Identifying the Sources of Fugitive Methane Associated with Shale Gas Development, updated with new data, Jan 2012

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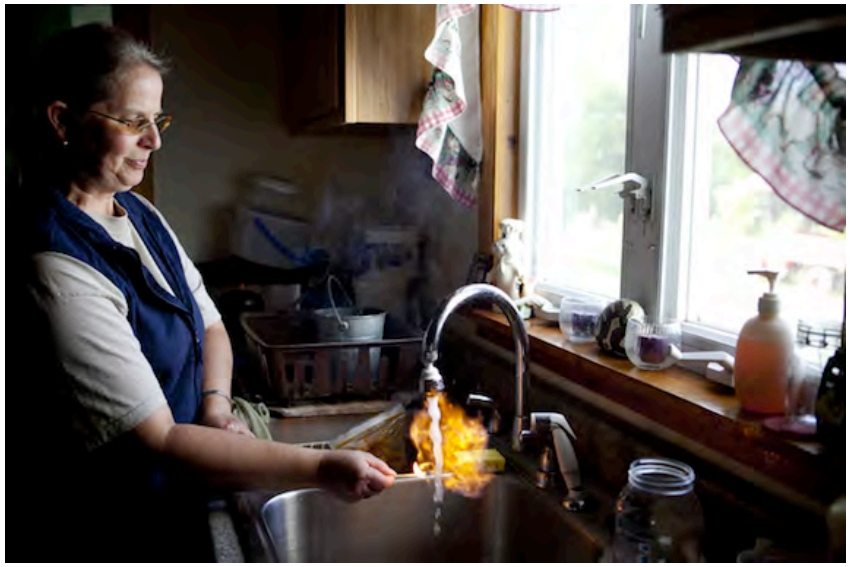
Original presented on Nov. 14, 2011 at "Managing the risks of shale gas: Identifying a pathway toward responsible development" held at Resources For the Future, Washington, DC.

http://www.rff.org/Events/Pages/Managing-the-Risks-of-Shale-Gas.aspx



http://shakespearessister.blogspot.com/2011/09/holy-shit.html

http://inafutureage.wordpress.com/2010/06/22/your-land-my-land-gasland/

http://www.treehugger.com/natural-sciences/alberta-oil-gas-collateral-damage-she-can-light-her-water-on-fire.html

Source of gas in burning water:

Industry induced

Or natural background?

Natural gas seeps

M. Schoell [1] and G. Etiope [2]

NW Alberta,
Canada

Eternal flame,
Chimaera Turkey

Anthropogenic gas seeps

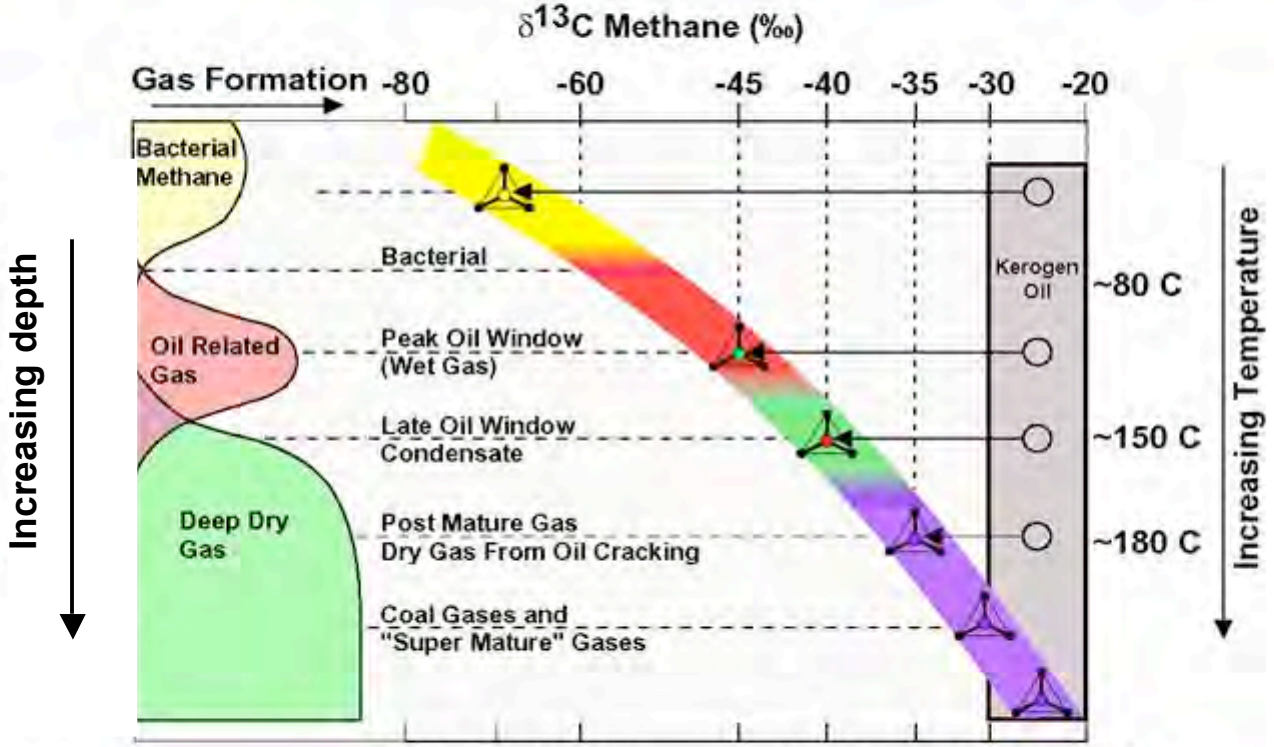
Well Head, Dimock, PA

Gas well, leaking 1914-2010, Turner Valley, Alberta

http://www.tcgasmap.org/media/Ingraffea%20Slides%207-25-11.pdf

New Technology Magazine | April 2010

Carbon Isotopes in Methane Are Related to Formation of Oil and Gas



M. Schoell

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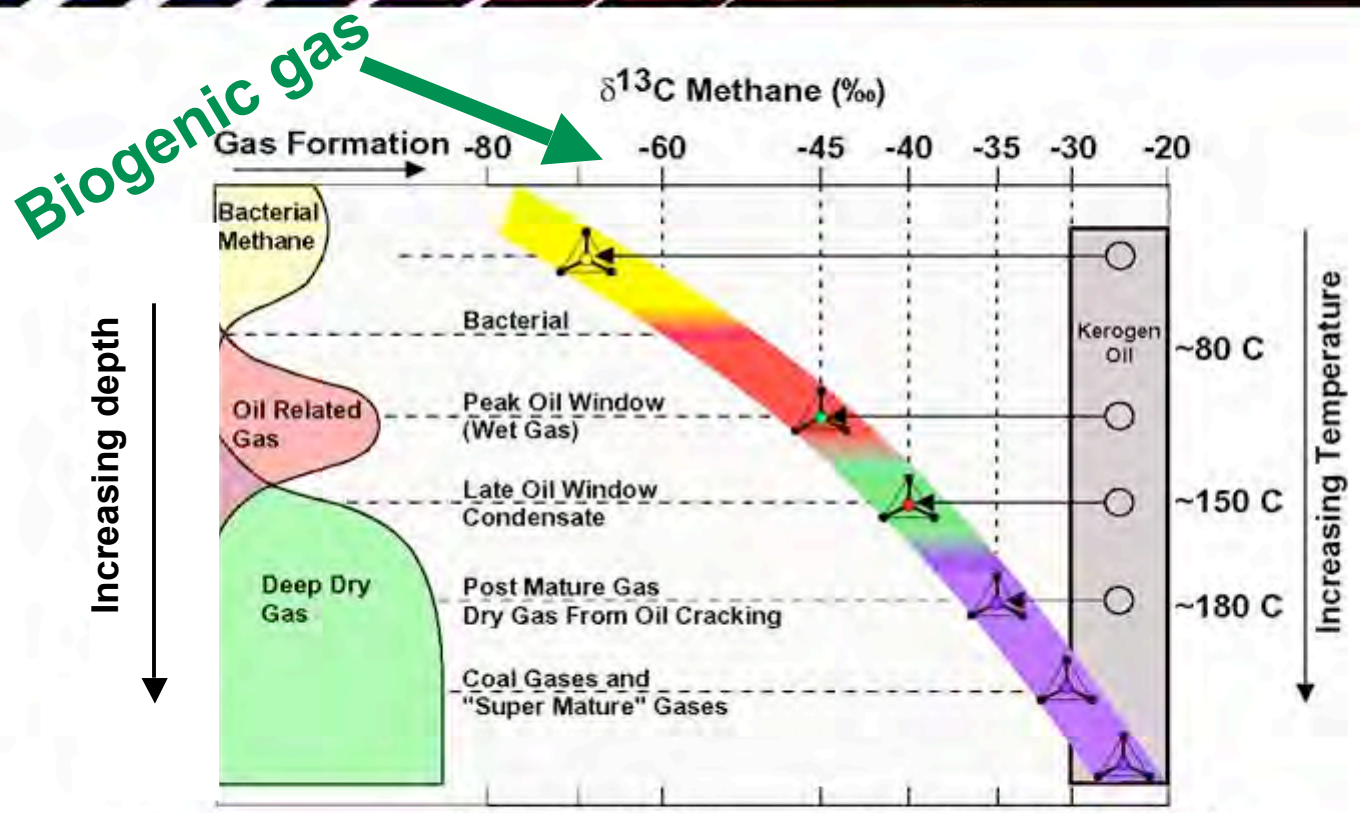

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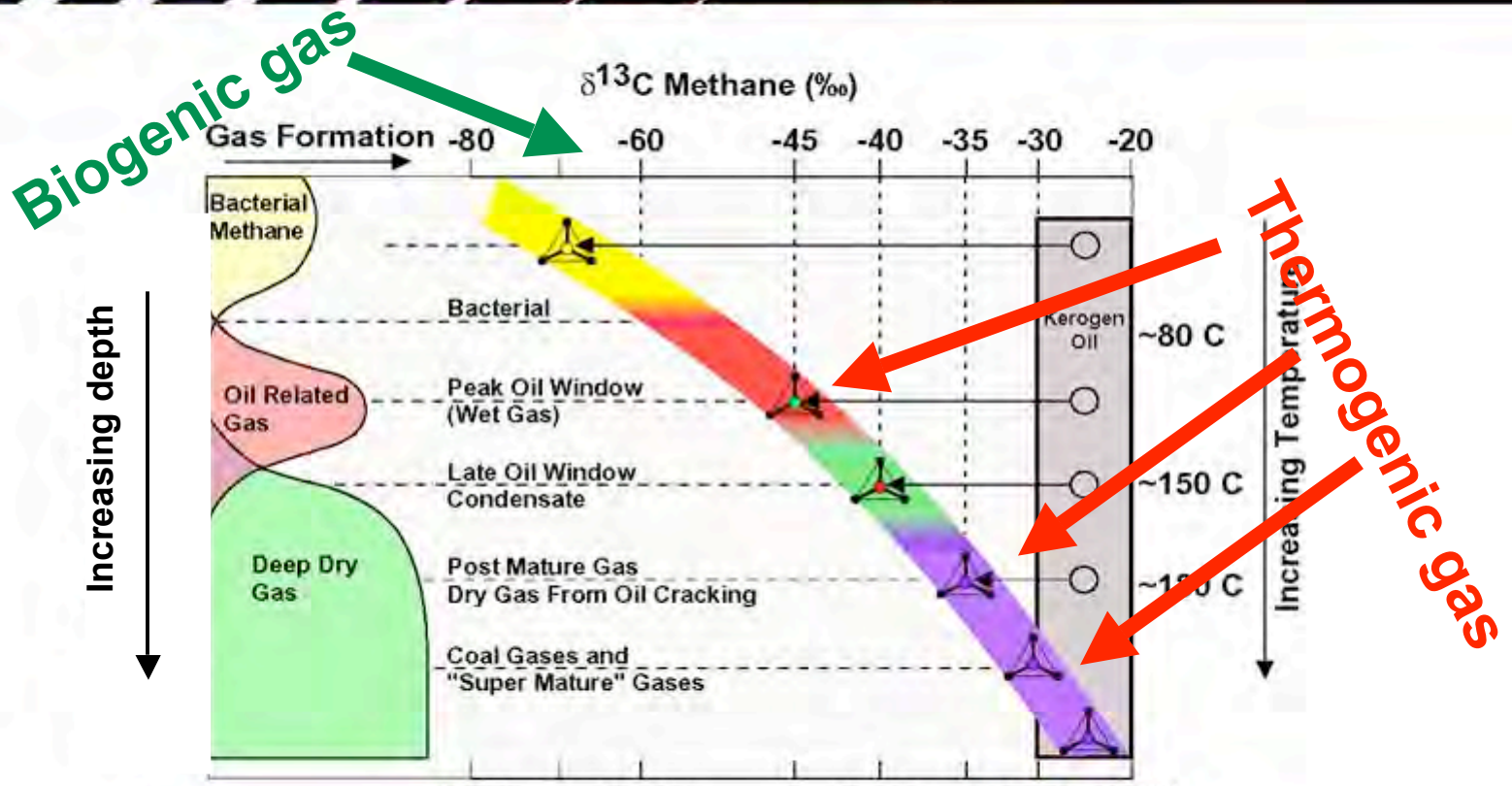

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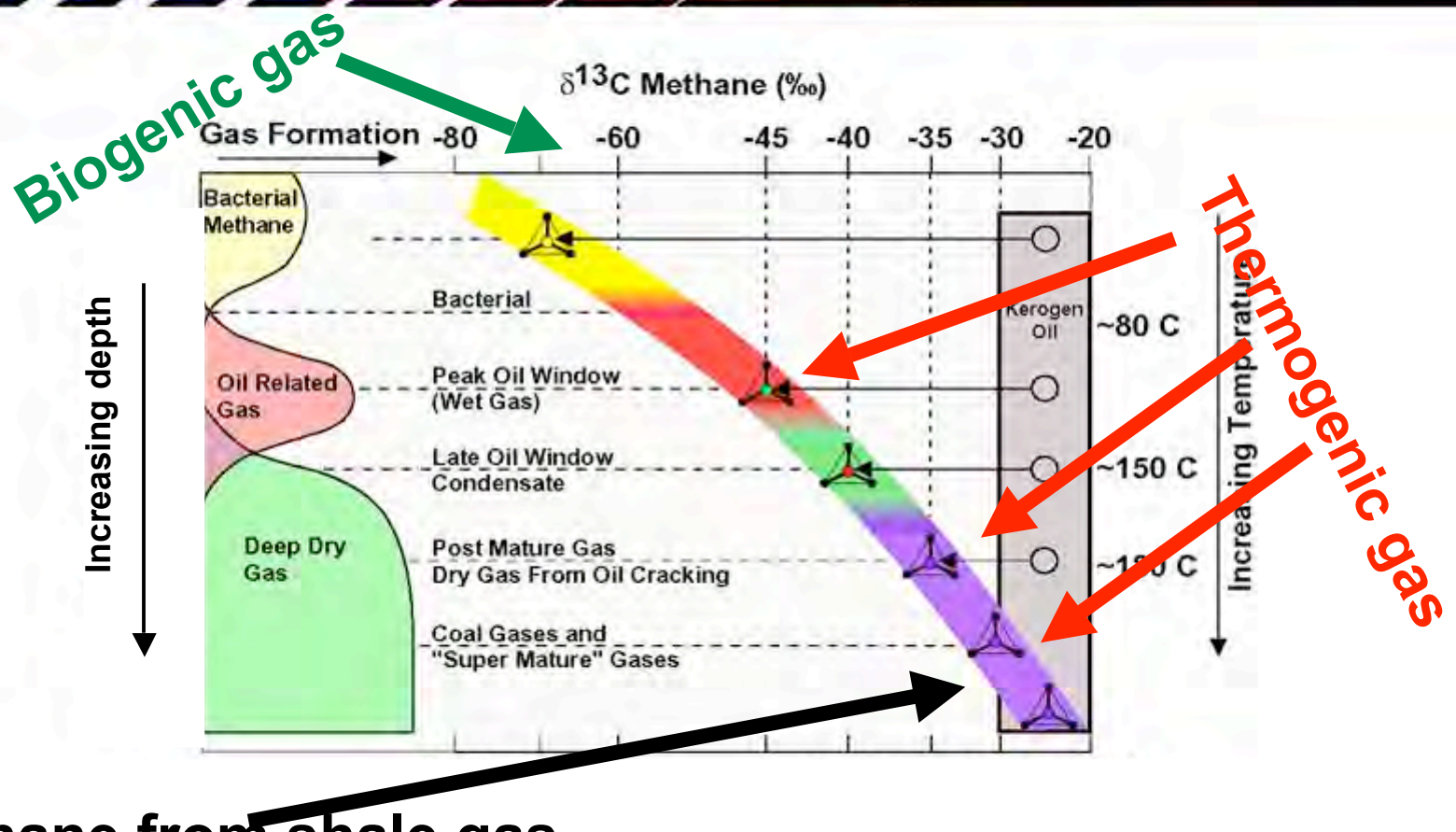

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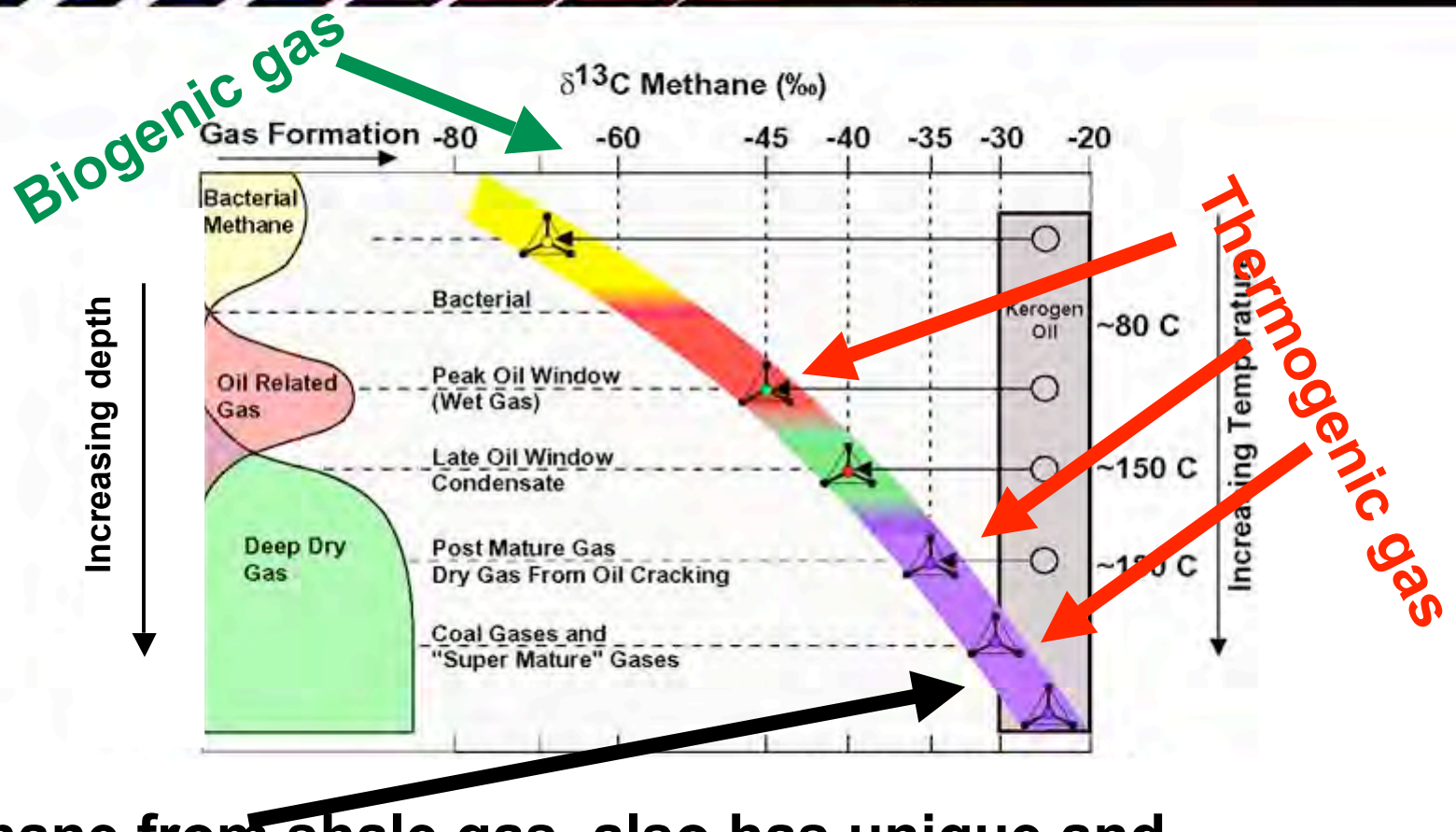

Methane from shale gas, also has unique and <u>diagnostic ethane and propane values</u>

M. Schoell

“If a well bore is properly cased with steel and cemented, the risk of any interaction between drinking water and fracturing fluid is ‘significantly diminished,’ said Mike Dawson, president of the Canadian Society for Unconventional Resources.”

“http://www.calgaryherald.com/technology/Living+fear+fracking/5627318/story.html#ixzz1cIDFq5Rv

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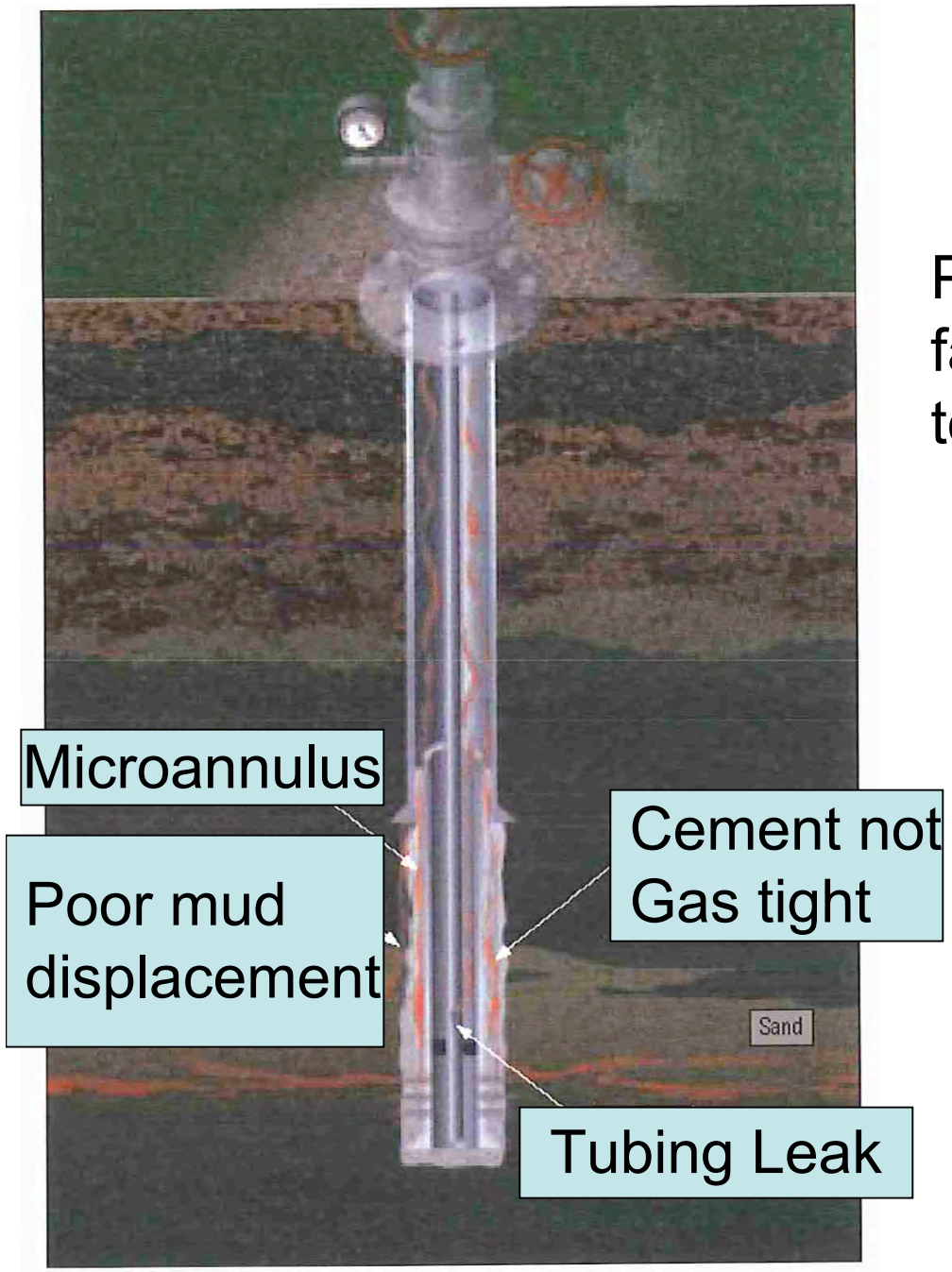
Yes, but, what happens if the job is <u>not</u> done right?

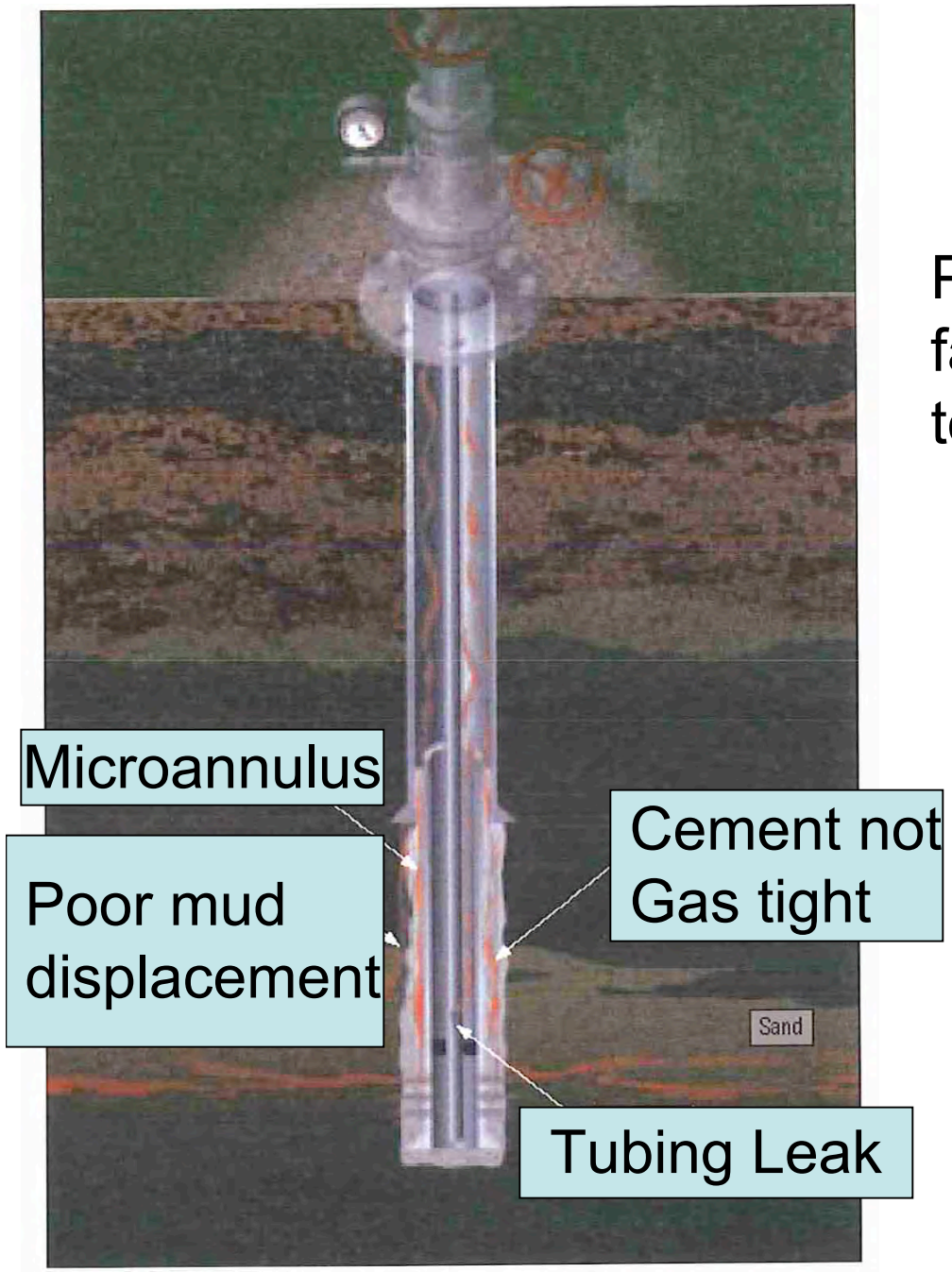
How <u>frequently</u> are instances of poor cementing and casing problems encountered?



From Schlumberger, Oilfield review

Poor cementing and tubing failures lead to gas migrating to surface, causing:

- Sustained casing pressure
- Surface casing gas



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Poor cementing and tubing failures lead to gas migrating to surface, causing:

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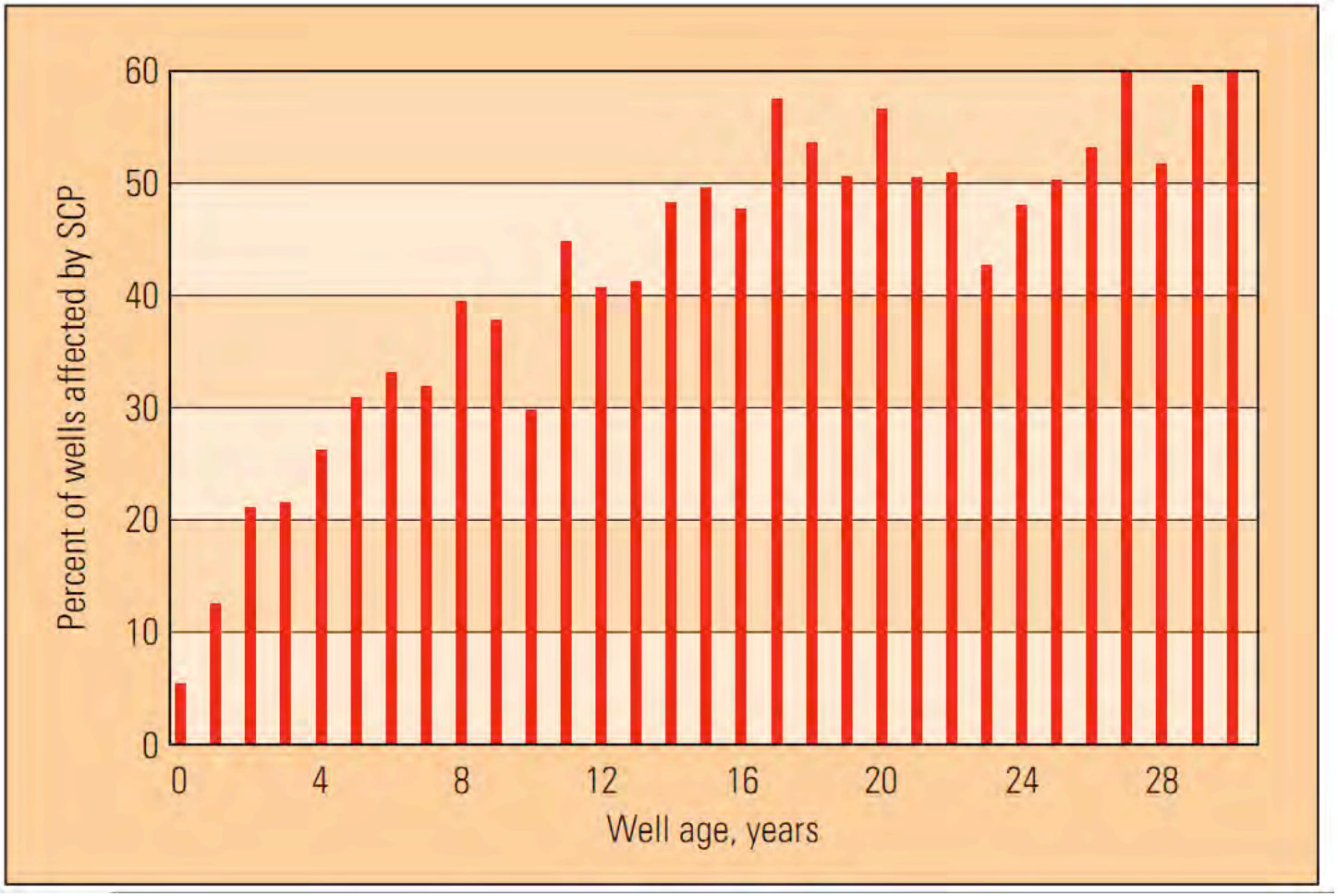
Note: gas can leak from production tubing or from anywhere up the well bore leading to

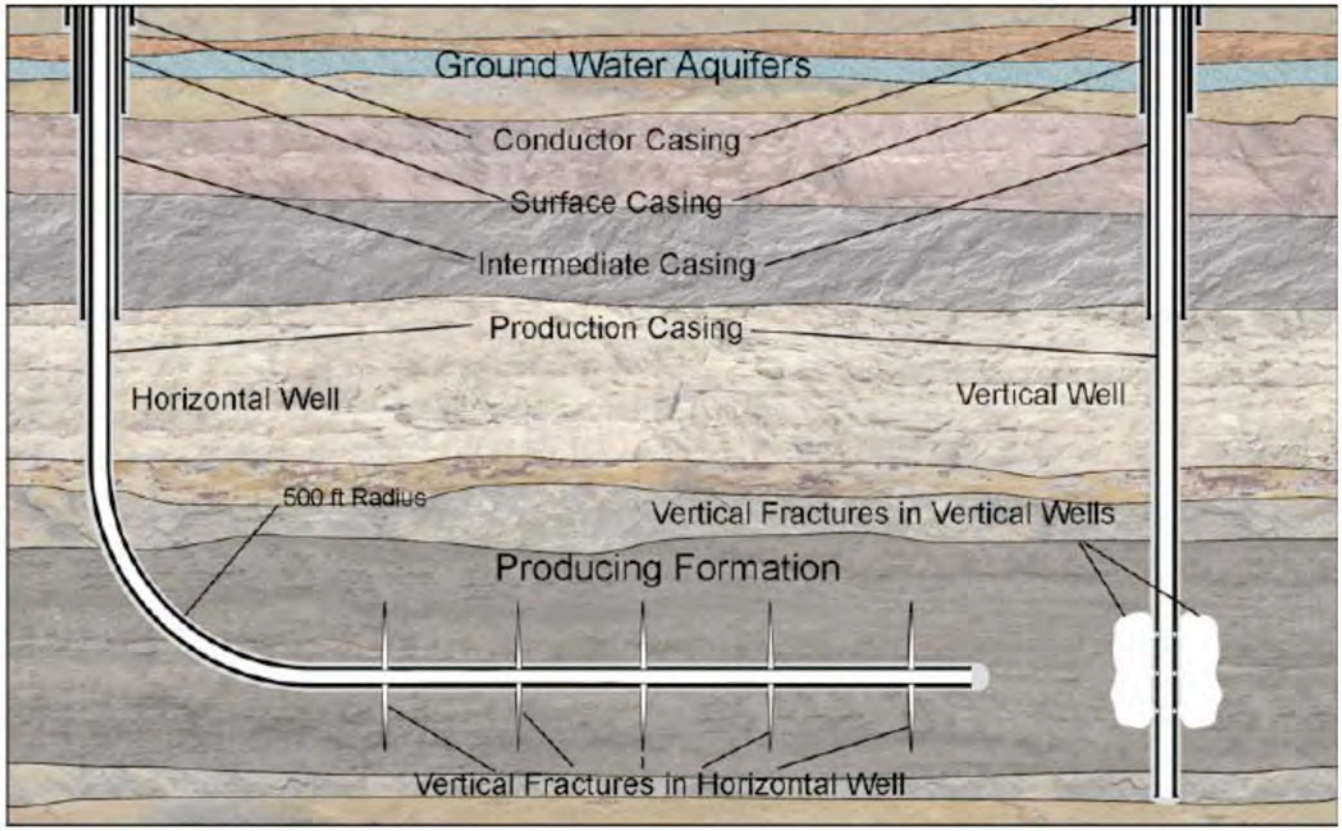
- Soil contamination
- Aquifer contamination

Problems and poor cementing are common and lead to gas migration and sustained casing pressure



From Schlumberger, Oilfield review

A series of casings are placed to intercept fugitive gas migrating along well bores



Schematic stratigraphy

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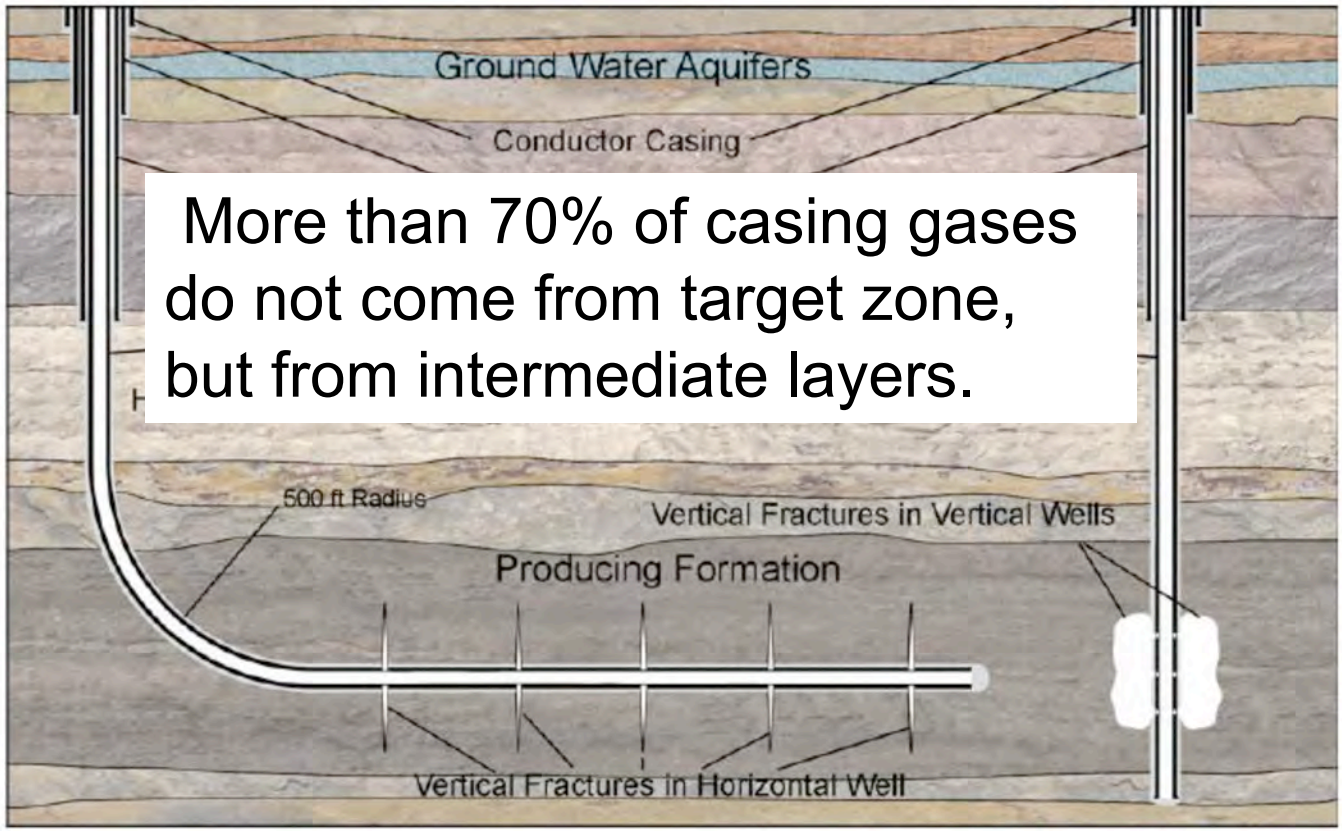

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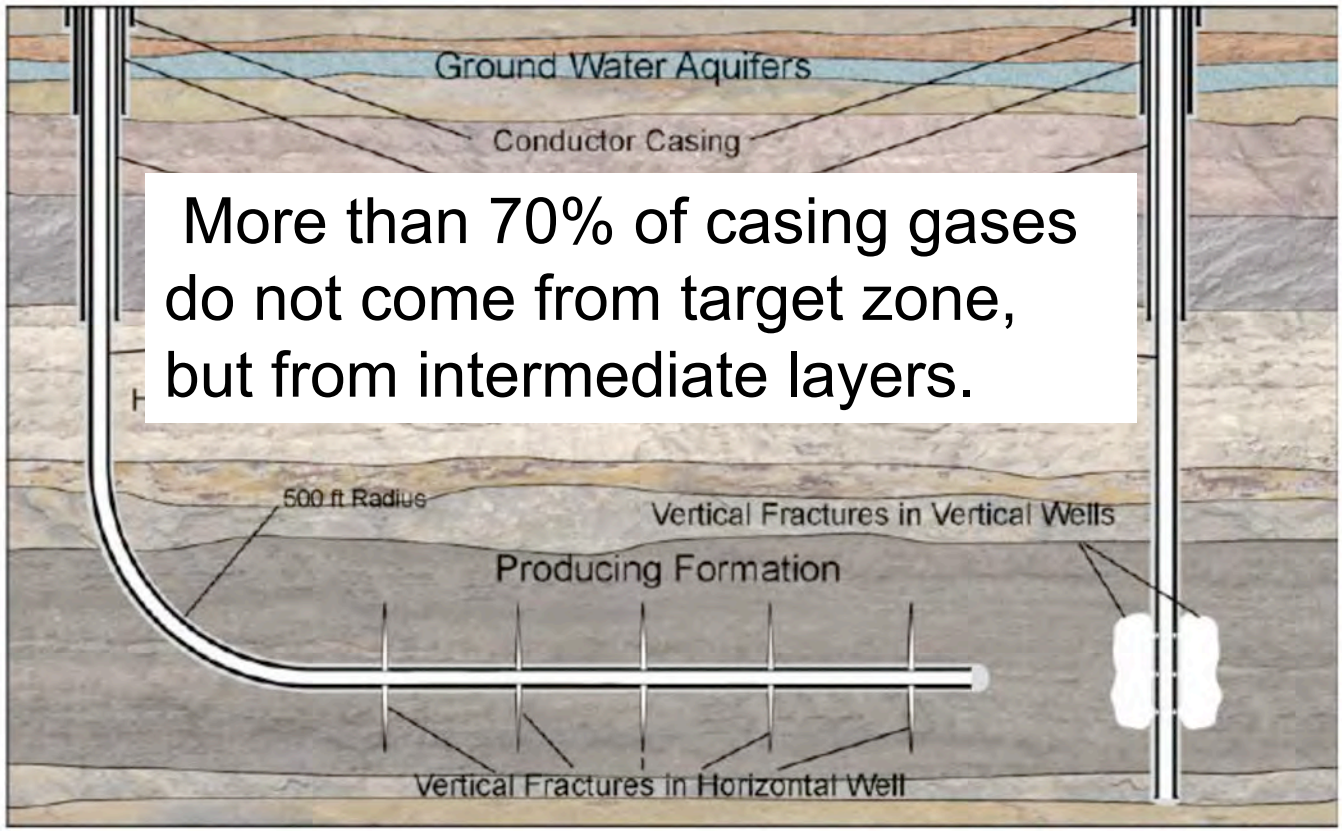


Schematic stratigraphy

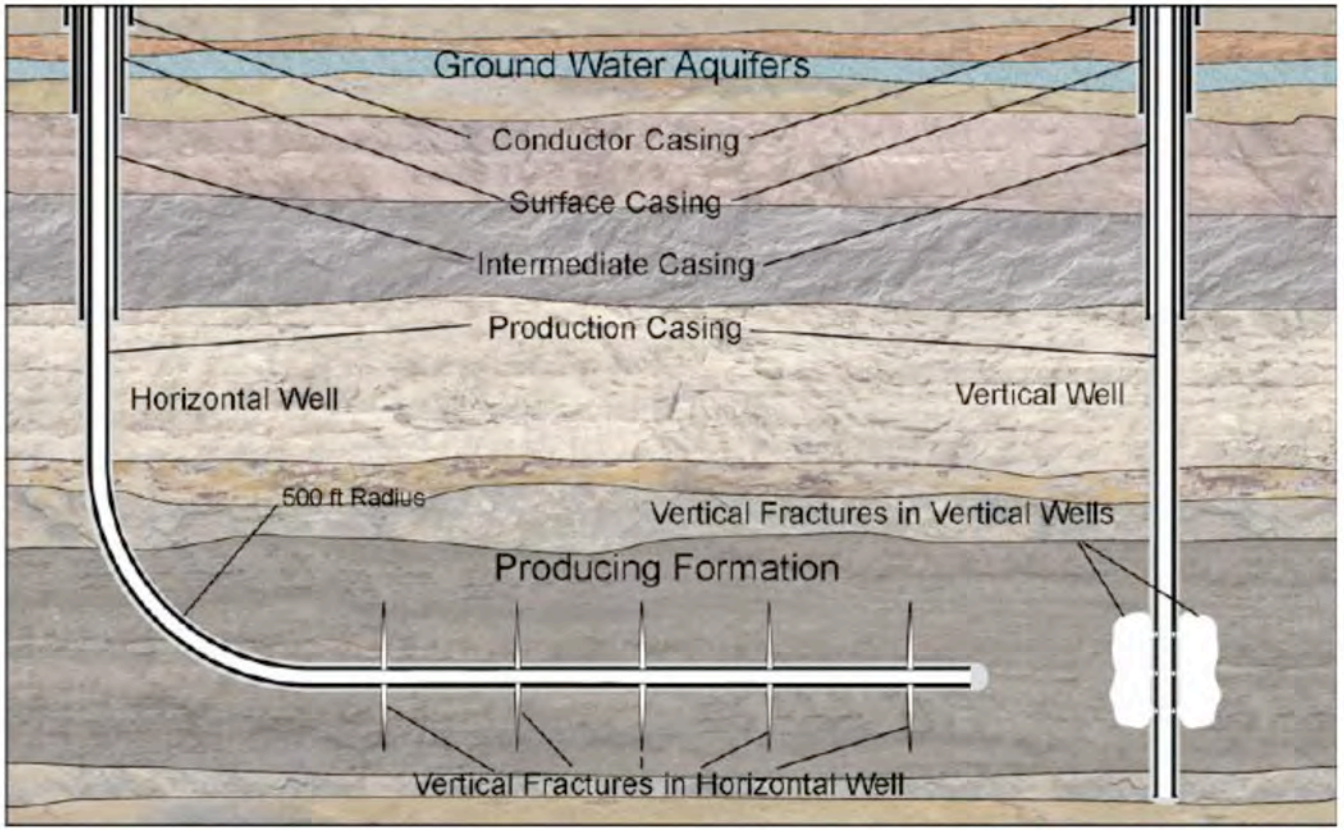
But are casings effective in preventing gas migration to surface?

Example from St Edouard Hz1a, Quebec

Carbon isotope values

	production gas	surface casing gas	gas bubbles well cellar *
methane	-37.17	-38.37	-36.61
ethane	-41.12	-37.54	-41.49
propane	-39.54	-32.08	-36.23

*Analysis are of gas from standing water in the well cellar. No data related to ground water at this well.



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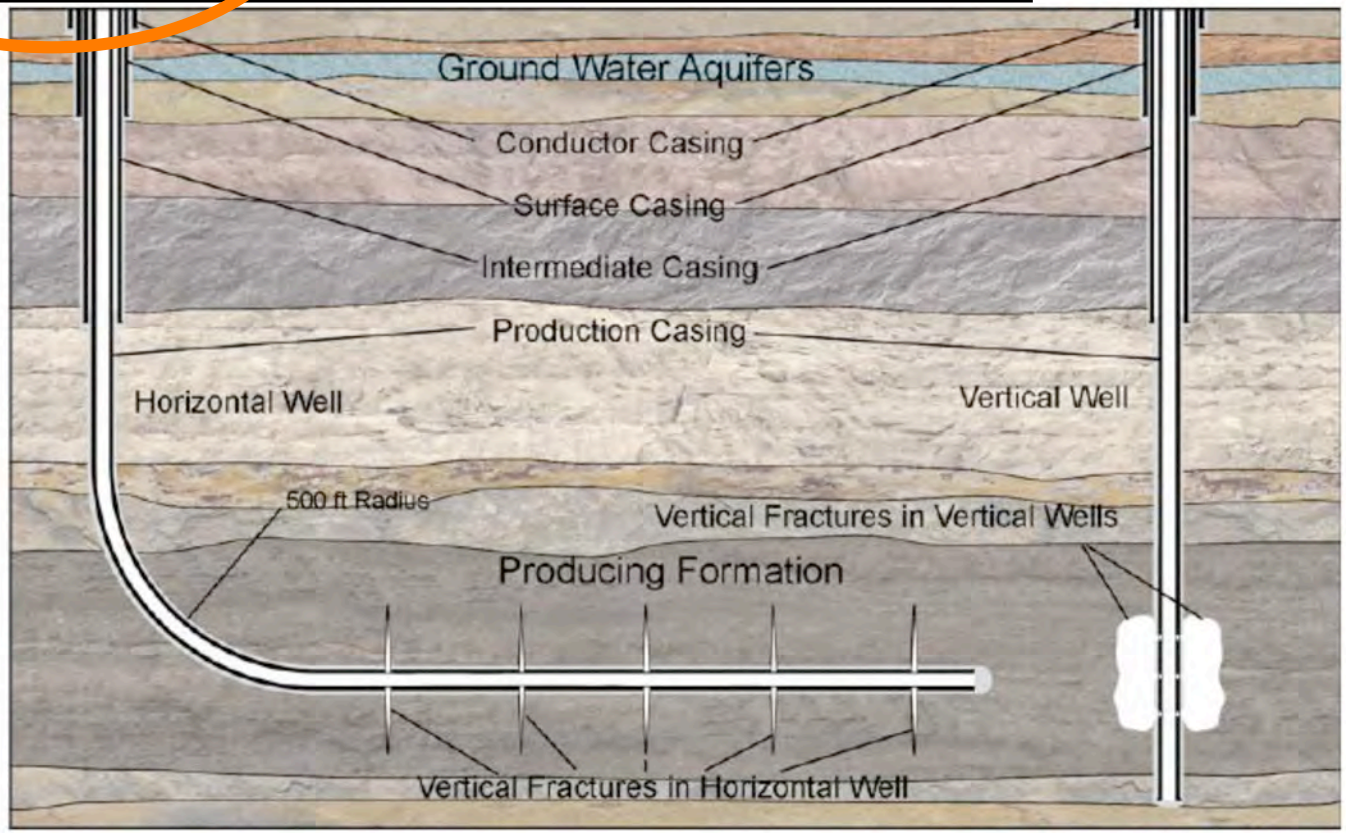
"roll over" or reversal, diagnostic of shale gas



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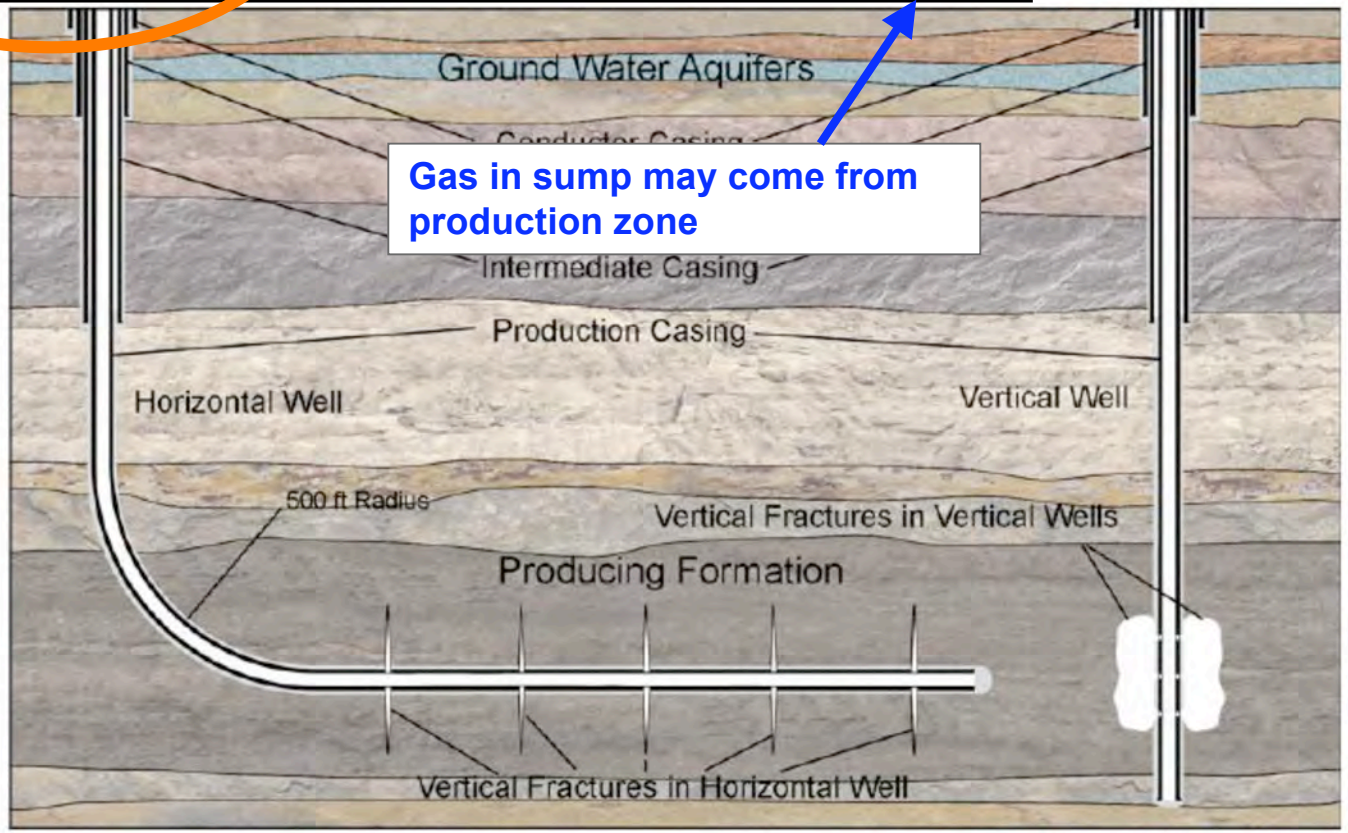

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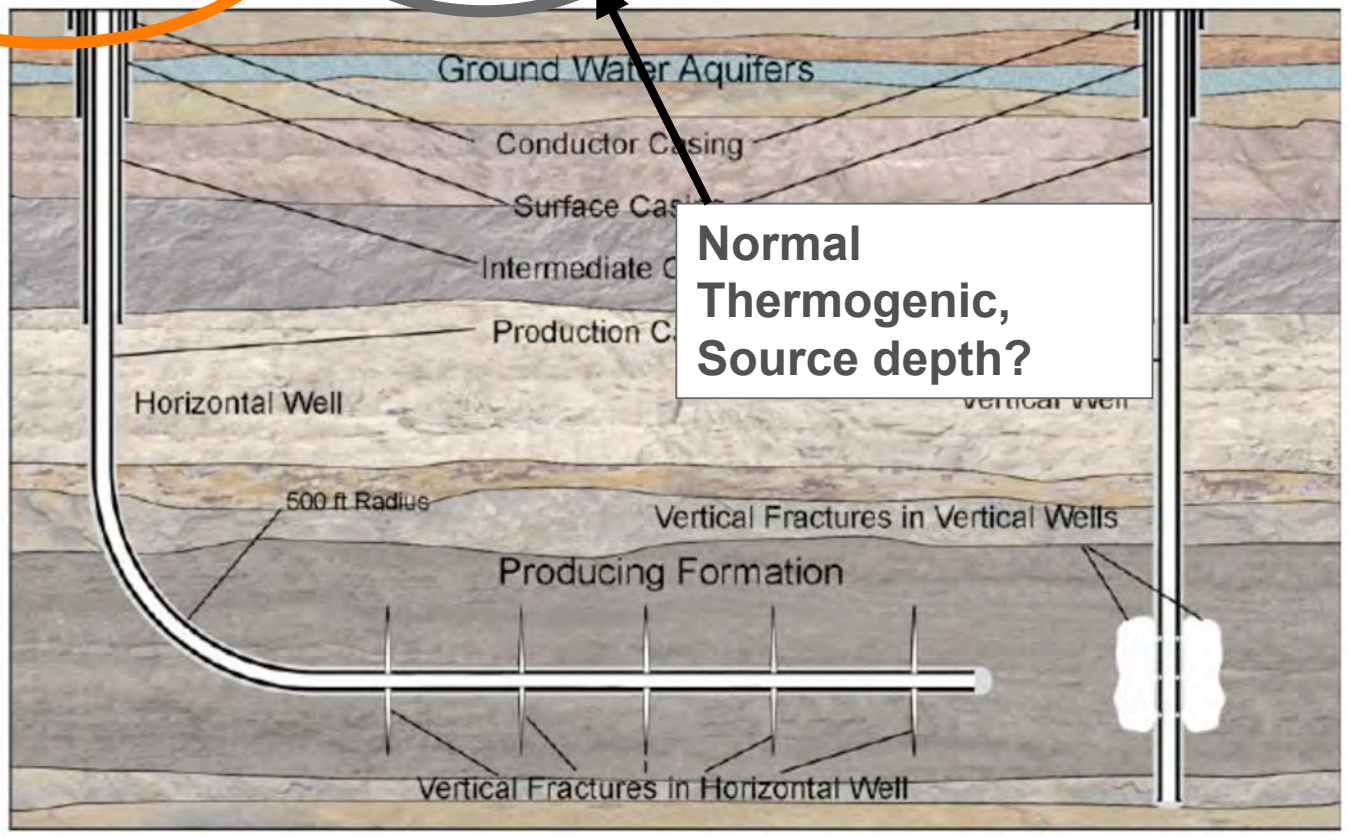
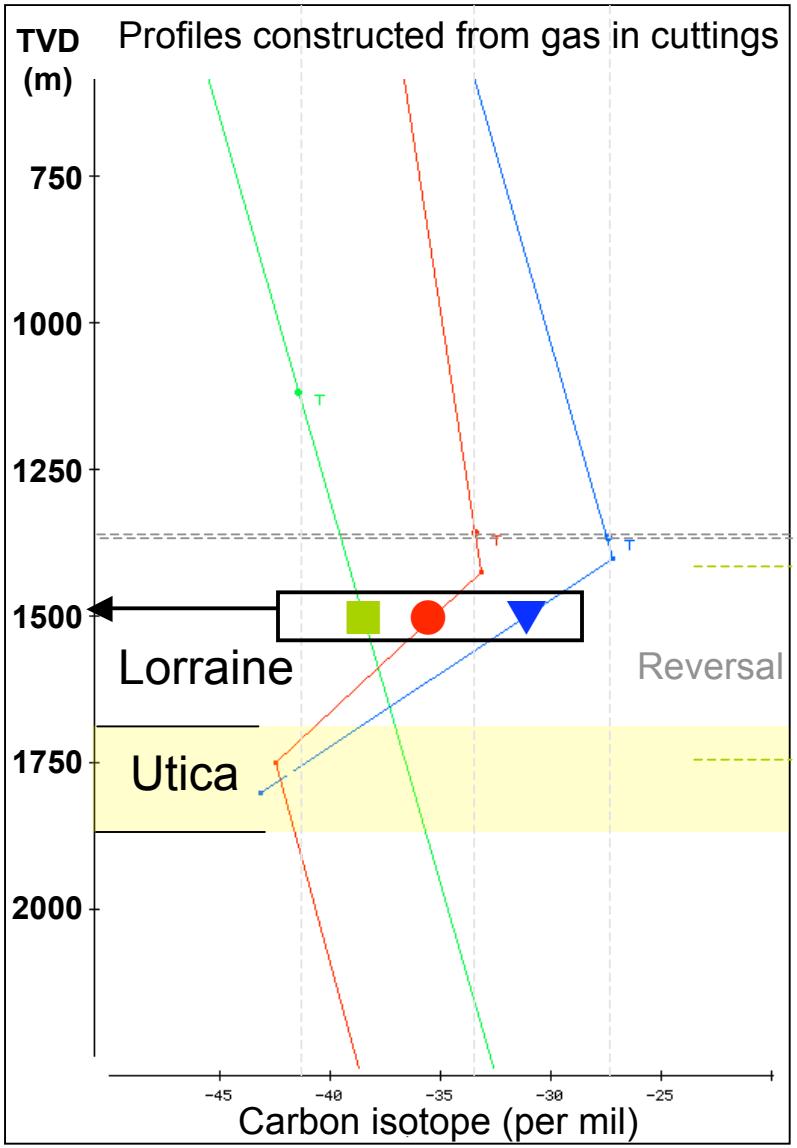


Normal Thermogenic, Source depth?

Schematic stratigraphy

Not related to Quebec Stratigraphy

Carbon isotope variation of gases with depth from Quebec



Profile courtesy of Talisman Energy (Chatellier et al., 2012 in prep)

The source depth of the surface casing gas from St Edouard Hz1a may be about 1500 m as revealed by comparing its isotope fingerprint with the profile:

Isotope fingerprint

C1 -38.37

C2 -37.54

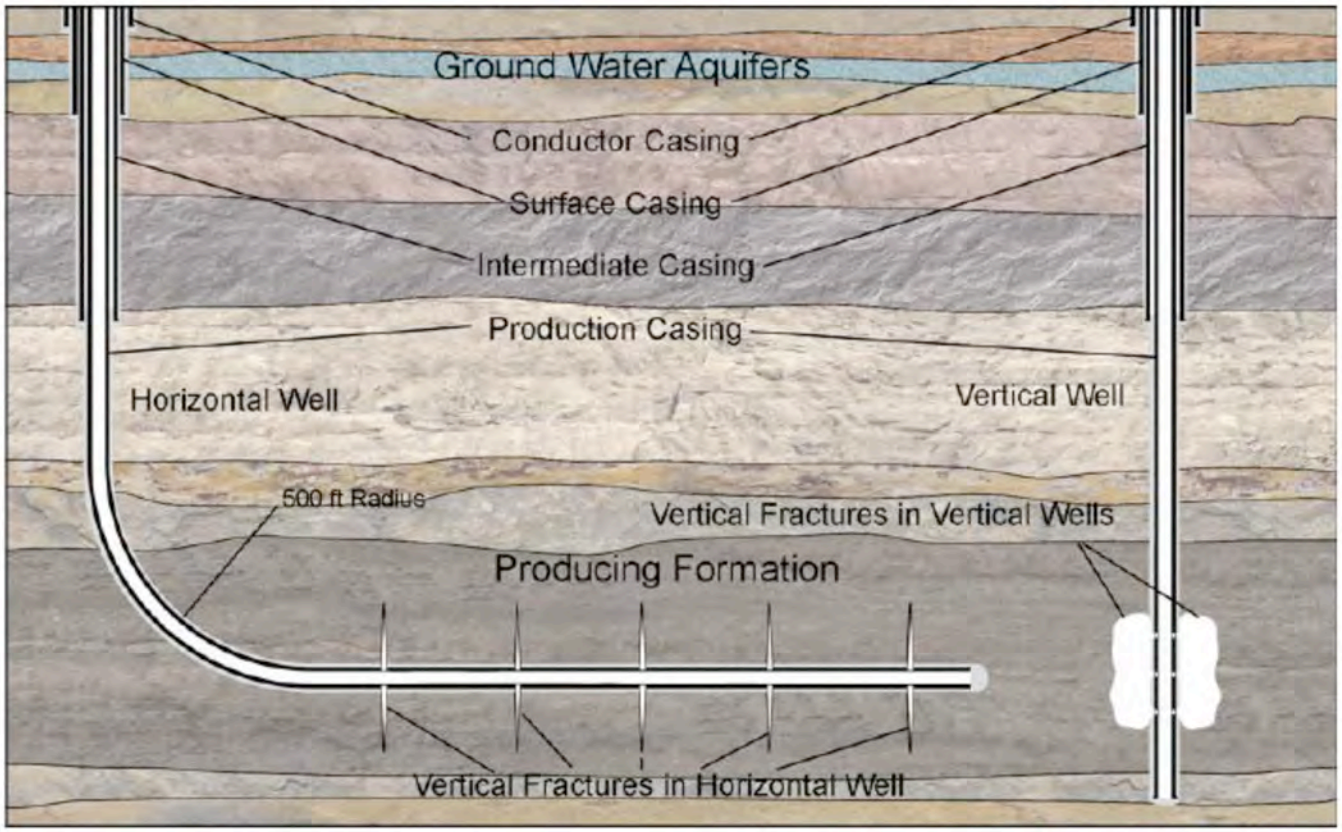
C3 -32.08

Example from Gentilley 2, Quebec

Carbon isotope values

	production gas	surface casing gas	gas bubbles in well cellar*
methane	-35.79	-43.97	-41.42
ethane	-36.05	-34.55	-33.42
propane	-28.26	-29.07	-27.39

*Analysis are of gas from standing water in the well cellar. No data related to ground water at this well.



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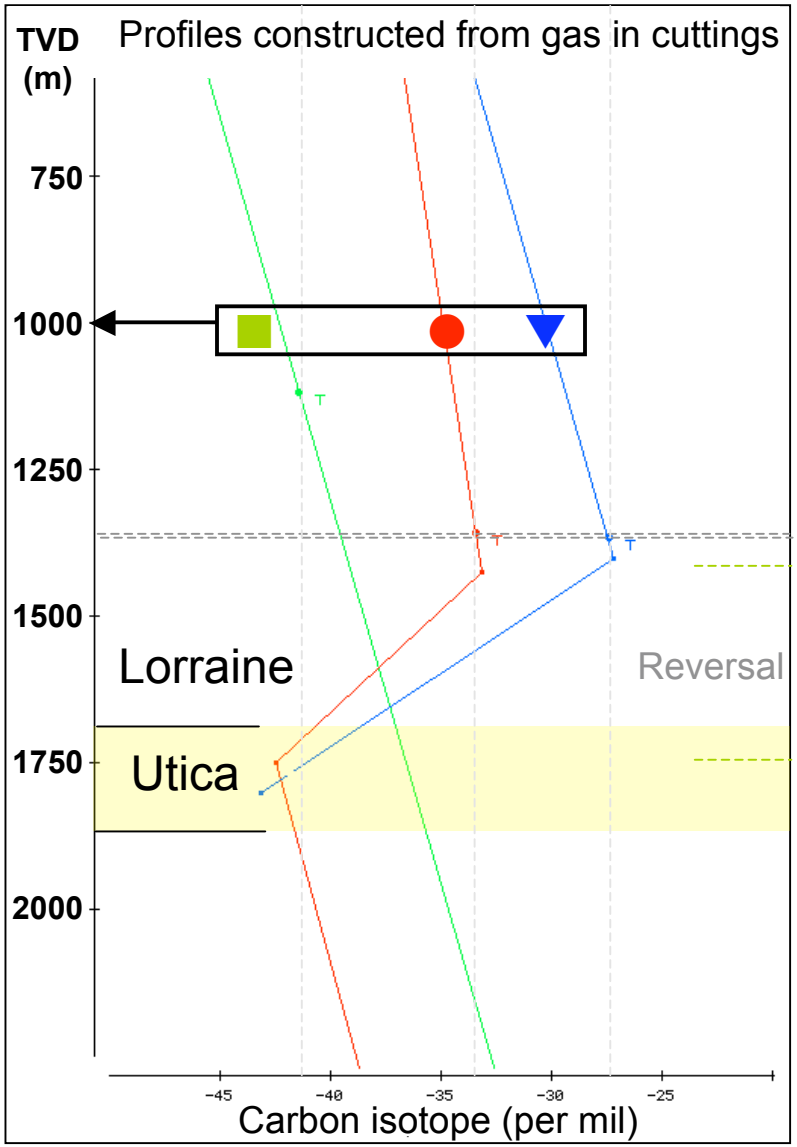
Carbon isotope variation of gases with depth from Quebec



Profile courtesy of Talisman Energy (Chatellier et al., 2012 in prep)

The source depth of the surface casing gas from Gentilley 2 may be about 1000 m as revealed by comparing its isotope fingerprint with the profile:

Isotope fingerprint

C1 -43.97

C2 -34.55

C3 -29.07

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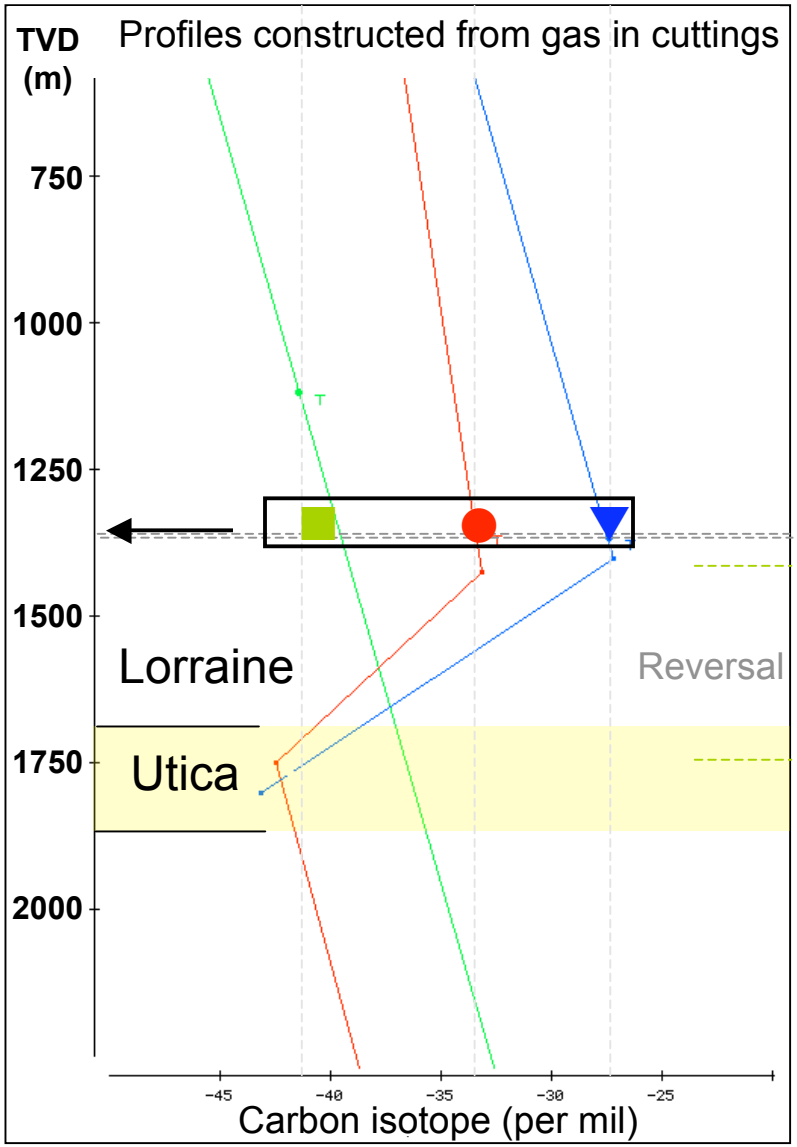


Profile courtesy of Talisman Energy (Chatellier et al., 2012 in prep)

The source depth of gas in the water in the well cellar from Gentilley 2 may be about 1300 m as revealed by comparing its isotope fingerprint with the profile:

Isotope fingerprint

C1 -41.42

C2 -33.42

C3 -27.39

Quebec data summary

- Gas analysis are from surface casing vents and from standing water in cellars near the well head

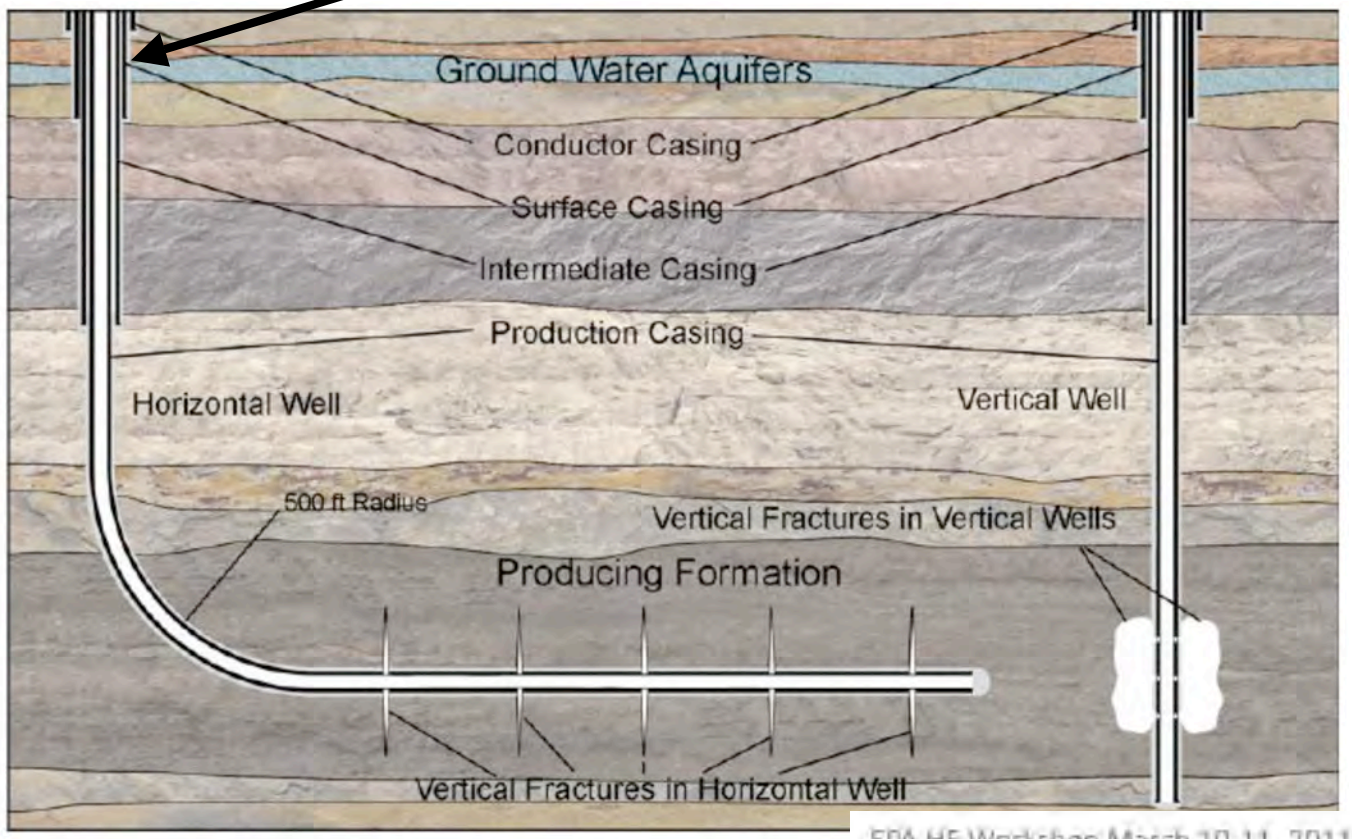
Not from the Aquifer

- No data related to groundwater is available
- Isotopic profiling is very useful to determine the source of gas.

An example from a shale gas well from Pennsylvania

Carbon isotope values

	Production gas	Surface casing gas
methane	-33.7	-33.2
ethane	-39.8	-39.1
propane	-42.1	-42.4



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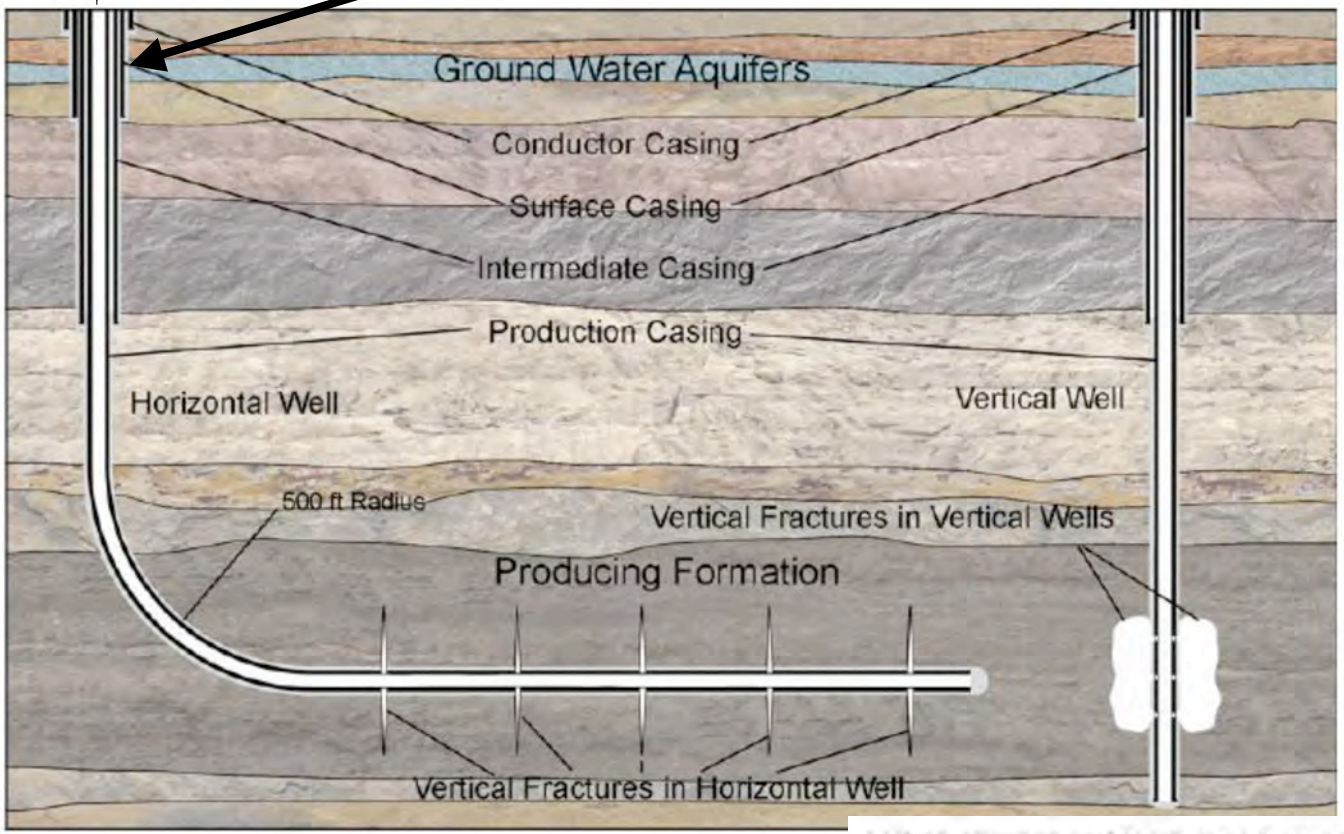

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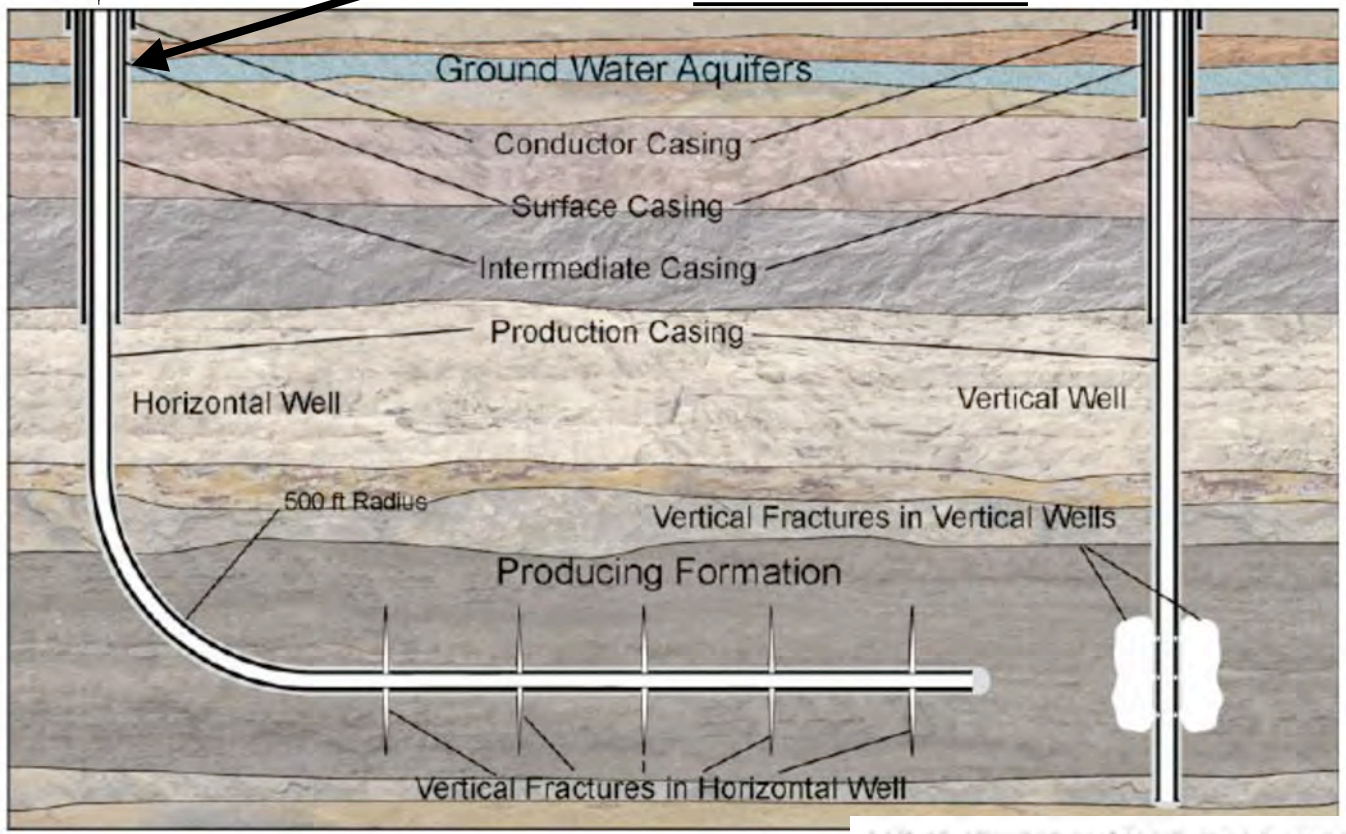
The gas isotope fingerprints are the same. Gas from the production zone has reached the surface.



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

Stephen G. Osborn[a], Avner Vengosh[b], Nathaniel R. Warner[b], and Robert B. Jackson[a,b,c,1]

[a]Center on Global Change, Nicholas School of the Environment, [b]Division of Earth and Ocean Sciences, Nicholas School of the Environment, and [c]Biology Department, Duke University, Durham, NC 27708

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 dramatically increasing natural-gas extraction. In aquifers overlying 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-

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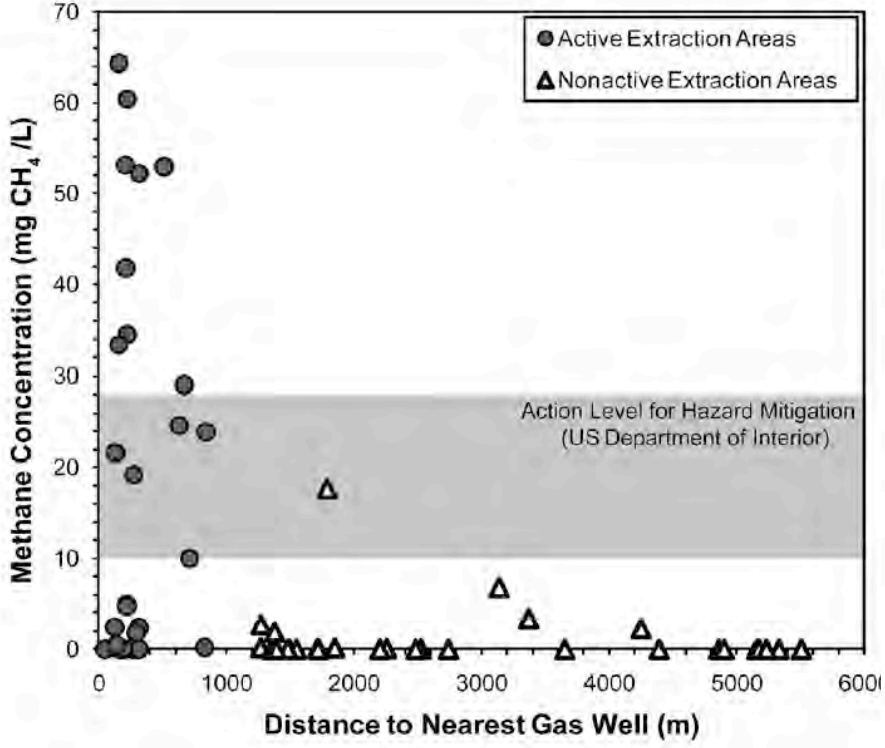

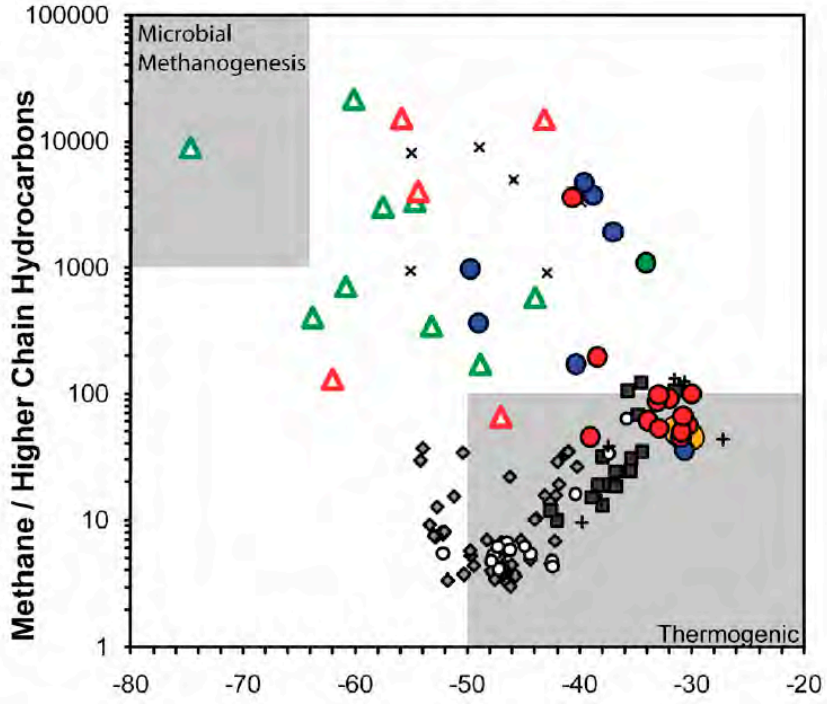

What is the source of methane in water wells?

Authors:

1) Gas released by hydraulic fracturing
2) Gas from faulty well bores/cement failure.

Critics:

1) Gas **not proven** to be from hydraulic fracturing
2) Gas may be natural background methane
3) Gas leaked from old wells
4) Gas from faulty well bores/cement failure.

More isotope data needed but what would conclusively ID problem gas?

Need isotope fingerprints for:

- Pre-drilling baseline for water wells
- Ethane (and propane) of water wells
- Gas from legacy/abandoned wells
- Gas in natural springs and seeps
- Gases from well casings
- Of production gases
- Mud gas isotope profiles in area.

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Conclusions
and suggestions to Industry and regulators:

To identify specific sources of gas contamination in groundwater we need to mandate baseline isotopic fingerprinting of methane, ethane and propane for:

- –Pre-development water wells
- –Production gases
- –Detailed gas isotope stratigraphy (mudgas isotope log)
- –Gases from:
  - – conductor, surface and intermediate casings
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The above requirements are not onerous.