

Shale Gas

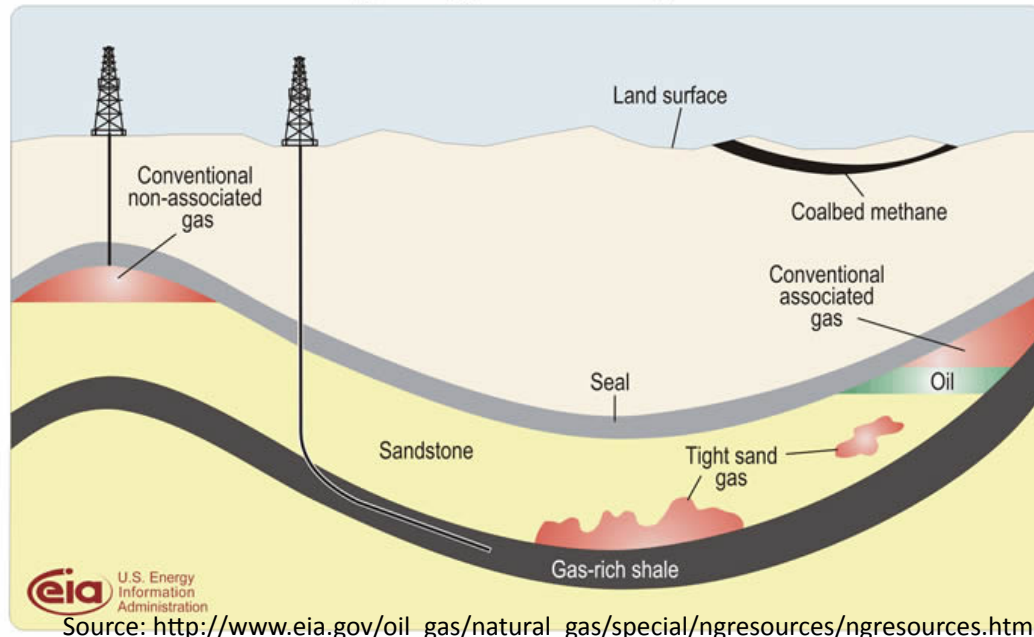
Luka Močivnik

25.10.2012

Shale

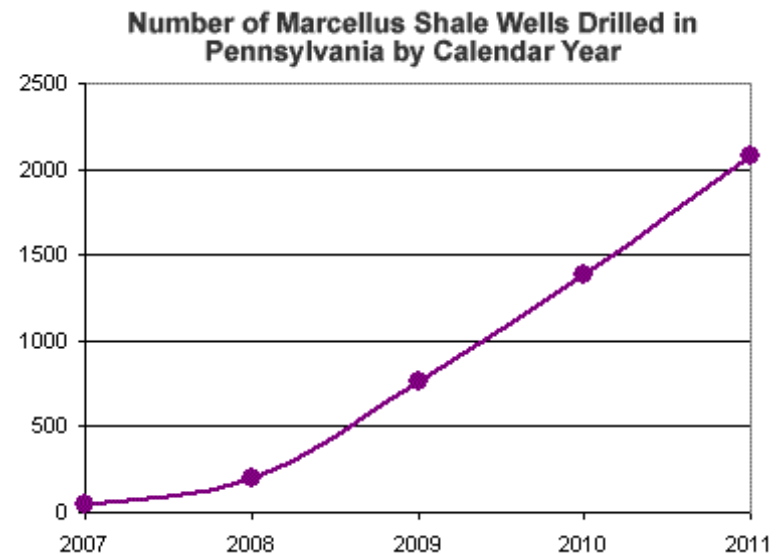
- Fine grained clastic sedimentary rock
 - Composed of mud which is mix of clay minerals and silt sized particles (0,0039-0,0625 mm) of other minerals (quartz, calcite)
- Forms by compacting in very slow moving water (lakes, lagoons, river deltas, continental shelves)
- Often has large amounts of organic material
- Very fissile, breaks in thin parallel layers
- Has very low permeability
 - Natural gas can get trapped in natural fissures in the rock

Schematic geology of natural gas resources

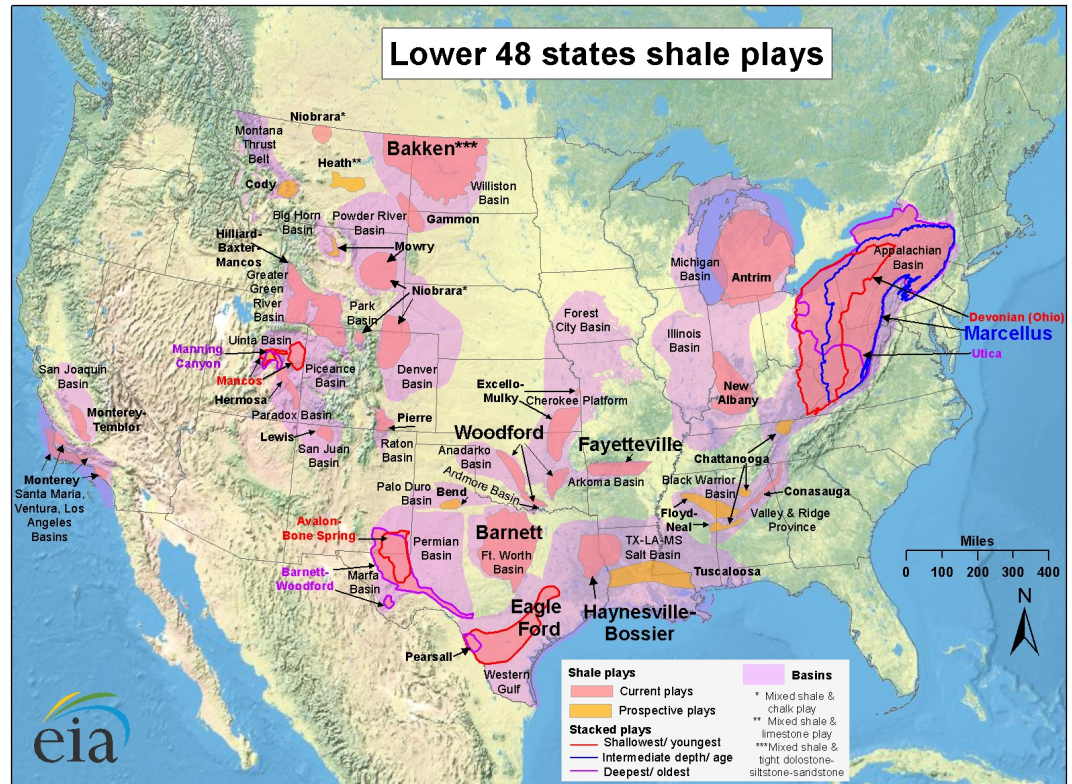


History

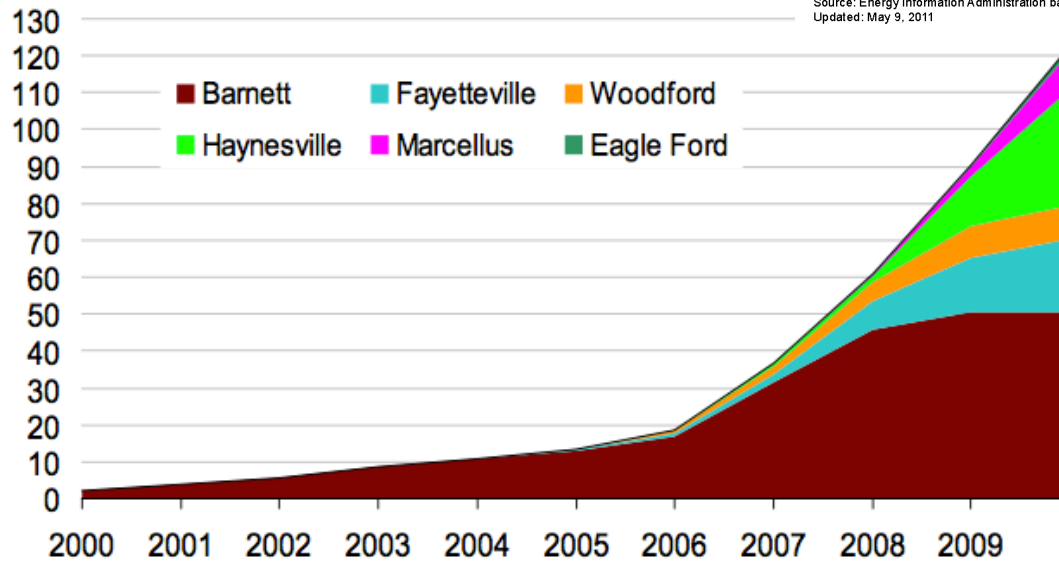
- First extracted in 1821 in Fredonia, NY
- First horizontal drilling in 1930s
- Hydraulic fracturing in 1947
- Development in 1970s and 1980s (government research projects and investments, private companies)
- First economical shale in 1998 in Texas
- In the last six to seven years production has been rising rapidly in the U.S.
 - Economically viable due to new technologies (horizontal slickwater hydraulic fracturing)
 - Smaller dependency on foreign gas



Source: <http://geology.com/articles/marcellus-shale.shtml>

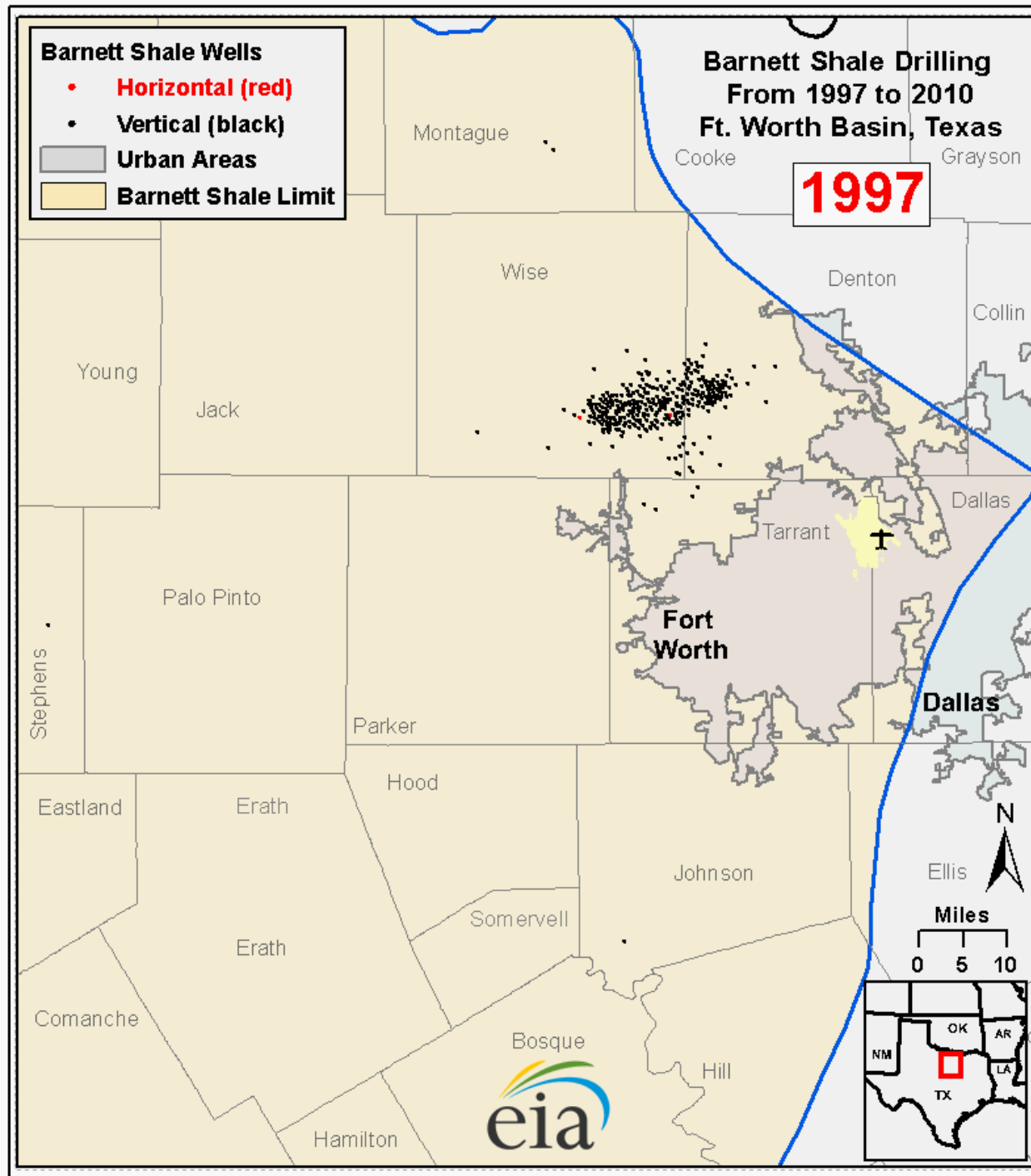


shale gas production
billion cubic meters



Source: EIA, Lippman Consulting (2010 estimated)

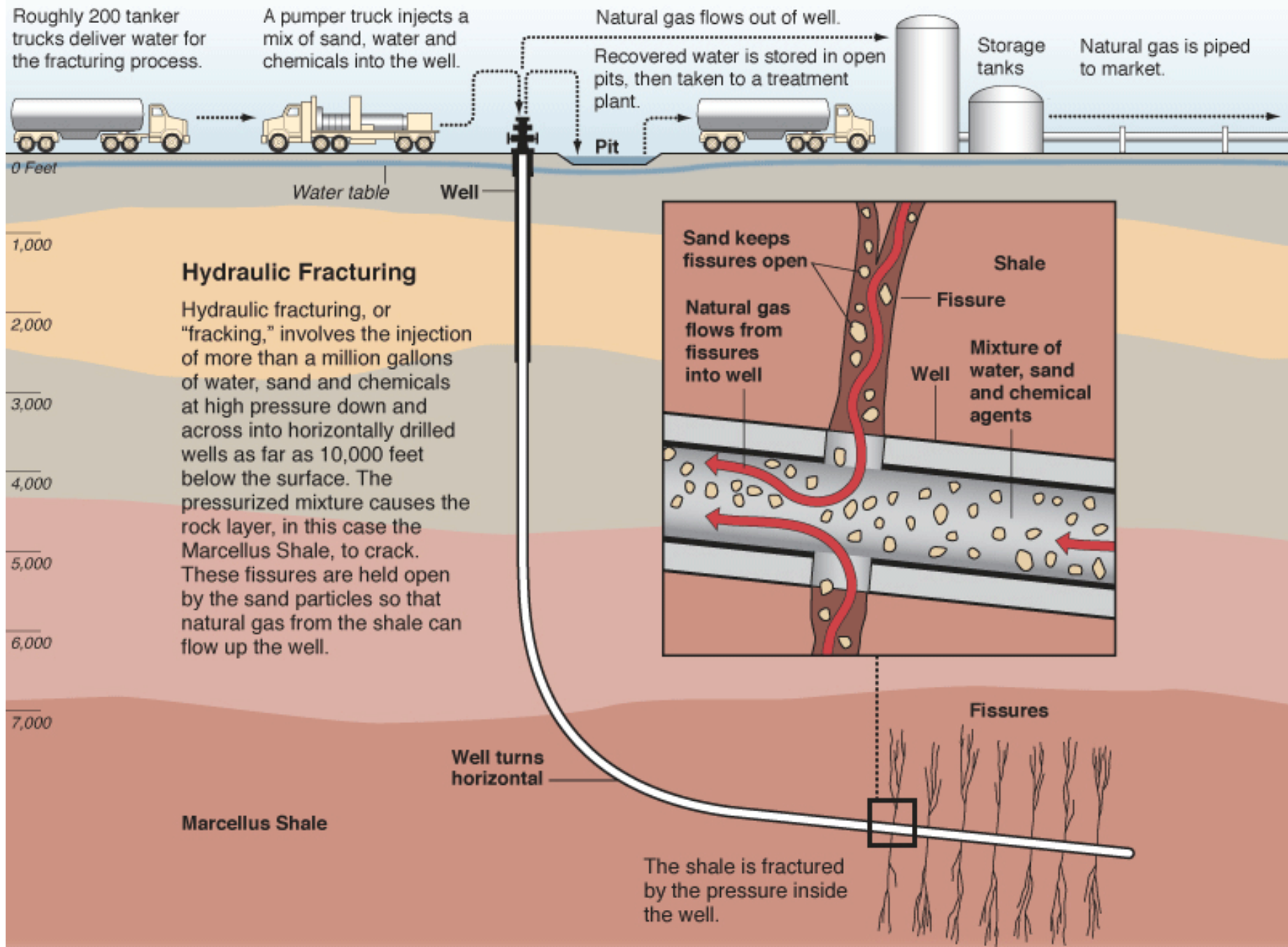




Source: <http://www.eia.gov/todayinenergy/detail.cfm?id=2170>

Hydraulic Fracturing - Fracking

- Method which works against the pressure of overlying rocks to create fissures
- Used at places with low permeability
- Cased well is drilled and turned horizontal at the deposit to cover larger area
- Perforating gun is inserted to create holes in the casing
- Fracturing fluid is pumped into the well (4,5-19 Ml per well)
 - 98-99,5 % water
 - Proppants (sand, ceramics) used to keep fissures open
 - Chemicals (gels, breakers, gases, foams, friction reducers,...) vary according to geological situation
- Once the fracturing has been completed fluid is pumped out and gas is being extracted
- Fracking is closely monitored
 - Modeling based on fluid properties, pressure rate, geological data
 - Radioactive tracers



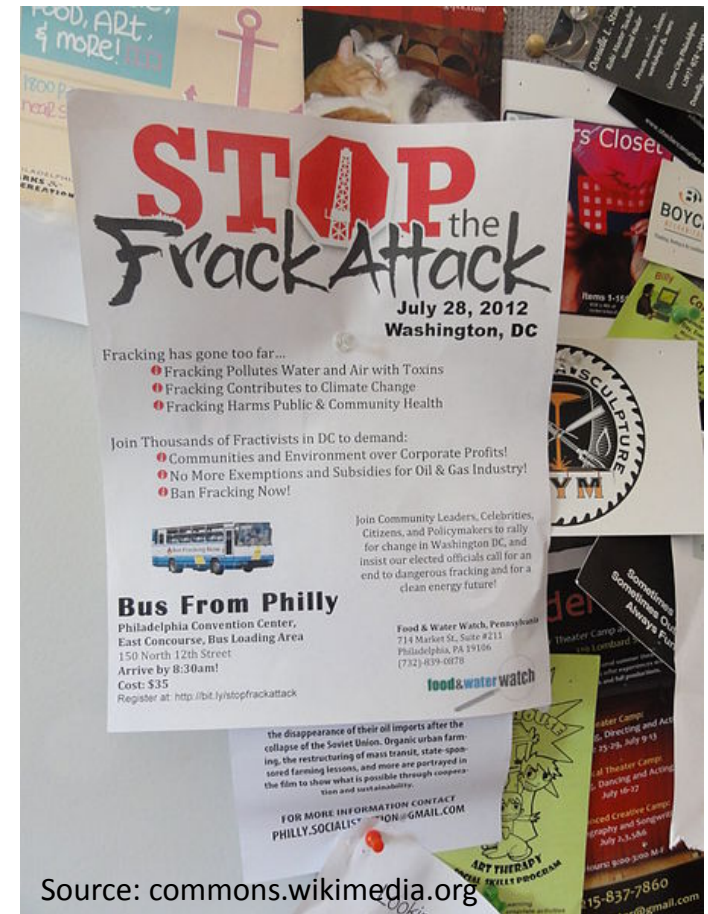
Environmental Impact

Climate:

- Methane leaks, venting (3,6-7,9 % of all pumped methane, according to study by prof. Robert W. Howarth)
- Several other studies claim the GHG footprint is much smaller (EPA, U.S. Department of energy, several universities), even as low as 1/2 - 1/3 of coal)
- Use of methane (indirect)
- Fracking is supported by Obama administration due to claimed smaller GHG footprint

Earthquakes:

- Many microearthquakes are thought to be caused by drilling, but only few are strong enough to even be detected
- Injections of waste water can be linked to larger earthquakes up to 3,3 or even 4th magnitude
 - Detected in Ohio, Japan, Canada



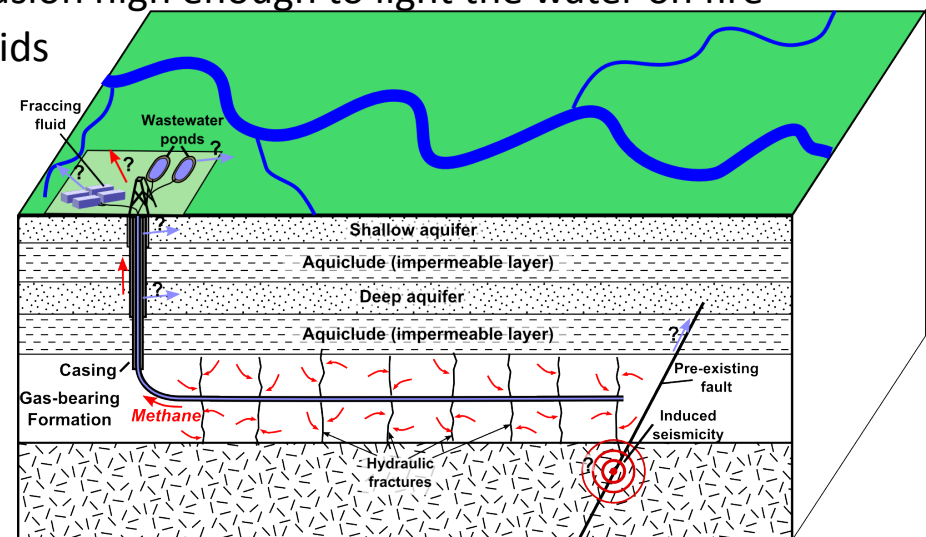
Environmental impact

Water:

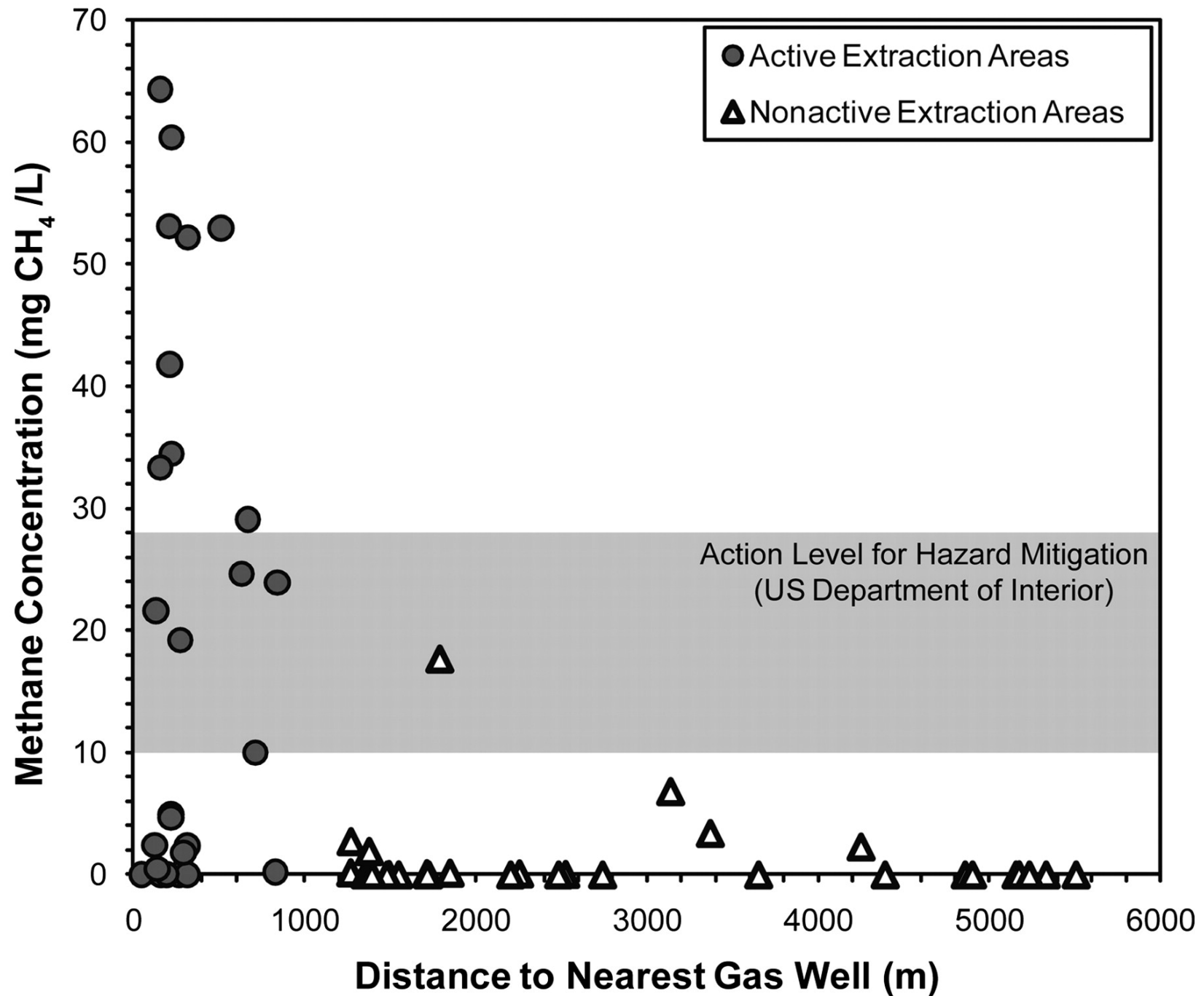
- Only 50-70 % of the fluid used in fracking is reclaimed
- Shale gas industry was exempted from Safe Drinking Water Act in 2005
- Numerous problems reported, most studies don't show direct correlation to fracking or are conclusive
- Study in Pennsylvania by Robert B. Jackson showed greatly increased concentrations of methane in drinking water wells less than 1 km from new gas well
 - First study to show direct correlation between fracking and water pollution
 - Methane was determined to be of fossil origin and therefore leaked from gas well
 - Concentrations of methane were on occasion high enough to light the water on fire
 - No pollution detected due to fracking fluids



Source: <http://www.telegraph.co.uk/finance/newsbysector/energy/oilandgas/7850130/Film-raises-shale-gas-pollution-fears.html>



Source: commons.wikimedia.org



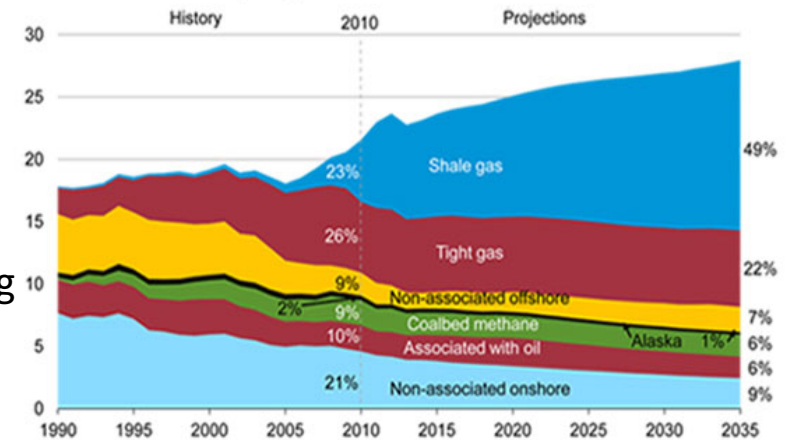
Source: <http://www.pnas.org/content/108/20/8172/F3.expansion.html>

Future of Shale Gas

- United States are increasing their production
- Some economists are questioning the profitability of shale gas
- Interests in the world are growing:
 - Canada: there are interests, but development is slow due to environmental concerns
 - China: is developing infrastructure and is planning to gain large amounts of gas from fracking, U.S. are sharing their technology, it has the largest reserves of shale gas in the world
 - Europe: there are interests, but development is also slow due to environmental concerns and political questions: it has been prohibited in some countries and regions, existing wells are in test phases
 - Australia: only non-test well outside USA
 - South Africa: Large deposits, explorations are beginning, with great opposition
 - Mexico and Argentina: large deposits, no development yet

U.S. Natural Gas Production 1990-2035

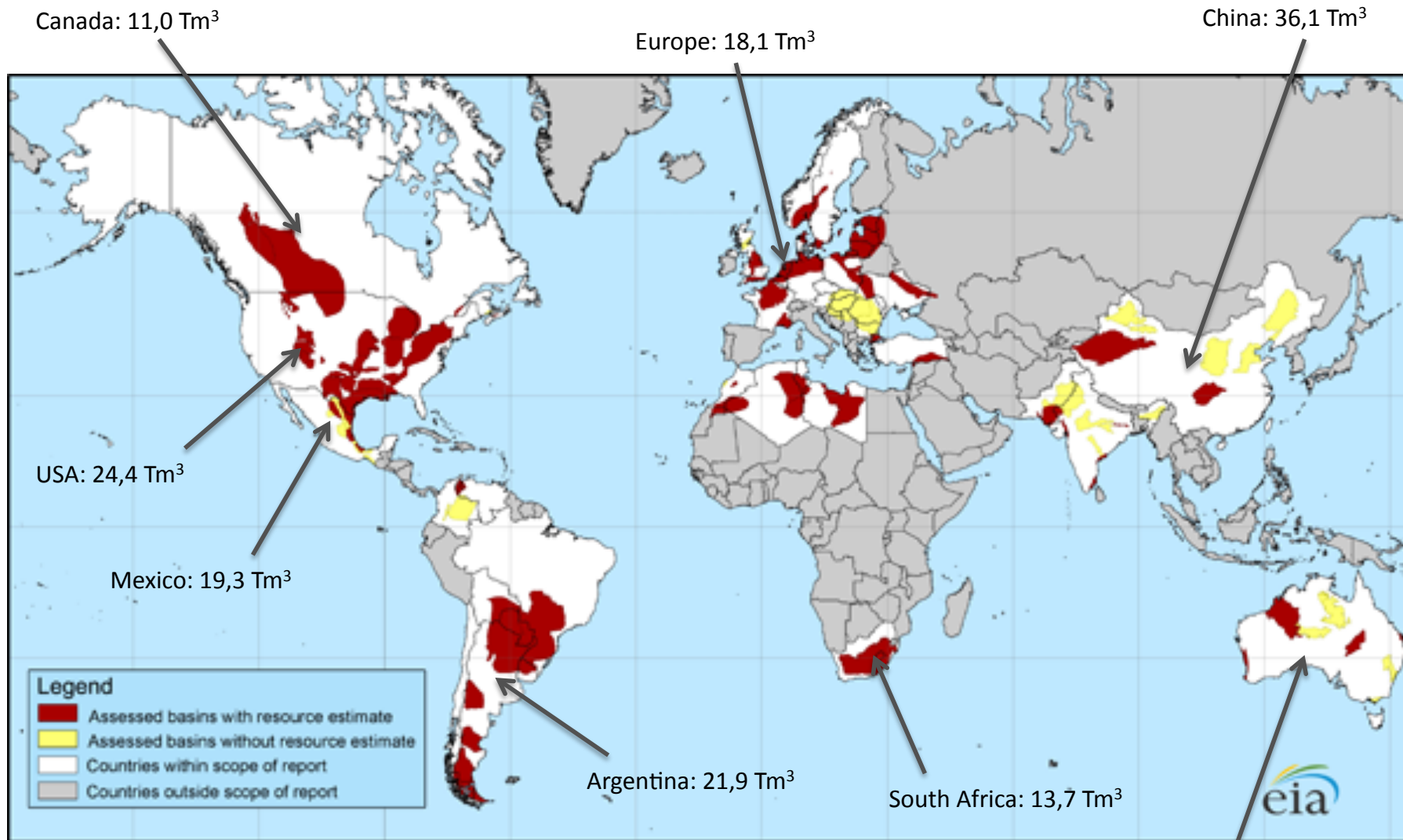
trillion cubic feet per year



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2012* (June 2012).

- World reserves of shale gas are estimated to be about the same as for the conventional natural gas (about 180 Tm³)

World Shale Gas Reserves



Source: <http://www.eia.gov/analysis/studies/worldshalegas/>

- World shale gas deposits and countries with over 10 Tm³ of technically recoverable shale gas reserves as per EIA survey

Sources

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