

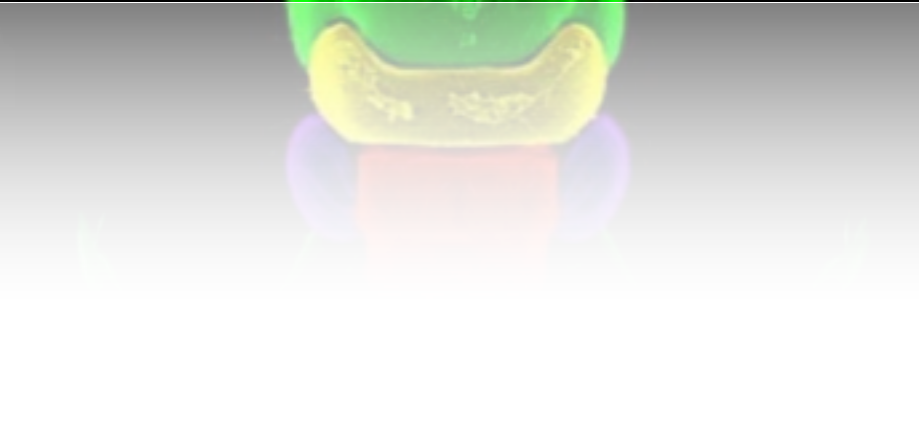
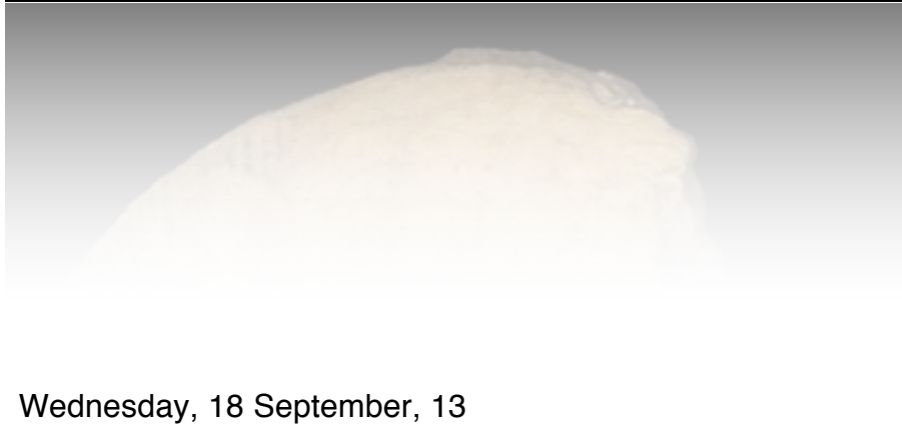


2013 **TORONTO**
SCIENCE FESTIVAL

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LIFE IN THE UNIVERSE

September 27-29



Origin of our Energy Endowment (II)

- *theories for how our gas & oil were made*
- *why is the middle east so rich in oil/gas*
- *oil sand, shale gas.... unconventional sources*
- *are we entering the 'age of gas'?*

Readings:

- 1) "Tracing Oil Reserves to Their Tiny Origins", NYTimes, Aug2, 2010
- 2) Muller, Energy for Future Presidents, Chap. 4, Chap. 6
- 3) look up wiki pages for new concepts/jargons



this week's tutorial:
assignment, turnitin...

Coal: mostly used to generate electricity

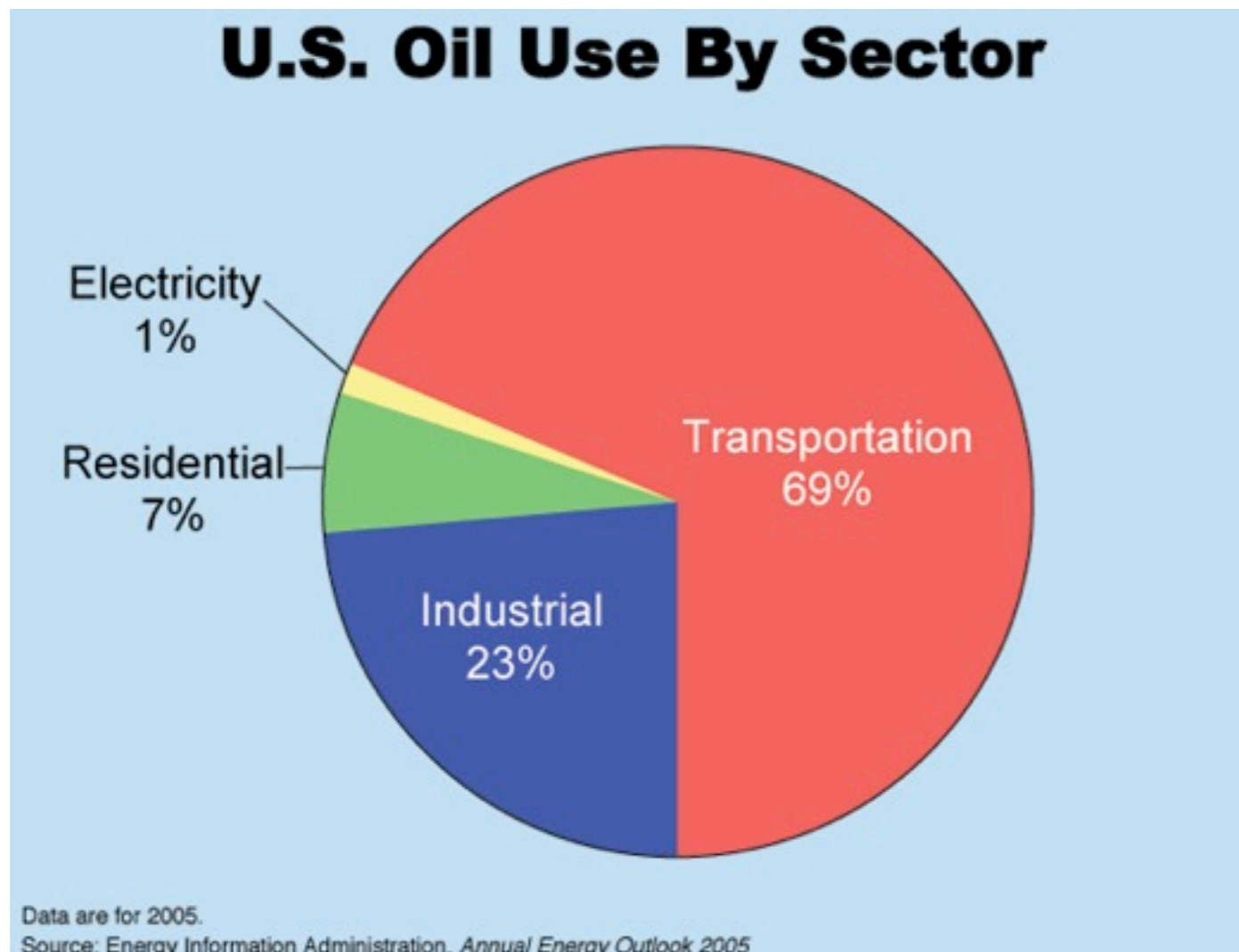
Oil: mostly used for?

1800s - kerosene and gas lamps

1859 - Edwin Drake struck oil 25 metre below ground in Titusville, Pennsylvania, setting off an oil boom.

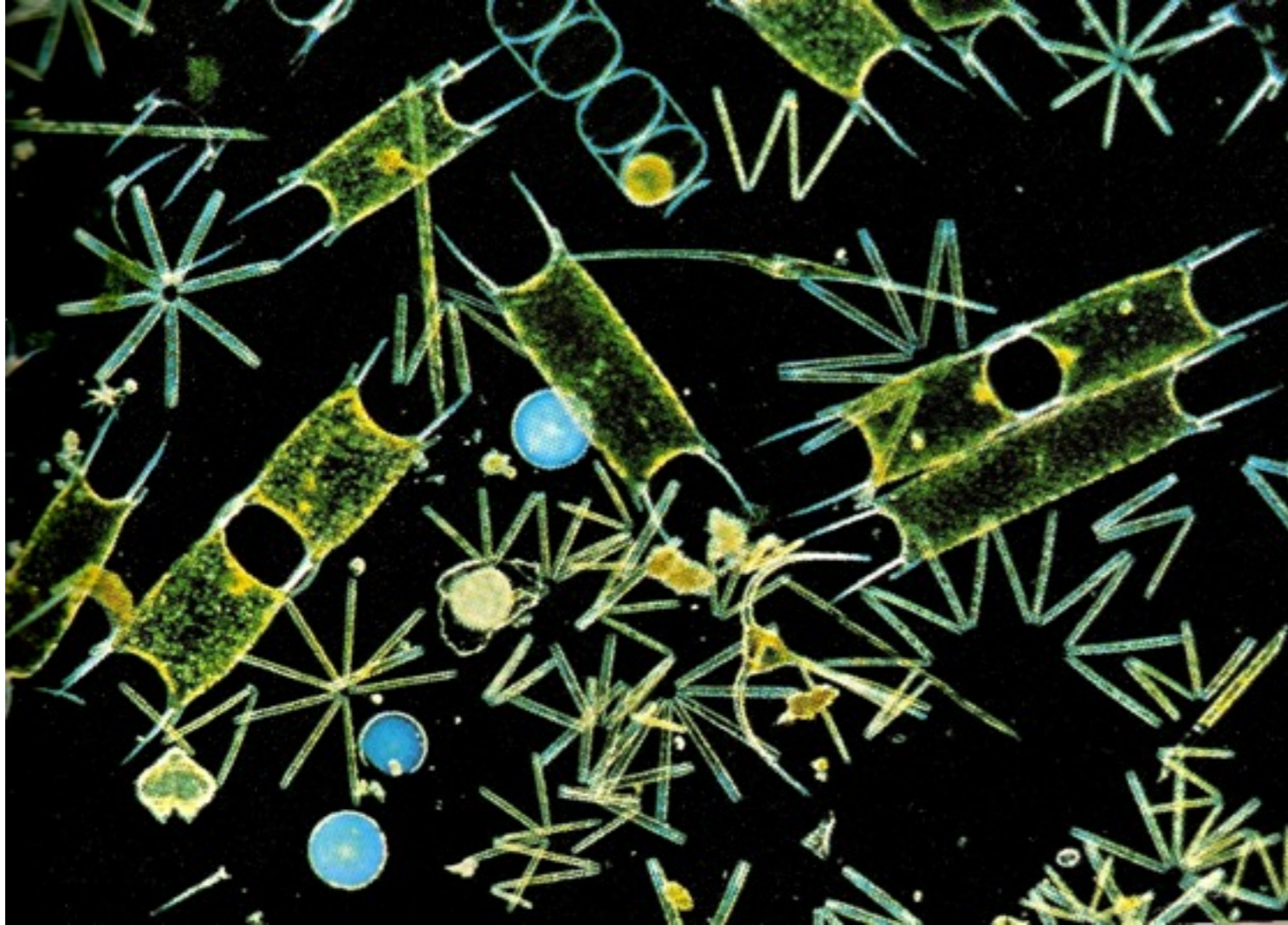
1895 - Invention of “internal combustion engine”

1896 - Henry Ford's first motor car



Gas (natural gas, CH₄)
have a fairly mixed use
among all sectors.

Theories for oil/gas formation



The 'standard' biogenic theory

plankton:
minute marine plants;
bottom of food chain

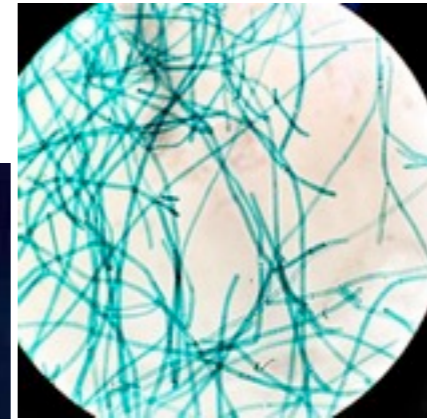
- Ancient planktons bloomed and died.
- Their bodies did not decompose.
- Buried at great depth, 'cooked' by pressure/temperature to hydrocarbon chains (hotter --> gas; colder --> oil)
- Oil/gas reserves formed in porous rocks, capped by hard rocks



diatom, a group of plankton
(NYT)

“Algae bloom”

algae: a group of photo-synthetic plankton



cyanobacteria
(blue-green algae)



Lake Erie '11



Lake Erie '11

- . if water nutrient rich, algae multiply exponentially
- . dead algae decompose, exhaust oxygen in water
- . the whole eco-system collapses.
- . multiple, large scale pre-historic algae blooms could be origin of oil/gas.

“over-population”



China '11

The Abiogenic Oil production

- . Deep carbon deposits from Earth's formation.
- . hydrocarbons generated by abiogenic processes.
- . petroleum upward migrate to surface through cracks.
- . we have a nearly infinite supply of oil/gas



Thomas Gold
(1920-2004)
american astronomer,
geophysicist

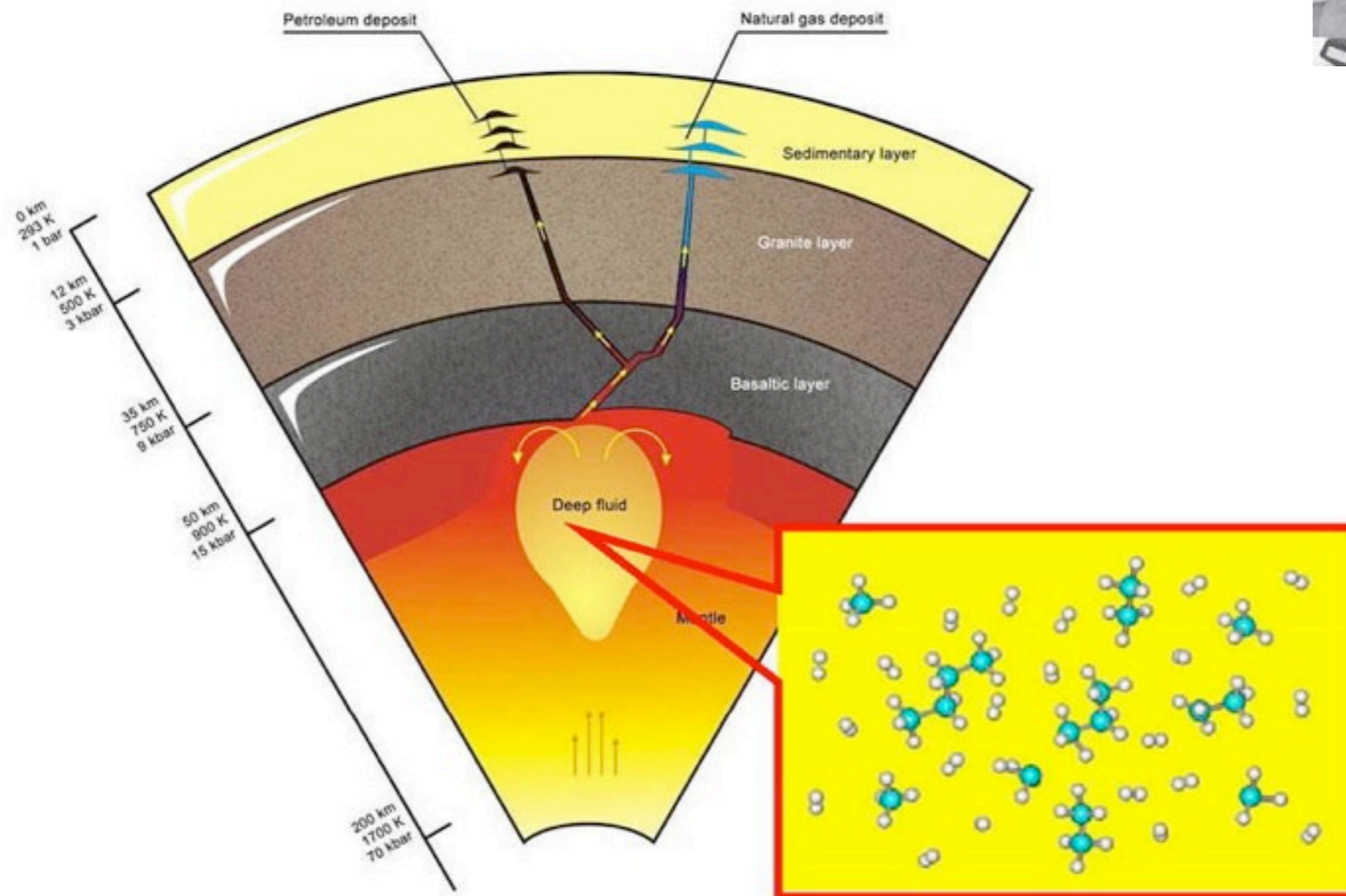


Image courtesy A. Kolesnikov and V. Kutcherov

Neptune: the outer-most planet



Solar System:
outer planets & their moons are rich
in natural gas (methane, CH₄)

Titan: Saturn's largest moon



many asteroids that hit the Earth also
deposited massive amounts of carbon



energy beyond Earth?

Prediction by biogenic theory:
-- oil/gas in sedimentary rocks
(ancient mud)

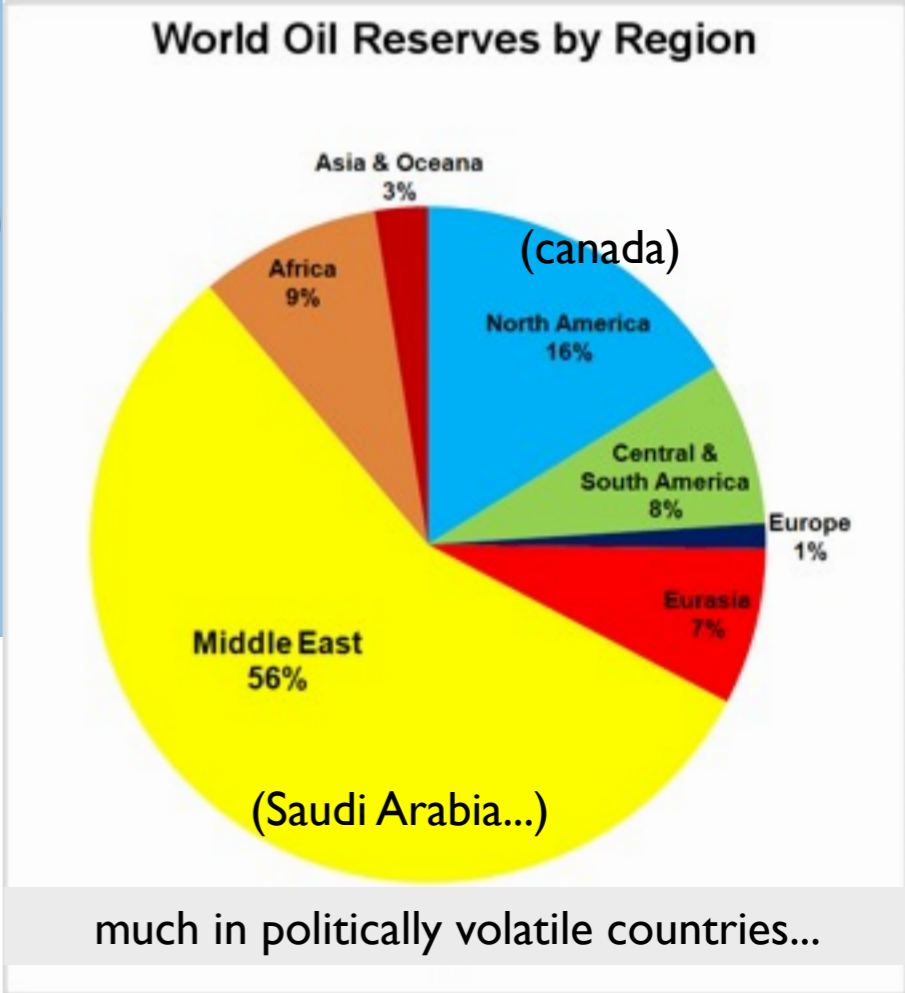
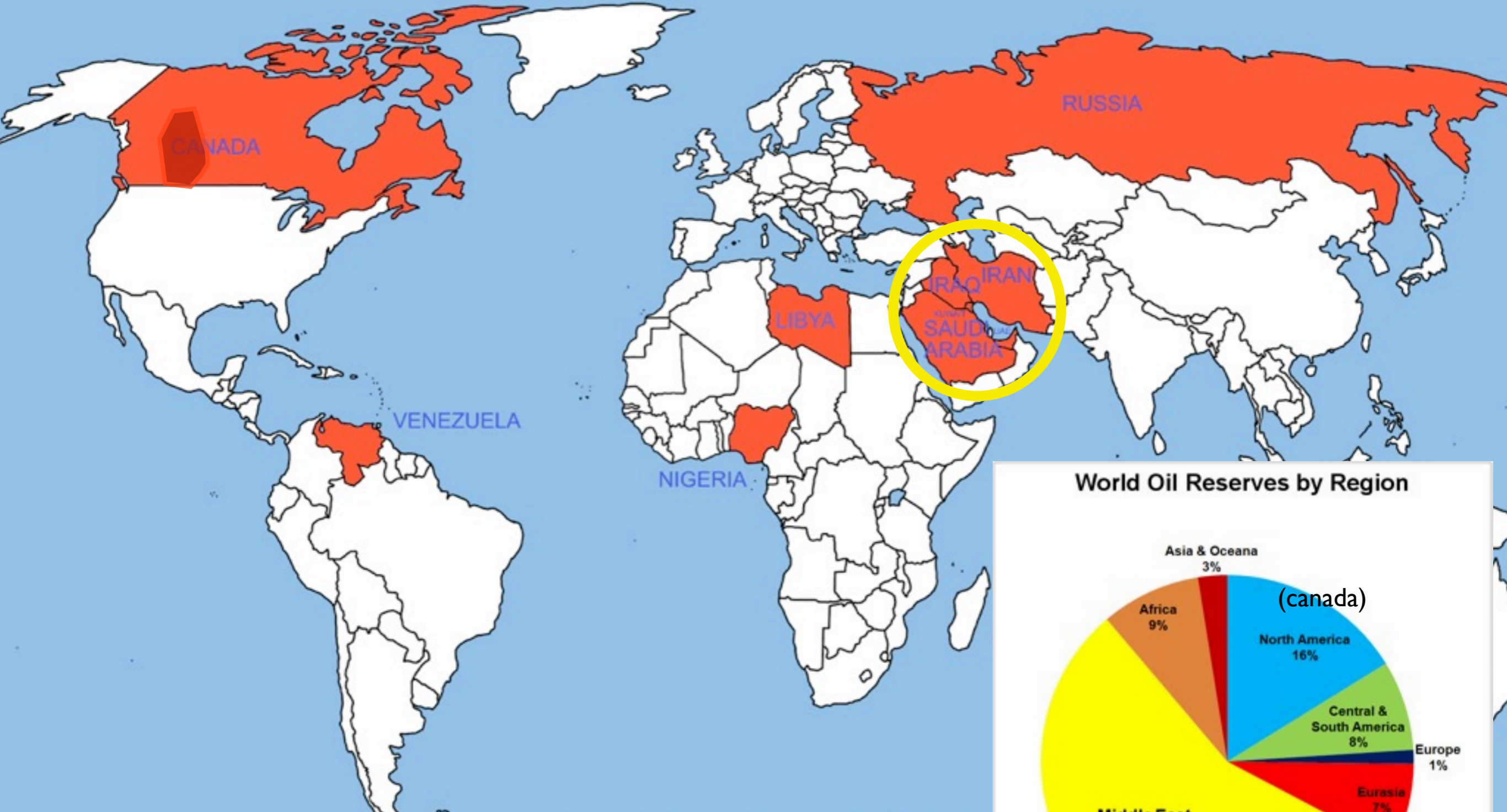
Prediction by abiogenic theory
-- oil/gas around cracks on the
Earth's crust (faults, impacts...)

the Siljan meteor crater, Sweden

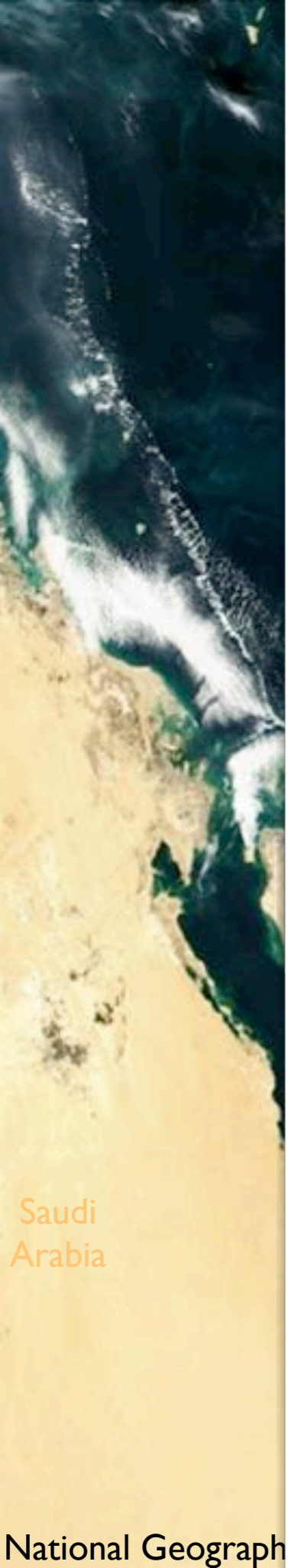


The test --
drilling at the
Siljan meteor
crater (1986)

Unlike Coal, Oil reserves are highly patchy.



- More than half oil reserves in middle east, around Persian Gulf.
- Biggest consumer (US, 25% world) has only 2% world reserve.



Kuwait, 1991

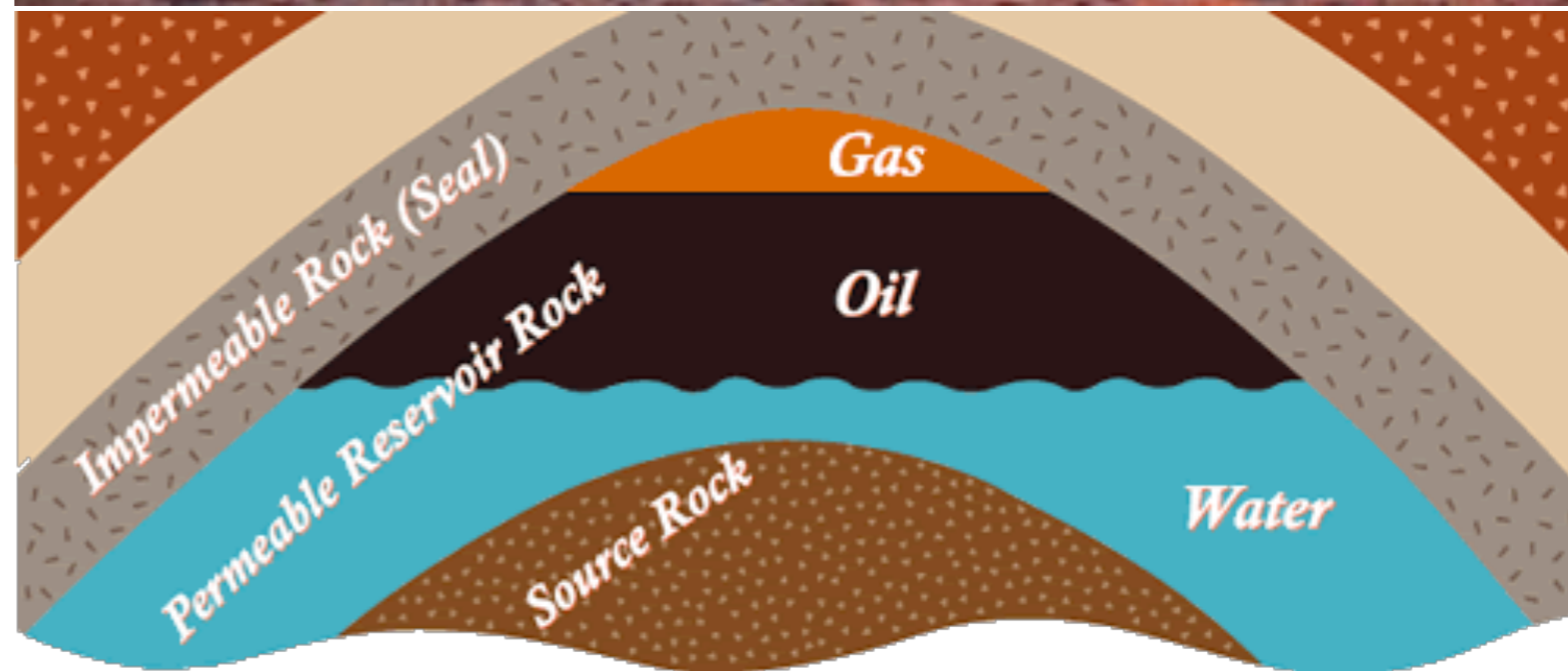


Iraq, 2003

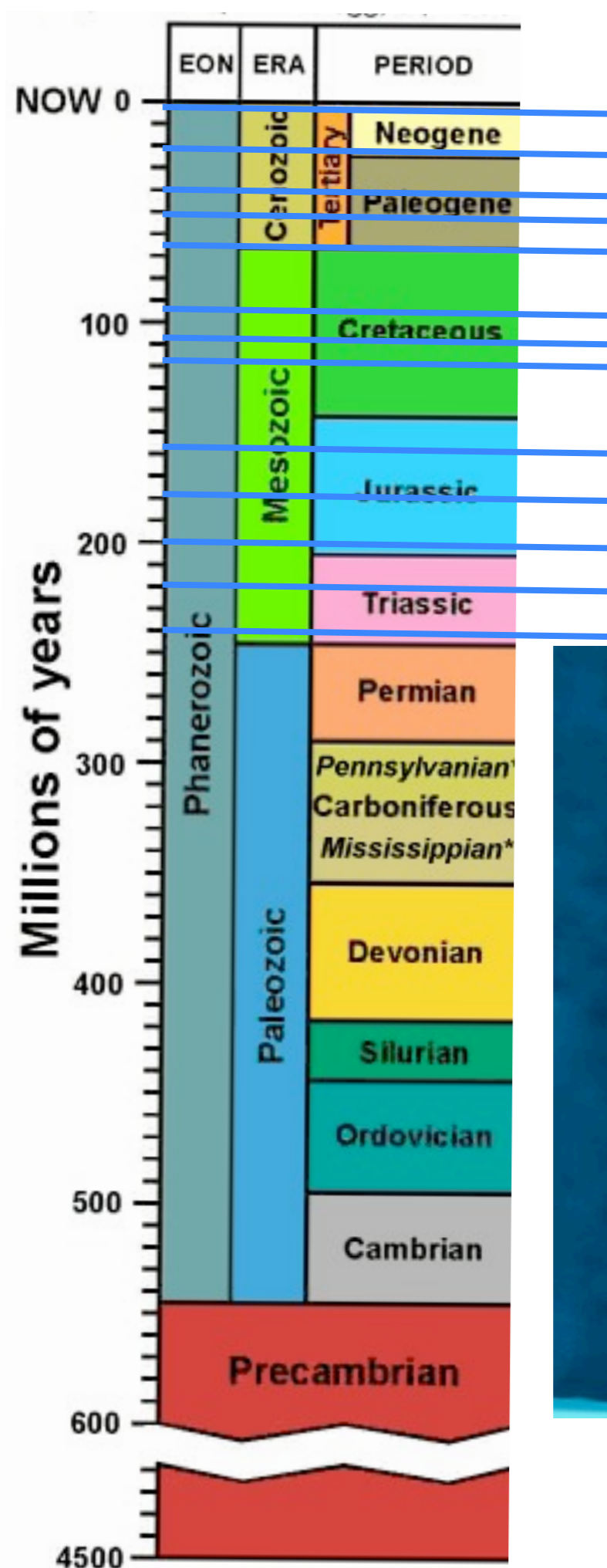


Saudi Arabia

Why is the Middle-East so rich in oil?



An 'accident of geology'



. most oil made in the so-called mesozoic period

. ~200 Million years ago, the current middle east was on the edge of a shallow tropical ocean, the Tethys ocean. Abundant planktons.

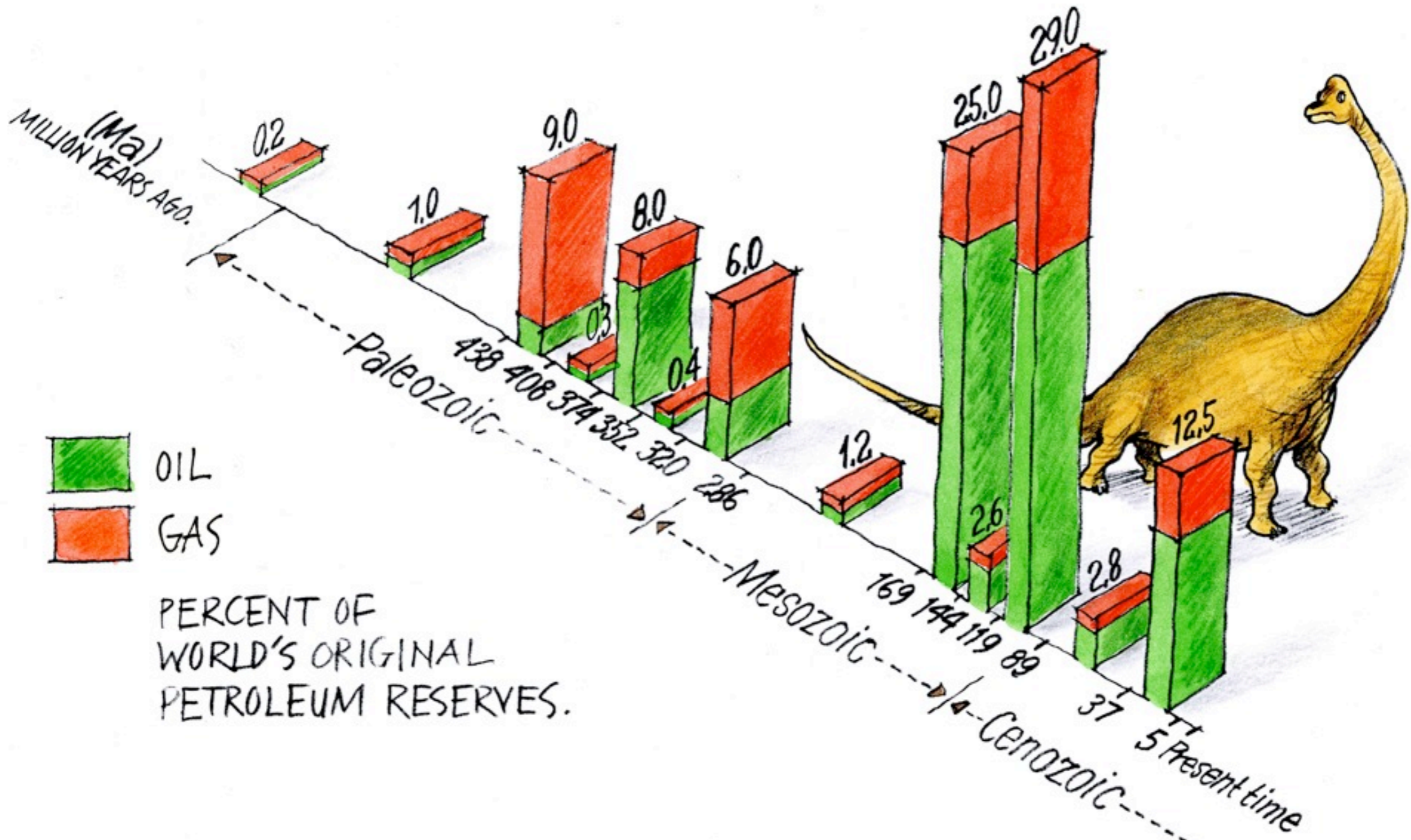
. the bottom of Tethys was stagnant and particularly anoxic (very little oxygen), unlike today's ocean

. other similar regions, in particular off-shore (ancient sea bed)



Paleo-geology Map (Ron Blakey)

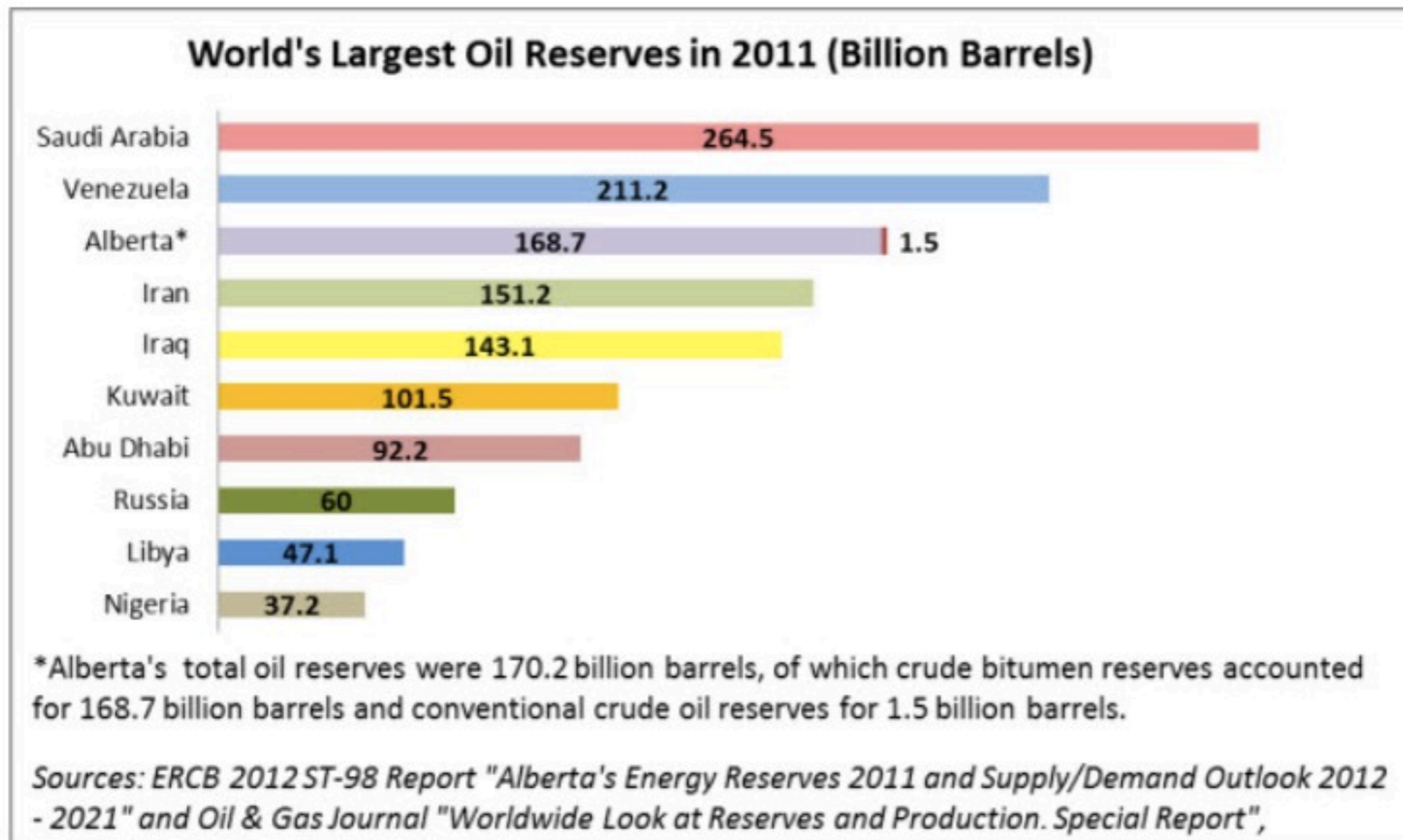
Question: why are dinosaurs un-important for forming oil?



Oil in Alberta -- another geological accident

- Alberta ranks third, after Saudi Arabia and Venezuela, in terms of proven global crude oil reserves.
- Almost all of Alberta's proven oil reserves are found in Alberta's oil sands.

.Alberta leads Canada in per capita GDP.



Alberta Energy
Ministry



Syncrude Aurora Tar Sands Mine, north of Fort McMurray in Alberta, Canada.

99% of Alberta Oil is in Oil Sand; extraction profitable only if oil price > \$60/barrel

- heavy oil (bitumen) embedded in sand;
- oil too viscous to flow;
- need steam or other solvent to extract;
- two tons of sand for 1/8 ton of heavy oil;
- higher cost (also environment)

Harper offers Obama climate plan to win Keystone approval

Sources say PM willing to accept emissions reduction targets proposed by the U.S.

By Chris Hall, National Editor, CBC News Posted: Sep 6, 2013 2:15 PM ET | Last Updated: Sep 6, 2013 10:08 PM ET



Prime Minister Stephen Harper, who talked with U.S. President Barack Obama during the G8 Summit in June and again at this week's G20 Summit in St. Petersburg, Russia, has proposed a North American strategy on climate change in a bid to gain approval for the Keystone XL pipeline, CBC News has learned. (Adrian Wyld/Canadian Press)



What is Keystone?
Why is Mr. Harper so keen?
Shall I support it?

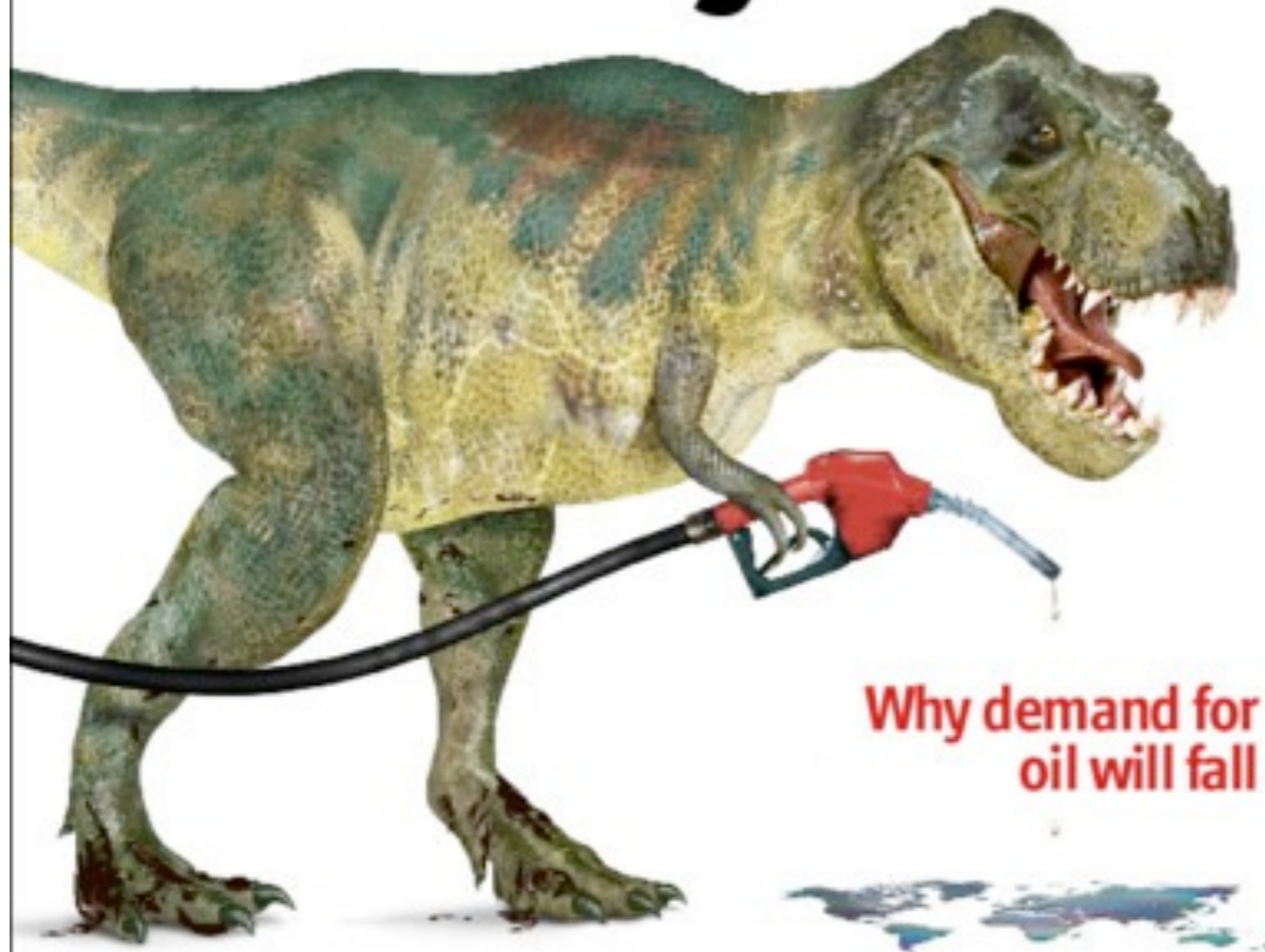
**The
Economist**

AUGUST 30^D-9TH 2013

Economist.com

Manning, Snowden and American liberty
The steep decline in Chinese executions
Behold, a pope who seems human
Omnicom and Publicis: Math Men
Art, it's a Doig's life

Yesterday's fuel



**Why demand for
oil will fall**

Economist, Aug 3, 2013

We believe that demand [for oil], not supply, could decline...

The first revolution was... "fracking"...to release huge supplies of [shale gas]...

The other great change is in automotive technology....

... [but a range of other economic factors]

a number of 'unconventional' fossil fuels have become significant over the past few years.

oil sand, shale gas, shale oil, oil shale... very confusing!

Source:

- . share similar source (marine, land plants) as oil/gas.
- . buried in mud and prevented from decomposing.

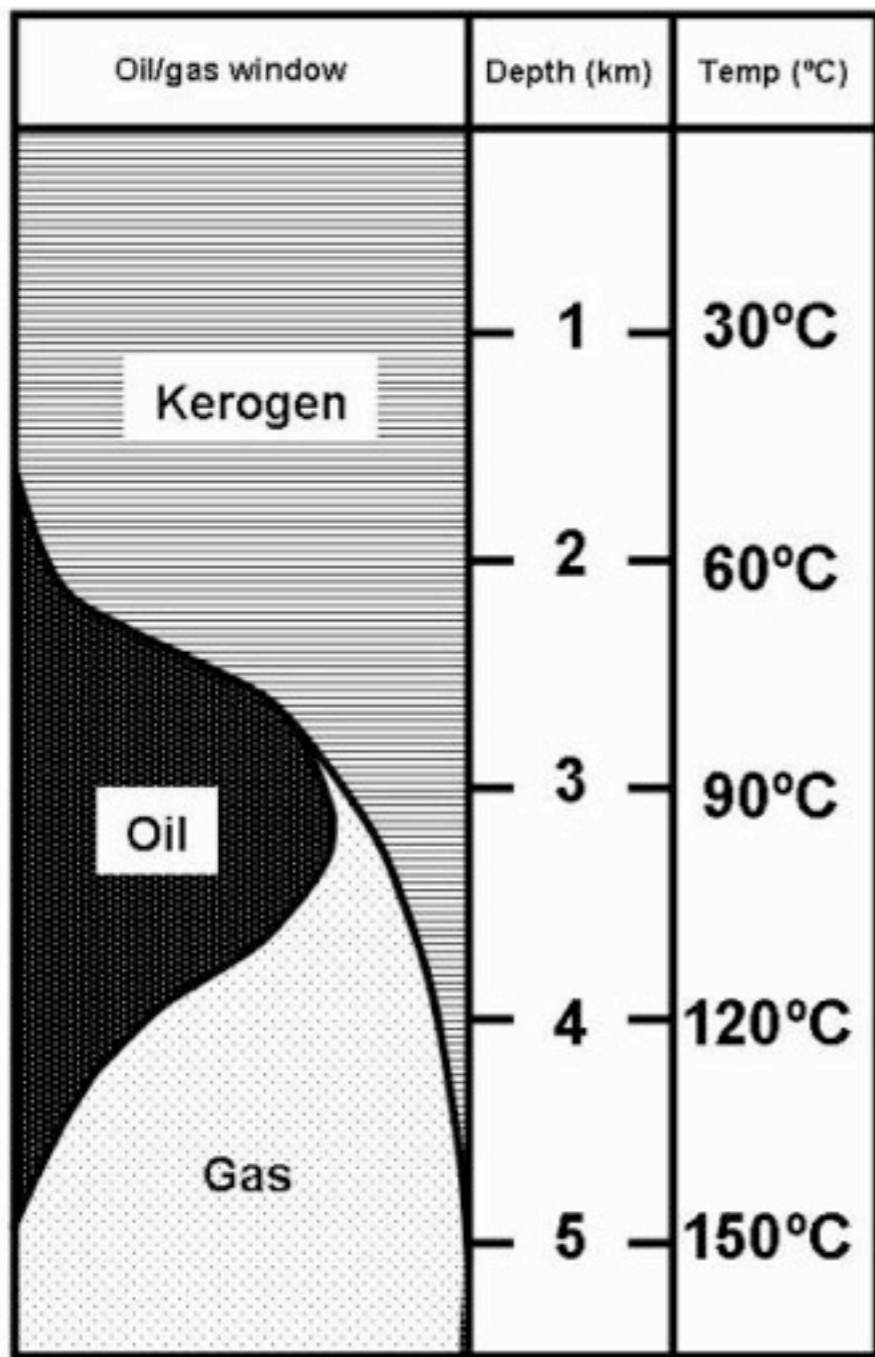
Formation:

- . if buried very deep, ground higher temperature, gas forms; less deep, can get oil.

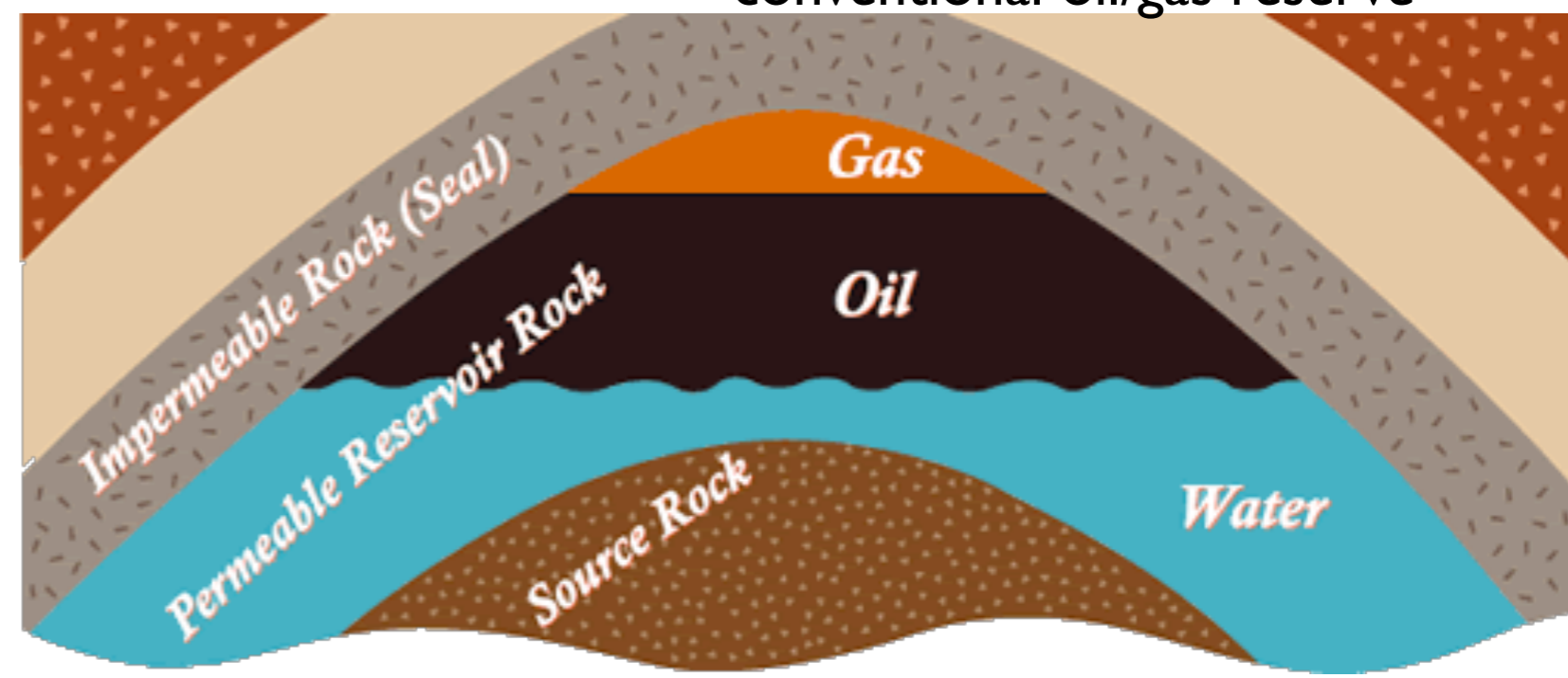
Migration:

- . different paths

Formation: the so-called oil window and gas window; Earth hotter deeper down.



conventional oil/gas reserve



Migration:

- . oil/gas accumulate above source rock, then capped by hard rock (impermeable)
- . if oil migrate to surface, **oil sand**
- . if gas stay in source rock, **shale gas**
- . if oil stay in source rock, **shale oil**
- . if kerogen in source rock, **oil shale**

requiring very different extraction technology.

shale rock that contains shale gas

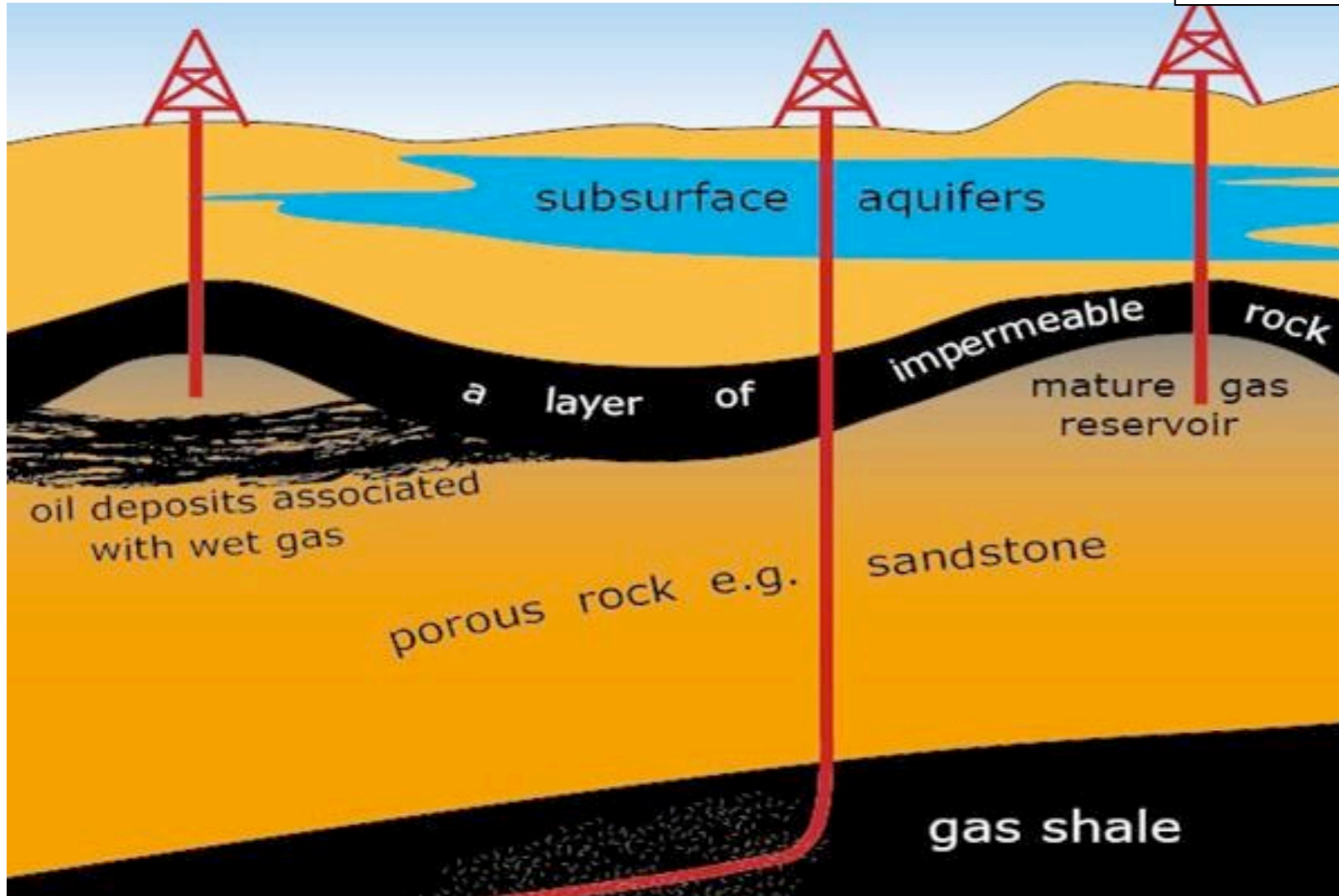


Getty Images: Matthew Lloyd

Extraction of shale gas, shale oil differs from conventional oil/gas drilling.

conventional gas/oil:
vertical drilling

E. Drake (1859)



shale gas: horizontal drilling + fracturing of rocks = “fracking” (invented 1949, breakthrough 1998 G. Mitchell)

Fracking splits public opinion down the middle, poll finds

ICM poll finds 40% of people would support hydraulic fracturing in their local area and 40% would oppose it

Fiona Harvey, environment correspondent
The Guardian, Tuesday 13 August 2013 15.49 BST

[Jump to comments \(353\)](#)

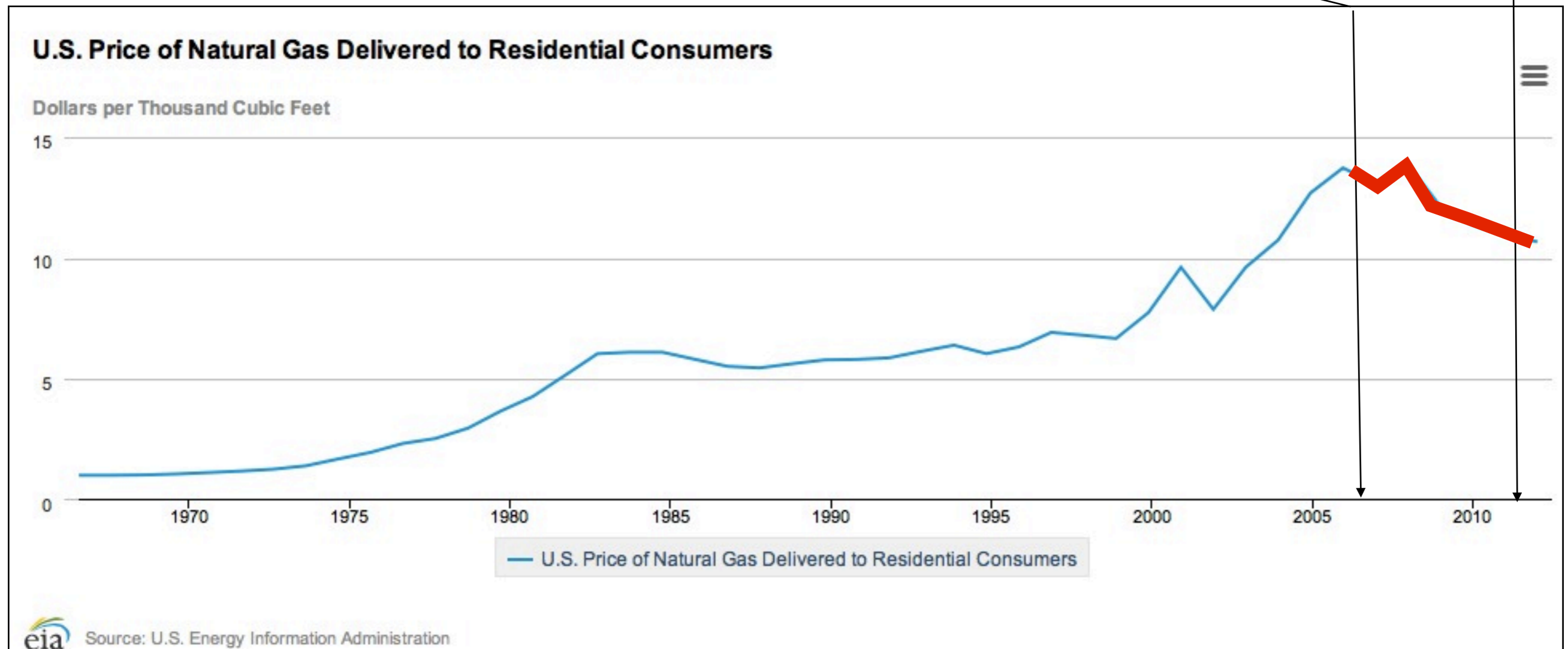
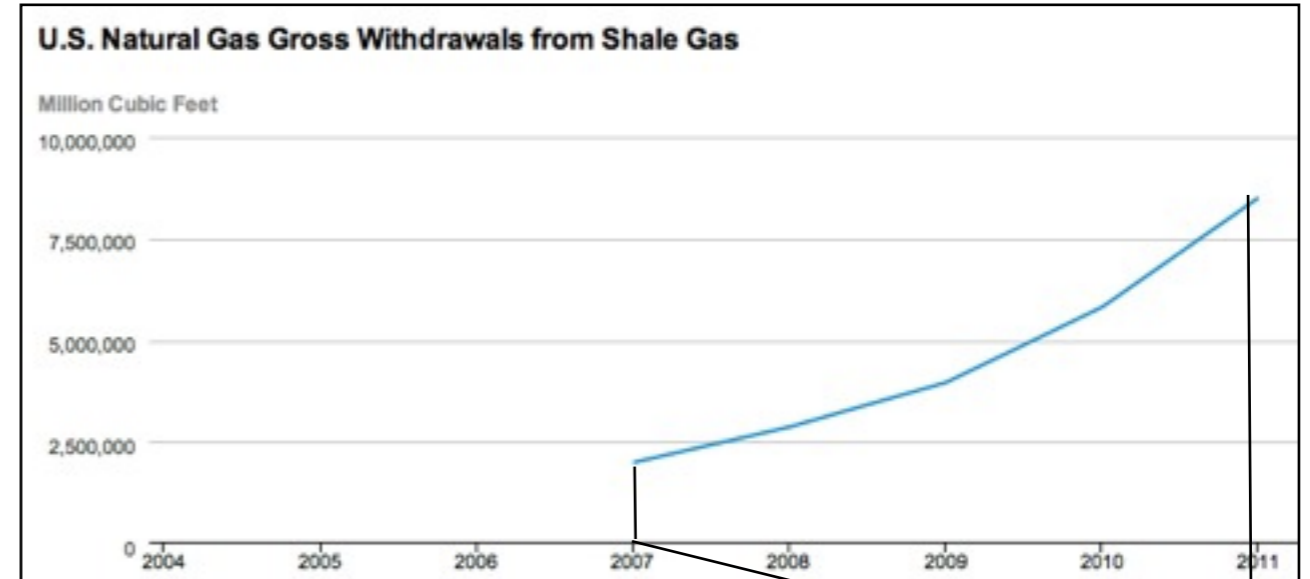


Fracking? What is it? Is it even an English word?

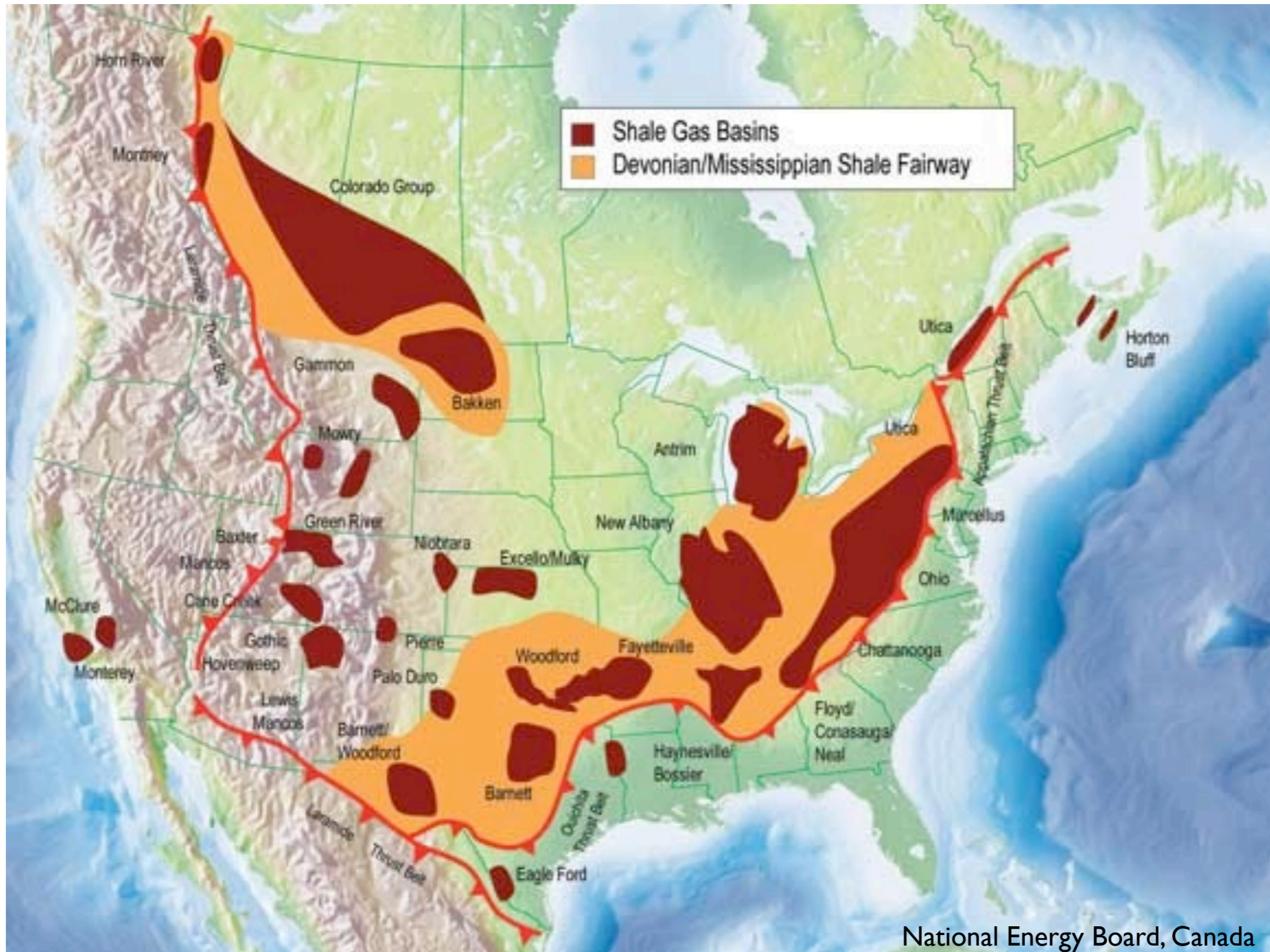
Really? It is going to change my future?

What should my opinion be?

Your life is already affected by the fracking boom....

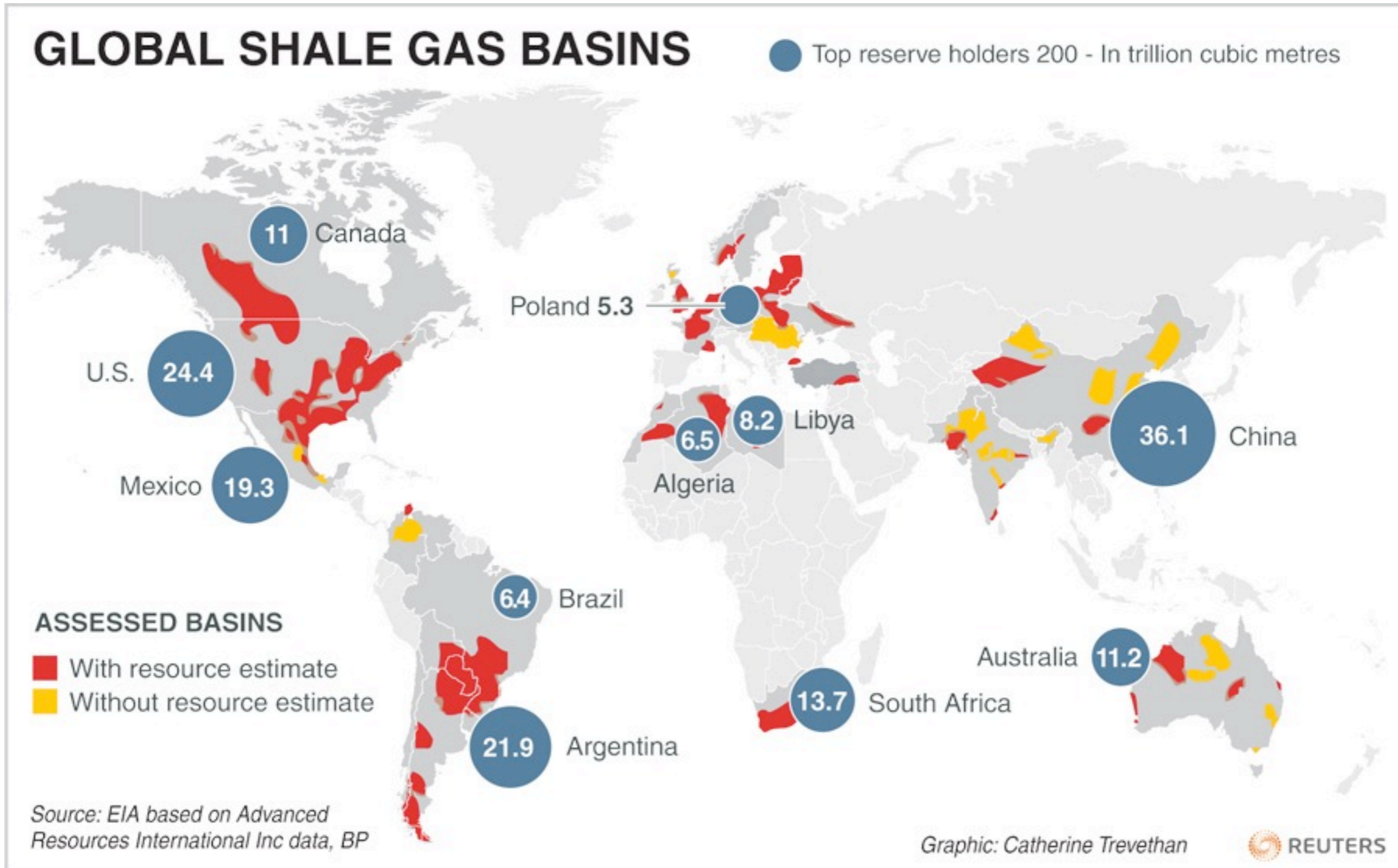


Guess which province has the shale gas?



Where is it?

Shale Gas: natural gas trapped within its source rocks.



game changer: China & US expected to have largest shale gas reserves
Not including: methane hydrate!

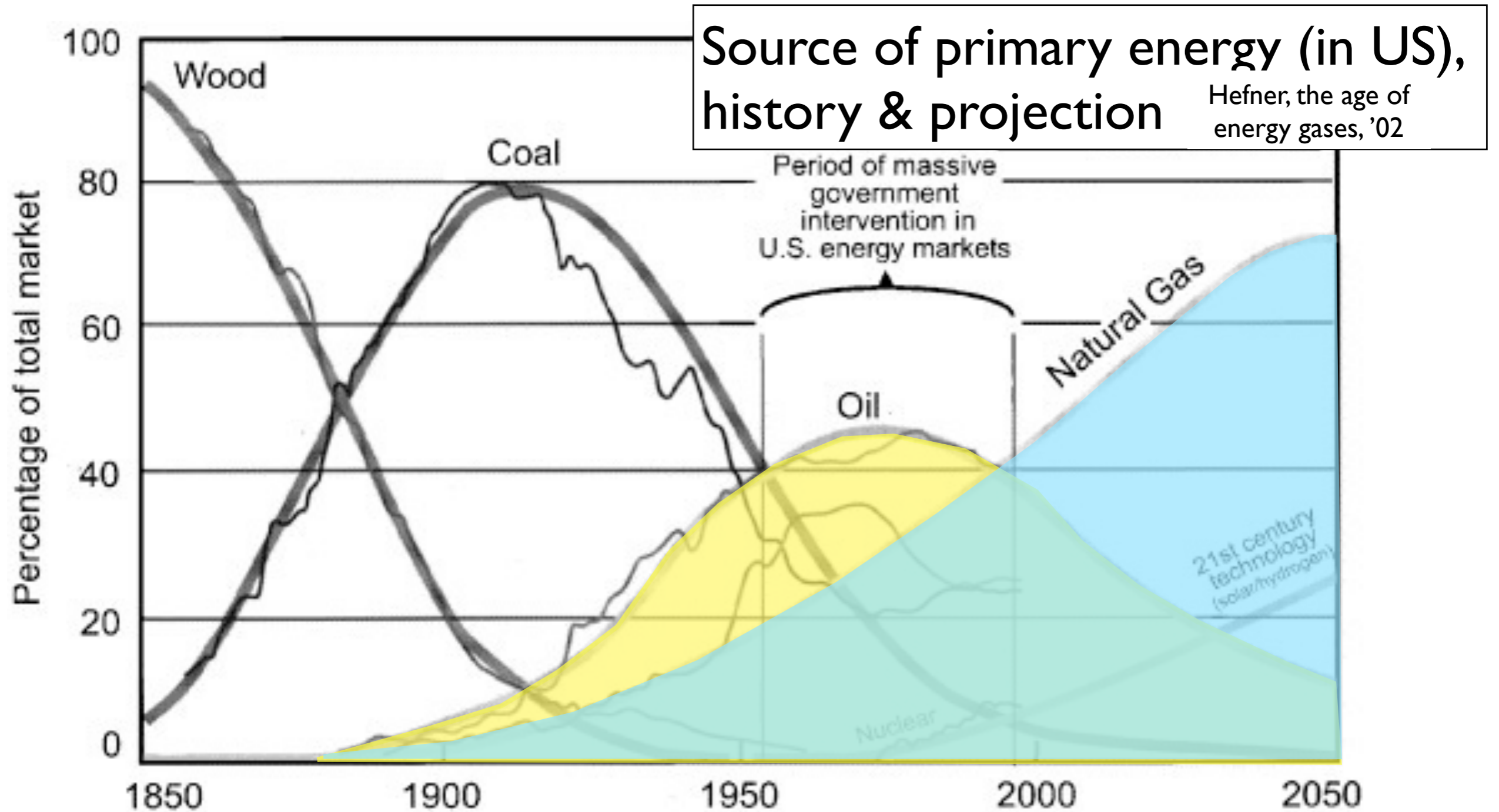
Shale gas/oil: How much is there? How long will it last us?

	Crude oil (billion barrels)	Wet natural gas (trillion cubic feet)
Total World		
Shale / tight oil and shale gas proved reserves	n/a	97
Shale / tight oil and shale gas unproved resources	345	7,201
Other proved reserves	1,642	6,741
Other unproved resources	1,370	8,842
Total	3,357	22,882
Increase in total resources due to inclusion of shale oil and shale gas	11%	47%
	35%	38%
	(values for US)	
Shale as a percent of total	10%	32%

EIA report June 2013

Are we entering an 'age of gas'?

What are the economic/political/environmental consequences?



gas(oline)? no,
Gas, please.



Summary: our energy endowment

. our good fortune with 'fossil fuel'

- woody plants 360-300 million yrs ago made coal
- coal was instrumental for industrial revolution
- coal still heavily used in developing worlds

- marine planktons made oil/gas
- current transportation relies heavily on oil
- technology developments avail us of shale gas/oil, oil-sand...

. our 'fossil fuel' dependency may come to an end?

- reserve-to-production ratio 50-100 yrs
- environmental issues

. with the major exception of nuclear energy, all our energy reserves come eventually from the Sun (coal, oil, gas, hydro, solar, wind, tide, biofuel...)

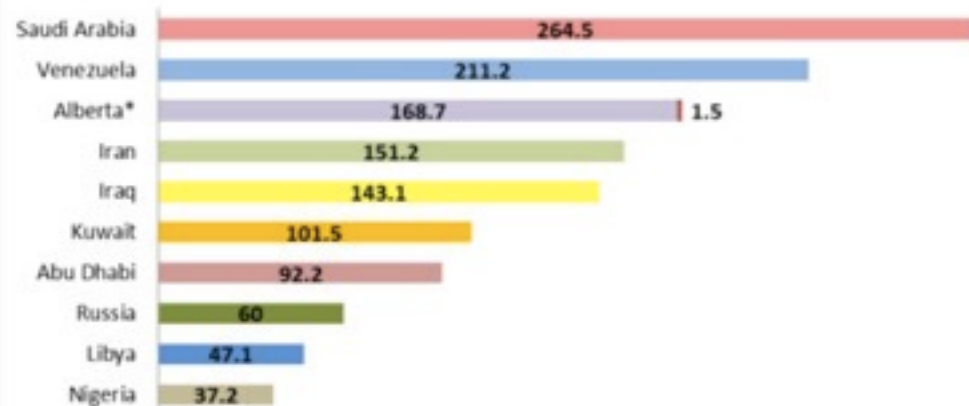
A quiet war --- Lomonosov Ridge, North Pole

“Canada, the Kingdom of Denmark (via Greenland), and the Russian Federation each assert that the Ridge is an extension of their own continental shelf. Proof of its continuation, would give the State access to the sea bed and natural resources beyond the current 200 nautical mile (nm) limit. The United States claims it to be an oceanic ridge and thus not an extension of any State's continental shelf, and therefore refutes any claim to its ownership.”

(www.stimson.org)

~100 billion barrels

World's Largest Oil Reserves in 2011 (Billion Barrels)



*Alberta's total oil reserves were 170.2 billion barrels, of which crude bitumen reserves account for 168.7 billion barrels and conventional crude oil reserves for 1.5 billion barrels.

Sources: ERCB 2012 ST-98 Report "Alberta's Energy Reserves 2011 and Supply/Demand Outlook - 2021" and Oil & Gas Journal "Worldwide Look at Reserves and Production, Special Report".

