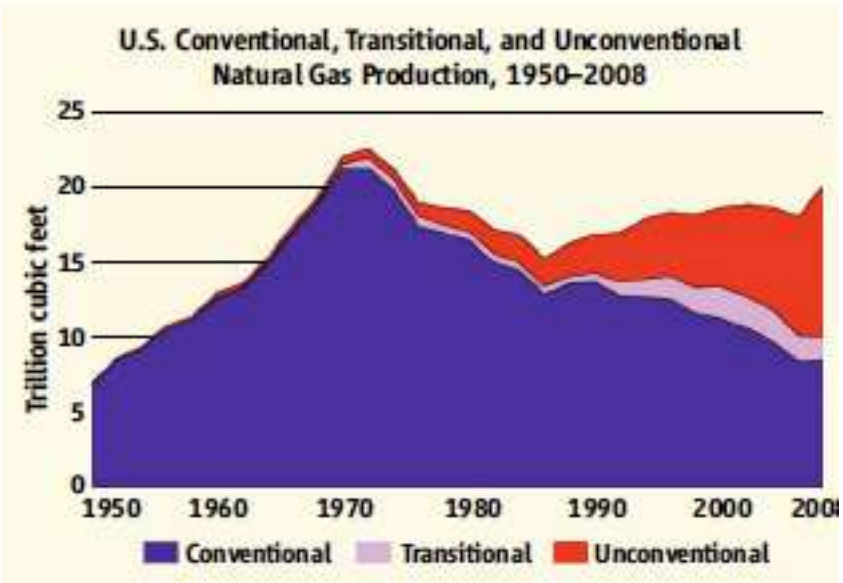
Oil—essentially CH_2

Intermediate amount of carbon per unit of energy.

Gas—CH_4

The least carbon per unit of energy. This is surely preferable to the other fossil fuels for this reason.

Ohio has considerable coal and considerable gas in shale formations. The coal is relatively “dirty”—high in contaminants such as sulfur. The gas is far below the surface in the Marcellus and Utica shales.




Montana Thrust Belt
Cody
Williston Basin
Gammon
Hilliard-
Baxter-
Mancos
Greater Green River Basin
Uinta Basin
Piceance Basin
Mancos
Hermosa
Paradox Basin
Lewis
San Juan Basin
Pierre
Raton Basin
Excello-
Mulky
Cherokee Platform
Woodford
Anadarko Basin
Ardmore Basin
Palo Duro Basin
Bend
Arkoma Basin
Fayetteville
Forest City Basin
Michigan Basin
Antrim
Illinois Basin
New Albany
Appalachian Basin
Devonian (Ohio)
Marcellus
Utica
Chattanooga
Black Warrior Basin
Conasauga
Floyd-
Neal
Valley and Ridge Province
Barnett
Permian Basin
Ft. Worth Basin
Texas-
Louisiana-
Mississippi Salt Basin
Haynesville-
Bossier
Barnett-
Woodford
Marfa Basin
Maverick Sub-Basin
Pearsall-
Eagle Ford
Eagle Ford
Rio Grande Embayment
Miles
0 100 200 300 400
N
Shale Gas Plays
Basins
Stacked Plays
Shallowest / Youngest
Deepest / Oldest
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1821 – First U.S. commercial natural gas well in Fredonia, New York, produces gas from shale.

…

1860s to 1920s – Natural gas, including gas produced from shallow, low pressure, fractured shales in the Appalachian and Illinois basins, is limited to use in cities close to producing fields.

Early 1970s – Development of downhole motors, a key component of directional drilling technology, accelerates. Directional drilling capabilities continue to advance for the next three decades.

Late 1970s and early 1980s – Fear that U.S. natural gas resources are dwindling prompts federally sponsored research to develop methods to estimate the volume of gas in "unconventional natural gas reservoirs" such as gas shales, tight sandstones and coal seams, and to improve ways to extract the gas from such rocks. Deeper buried shales, such as the Barnett in Texas and Marcellus in Pennsylvania, are known but believed to have essentially zero permeability and thus are not considered economic.

1980s to early 1990s – Mitchell Energy combines larger fracture designs, rigorous reservoir characterization, horizontal drilling, and lower cost approaches to hydraulic fracturing to make the Barnett Shale economic.

2003 to 2004 – Gas production from the Barnett Shale play overtakes the level of shallow shale gas production from historic shale plays like the Appalachian Ohio Shale and Michigan Basin Antrim plays. About 2 billion cubic feet (Bcf) of gas per day are produced from U.S. shales.

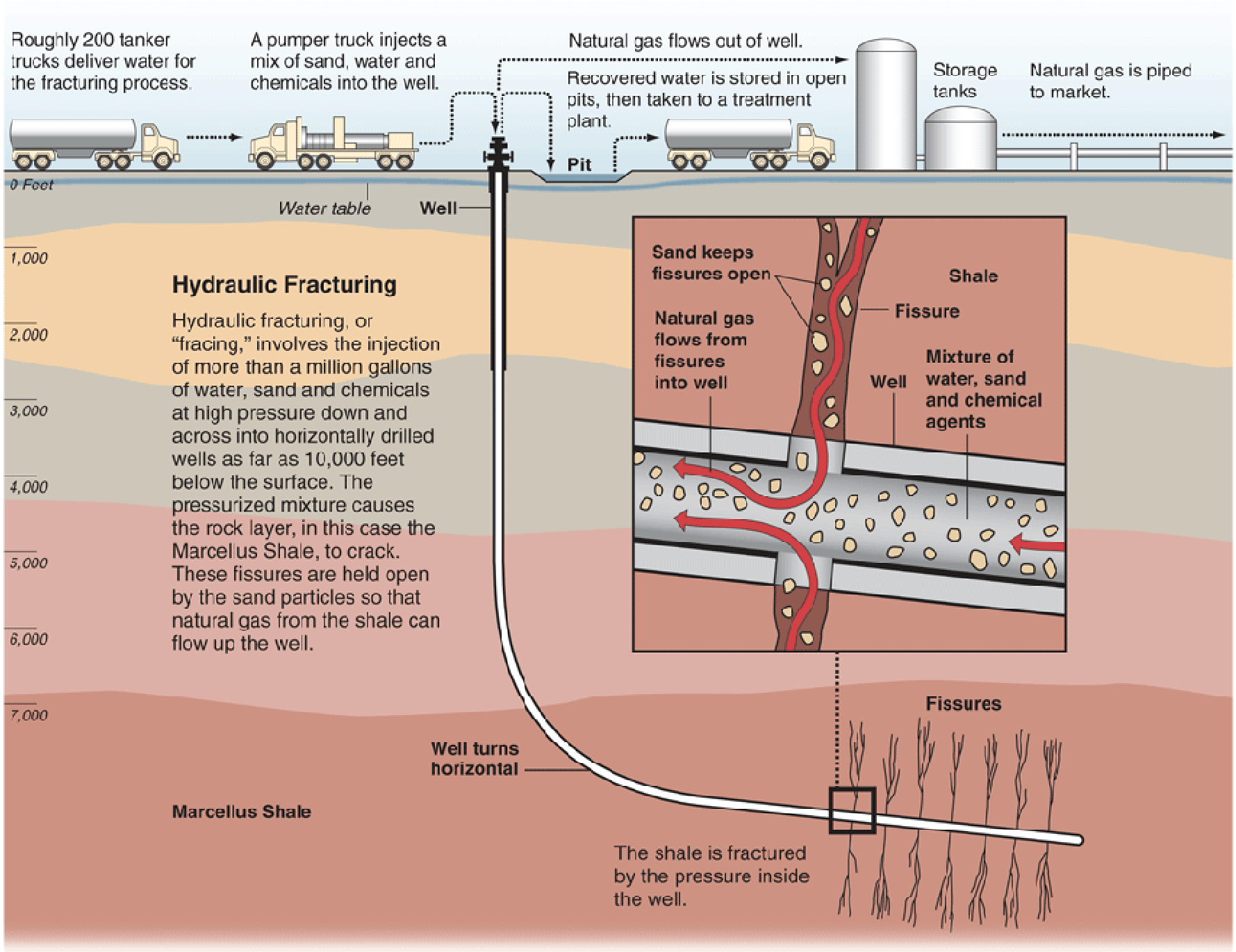
2005 to 2010 – Gas production from Barnett Shale grows to about 5 Bcf per day. Development of other major shale plays begins in other major basins.

2010 – The Marcellus shale underlies a significant portion of the mid-Atlantic/NE region—close to East Coast metropolitan natural gas demand centers—and is thought to contain nearly half of the technically recoverable shale gas resource.

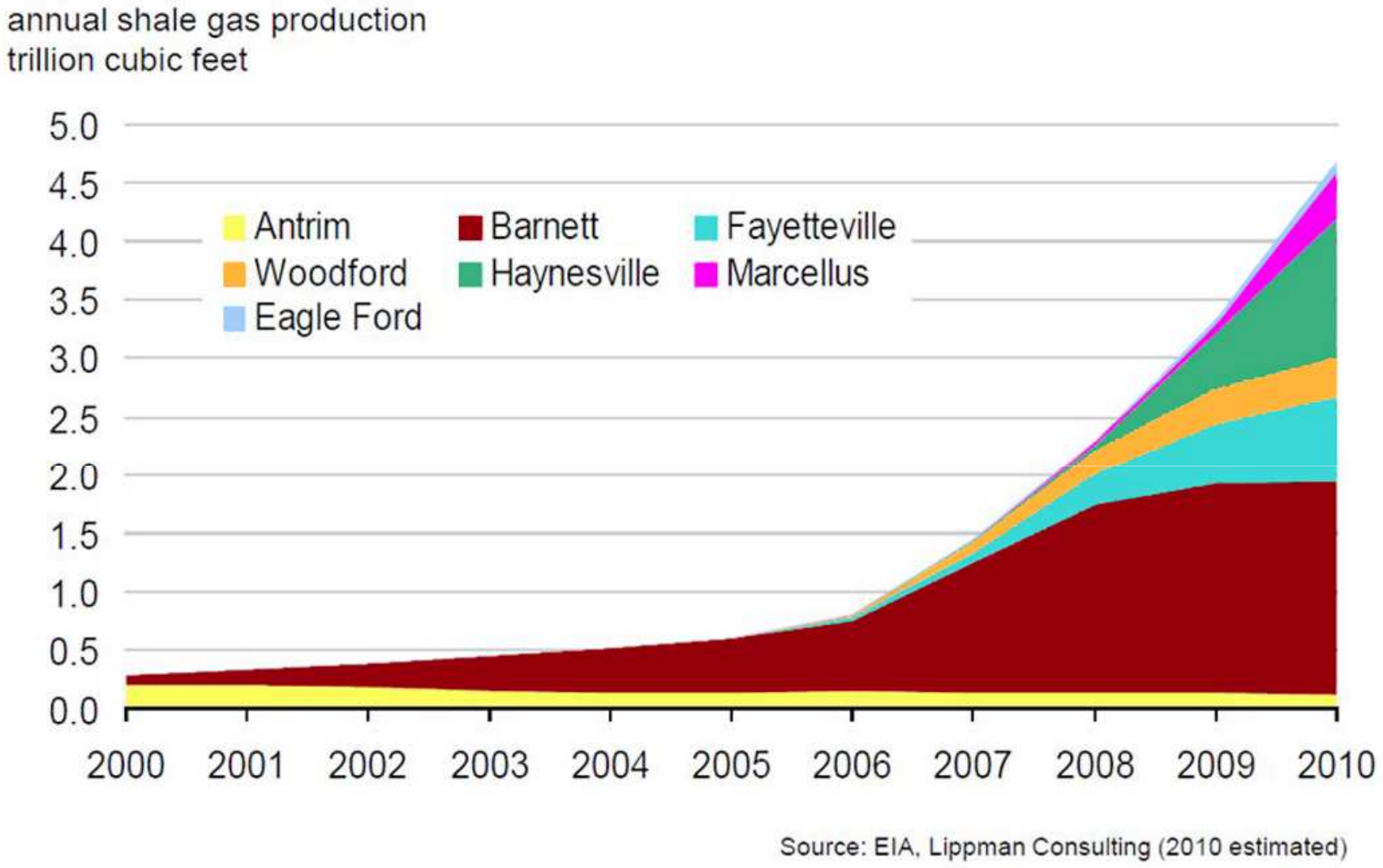
About 360–415 million years ago, during the Devonian Period of Earth's history, the thick shales from which we are now producing natural gas were being deposited as fine silt and clay particles at the bottom of relatively enclosed bodies of water. At roughly the same time, primitive plants were forming forests on land and the first amphibians were making an appearance.

Some of the methane that formed from the organic matter buried with the sediments escaped into sandy rock layers adjacent to the shales, forming conventional accumulations of natural gas which were relatively easy to extract. But some of it remained locked in the tight, low permeability shale layers.

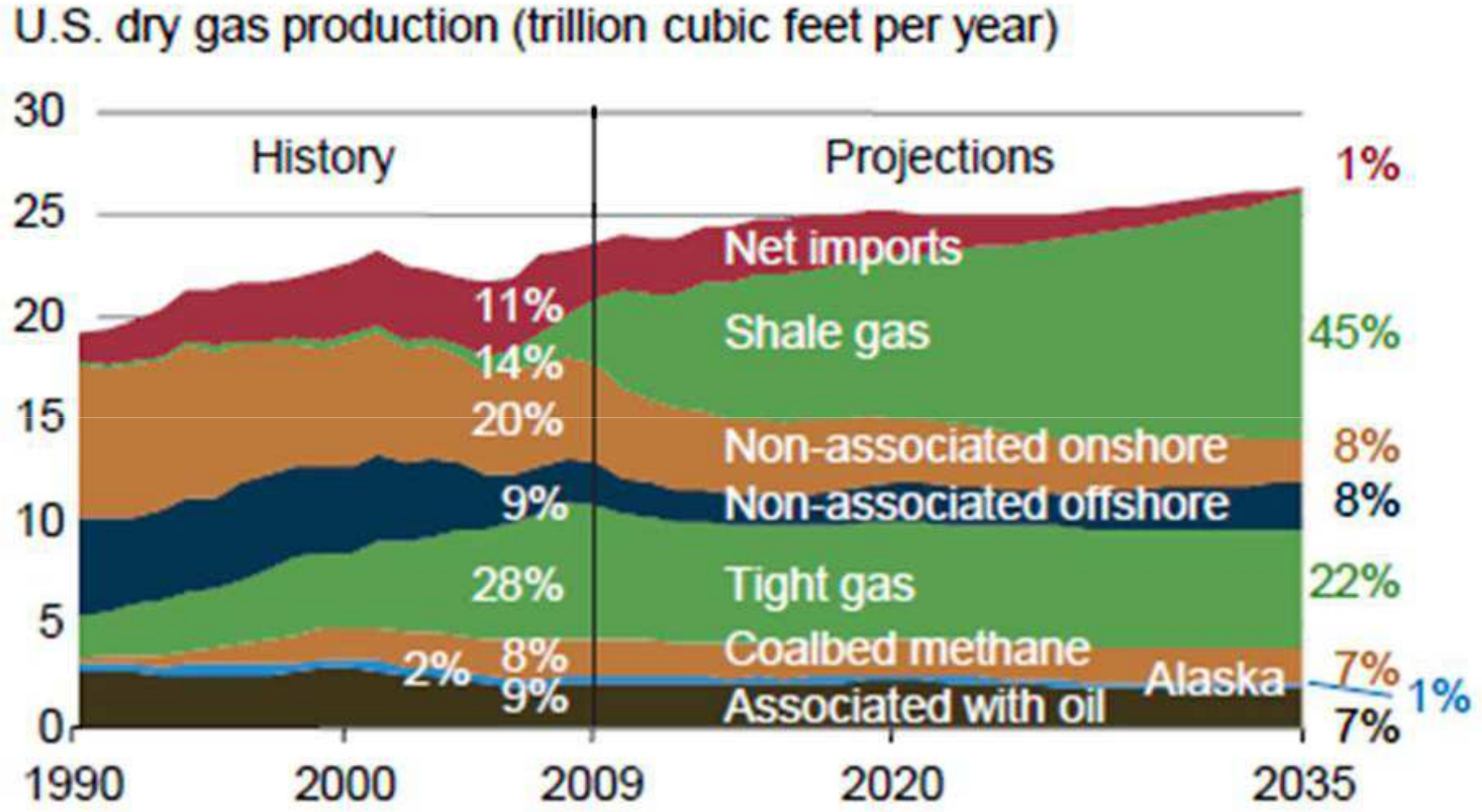
More detail on the Marcellus shale



Graphic by Al Granberg



Source: EIA, Lippman Consulting (2010 estimated)


U.S. dry gas production (trillion cubic feet per year)
30
25
20
15
10
5
0
History
Projections
1990
2000
2009
2020
2035
Net imports
Shale gas
Non-associated onshore
Non-associated offshore
Tight gas
Coalbed methane
Alaska
Associated with oil
11%
14%
20%
9%
28%
8%
2%
9%
1%
45%
8%
8%
22%
7%
1%
7%

Vice President Cheney's gift

Section 322 of PL 109-58 amended the Safe Drinking Water Act to exempt all fracturing fluids except diesel from EPA regulations.

Subtitle C—Production

SEC. 322. HYDRAULIC FRACTURING.

Paragraph (1) of section 1421(d) of the Safe Drinking Water Act (42 U.S.C. 300h(d)) is amended to read as follows:

"(1) UNDERGROUND INJECTION.—The term 'underground injection'—

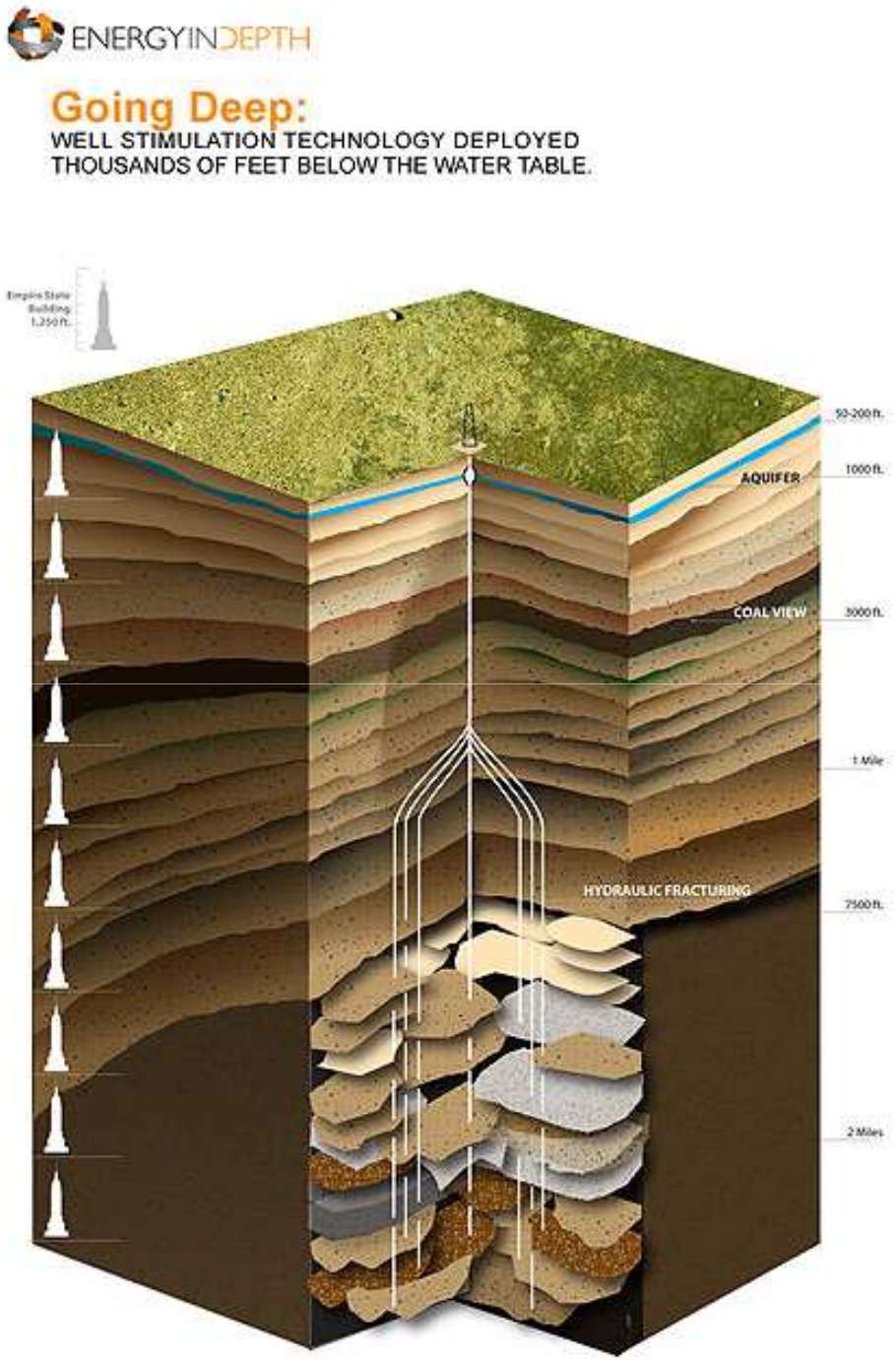
"(A) means the subsurface emplacement of fluids by well injection; and

"(B) excludes—

"(i) the underground injection of natural gas for purposes of storage; and

"(ii) the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities.".

The industry claim is that with this technology, there is no groundwater contamination.



Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing

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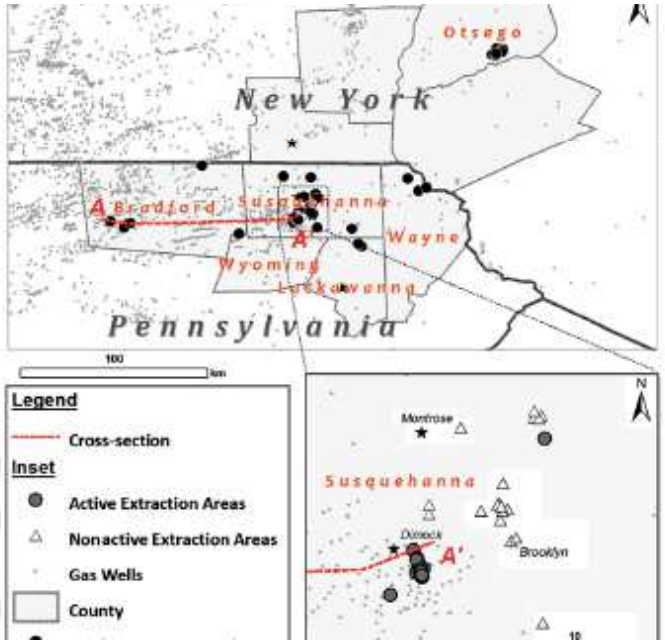
Edited* by William H. Schlesinger, Cary Institute of Ecosystem Studies, Millbrook, NY, and approved April 14, 2011 (received for review January 13, 2011)

Directional drilling and hydraulic fracturing technologies are dra-

the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York, we document systematic evidence for methane contamination of drinking water associated with shale-gas extraction. In active gas-extraction areas (one or more gas wells within 1 km), average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well and were 19.2 and 64 mg CH_4 L^{-1} ($n = 26$), a potential explosion hazard; in contrast, dissolved methane samples in neighboring nonextraction sites (no gas wells within 1 km) within similar geologic formations and hydrogeologic regimes averaged only 1.1 mg L^{-1} ($P < 0.05$; $n = 34$). Average δ^{13}C-CH_4 values of dissolved methane in shallow groundwater were significantly less negative for active than for nonactive sites (−37 ± 7‰ and −54 ± 11‰, respectively; $P < 0.0001$). These δ^{13}C-CH_4 data, coupled with the ratios of methane-to-higher-chain hydrocarbons, and δ^{2}H-CH_4 values, are consistent with deeper thermogenic methane sources such as the Marcellus and Utica shales at the active sites and matched gas geochemistry from gas wells nearby. In contrast, lower-concentration samples from shallow groundwater at nonactive sites had



Ohio.com
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Monday, February 27, 2012

Three years after drilling, feds say natural gas in Medina County well water is potentially explosive

By Bob Downing
Beacon Journal staff writer

Published: January 17, 2012 - 12:00 AM

Sandy (left) and Mark Mangan with their dog, Lou, outside their State Road home in Granger Township, Ohio. Their home is one of two in Medina County that have been deemed a public health threat by a federal health agency because of potentially explosive levels of natural gas in their drinking water that the Mangans say

GRANGER TWP.: A federal health agency says potentially explosive levels of natural gas at two houses in eastern Medina County are a public health threat.

The problems in the two drinking water wells appear linked to the nearby drilling of two natural gas wells in 2008, says the Agency for Toxic Substances and Disease Registry, part of the U.S. Centers for Disease Control and Prevention.

That news contradicts repeated statements from the Ohio Department of Natural

Fracking: answer to our energy crisis, or could it be a disaster for the environment?

Fracking – the extraction of shale gas – was halted last year after it was linked to a series of tremors in Lancashire. Drilling companies hope a decision due soon will allow them to restart operations. But protesters say fracking can lead to water contamination, methane leaks and animals dying

• Click here to see a graphic explaining how fracking works and where the planned sites in the UK are

Robin McKie, science editor

guardian.co.uk, Saturday 25 February 2012 18.15 EST

Article history

Environment

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3 Nov 2011

Should fracking be banned in the UK?

“The increase over the nation’s midsection has gotten steeper since 2009, due to more quakes in a variety of oil and gas production areas, including some in Arkansas and Oklahoma, the researchers say.

“Fracking at fault? Probably not

“It’s not clear how the earthquake rates might be related to oil and gas production, the study authors said. They note that others have linked earthquakes to injecting huge amounts of leftover wastewater deep into the earth.”

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Study ties oil and gas production to Midwest quakes

USGS team says human activity 'almost certainly' causing rise in minor seismic activity

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By Malcolm Ritter
Associated Press
updated 4/6/2012 9:35:18 PM ET

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NEW YORK — Oil and gas production may explain a sharp increase in small earthquakes in the nation's midsection, a new study from the U.S. Geological Survey suggests.

The rate has jumped sixfold from the late 20th century through last year, the team reports, and the changes are "almost certainly man-made."

Outside experts were split in their opinions about the report, which is not yet published but is due to be presented at a meeting later this month.

The study said a relatively mild increase starting in 2001 comes from increased quake activity in a methane production area along the state line between Colorado and New Mexico. The increase began about the time that methane production began there, so there's a "clear possibility" of a link, says lead author William Ellsworth of the USGS.

The increase over the nation's midsection has gotten steeper since 2009, due to more quakes in a variety of oil and gas production areas, including some in Arkansas and Oklahoma, the researchers say.

USGS

The U.S. Geological Survey's national seismic hazard map indicates that many parts of the Central and Eastern United States have moderate to high long-term hazard, even though they have not experienced recent large quakes. The white circles indicate quakes of magnitude 6.5 or greater that have occurred since 1978.