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GSNI Geological Survey of Northern Ireland
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Introduction to Hydraulic Fracturing

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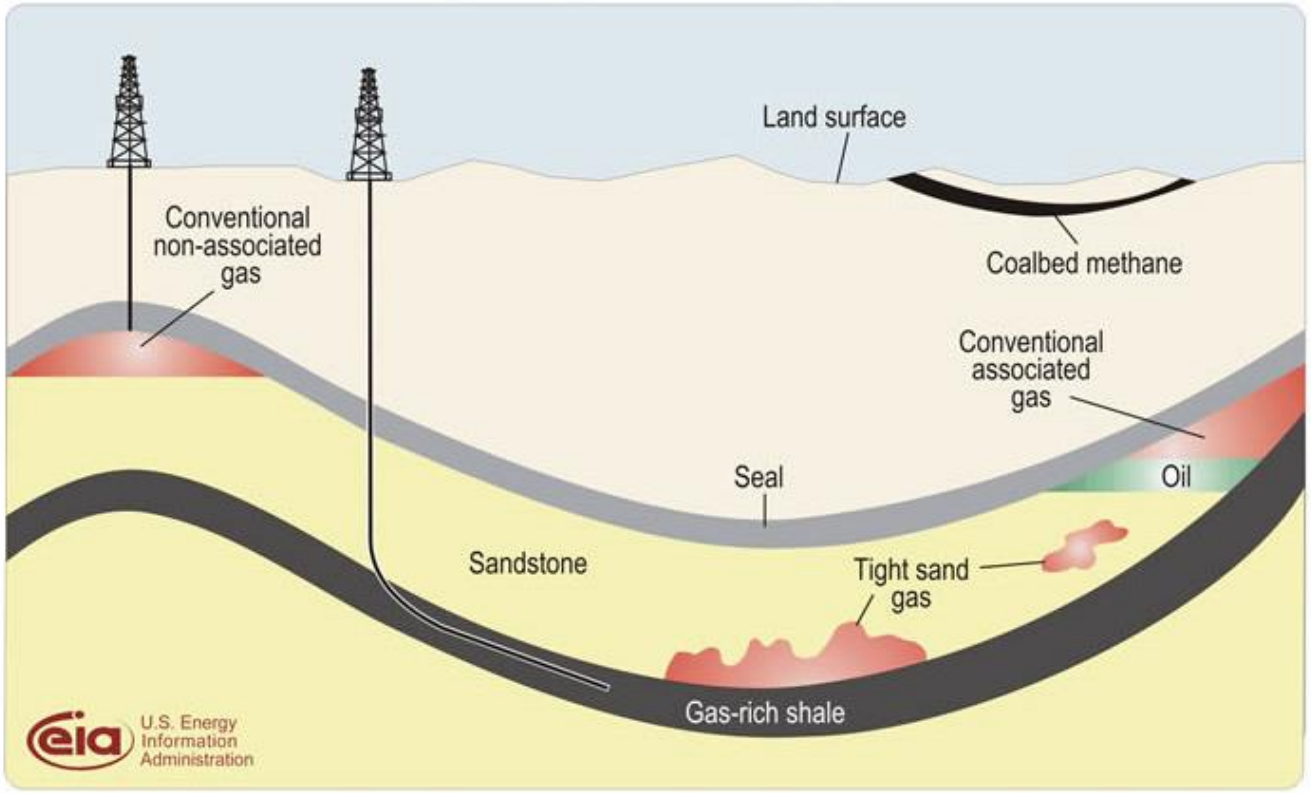
My Background

- MSci and PhD in geology
- 5 years as reservoir geologist and senior reservoir geologist in oil and gas service industry. Worked on a range of reservoir types in Norway, UKCS, Algeria, India, Sri Lanka.
- 9+ years as Energy Geologist at GSNI providing geological advice and expertise to DfE.
- In-depth knowledge of NI geology, exploration history.
- Not a reservoir engineer nor have directly worked in fracking industry, but experienced in assessing Petroleum Licence applications, which requires good understanding of the high volume hydraulic fracturing process.

1. Conventional and unconventional hydrocarbons



Source: EIA. Adapted from *United States Geological Survey factsheet 0113-01* (public domain)

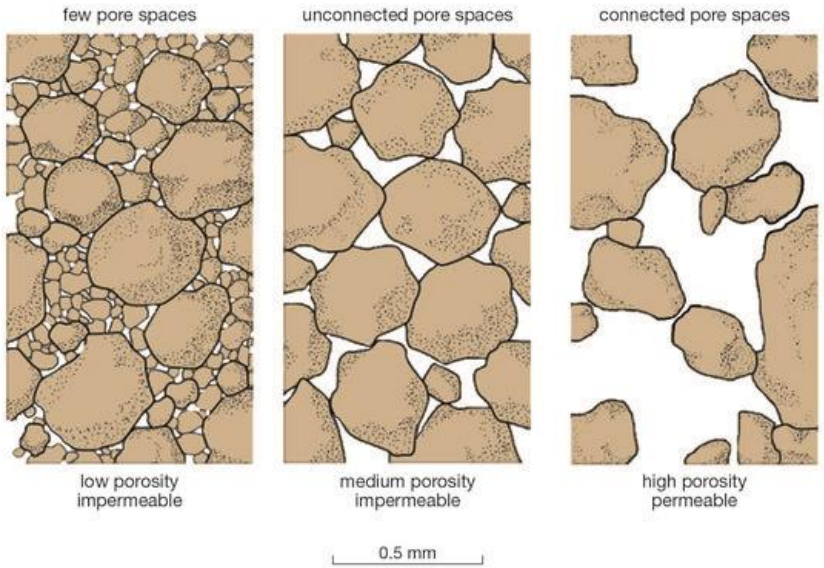
<u>Conventional hydrocarbons</u>

- non-associated dry gas
- oil and associated wet gas (require a seal and a trap - reservoir and structure)

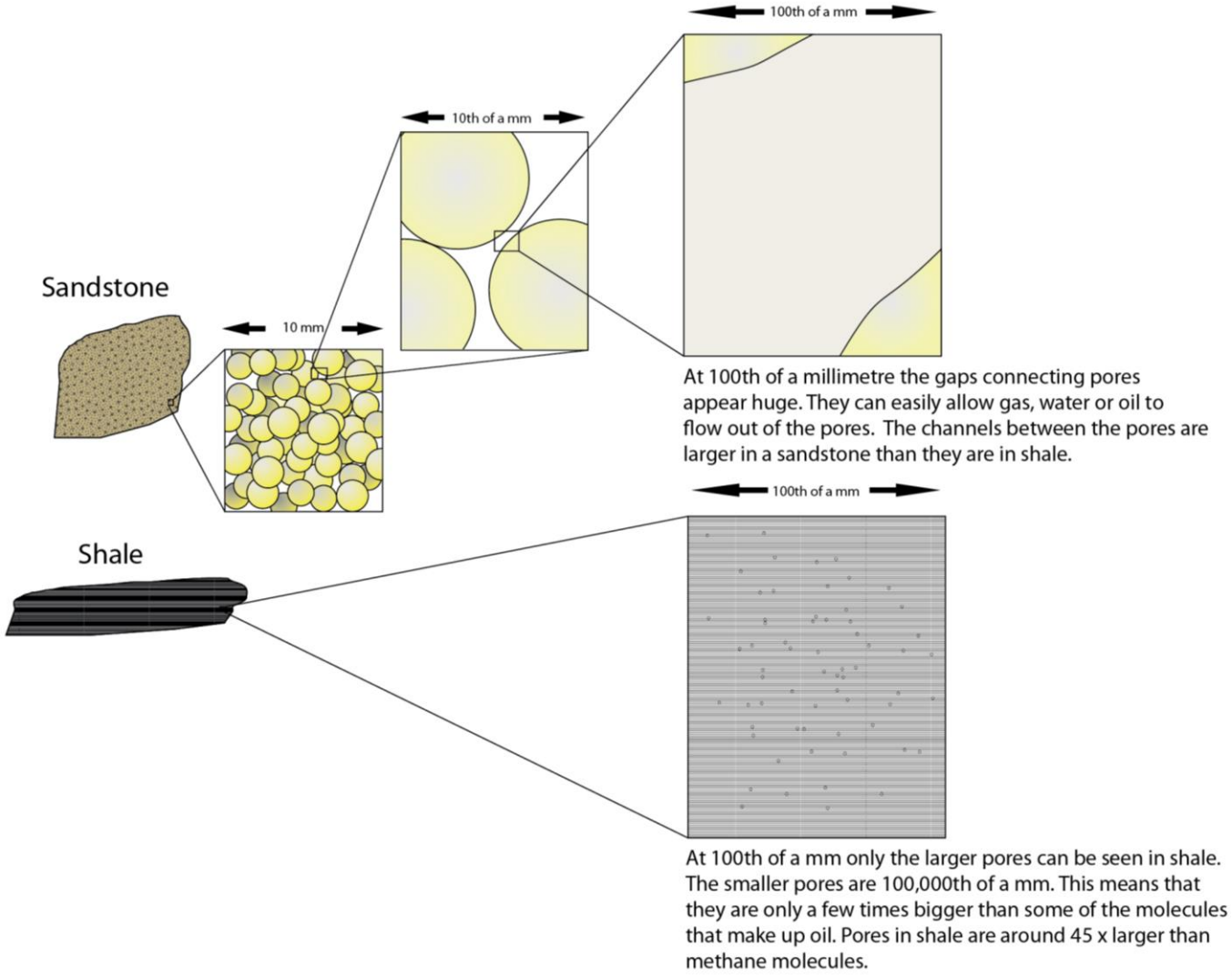
<u>Unconventional hydrocarbons</u>

- coal bed methane
- tight gas sandstone
- shale gas (the reservoir acts as both the source and the seal)
- tar sands
- low permeability rocks such as porcellanite

2. Reservoir properties



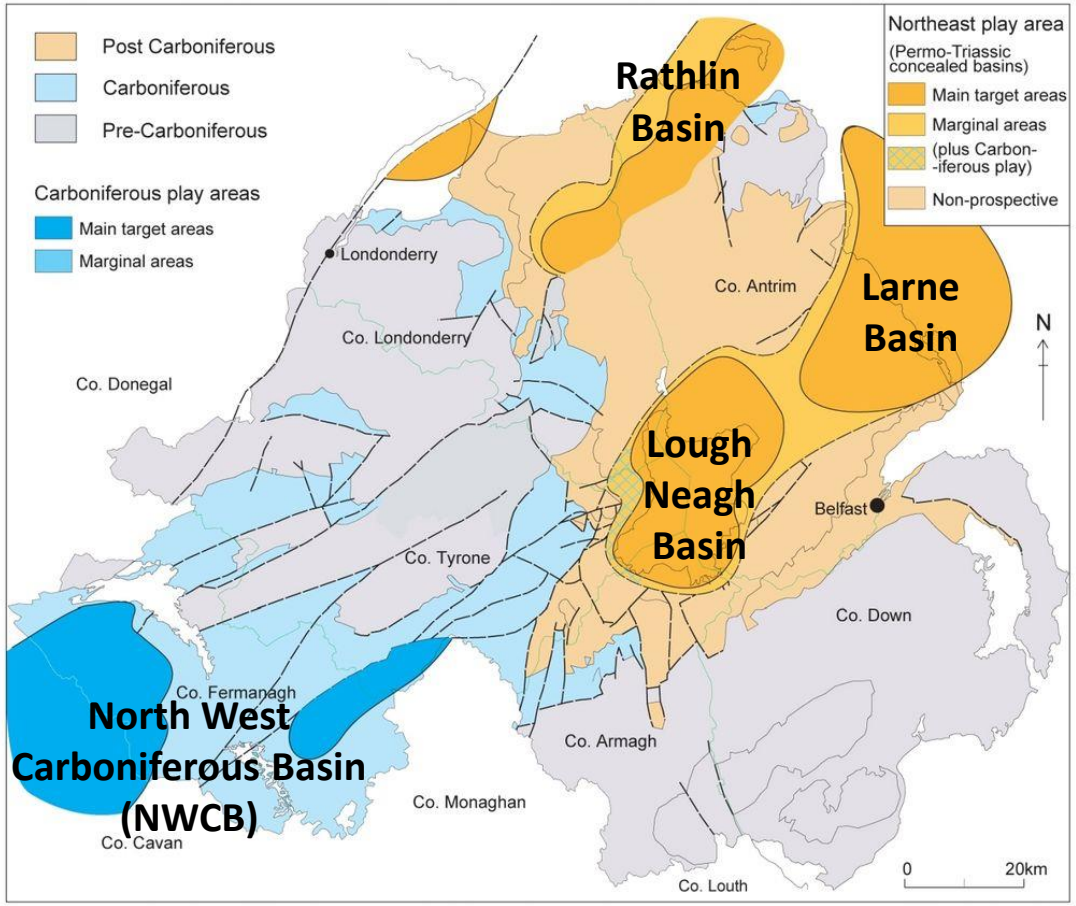
Source: https://www.dmp.wa.gov.au/Petroleum/Introduction-to-unconventional-25621.aspx



Conventional hydrocarbon reservoirs have the presence of two characters.

- Porosity (space between grain) to hold hydrocarbons.
- Permeability (connection between the pores) to allow hydrocarbons to flow towards the well.

3. Hydrocarbon prospectivity in Northern Ireland



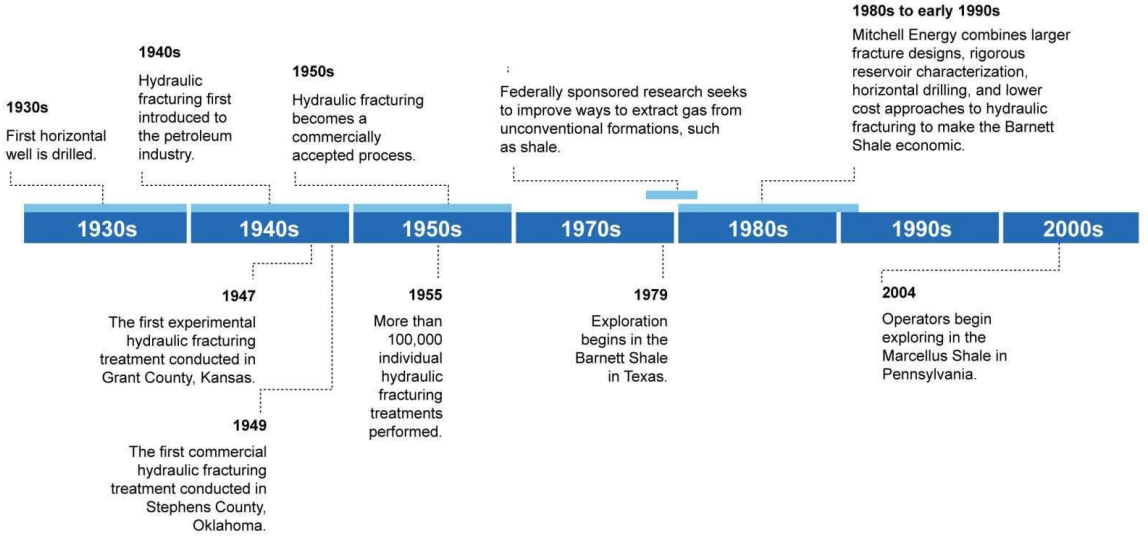
Source: GSNI

4. Historic development of hydraulic fracturing for shale gas.

Hydraulic Fracturing employed in the shale gas industry is a combination of two techniques.

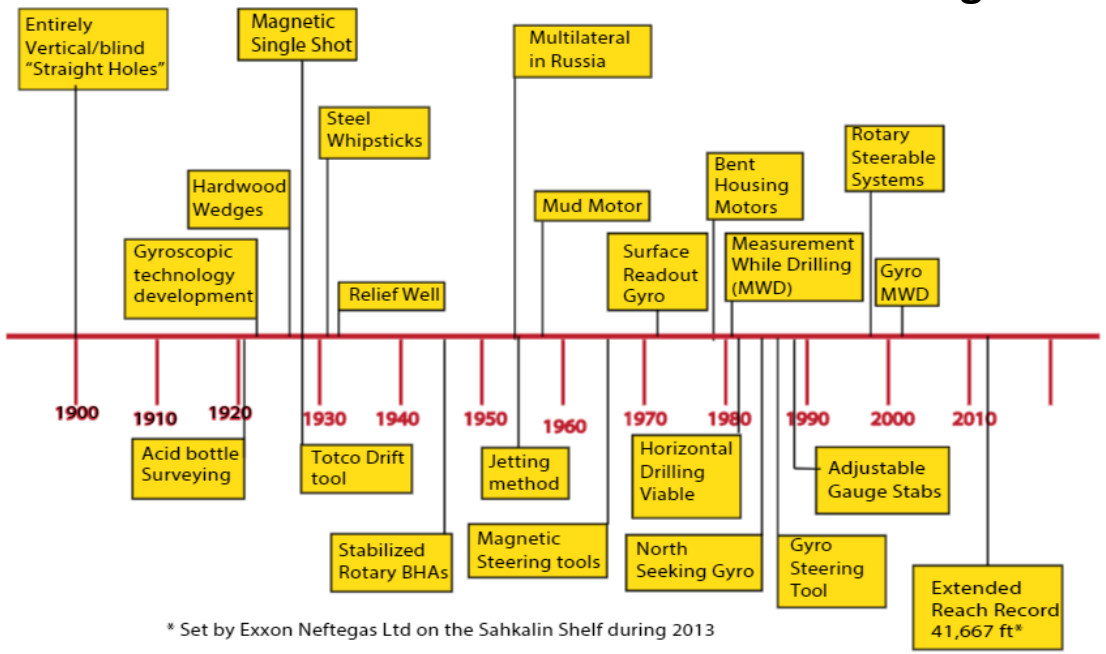
- Drilling of long horizontal lateral extensions to the well made possible by directional drilling and
- Fracturing of the rock using high-volumes of water

History of hydraulic fracturing



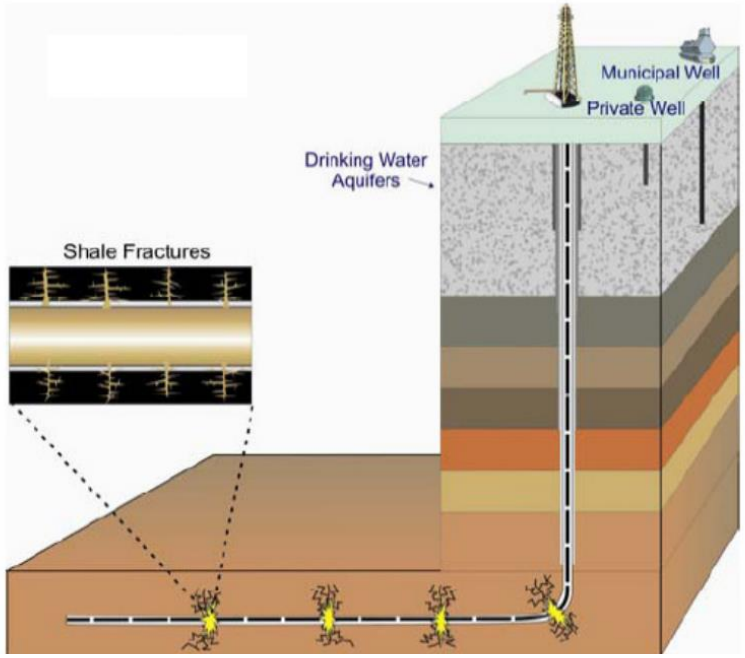
Source: U.S. Government Accountability Office.

Evolution of horizontal drilling



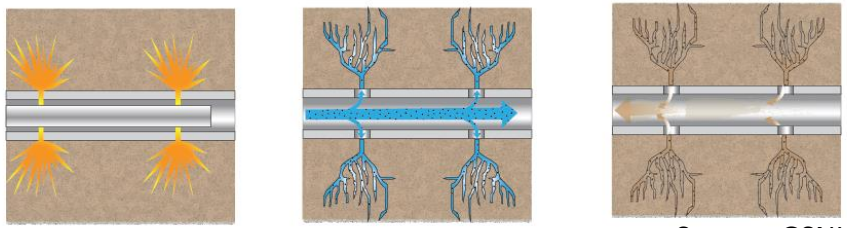
Source: IADC, 2015. Drilling Manual

5. Shale gas high-volume hydraulic fracturing process

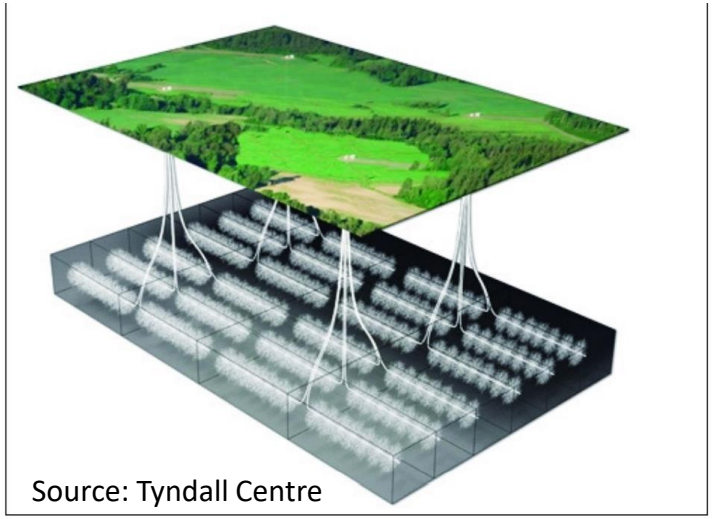


Source: US EPA Hydraulic Fracturing Research Study – Scoping Backgrounder, 2010

- Vertical drilling to target depth (typically 2 km)
- Drilling of laterals within the shale formation (up to 1.5 km)
- Setting steel casing within the well
- Perforation of casing
- Injection of frack fluid (water, proppant, chemicals)
- Production of gas from open fractures
- Drilling of further wells and laterals from the well pad



Source: GSNI

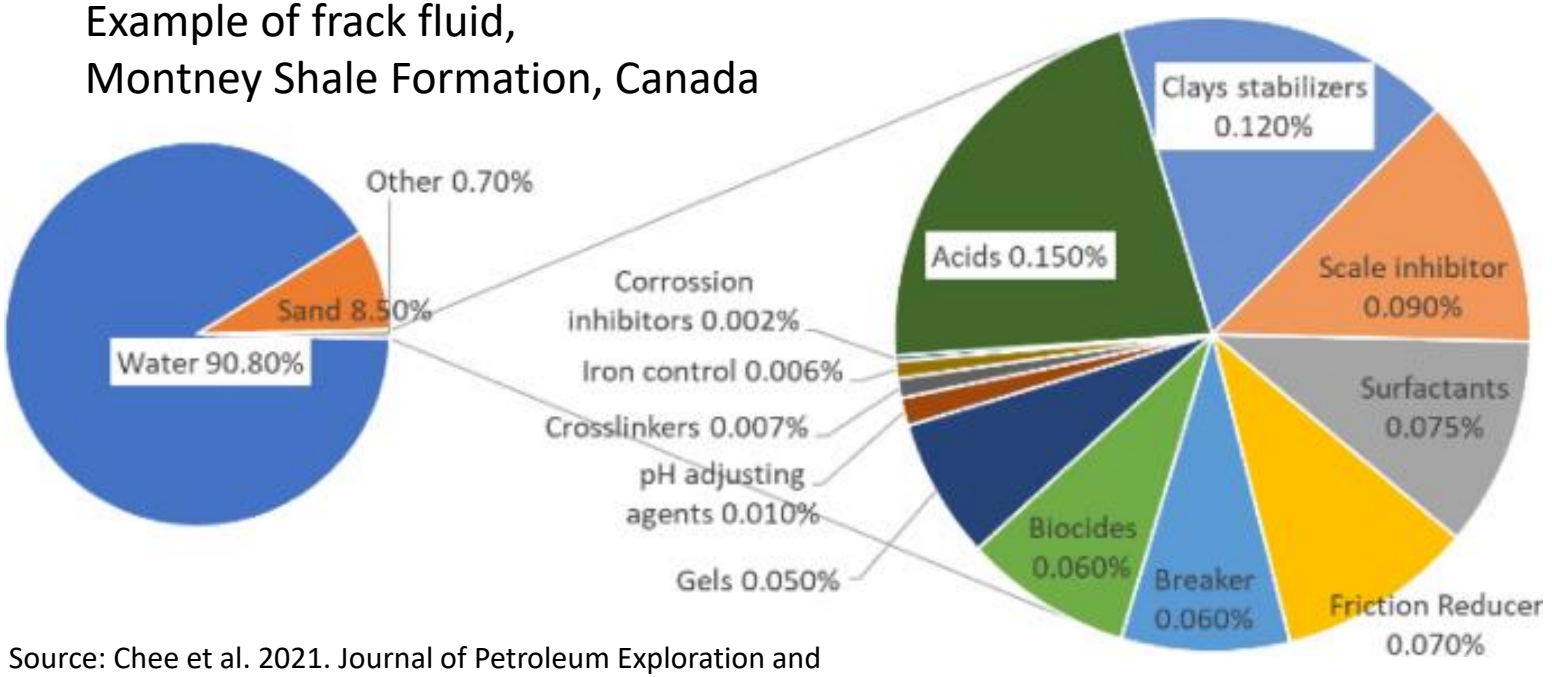


Source: Tyndall Centre

6. Frack Fluid composition

Frack Fluid = Base Fluid + Proppant + Additives

Example of frack fluid,
Montney Shale Formation, Canada



Source: Chee et al. 2021. Journal of Petroleum Exploration and Production, 11, 1973-1991

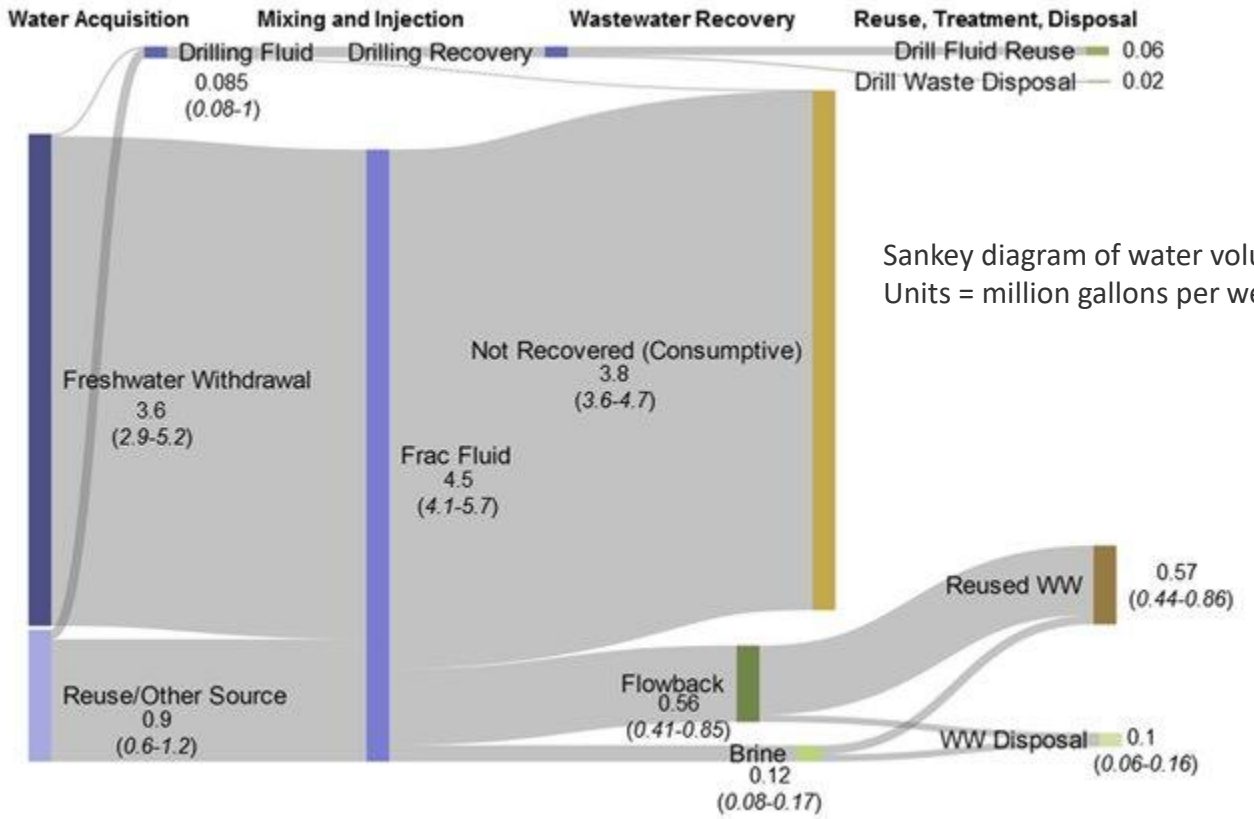
Compound	Purpose	Common application
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
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 juice beverages, lemon juice
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring





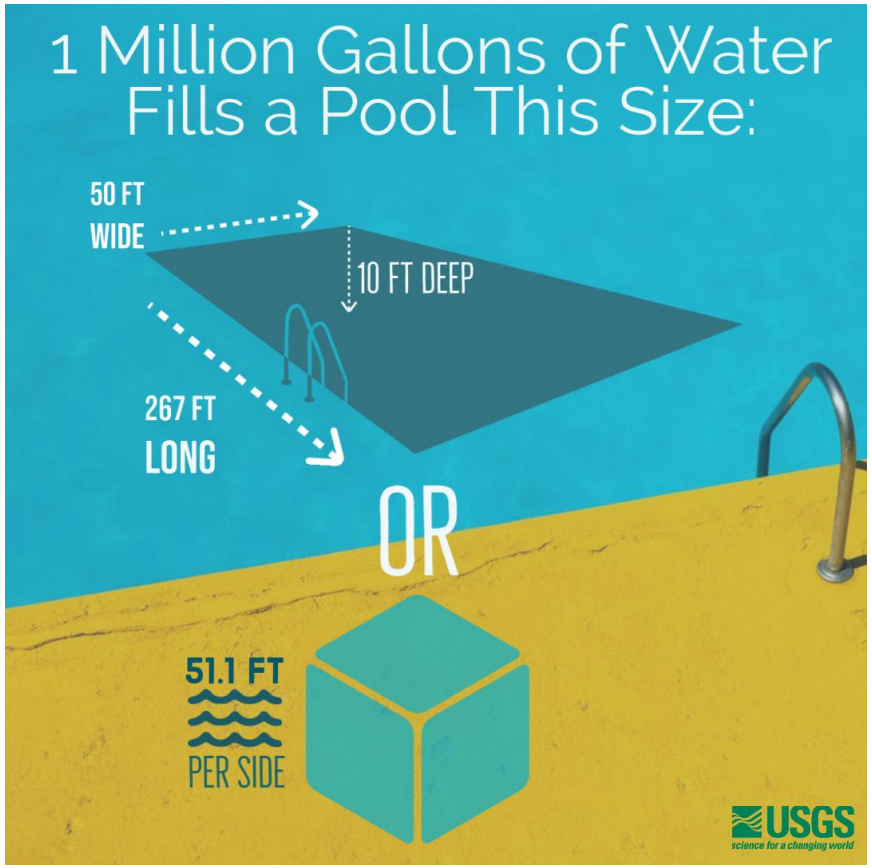
Source: https://oilandgasinfo.ca/know-fracking/what-is-frac-fluid-made-of/

7. Frack fluid volume, flowback water and produced water



Sankey diagram of water volumes
Units = million gallons per well.

Habicht et al., 2015. The Potential Environmental Impact from Fracking in the Delaware River Basin



1 million gallons = 4.54 million litres

8. Petroleum production technologies for conventional and unconventional reservoirs

- **Perforations** - small explosive charges which penetrate the steel casing.
- **Fishbone drilling** - the drilling of multiple slim laterals
- **Acidisation** – injection of dilute acid such as HF or HCL. Acid can be pumped into the reservoir to dissolve minerals and increase permeability. When done with a low-permeability reservoir this is called an '**acid frack**'.
- **Low-volume fracturing** - usually termed '**well stimulation**'. Used to remedy damage to proximal part of reservoir. Fracturing may only extend a few feet from the wellbore.
- **High-volume hydraulic fracturing**- requires higher volumes of water, greater amounts of proppant and greater pressures.
- **Water/gas/steam/polymer flood**. Generally carried out under lower pressure and utilising the rock's existing permeability.

9. Industries that use types of fracturing

- **Shale gas –** High-volume hydraulic fracturing, 9000 psi, volumes can be 1.9-6.4 million gallons per well.
- **Water wells** - Low-volume hydraulic fracturing, 500-2000 psi with proppants and not usually with additional chemicals)
- **Tight gas sandstone** – High-volume hydraulic fracturing, usually 11,000-400,000 gallons per well because the sandstones are often thinner than shale formations.
- **Coal bed methane (CBM)** – Low-volume fracturing is sometimes carried out. Injection of water or foaming agent at lower volume and pressures than HVHF due to shallow depth.
- **Enhanced Geothermal Systems (EGS)** – In this one niche type of geothermal, low-volume fracturing using hydraulic (water), thermal (steam) or chemical (acid). Little prospect for this type of geothermal in NI, which has prospectivity in porous and permeable geothermal reservoirs. Currently no operating deep EGS projects worldwide, with the technology only at demonstration phase.