Geology - Environment

Shale Gas

Geology and Environnement

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GAZ de SCHISTE = mauvaise traduction de l'anglais 'shale gas'

'Shale' mot anglais, n'a pas de traduction simple en français
un 'shale' est une roche sédimentaire <u>litée</u> à grain <u>très</u> fin, en général argileuse ou marneuse;

'Schiste' *s.l.* (à éviter!) = toute roche susceptible de se débiter en feuillet
⇒ aussi bien un schiste métamorphique (= *schist* en anglais)
⇒ qu'une roche présentant un clivage ardoisier (= *slate* en anglais)
⇒ ou bien une 'pélite' (argile, argillite) feuilletée (= *shale* en anglais);

'Schiste' *s.s.* = roche ayant acquis une schistosité sous l'influence de contraintes tectoniques, processus tectono-métamorphiques.

CONCLUSION: 'gaz de schiste' contenu dans des argiles et marnes litées, SEDIMENTAIRES
= 'GAZ de MARNES' OU 'GAZ DE PELITES'

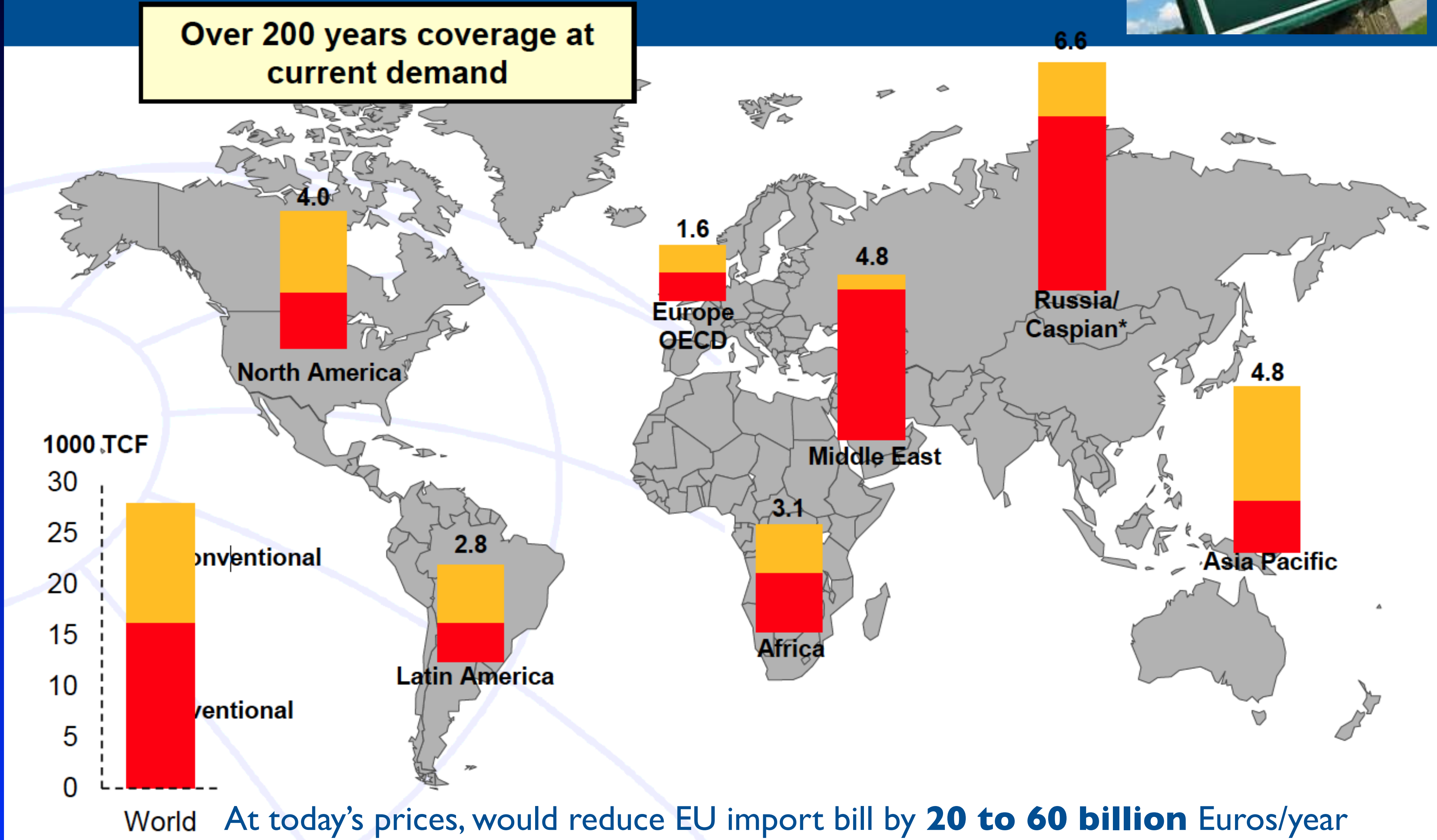
vast dormant gas (and oil) resources economically exploitable

Geological conditions of Shale Gas

- Depositional <u>environment</u> : 'marine-lacustrine' clays with qz-feldspars-carbonates => 'BRITTLE' for hydraulic fracturing
- <u>Exploitation depth</u>: > 1000m et < 4000m = gas window (and pressure)
  The shale gases > 4000m are not rentable
- 300-500bars surpressure at 2500m
  (lithost p = 250bars/km, water column p : 100 bars/km
- TOC (total organic carbon) : > 2 wt %
- <u>Thermal Maturity</u> : Ro > 1.0%, ideally > 1.3%
  nb the oil window starts at Ro = 0.5%, the gas window at 0.8% and beyond 3.0 % = 'graphite'.
- Tiny <u>porosity</u> : nanopores and micropores (<< 5%)
- <u>Permeability</u> : 0.0001 – 0.001 md


‘BRITTLE’ i.e. < 30% clays <=usa
for the hydraulic fracturing
© geology.com

Remaining Global Gas Resource

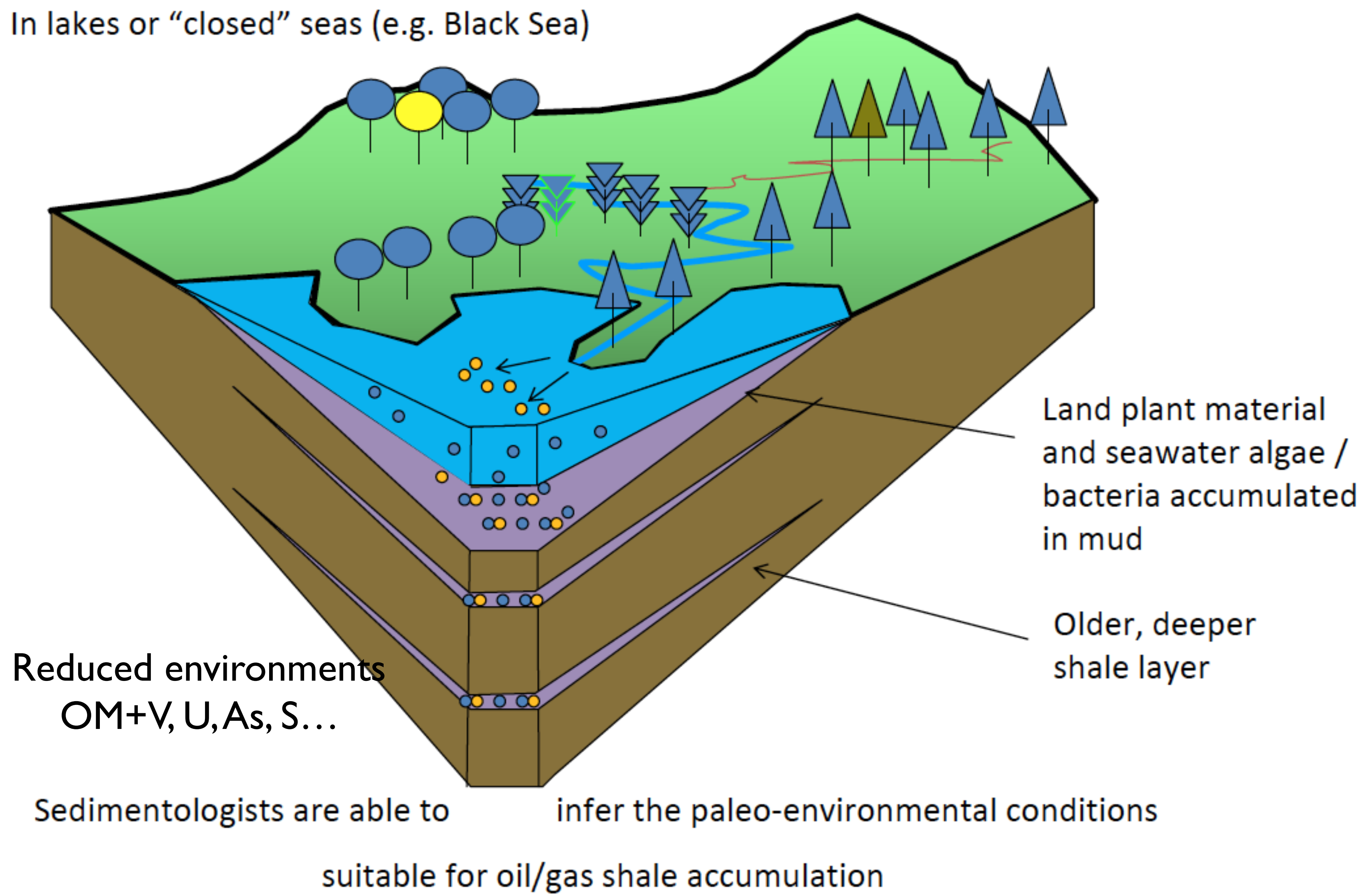


At today's prices, would reduce EU import bill by **20 to 60 billion** Euros/year

From Baeckelmans, Exxon 2013

*Source: IEA; *Includes Europe Non OECD*

Where does the fine grained material and organic material come from?



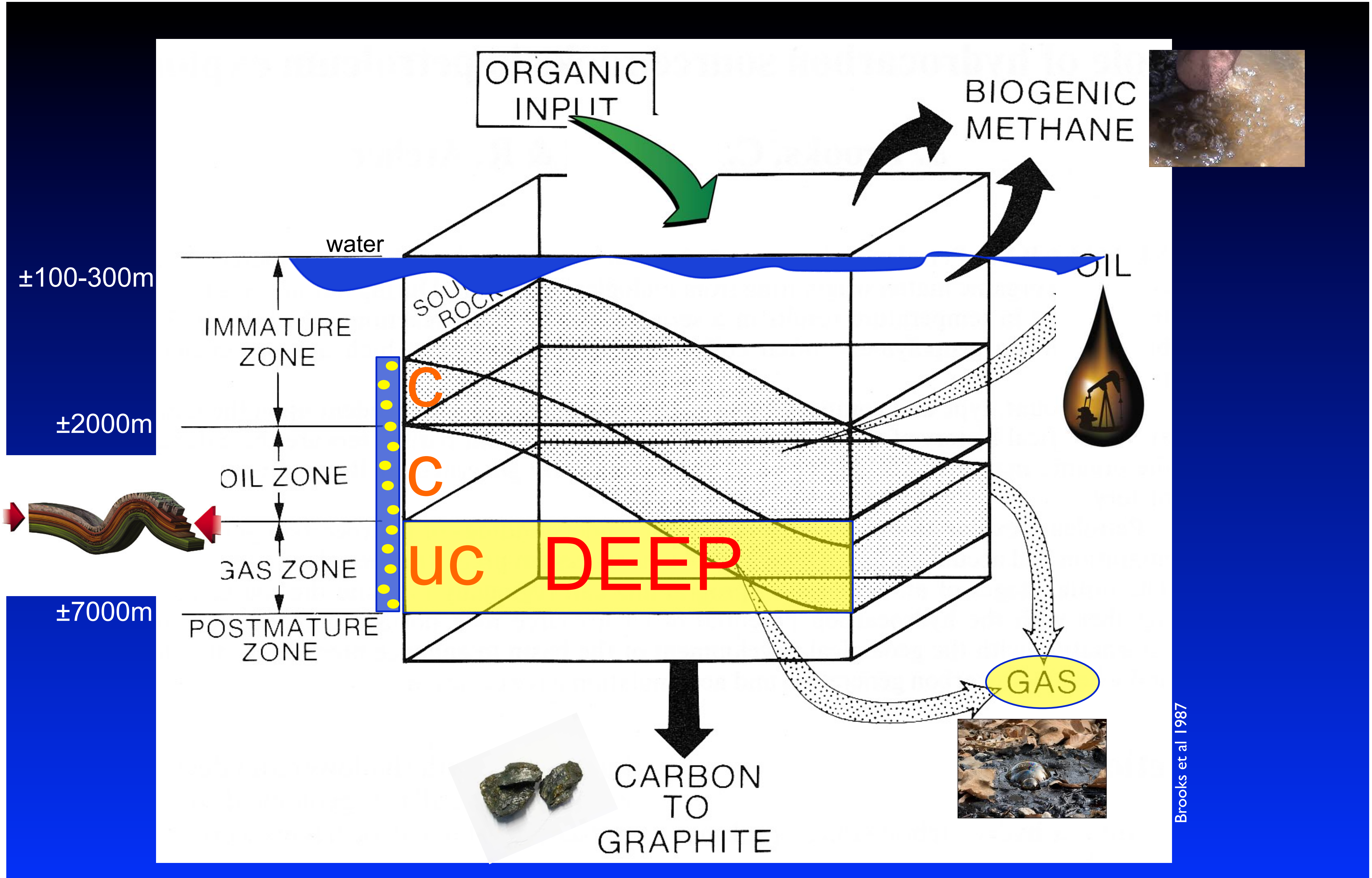
Swennen, KUL, 2013

MATIERE ORGANIQUE : ASPECT MACROSCOPIQUE

Déblais de “black shales “ d’âge Silurien (Anti-Atlas, Maroc)

« Oil shales » d’âge Campanien-Maastrichtien (Jordanie)

http://www.blackshale.com/



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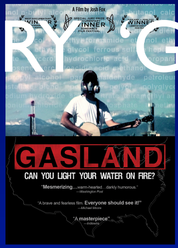
FOSSIL FUELS and RENEWABLE ENERGY

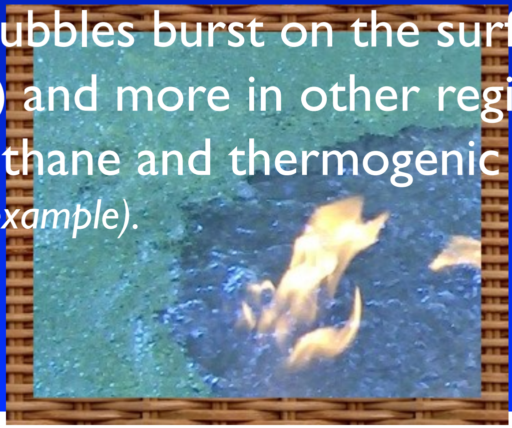
All REN developments are subsidized by the gouvernments,
they can not compete with the petrochemical industry, excepted in some cases (biomass)
⇒ only fossil fuels allow petrochemical manufactures some more than 150 plastic and other by-products used daily.

DOCUMENTARY 'GASLAND' (Josh Fox, 2009 in Colorado State)



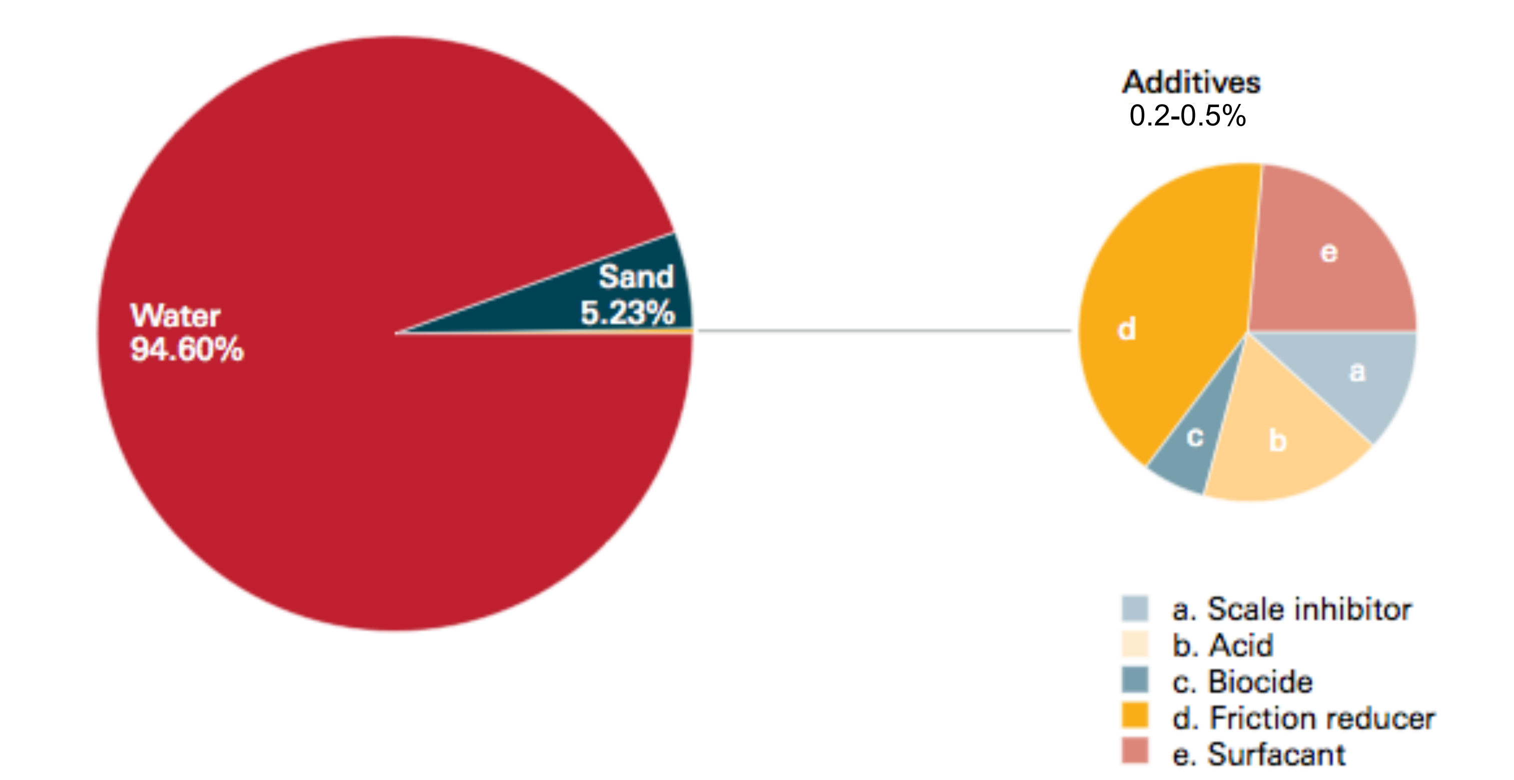
This concerns **BIOGENIC** methane, very well known in marshes/swamps etc…. ….. causing wips in cementeries, so in surface environments **AND NOT** thermogenic methane in the deeper areas, responsible of firedamps.

In the wetlands of Colorado, many gas bubbles burst on the surface water rivers and this is known for over 200 years (Pennyslvania) and more in other regions.
It is very easy to distinguish biogenic methane and thermogenic methane *(see chemistry of carbon, hydrogen isotopes … for example).*



HYDRAULIC FRACTURING/STIMULATION IS AN OLD TECHNIQUE 1940-1950

Hydraulic fracturing, or *"fracking"*, is the process of drilling and injecting fluid into the ground at a high pressure (> 100 to 600 bars or >) in order to fracture shale rocks to release natural gas inside.



UK report, 2012

HYDRAULIC FRACTURING/STIMULATION IS AN OLD TECHNIQUE 1940-1950

More 'fissuration' than 'fracturing'

It creates small fractures (typically less than 1mm)

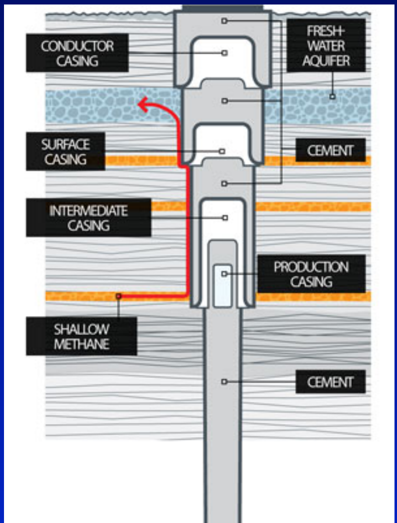
Fracking is a completion technique and not a drilling technique.

The drilling of a well and the completion of a well are two independent techniques done at separate times and, usually, by two different contractors.

Drilling fluids and frac fluids are not the same and are not used at the same time.

(also in **geothermal** energy)

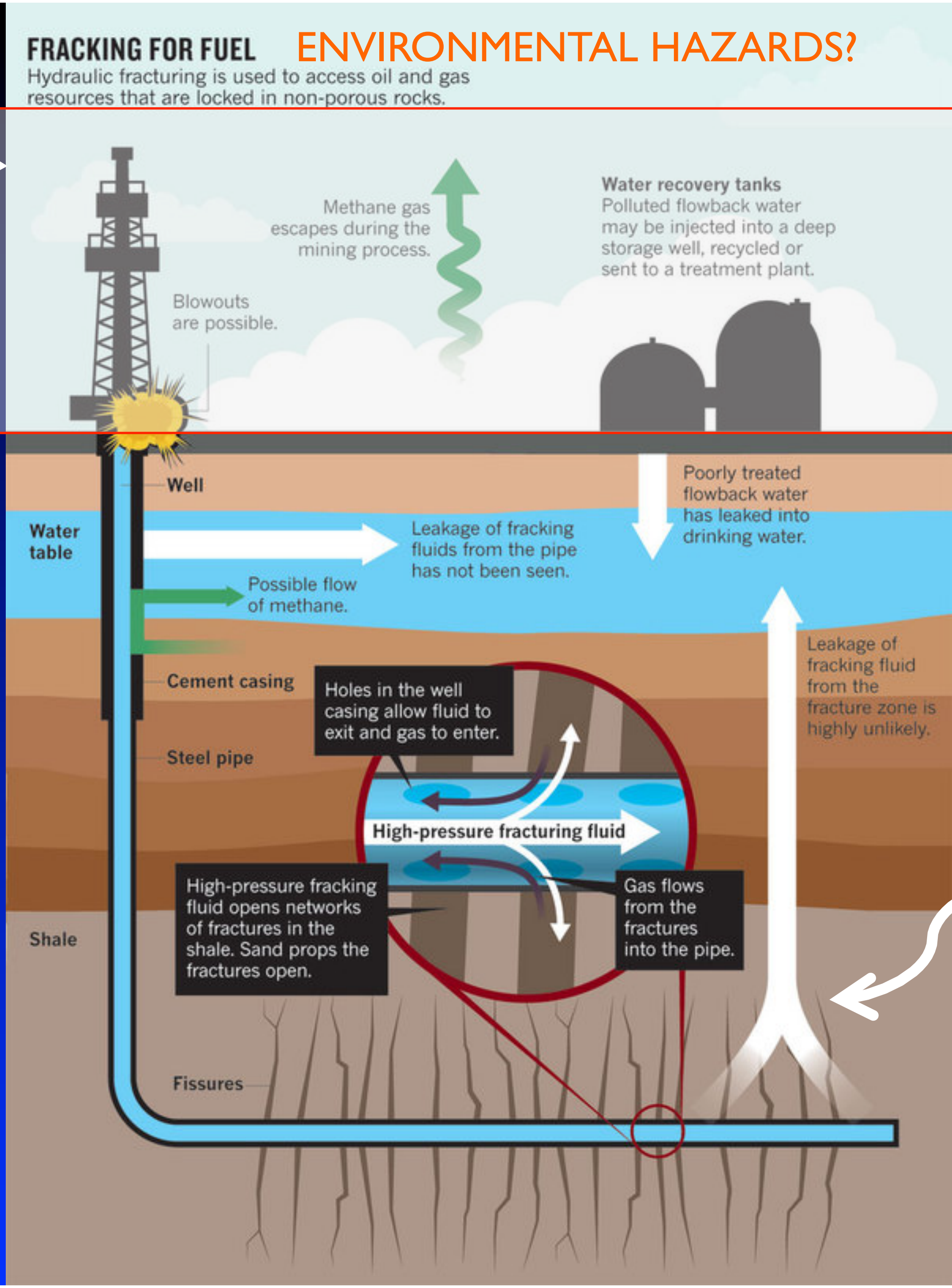
?1 to ?9% CH_4
due to the
flowback [1,6%]
and/or
pipeline leak
(+flare)



The problem can be corrected by using stronger cement and processing casings to create a better bond, ensuring an impermeable seal.

CASING : 10 => 150 m

Howarth et al., Nature 2011



Hydrovertical fractures penetrate the rock on several 10'-100'm

1% may exceed 350 m
The recorded max is 600 m

The fracking fluid itself, thickened with additives, is too dense to ascend upward through such a channel.

DEEP?

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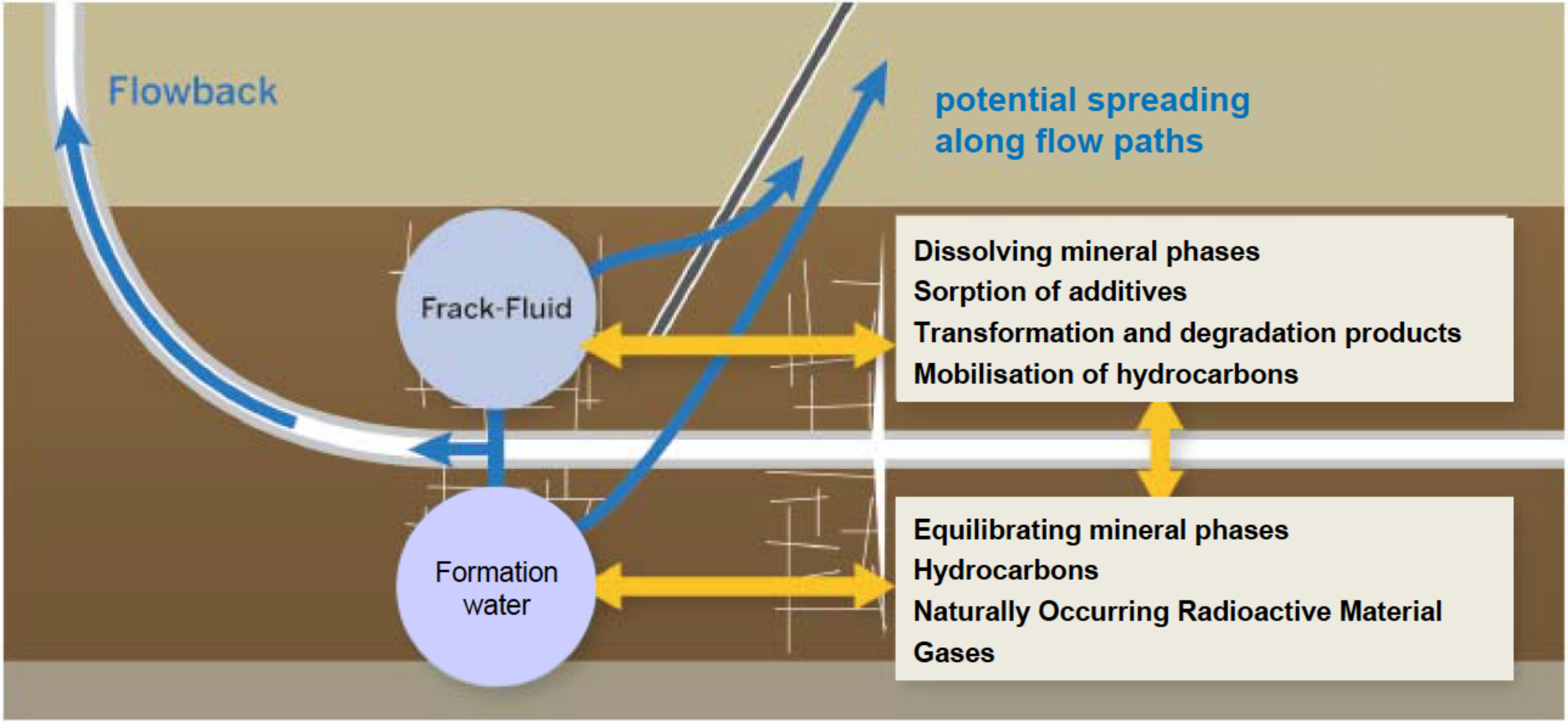
Frac fluids and flowback

(Schluter DMT, 2013)



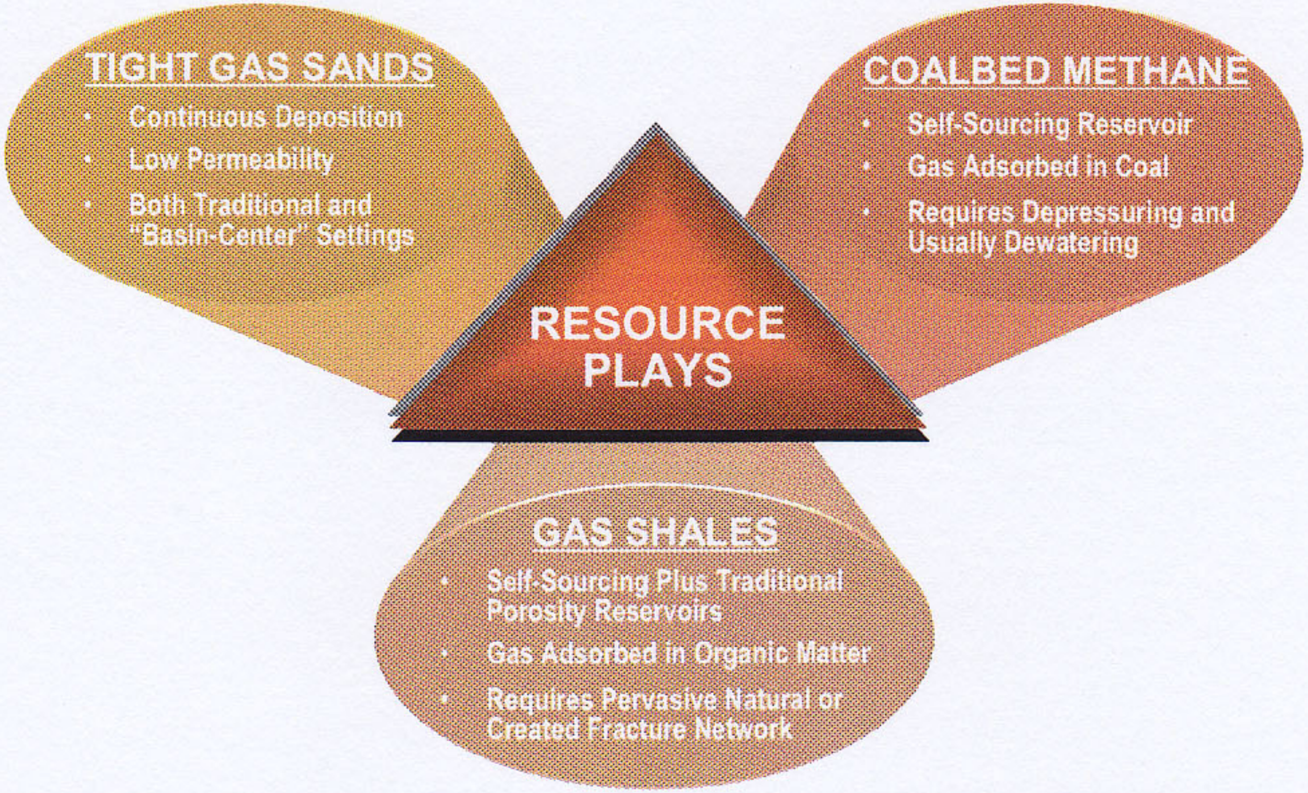
- **Vertical and horizontal transport of frac fluid can be modelled and are expected to be very limited**


Costs for a production well in the US/EU
min. $4 million (US) to $12 million (Pol)
Under good conditions (with about 20% wells non-productive)
Nb 2013 estimation (geology) ÷10 Poland =>?Exxon), X2 vs 2008 Bakken basin, USA
RICCELLI

SEDIMENTARY BASINS

What Is Unconventional Gas?

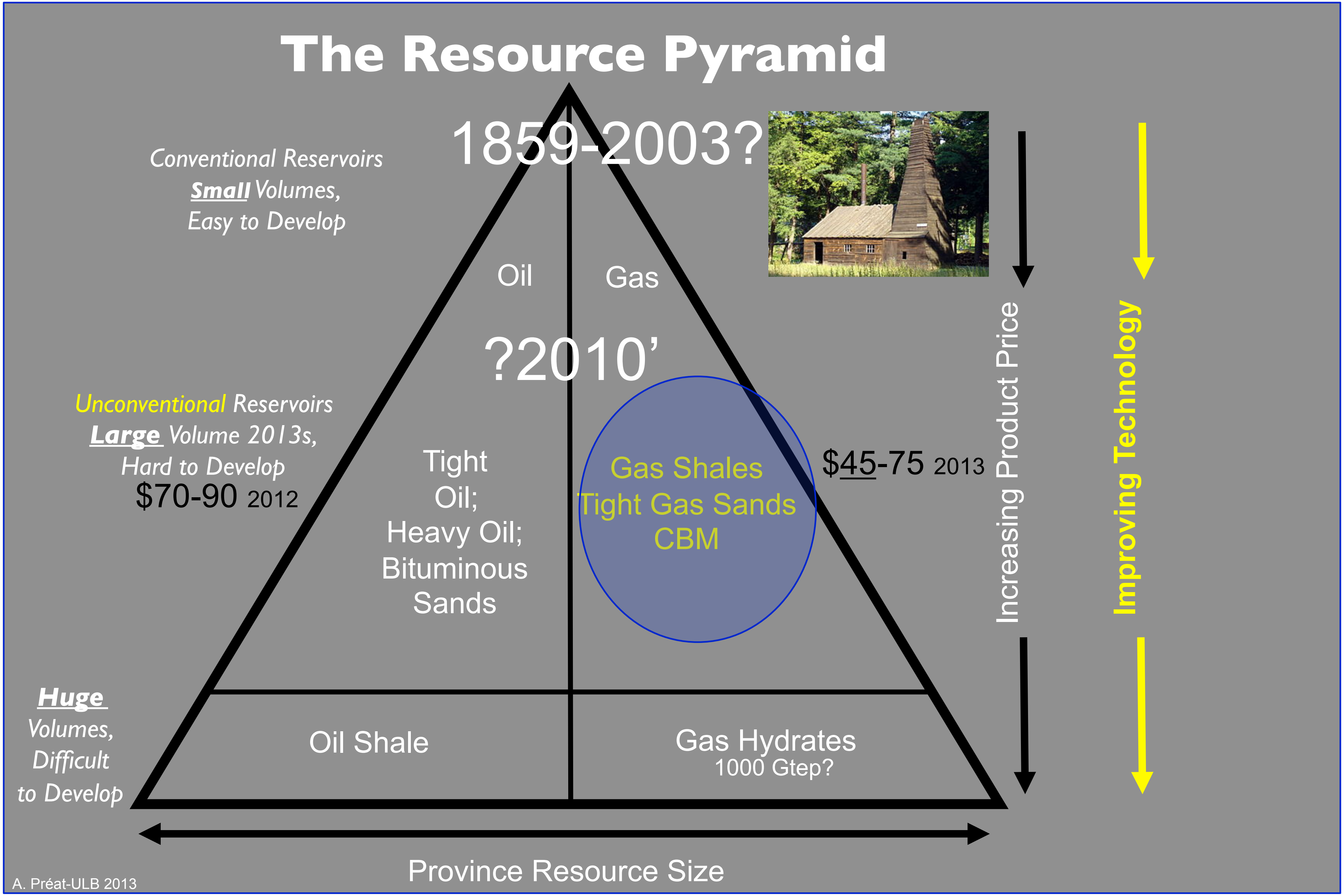
Three natural gas sources comprise today's unconventional gas. Methane hydrates, a fourth candidate, is not yet ready for "prime time".



Kuuskraa & Steven 2009

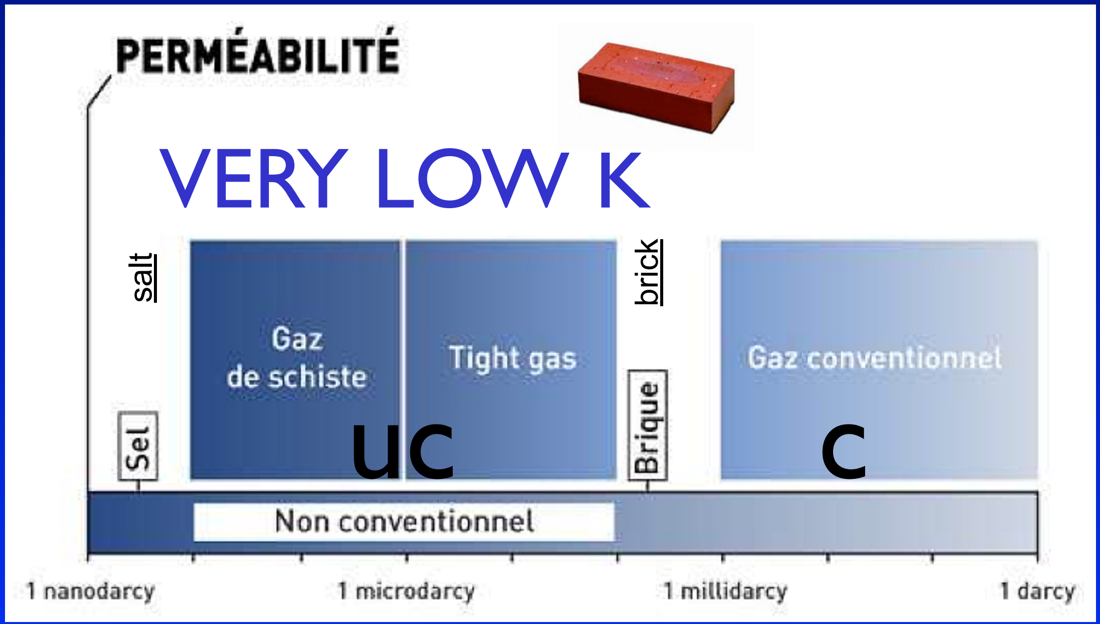
MAJOR EXTENSIONS, LARGE VOLUMES

valid for all geological periods


The Resource Pyramid
1859-2003?
Conventional Reservoirs
Small Volumes,
Easy to Develop
Oil
Gas
?2010'
Unconventional Reservoirs
Large Volume 2013s,
Hard to Develop
$70-90 2012
Tight
Oil;
Heavy Oil;
Bituminous
Sands
Gas Shales
Tight Gas Sands
CBM
$45-75 2013
Increasing Product Price
Improving Technology
Huge
Volumes,
Difficult
to Develop
Oil Shale
Gas Hydrates
1000 Gtep?
Province Resource Size
A. Préat-ULB 2013

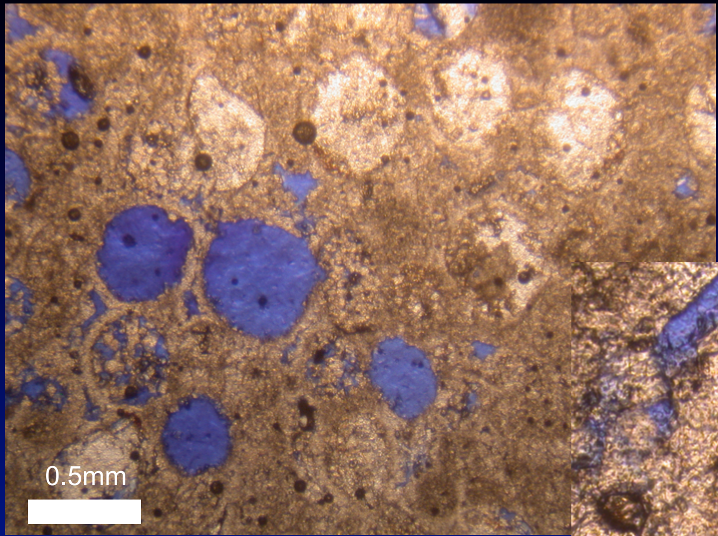
These are THE GEOLOGICAL CHARACTERISTICS OF THE ROCK
that distinguish 'conventional' and unconventional' gas AND NOT their chemical nature, because it is in all cases natural gas (mostly methane).

The quality of a reservoir rock is characterized by its porosity and permeability.
The unconventional gas reservoirs are also the source rocks ('virtually no porosity', 'no K')
=> large gas volumes NOT connected in ultra-compact rocks.



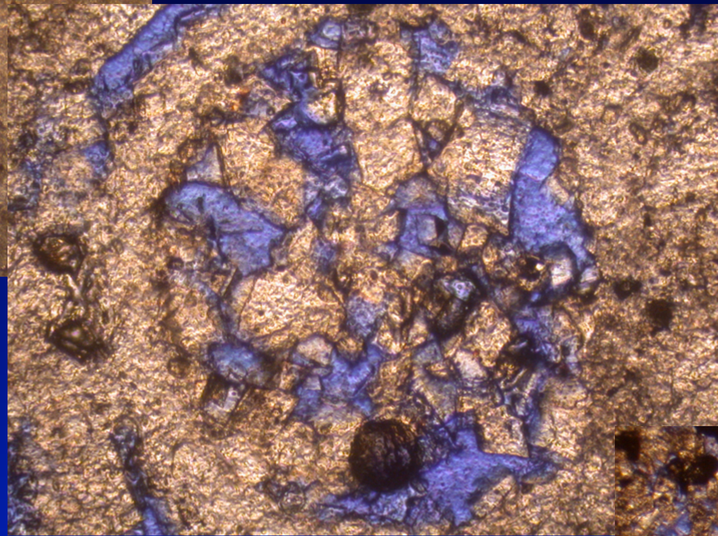
Conventional Carbonate

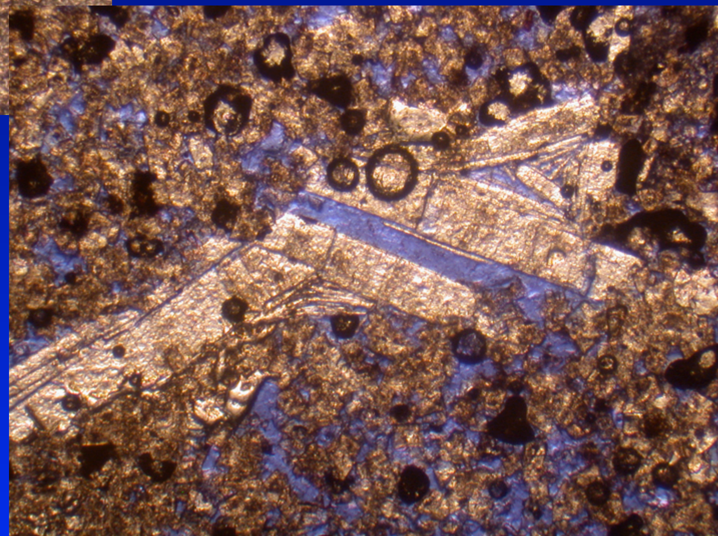
µm-mm->cm, MOLDIC, vuggy, intercrystalline . . .



good porosity-permeability

Oolite dolopackstone
partly plugged by anhydrite
(Cretaceous, Angola, *Préat 2013*)
Diameter oolites : 400 µm

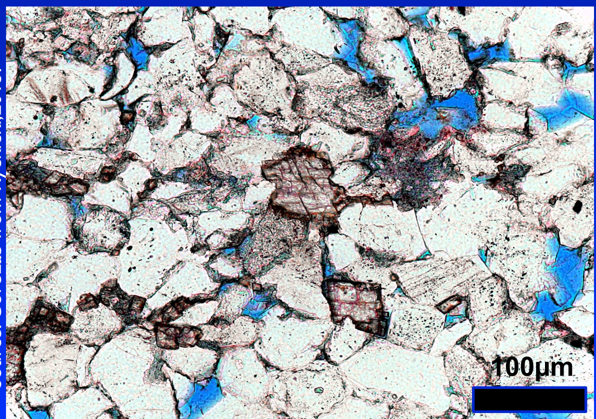




Conventional Sandstone

> 62 µm – mm, > mm sand …

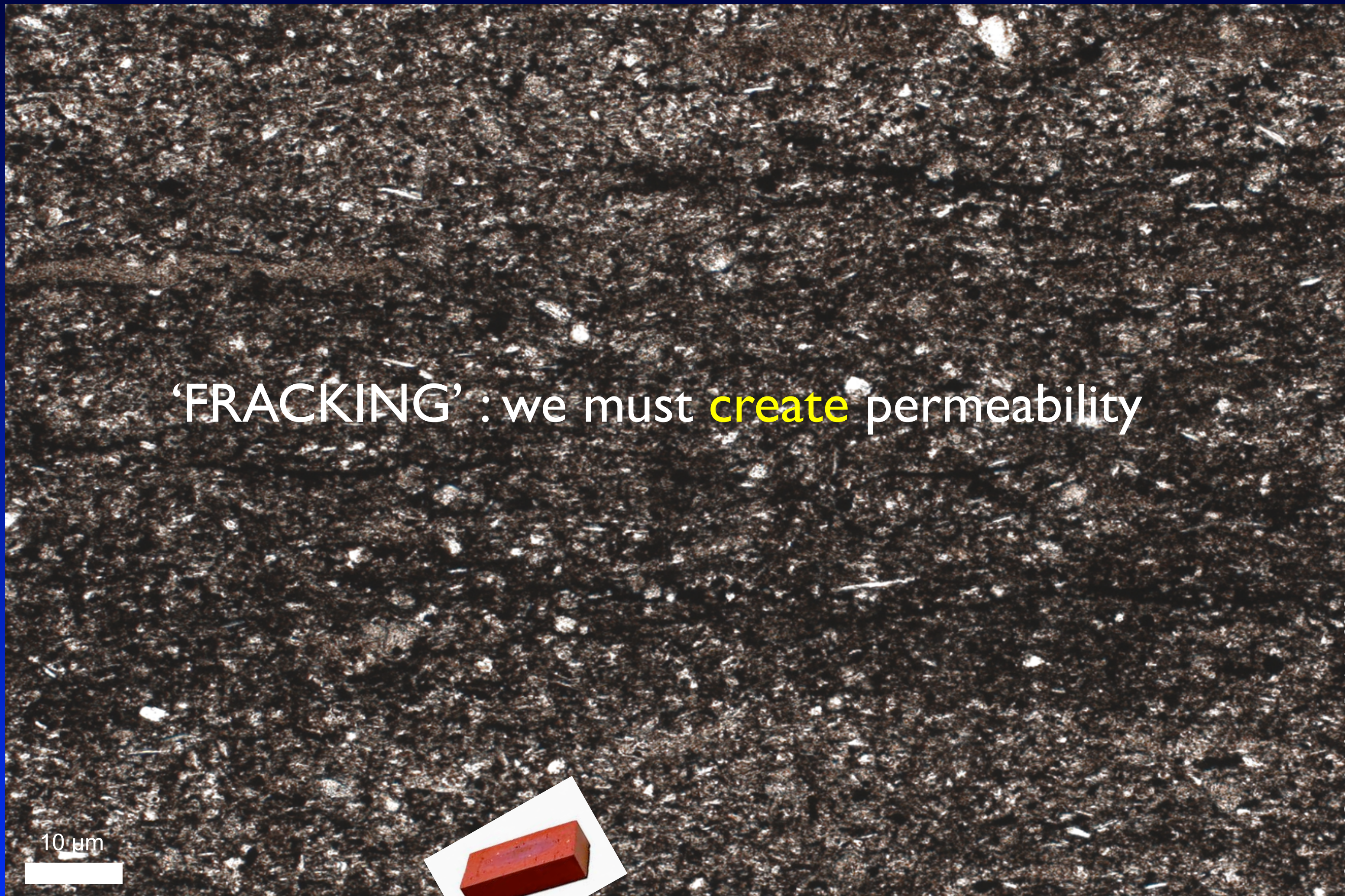
Source: CoreLab from Ryckicki,2013.



good porosity-permeability

Unconventional Reservoir Shale

< 1 μm - <62 µm : clay, mud, silt

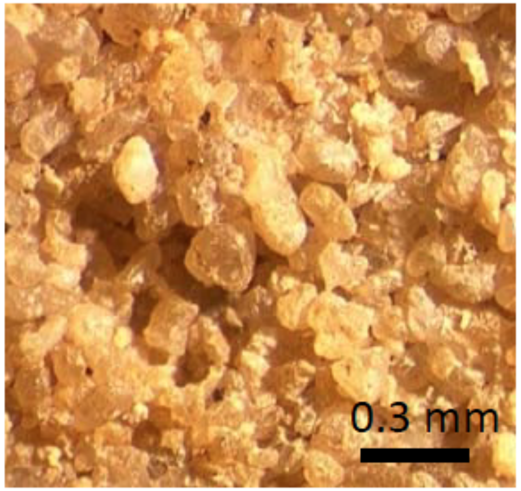


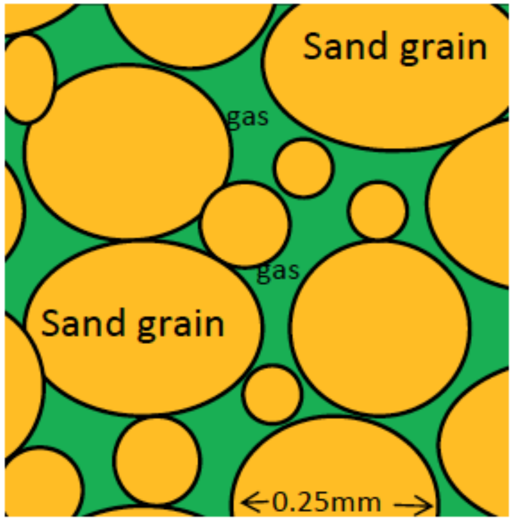
Source: CoreLab from Ryckicki, 2013.

virtually no porosity-no permeability

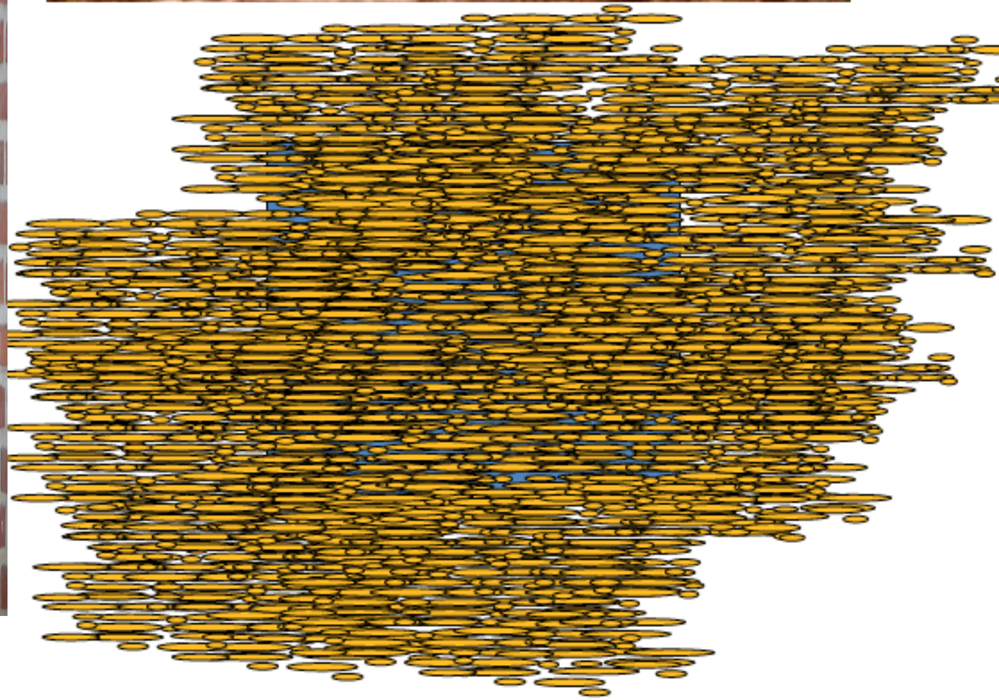
Sandstone versus Shale

Sandstone





Shale



Micron-sized porosity between grains

Nanometer-sized porosity between clays

Swennen, KUL, 2013

‘FRACKING’ : we must create permeability

⟹ a crack network is produced through an injection of water under pressure (600 bars) in the reservoir, allowing gas to flow to the well

⟹ to the injected water is added:

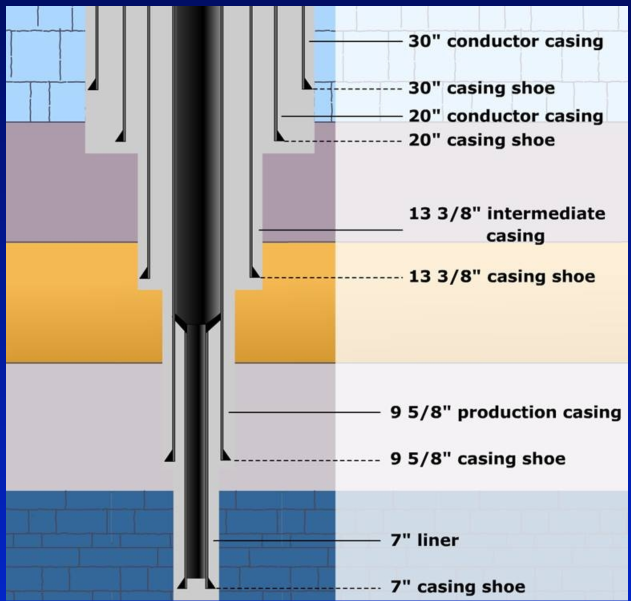
- proppants (sand, ceramic) which hold open (mm) cracks
- a very small quantity of additives (± 0.5% of the total injected volume), = bactericides, gelling agents and surfactants. The composition depends on the well conditions, p-T, amount of proppants….
  Objective : to sterilize and avoid bacterial contamination of the reservoir

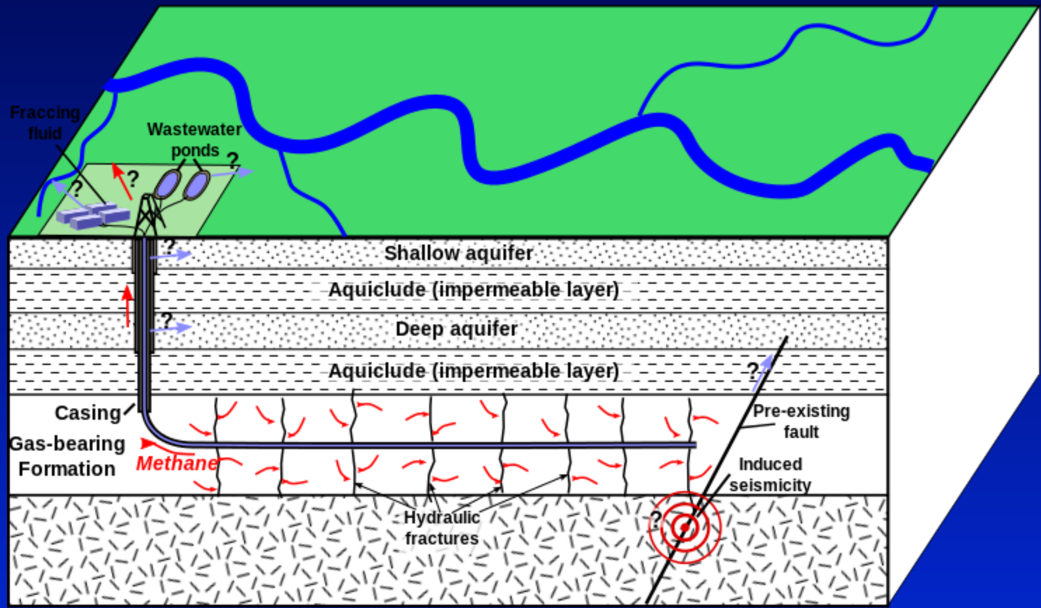
⟹ each well is fractured in several stages (sections 10’m => 300 m, distance 2 km)

=> it requires a large number of wells and the use of clusters (combination of 10 to 30 heads of horizontal wells from a centre point to limit the footprint)

When a well is properly constructed => near surface aquifers are separated from the (shaly) aquifer (from the outside in) by a layer of cement, steel surface casing, a layer of cement, another layer of steel pipe called intermediate casing, and production casing or tubing.

Cement is used in the wellbore across thousands of feet to bond the rock wall of the wellbore to the casing pipe. No fluids can travel up the cement (vertically) or through it (horizontally).

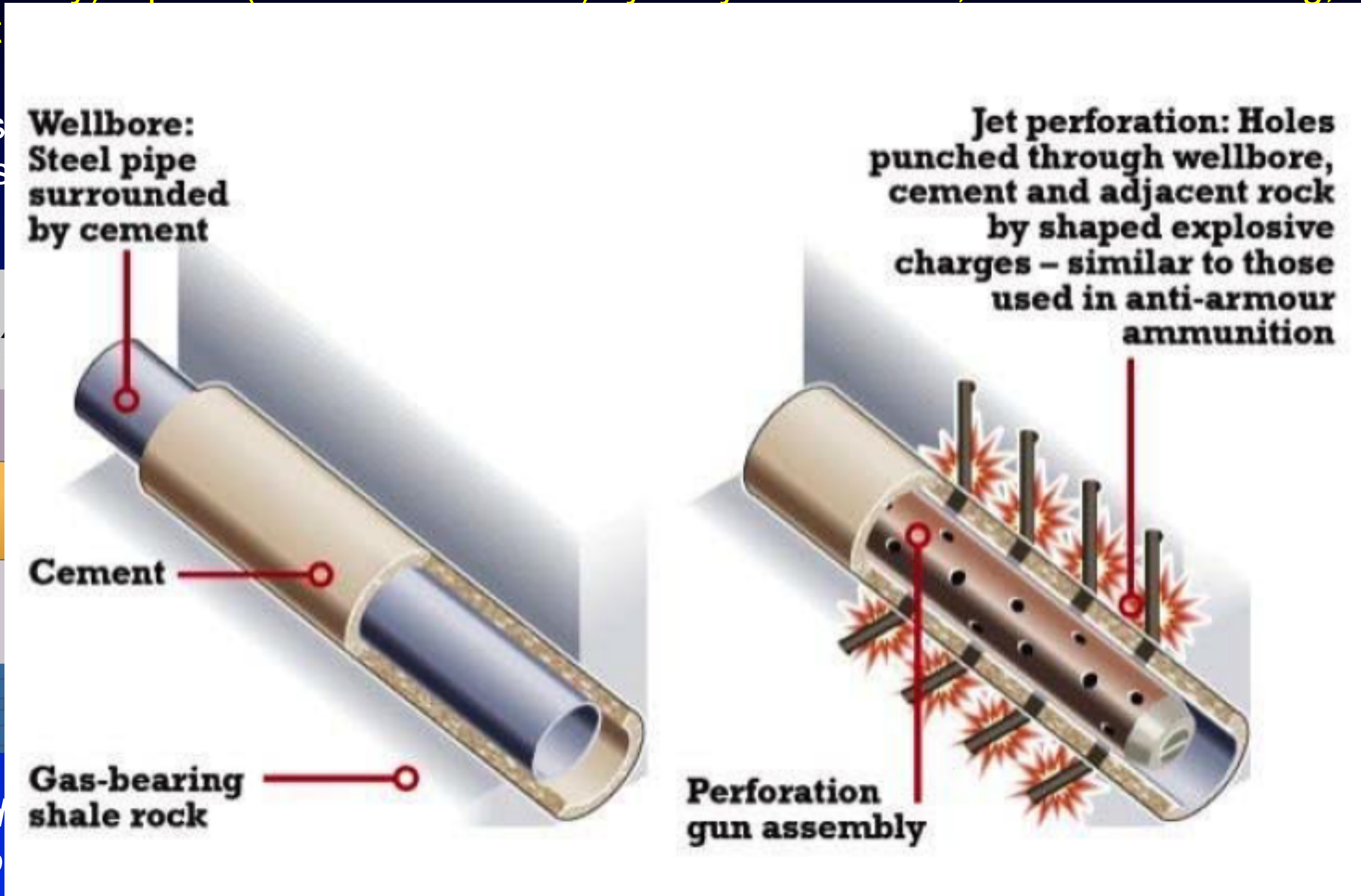




In Colorado, and many places in the Rocky Mountain region of the US, reservoirs with low porosity and low permeability that need stimulation sit a considerable depth (± 6500-8000 ft below surface) compared to aquifers (0-2000 ft below surface). That depth separation is an important flow barrier between the hydrocarbons that sit in naturally overpressured reservoirs and the surface.

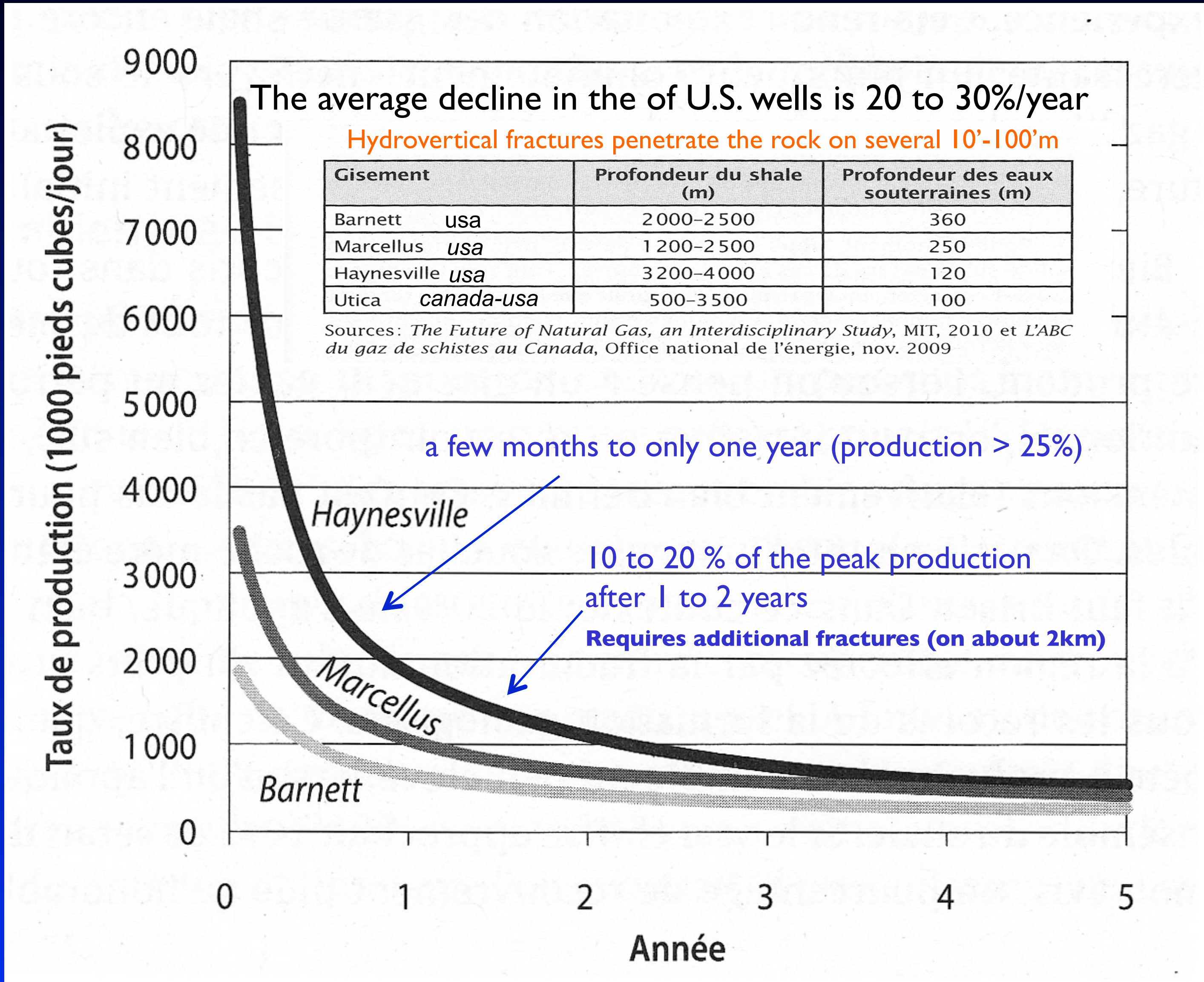
When a well is properly constructed => near surface aquifers are separated from the (shaly) aquifer (from the outside in) by a layer of cement, steel surface casing, a layer of cement … or tubing.

Cement is … bore
to the cas… lly).



*In Colorad… w porosity
and low p… w surface)
compared to aquifers (0-2000 ft below surface). That depth separation is an important flow barrier between the hydrocarbons that sit in naturally overpressured reservoirs and the surface.*

Typical production of shale gas wells in various geological structures
(very different of conventional fields)



Gisement	Profondeur du shale (m)	Profondeur des eaux souterraines (m)
Barnett usa	2 000–2 500	360
Marcellus usa	1 200–2 500	250
Haynesville usa	3 200–4 000	120
Utica canada-usa	500–3 500	100

Sources: *The Future of Natural Gas, an Interdisciplinary Study*, MIT, 2010 et *L'ABC du gaz de schistes au Canada*, Office national de l'énergie, nov. 2009

MIT 2010 in Mousseau 2010

gas productivity
= rapid decline <3y
more fracking
more water
….

Life well : probably > 15 years, close to 30 years
Recovery > conventional hydrocarbons

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Typical production of shale gas wells in various geological structures

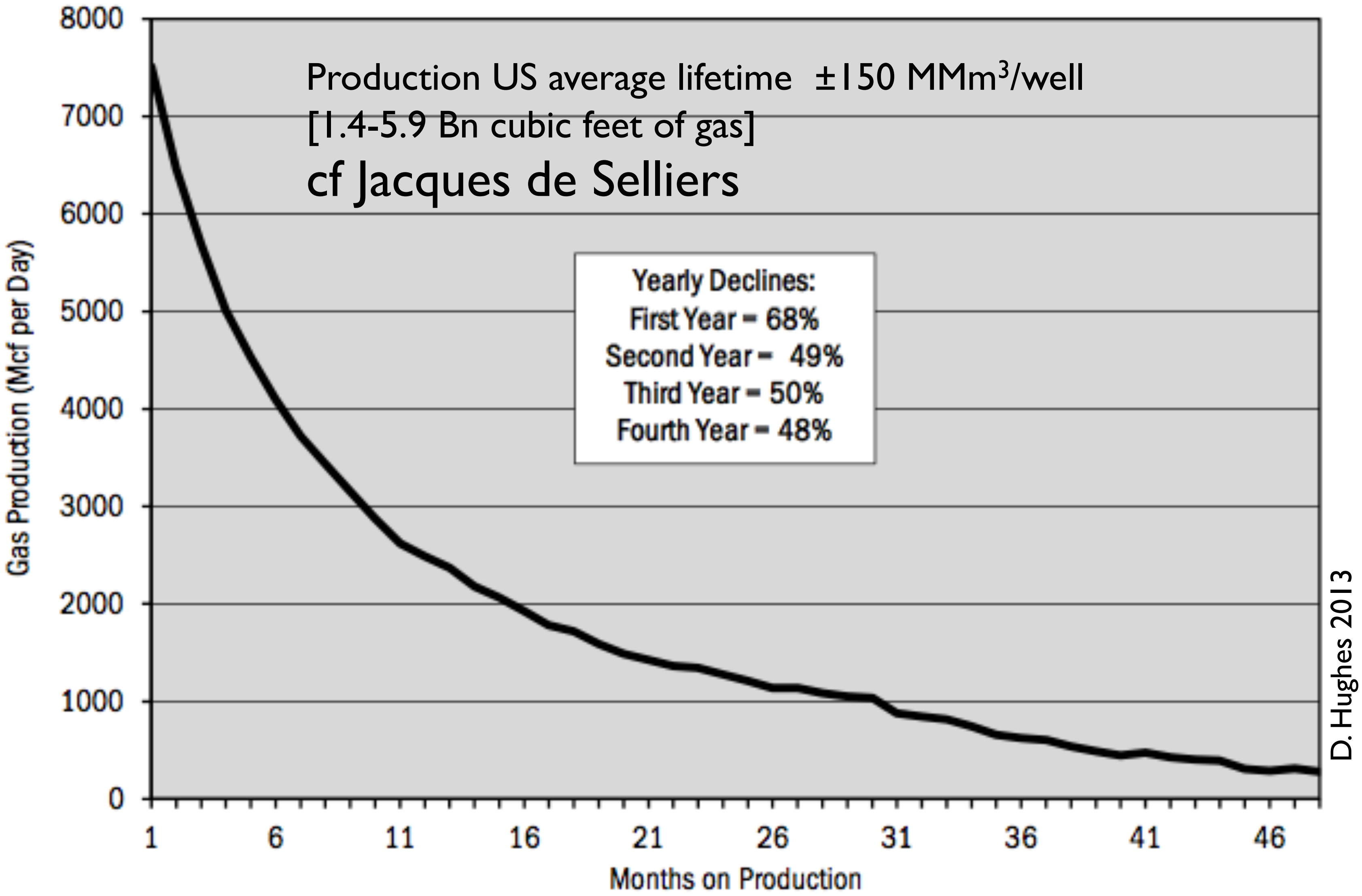


Figure 43. Type decline curve for Haynesville shale gas wells.[84]

Based on data from the four years this shale play has been in production.

Recovery > conventional hydrocarbons

ENVIRONMENTAL HAZARDS?

Many independent reports, aslo from government and oil companies [G. Medaisko, 2012, in *Foreurs/Drillers Contact n°101*]

POLLUTION OF GROUNDWATER

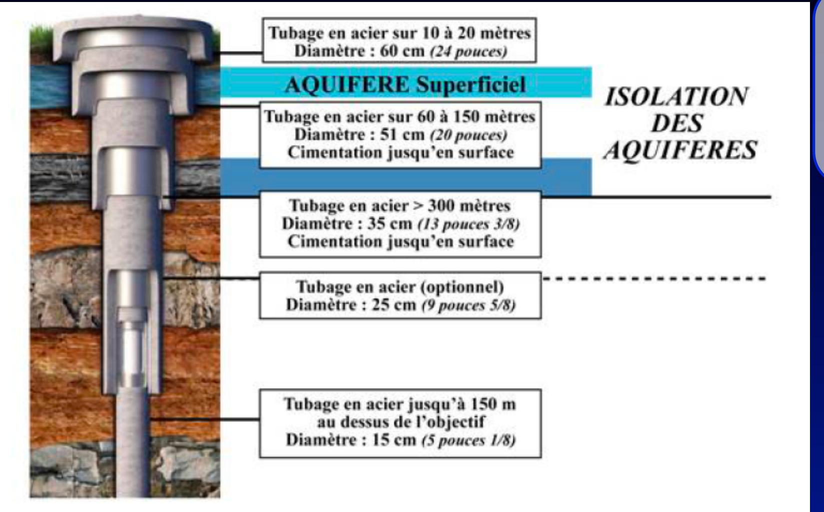
Agriculture is one of the biggest polluters, does not pay pollution tax virtually (in France), taxes are borne by the private (85%) and industrial (15%)
(see 6th World Water Forum, Marseille, March 2012)

Oil geologists know the position of the groundwater in almost all sedimentary basins of the world => 'MONITORING' is easy,
⇒ the drilled hole is cased by installing stainless steel hollow columns of different diameters FOR ISOLATION of aquifers or low resistance (friable) layers (to avoid caves) …
= = > these casings are CEMENTED …

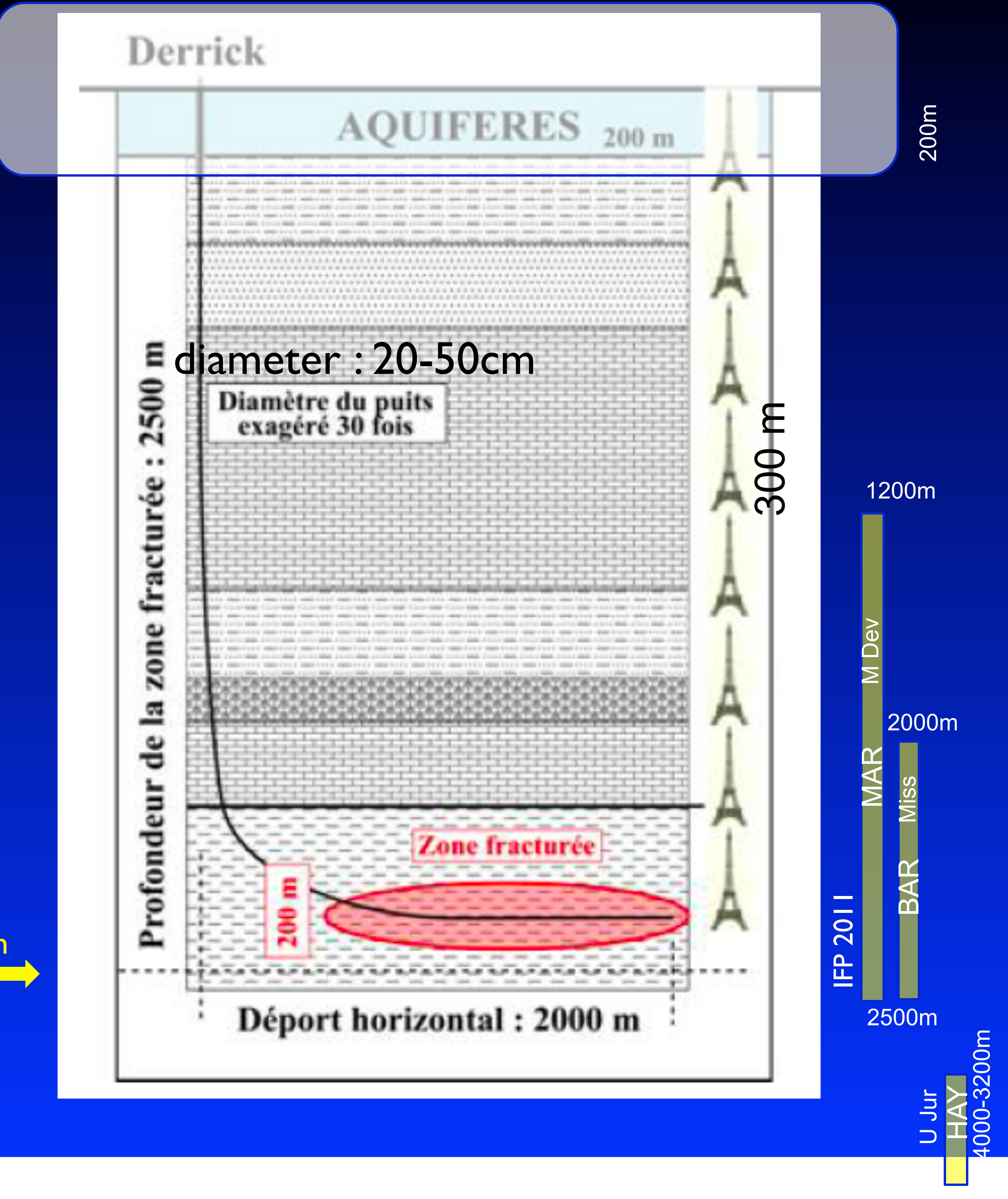
On 6,000 holes drilled in France (excluding Pechelbronn), only two cases of pollution of an aquifer occured due to poor cementing (BRGM data).
<u>At Dimock (Gasland) pollution existed but was not due to oil drilling</u>
(see EPA= U.S. Environmental Protection Agency, 25 July 2012)

The shale gas are WELL BELOW aquifers, at kilometer depths.
Groundwater is also crossed to produce conventional oil and/or gas.

CEMENTATION on 10'm, if necessary100'm



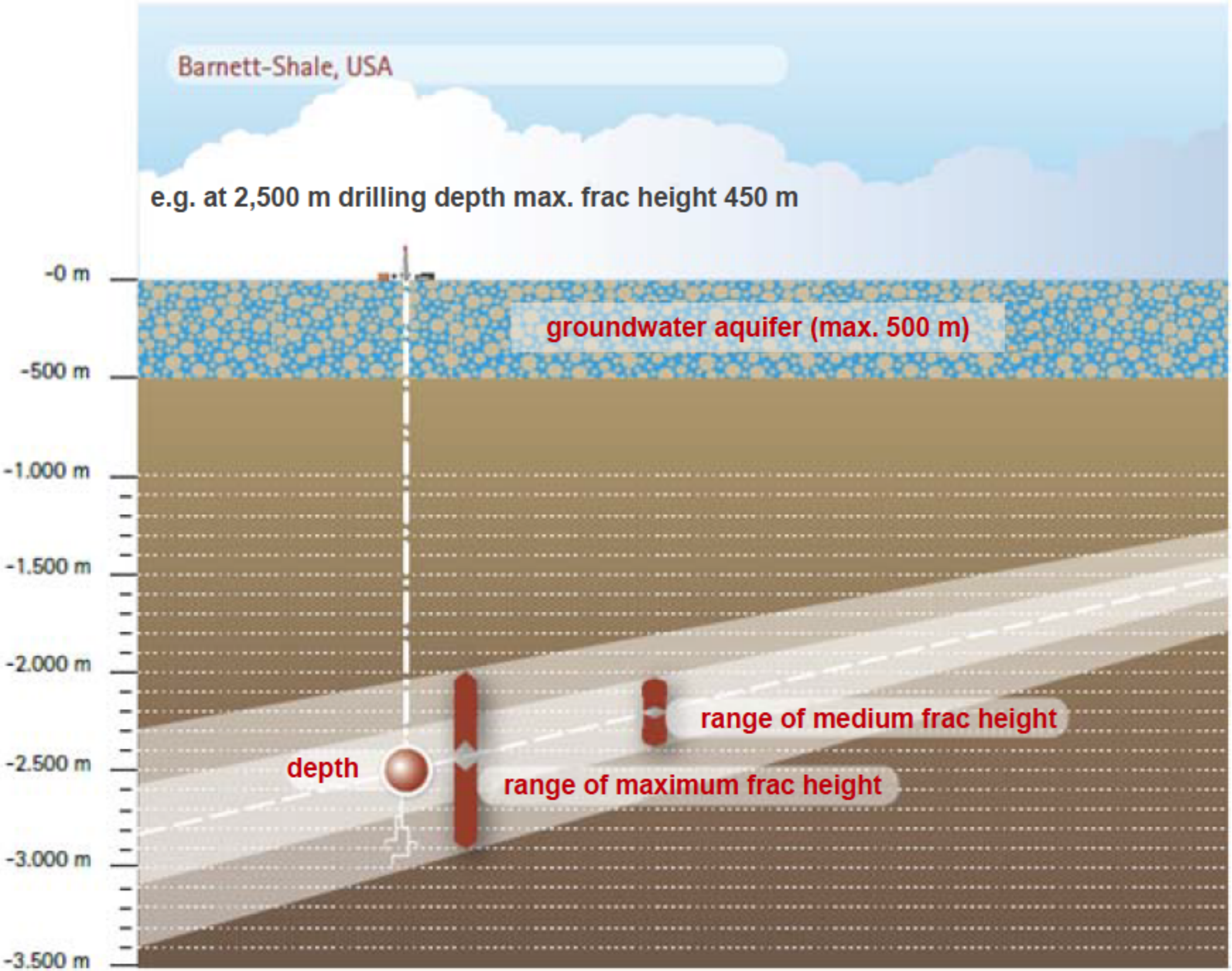
Architecture type d'un puits de "Gas Shale" dans les Marcellus Shale (USA)
(source Range Resources)



The shale gas are
WELL BELOW aquifers,
at kilometer depths

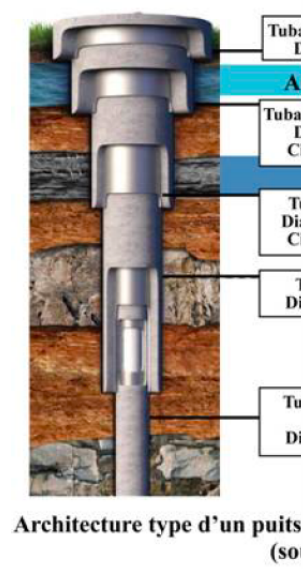
Depth of the fractured zone : 2500 m

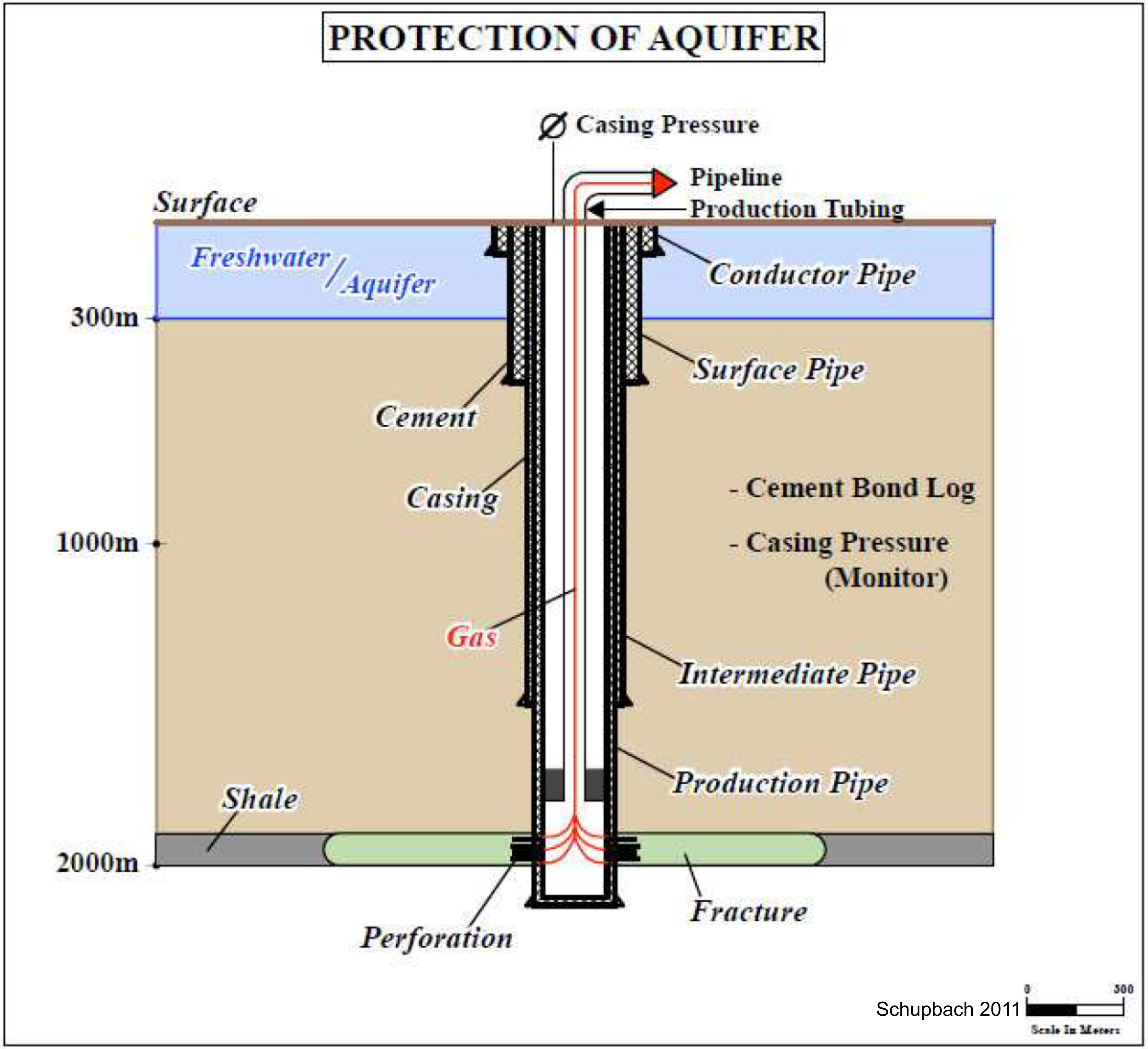
Architecture type d



Source: Risk Study Fracking / ExxonMobil

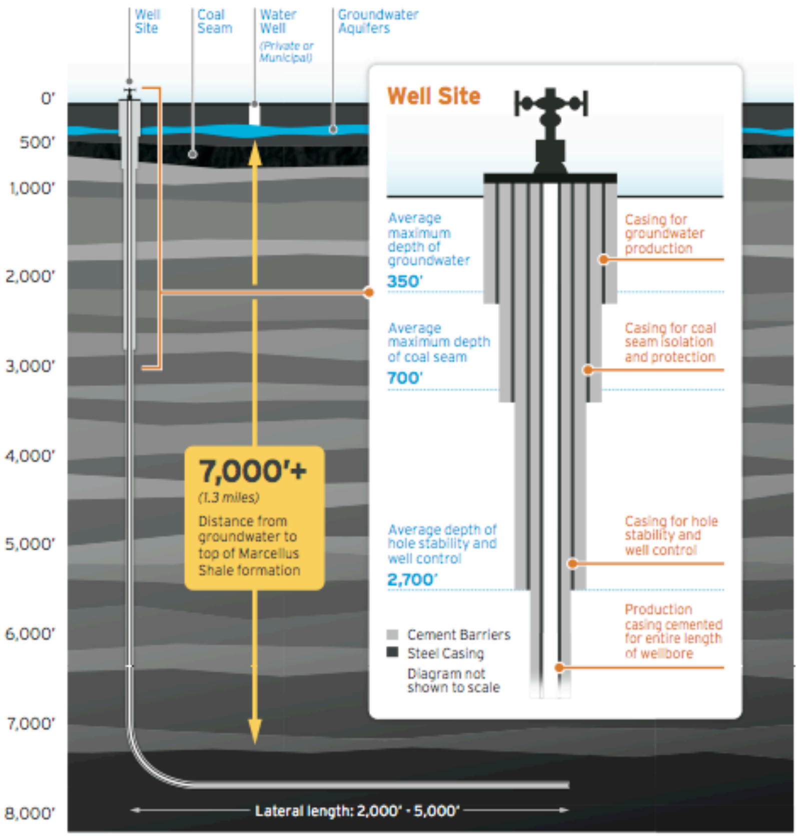
4000-3200m


Tuba
A
Tuba
Architecture type d'un puits
(so


PROTECTION OF AQUIFER
Ø Casing Pressure
Pipeline
Production Tubing
Surface
Freshwater/Aquifer
Conductor Pipe
300m
Surface Pipe
Cement
Casing
- Cement Bond Log
1000m
- Casing Pressure (Monitor)
Gas
Intermediate Pipe
Production Pipe
Shale
2000m
Fracture
Perforation
Schupbach 2011
0
300
Scale In Meters

Responsible Development Means Building Layers of Protection

Chevron's Marcellus wells are designed and drilled with control systems to protect groundwater throughout the life of the well, which can be decades.



An example of our Marcellus Shale operations. Scale of well site and well bore are increased for clarity.

Wherever Chevron operates, we design, build and produce wells while protecting people and the environment. Some protective measures in the Marcellus include:

Testing fresh water sources prior to drilling, including all water wells within 3,000 feet of a wellhead, to establish a baseline for the water quality.

Conducting vertical drilling with air to eliminate the potential for groundwater contamination.

*Installing up to eight layers of steel casing and cement to form multiple barriers between the well and groundwater.

*Ensuring all steel casing is surrounded by cement, from the bottom of the well to the surface.

Investing in high-quality pipes designed for decades of service.

Conducting a combination of tests to verify casing integrity. These tests include performing:

- Strength tests on cement used in every well.
- Pressure tests prior to hydraulic fracturing to validate quality well construction.
- Quarterly visual inspections and, when appropriate, pressure tests to confirm the long-term integrity of operating wells.

So far in 2013, only ONE MINUTE NUMBER of groundwater contamination due to fracking has been postponed, despite 100,000 wells in the USA [a million all together] and millions frackings

• *The Royal Society / Royal Academy of Engineering report on shale gas extraction in the UK"*
Robert Mair, Cambridge University and Royal Society , UK : 2000 wells (non-shale gas) over the past 30 dernières years, with 200 hydrofractured (the first shale gas well in 1875)
http://www.raeng.org.uk/news/publications/list/reports/Shale_Gas.pdf

•*Environmental concerns with shale gas development in the United States*
Robert Siegfried, Research Partnership to Secure Energy for America (RPSEA)
http://www.rpsea.org/

2009 : 493,000 wells USA [93,000 Texas, 71,000 Pennsylvania)
2010: 3000 operating license in Pennsylvania (117 in 2007)

HOWEVER, contaminations of groundwater, linked to rising methane along the casing were found, especially at the beginning exploitation of shale gas. Technology evolves, these contaminations are rare and almost non-existent. This is also the case of conventional gas fields.

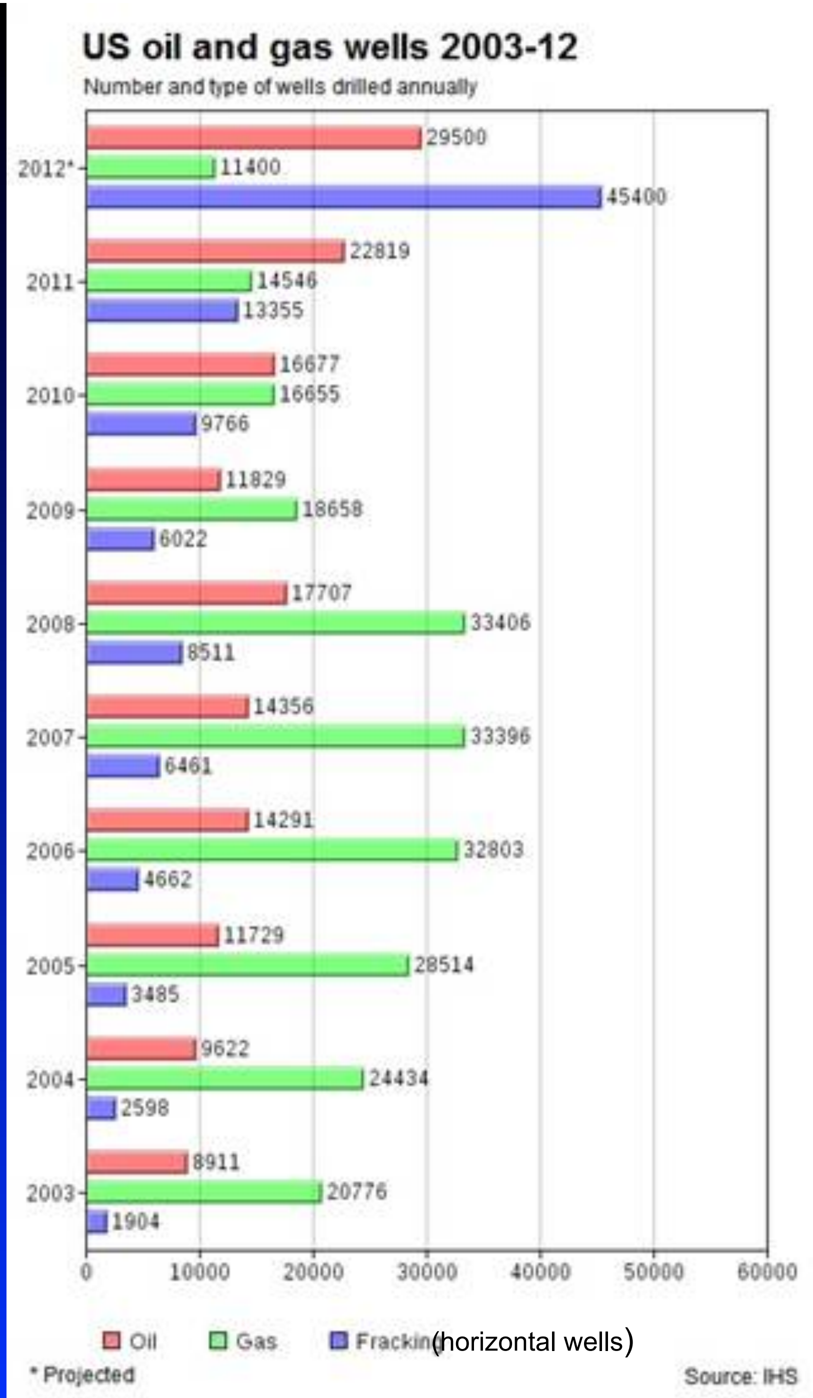
If the conditions for successful implementation are met, no contamination is to be expected.

2003-2012
102,164 wells

(millions of frackings)

500 000 frackings in 2012
= 220Gm³ or 1/3 gas prod USA
(2% en 2000)

c gas = opposite trend

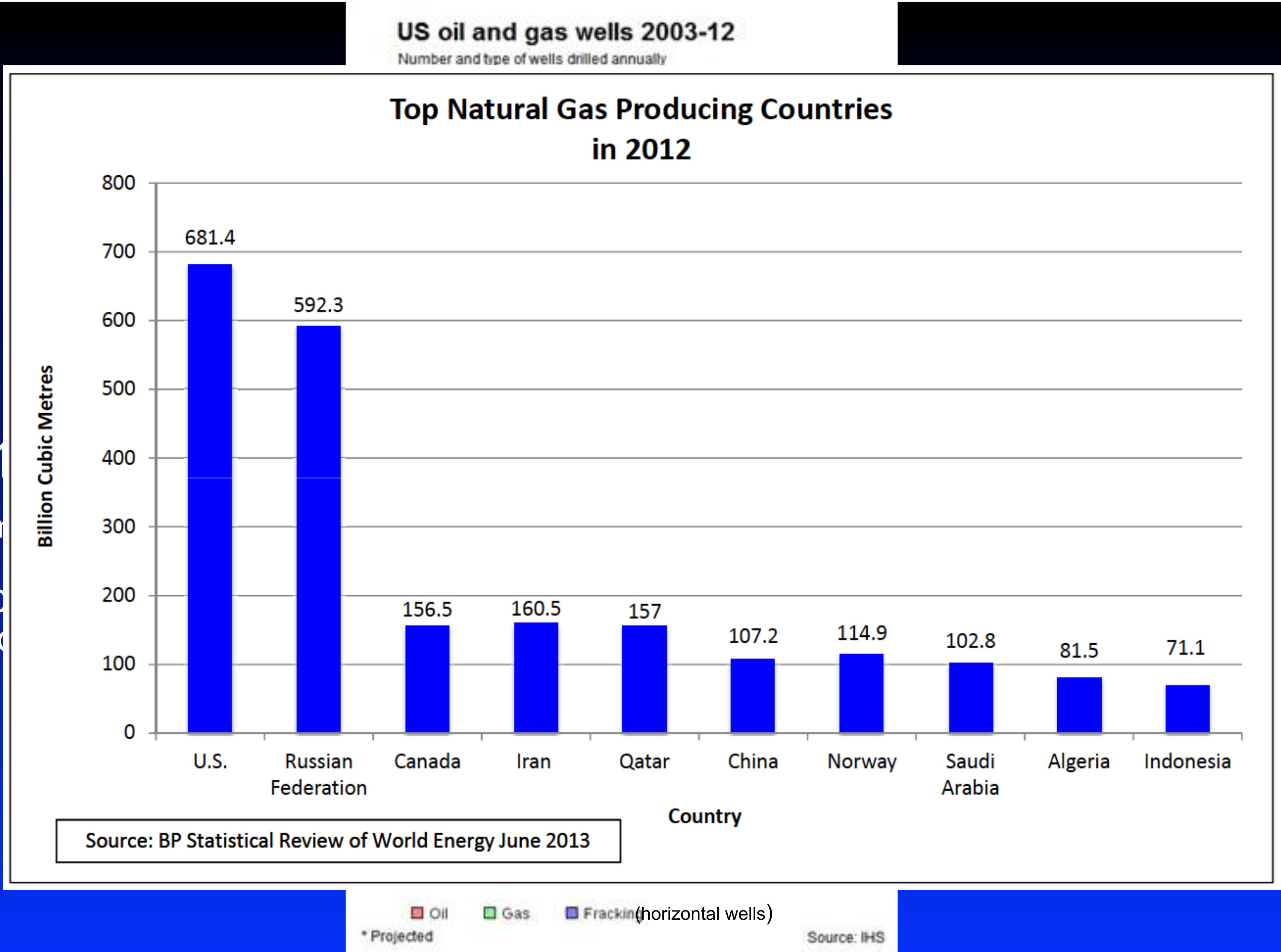


45,400 wells

in 10 yrs
x ≈ 25

1904 wells

http://www.nbcnews.com/business/power-shift-energy-boom-dawning-america-1C8830306



http://www.nbcnews.com/business/power-shift-energy-boom-dawning-america-1C8830306

To date in 2013, hydraulic fracturing (1949) remains the best technique for the production of shale gas

= > electric arcs (Chevron, U. Pau…) in a tube filled with water : microcracks by a shock wave,
but too localized, not interesting. .. ? Advantage = water and chemical additives are almost unecessary
Patent U. Pau + CNRS but tests require 20 million € ! (nb potential evaluation = 30 wells,)
= > explosives : Russian trials and USA in the 1960s' with atomic bombs! and nitroglycerin,
= > diesel : USA, early with carcinogenic BTEX (benzene, toluene, ethylbenzene, xylene),
= > propane : recent interest => increases reservoir recovery BUT flammable in surface,
propane is injected in a gel form (for conveying the sand), it is also recycled (tested in 600 wells)
= > fuoropropane : non flammable propane (France, 2013/2014?)
= > injection of CO_2 or water vapor (see heavy oils) or liquid helium (when warmed,
its volume increases 700x => cracking rocks)

CONCLUSION : hydraulic fracturing is the right solution and is perfectible (technology changes).

ENVIRONMENTAL HAZARDS?

QUANTITIES OF WATER USED IN HYDRAULIC STIMULATION

Hydraulic stimulation of a horizontal drilling requires between 1,000 and 20,000 m^3 of water [= 7 olympic pools] some of which are treated and/or recycled from previous drillings.
NEW TECHNOLOGIES (= superfracking) : water is reduced by 50%.
FUTURE : using nanotechnology being tested, the water will not be necessary and many chemicals either.

USA : water consumption is between <0.1% and 0.8% of regional consumption used by the public sector, industrial, mining, irrigation, agriculture combined, for the four large fields of Barnett, Fayetteville, Haynesville and Bakken where several hundreds of wells a year are drilled in each field.

Hydraulic fracturing can use wastewater (cities ...), brackish water, highly saline waters of geological formations (...) and sometimes 100% recycled water.
The oil producers are also water producers! = Easy technology
(treated by Veolia etc.)

10 to 20 million liters/well ... or a 20,000 l truck every 30 min for 11 to 21 days (fracturing time before production) = Golf course : 1.2 million liters / day (for maintenance)

811 golf courses in Pennsylvania consume as much water a month throughout the industry shale gas in this State for 2.5 years

ENVIRONMENTAL HAZARDS?

QUANTITIES OF WATER USED IN HYDRAULIC STIMULATION

to produce an energy of 1mmbtu (energy 28 m^3 gas eq.)

Source	Number of liters	
Shale gas	2-20	
Nuclear (uranium ready)	30-50	
Oil	30-80	
Coal (ready, power plant)	20-120	
Ethanol (corn-derived fuel)	9,500-11,0000	> 1 : 10,0000
Biofuel (soybean-derived)	50,000 -280,000	

Ground Water Production Council and US Dept Energy, 2010

ENVIRONNEMENTAL HAZARDS?

AIR POLLUTION

Shale gas used as fuel in a power plant emits 60% of CO_2 less than coal.

Emissions of methane in the atmosphere : 10% of all greenhouse gas, only 3% are from gas wells, pipelines and leaks from storage tanks on the surface.
The remaining 7% = garbage deposits, coal mines, stomach fermentation livestock.

To date, no incidence of cancer has been demonstrated in the U.S. near the deposits.

ENVIRONNEMENTAL HAZARDS?

CHEMICALS

The stimulation fluid = 99.51% water containing graded sand and/or ceramic beads (mm-sized) and 0.49% represented by 12 chemical additives (from the food).

At the beginning of the fracturing in the USA (1949), additives were more numerous and some carcinogenic. Today chemicals can no longer be secret, and only 3 or 4
both are combined according to the nature of the bedrock and the quality of the water used.

- 1 Acids (0,123%)
  HCL (and similar) has been used for over 60 years in carbonate reservoirs
  also used for cleaning our swimming pools, to purify our drinking water ....
- 2 Biocides (antibacterial) (0.001%) glutaraldehyde, ethanol, methanol
  Against the invasion of the wells by sulphate-reducing bacteria producing H_2S
  <u>Today : water stimulation is subject to uv => biocides are/will be not necessary</u>

biocides = disinfectants in surgery, dentistry to sterilize equipment

- 3 Corrosion inhibitors tubing (0.002%): ethylene glycol, propylene glycol, alcohol, NaOH
  = products used in pharmacy, in the manufacture of plastics, soaps .... food additives

ENVIRONNEMENTAL HAZARDS?

CHEMICALS

- 4 Anti-rust agents (0.004%)

  = *citric acid, cf. our drinks (lemon juice) and dishes*
- 5 Crosslinked polymers (0.007%) = natural origin Ti, Zr, B salts, Fe salts

  To increase the viscosity of the fluid as temperature increases

  = *cosmetics, soaps, laundry detergent*

....

• 6 Fractionation agents (0.01%) • 7 Acidity modifiers (0.011%) • 8 Antitartar agents (0.043%) • 9 Gelling (0.056%)
• 10 Clay stabilizers (0.06%) • 11 Polymers (0.085%) • 12 Friction reducers (0.088%)

= *cosmetics, hair coloring, plastics, detergents, softener, mouthwash, dentifrice, food etc..*

- Proppants

'Quartzitic' sand or pure silica to keep the cracks open : 750t of sand per 15,000m^3 of water

= very inert material (chemically)

- Stimulation water p > lithostatic p (+depends on fissile properties bedrock) => 600 bars or <

To replace the water : propane, CO_2, nitrogen, oil, polymer gels, landfill injection tests (inconclusive)
electric arc, bacterial injection (inconclusive) ….. => <u>Hydraulic cracking remains the best (technical, economic)</u>

Typical Chemical Additives Used in Frac Water

Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics
Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring

Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).

The actual chemicals are used in many industrial and even domestic applications

De Fauw, GDF Suez 2013

ENVIRONNEMENTAL HAZARDS?

CHEMICALS

12 types of chemicals> < 596 chemicals with some carcinogenic never appointed by Josh FOX
12 types of chemicals> < 2000 'chemicals sometimes mentioned on TV trays!
In reality a dozen products in small concentrations from 750 references sold by 2,500 companies in the U.S. (2012)

SEISMICITY

- Related to compression and decompression performed on an oil reservoir via injection and recovery. Also valid in the conventional fields.

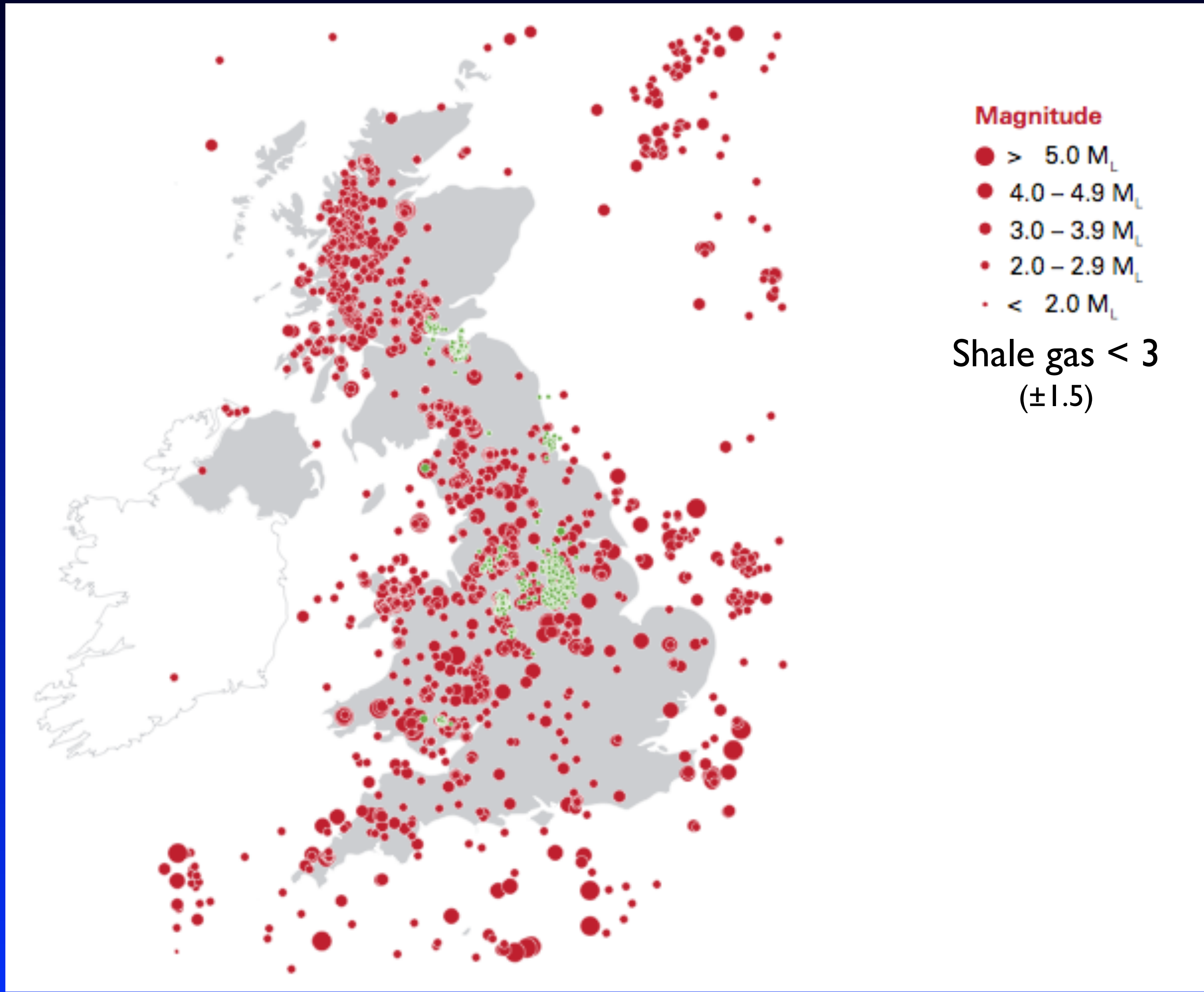
Many data ==> MINI-EARTHQUAKES or 'microseismicity' < 3
= 'passing a truck on a road' (see UK, USA ...), 18 April 2013 WACO fertilizer plant 'with a 2.1 earthquake'
⇒ no effect due to the rapid adjustments in the basement (the reservoir rocks are 'poroelastic', the pores open during injection and compress after recovery).

- NB CCS => also seismicity…. !

Natural seismicity (red) and induced by coal mining (green) in UK from 1382 to 2012, British Geological Survey, 2012

FIRST DRILLING!
April-May 2011
two seismic tremors
2.3 and 1.5
felt in Blackpool
(Lancashire, Yorkshire)
during frack operations
depth 2km,
500 of the drillcore
Cuadrilla Resources Ltd

pre-existed….
Bowland Shale
(Carboniferous)



Shale gas < 3
(±1.5)

- Seismic events/ »erthquakes » in connection with natural gas production from unconventional deposits are possible BUT :
- Earthquake triggered by gas production from unconventional deposits are less probable than from conventional deposits ;
- Combining mointoring and controlling frac process will probably allow to minimize the risk ;
- For newly developed deposits a dense monitoring network makes sense.

ENVIRONMENTAL HAZARDS?

ABANDONMENT OF WELLS : LONG TERM

The wells are plugged with compressed clays and/or concrete => 100' years sealing + monitoring,

Not specific to shale gas,

Technological advances are foreseen.

ENVIRONMENTAL HAZARDS?

INFRASTRUCTURE : PROBABLY THE BIGGEST PROBLEM!

Installations and equipment = pumps, mixers, trucks (semi-trailers)

Drilling platform 100mx100m > for vertical drilling

BUT there are 23 horizontal drillings from a small area of the platform,

and wells are spaced, they drain in great depth a 10 to 75 km^2 area,

There are 3.5 platform/km^2 with 6 to 40 wells per platform,

The derrick 30-40m in height remains in place 2 to 3 weeks, the plumbing surfaces not longer needed are removed after a few years,

The infrastructure is deployed in a short time [1.5 years] and the land rehabilitated after.

EN

Chemicals at the well site

Most probable risk scenario is a transport accident

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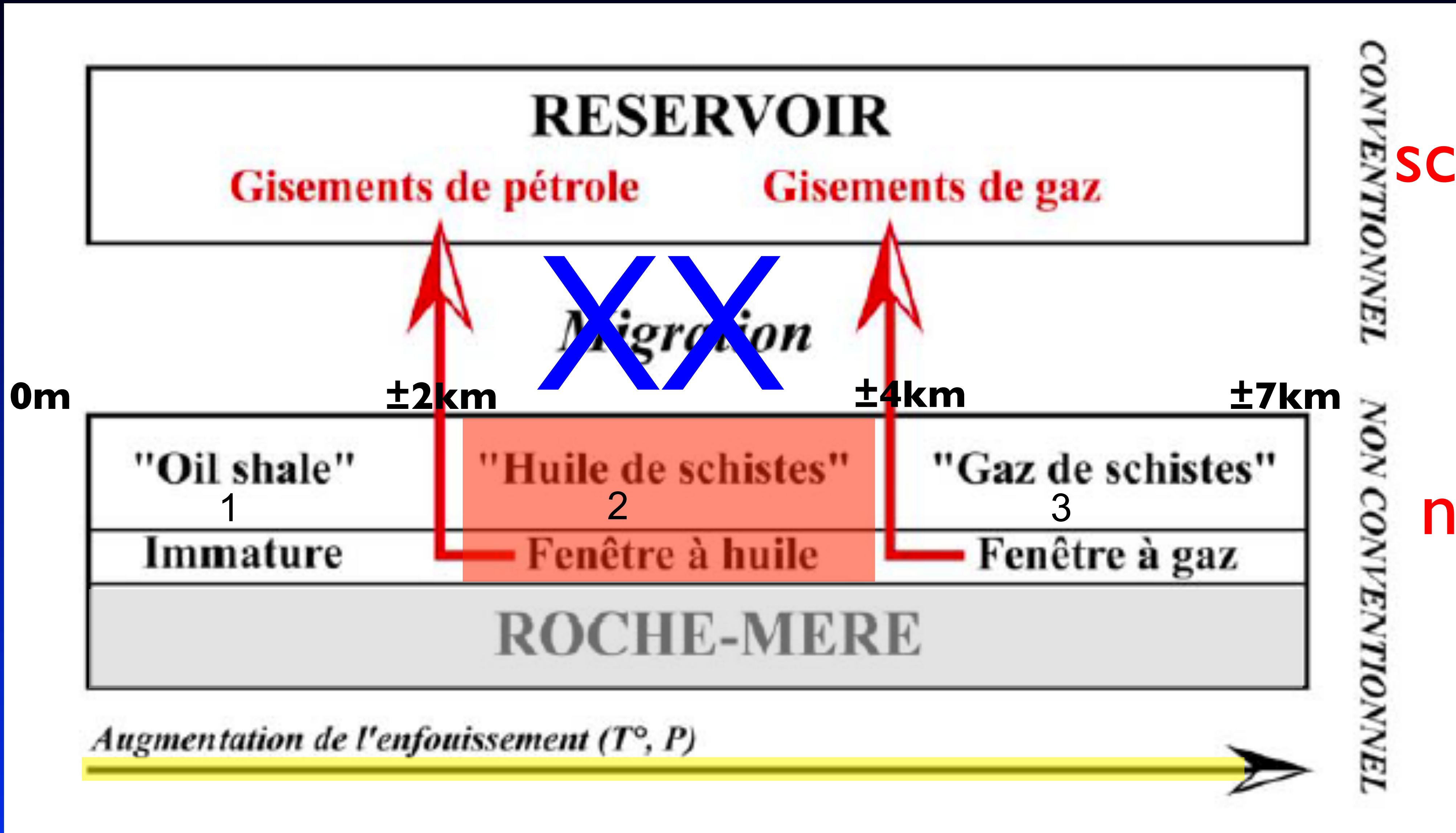
Schluter DMT, 2013

WAITING

The gas price = U.S. $3 mmbtu => prod. electricity rather than from coal ...
($8 in 2008, saving $103 billion/year + $50 billion/year for transport)
The price of Gazprom: $12 with a third for transport
nb Japan gas prices $17
Prices too low?
Shift to the shale-oil (Eagle Ford, Bakken, Utica) and fields with gas potential more attracting (Marcellus)

IS THE FUTURE HERE ?

The best 'liquid rich' areas are those of intermediate maturity between gas and oil windows : the producer extracts the recoverable oil at $100/bbl (2012), the production of this oil is boosted by the gas down dip (Utica, Eagleford).



1. oil shale (bituminous) = KEROGEN

2. shale oil = MATURE =>c and nc

3. shale gas = gas window

OIL SHALE ≠ SHALE OIL

‘shallower/immature’

‘deeper/oil-window’

HOW TO CONCLUDE ?

until now?

no ‘Seveso’, no ‘Union Carbide’

no ‘ Tchernobyl’, no ‘Fukushima’

no ‘Exxon Valdez’, no ‘Erika’, no ‘Prestige’

The big concern is the possibility of fractures in geological structures which could mean a migration of these components towards aquifers due to high pressures.
This point strengthens a broad control over aquifers, surface waters or even atmosphere before, during and after shale gas exploitation (see Poland, UK… today…)

US claim that no serious accident happened because most of the drillings are in remote areas, deserts … For Europe where all areas, almost, are crowded the problems of contamination is much more dangerous…

Franklin and Marshall College
Department of Earth and Environment
United States, 2013
"Many environmental problems associated with fracking are documented in the scientific literature, but I truly have not seen a single paper documenting groundwater contamination from fracking fluids as a direct result of fracking … . From well construction defects – yes, for CH4 at least "

2013 : Marcellus Shale (Pennsylvania): 500 trillion cubic feet (50ans de consommation…)
10' de milliers de puits => seulement 8 avec très FAIBLES tremblements de terre SANS dommages
200 puits privés pour l'eau => qualité de l'eau inchangée
quelques accidents : camions et stockage

What caused the sucess of gas shale production in the US?

Decrease conventional reservoirs (geopolitical situation)
Stimuli US Department of Energy & Gas Research Instittue
'Tax credit' in early phase of development
Agressive small E&P companies (not the majors)
Large number of drilling companies = more agressive competitive environment keeping prices low
Good knowledge horizontal drilling
Legislative environment (also environmental laws are less stringent)

Nb Large US sedimentary basins ≠ Europe's strong compartimentalization of the geological setting
=> costs per well are lower in the US (:2-:3) …

BUT : 16 July 2013 (The Guardian)

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Bowland Shale contains 50% more gas than the combined reserves of two of the largest fields in the United States. Photograph: Bloomberg via Getty Images


THAN YOU…
and:…
Trust Technology
Develop Research