

Hydraulic fracturing and its impact



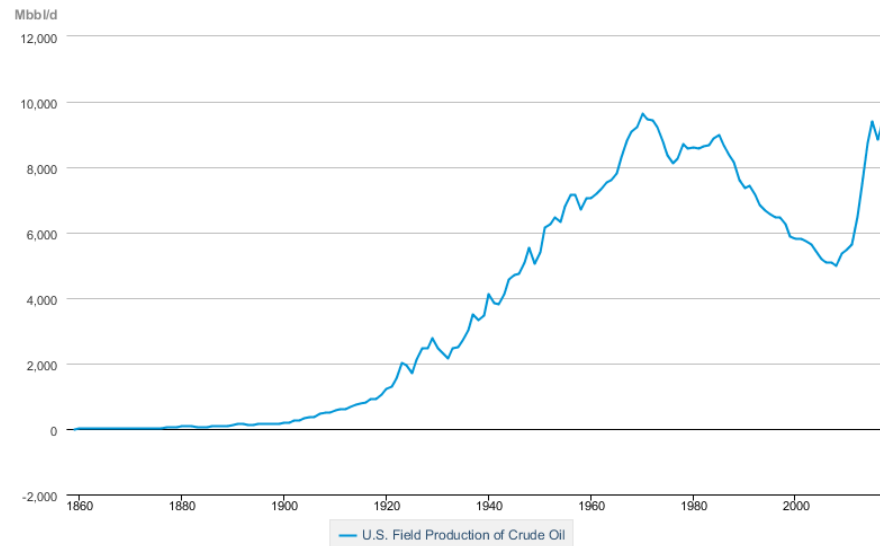
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US Total Oil Production

Crude Oil Production



 Source: U.S. Energy Information Administration

Production by state

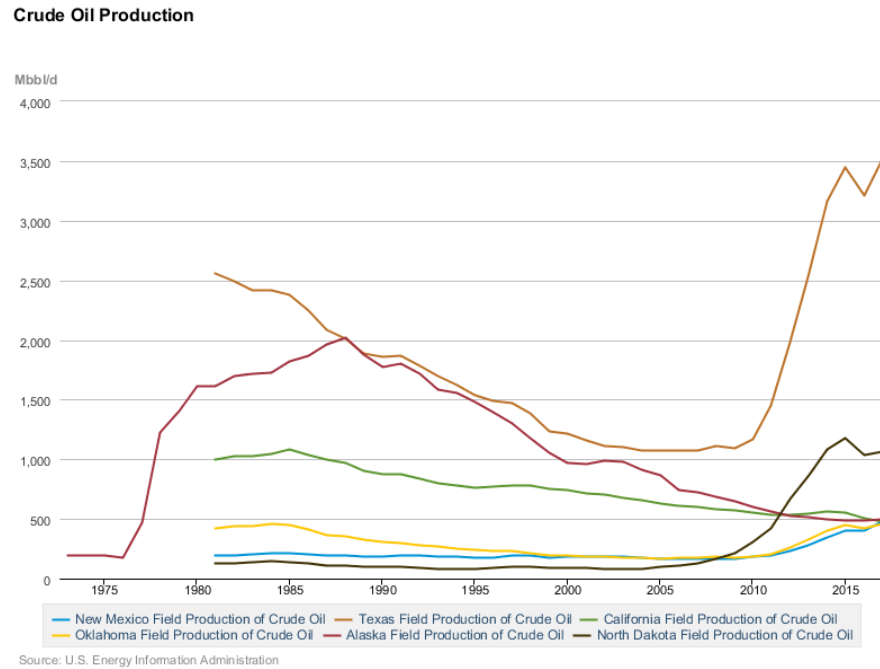
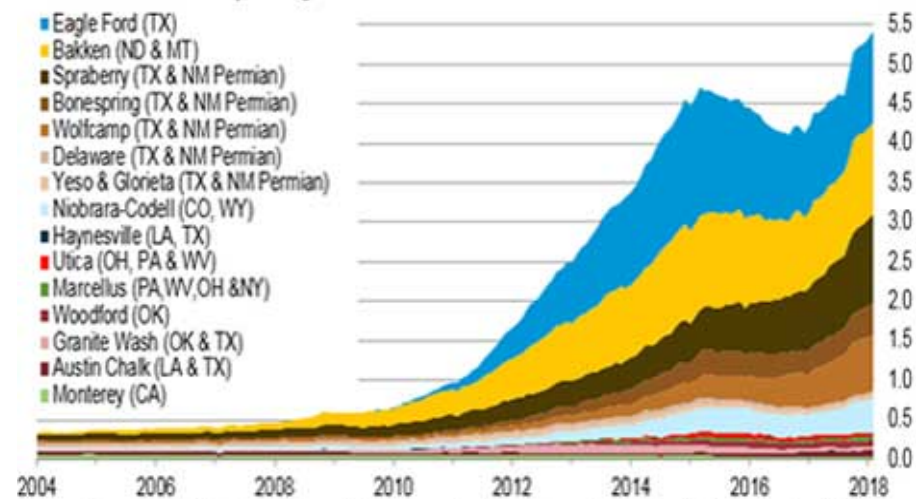


Image Source: EIA

Production by play

U.S. tight oil production—selected plays
million barrels of oil per day

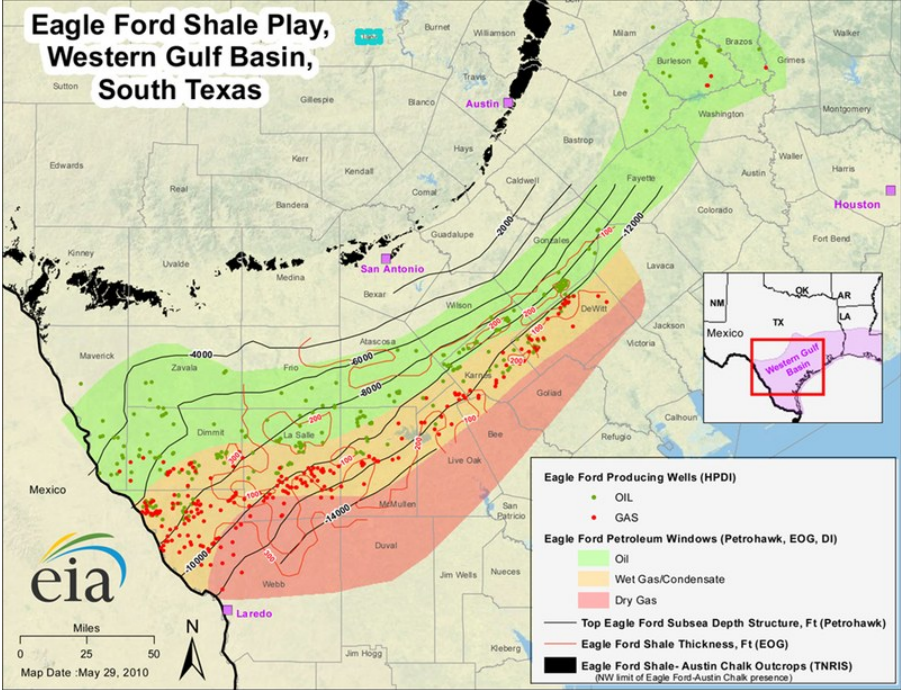


Sources: EIA derived from state administrative data collected by DrillingInfo Inc. Data are through February 2018 and represent EIA's official shale gas estimates, but are not survey data. State abbreviations indicate primary state(s).

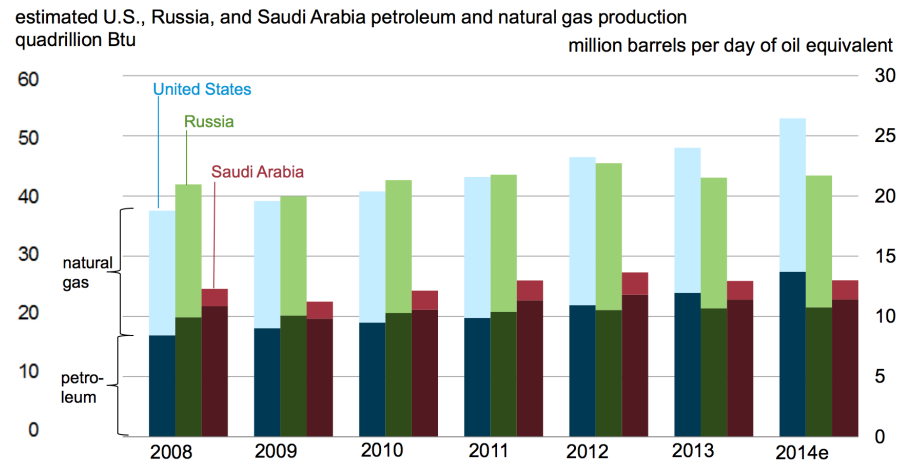


Source: EIA

Eagle-Ford Shale

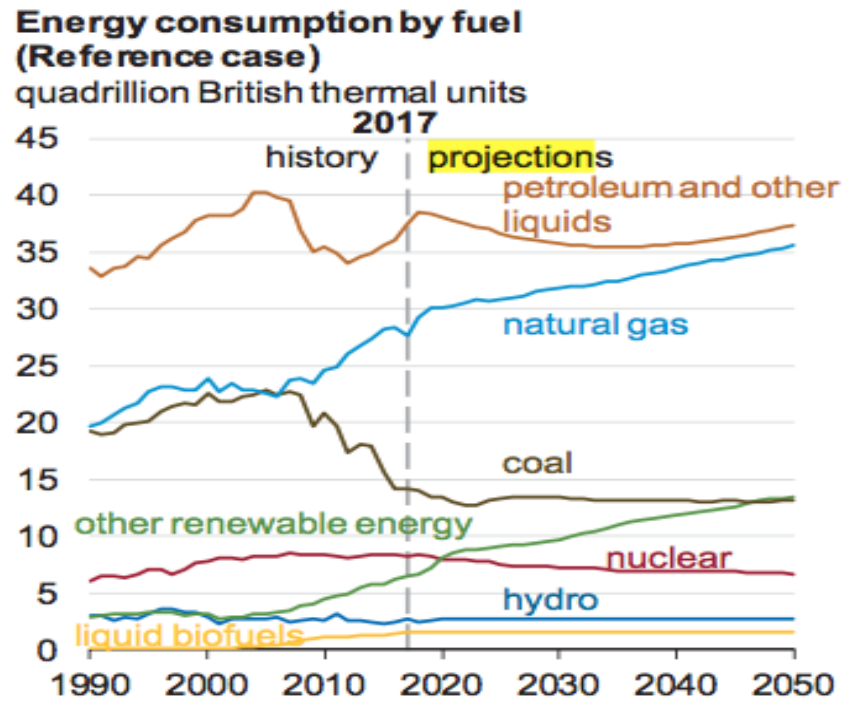


US, Russia, Saudi Arabia equivalent oil production



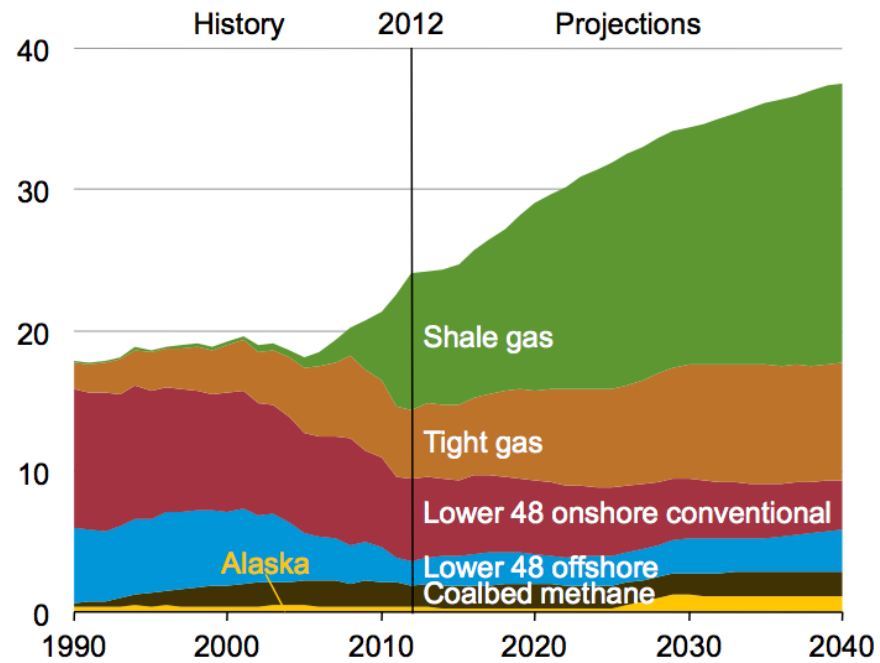
Source: EIA

Total energy use projection



Source: EIA

Natural gas by source

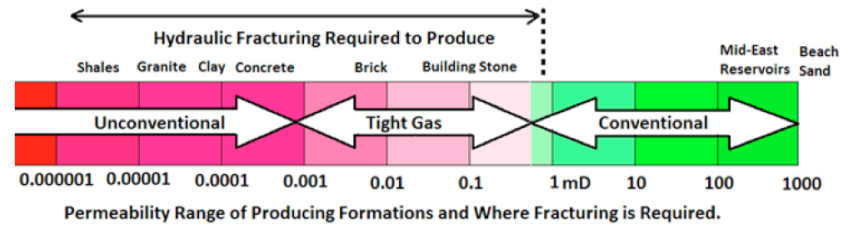


Source: EIA

Shale

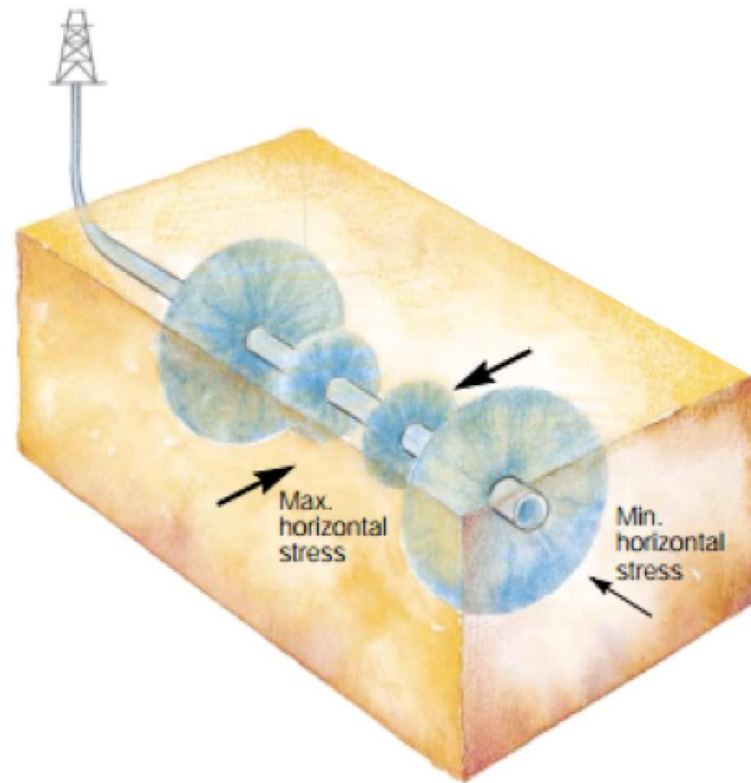


Source: Wikipedia <http://en.wikipedia.org/wiki/Shale>



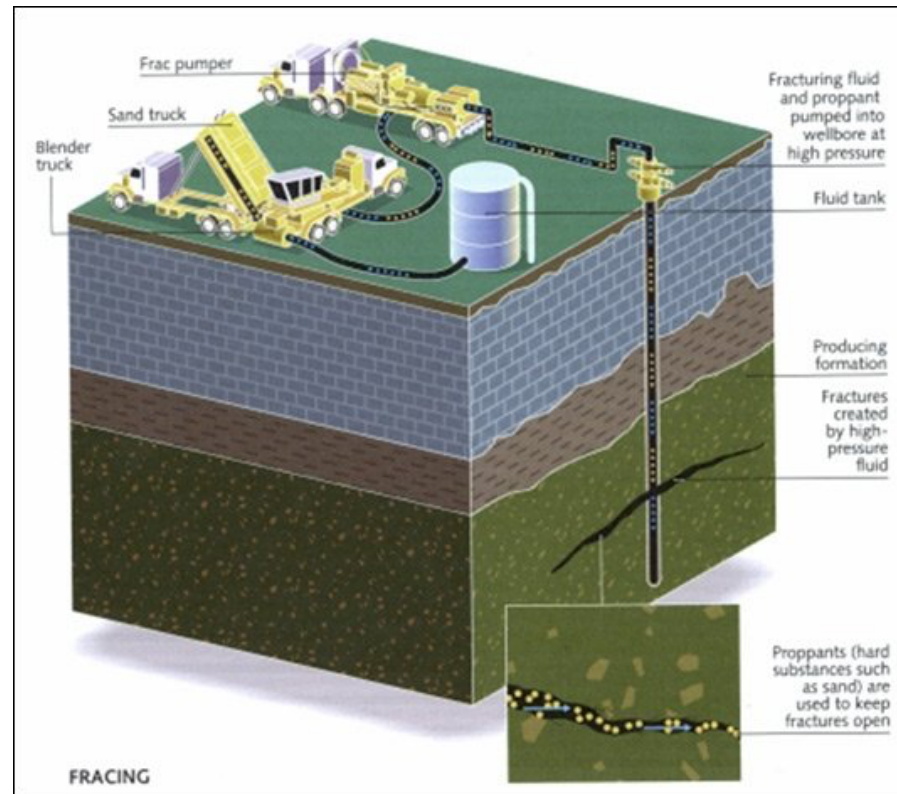
Source: George King, Hydraulic Fracturing 101

Hydraulic fracturing



Source: George King, Hydraulic Fracturing 101

Frac pump trucks



Source: Jon Olson

Barnett frac job in progress



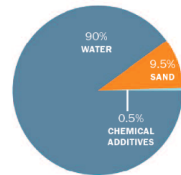
Source: Jon Olson

Is it safe?

- Groundwater contamination
- Earthquakes (induced seismicity)

Fracturing fluids

Typical Shale Fracturing Mixture Makeup



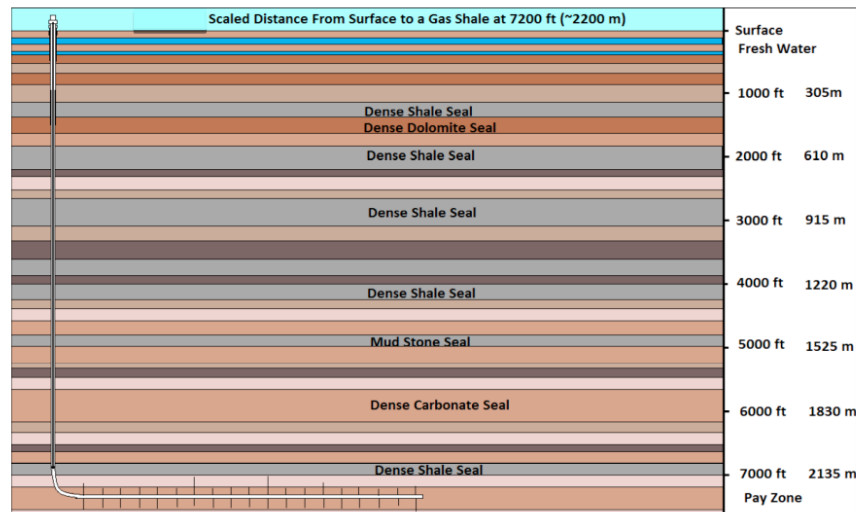
Chemical Disclosure Registry:
<http://fracfocus.org/>

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 |
| Polycrylamide | 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 |

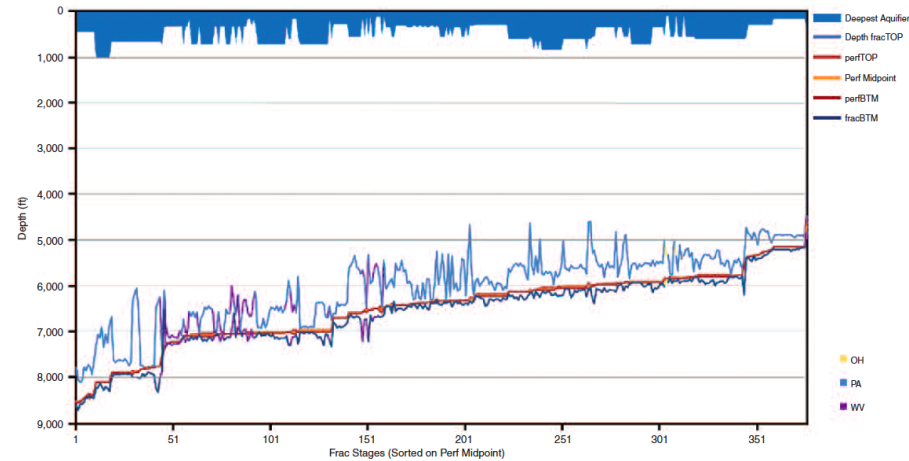
Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).

Groundwater separation



Source: George King, Hydraulic Fracturing 101

Marcellus mapped fracture treatments

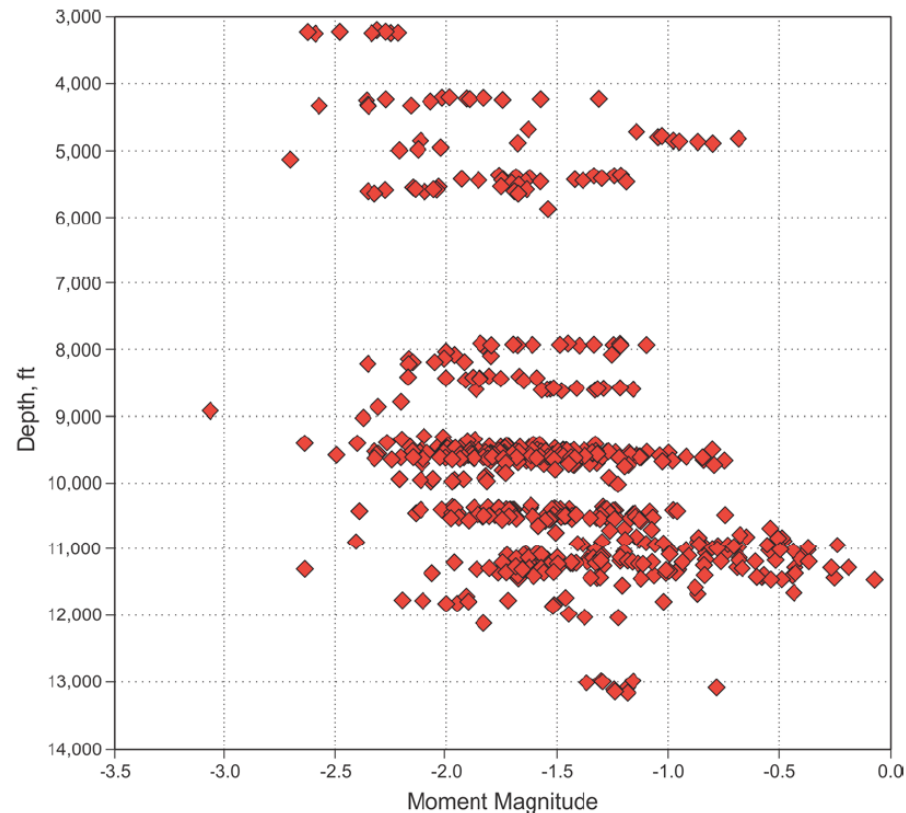


Source: Fisher, K. Data Confirm Safety of Well Fracturing. The American Oil and Gas Reporter. July 2010

Does hydraulic fracturing produce earthquakes?



Eagle-Ford moment magnitude



Source: Warpinski, N.R., Du, J. Zimmer, U. Measurements of Hydraulic-Fracture-Induced Seismicity in Gas Shales. SPE Conference on Hydraulic Fracturing Technology. SPE 151597. February 2012.