

# Shale Gas and Hydraulic Fracturing

Richard Davies

Durham University

[richard.davies@dur.ac.uk](mailto:richard.davies@dur.ac.uk)

# Professor Richard Davies

Professor of Energy

Director Durham Energy Institute

Durham University

UK

[richard.davies@dur.ac.uk](mailto:richard.davies@dur.ac.uk)

- 1995-2003 oil and gas Industry
- 2003-Present Academic in UK
- Published ~ 70 papers on petroleum geology
- 2007-2011 Lusi mud volcano from drilling (13,000 homes lost). Company claimed earthquake – we determined well blowout.
- Working on shale gas risks

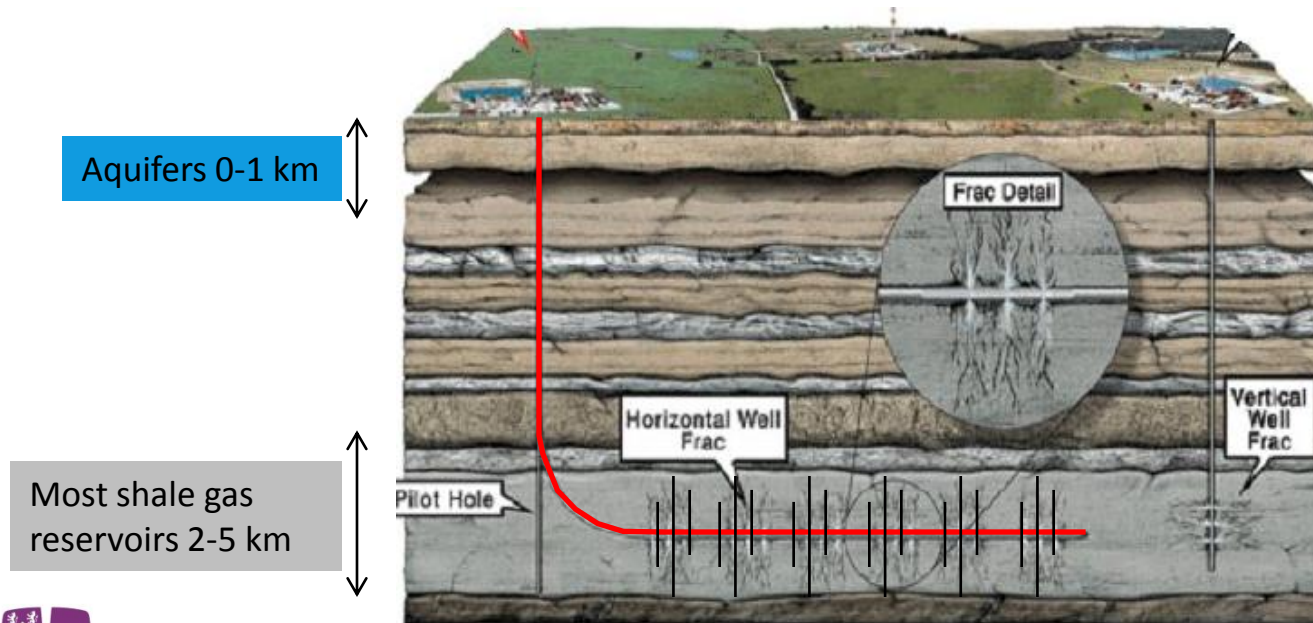


Durham University, UK



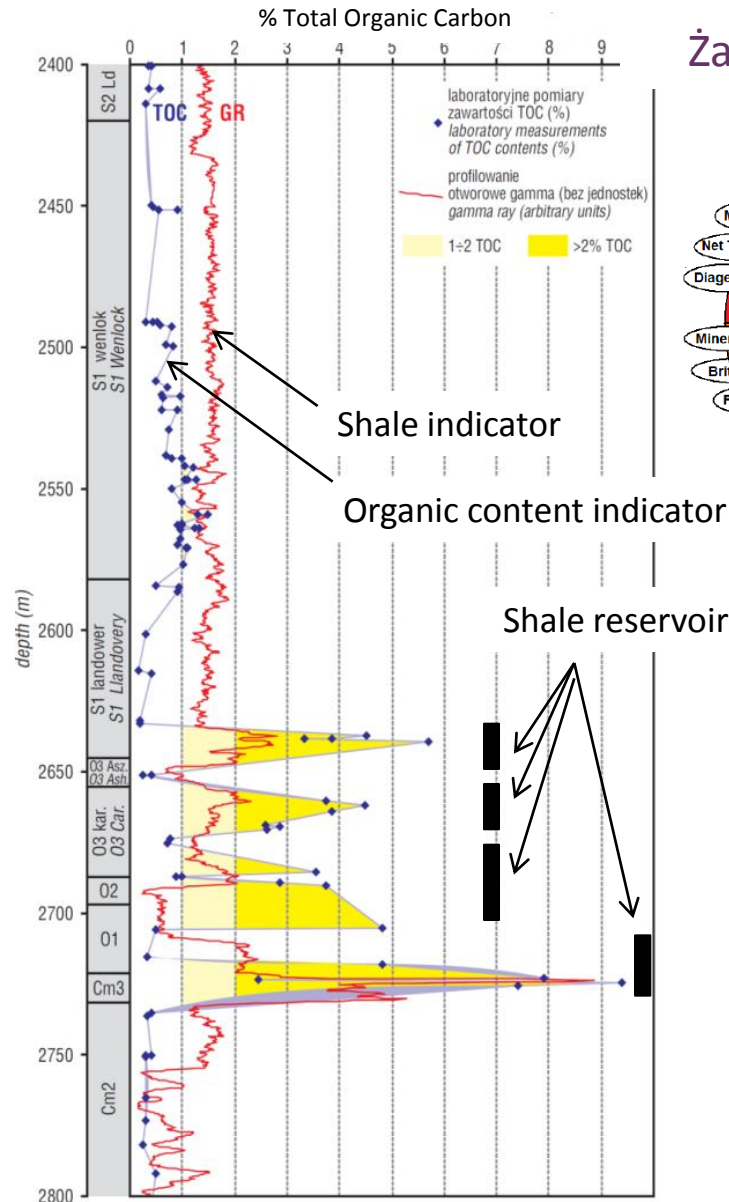
# Shale gas and 'fracking'

- Organic matter trapped during the deposition of fine-grained shale rocks.
- Low permeability
- Hydraulic fracturing since 1940, applied with horizontal wells from 1990 onwards (Barnett, Texas).
- Widespread use is new and therefore caution is appropriate
- **Issues of concern (a) contamination of drinking water (b) earthquakes (c) water use and waste water**

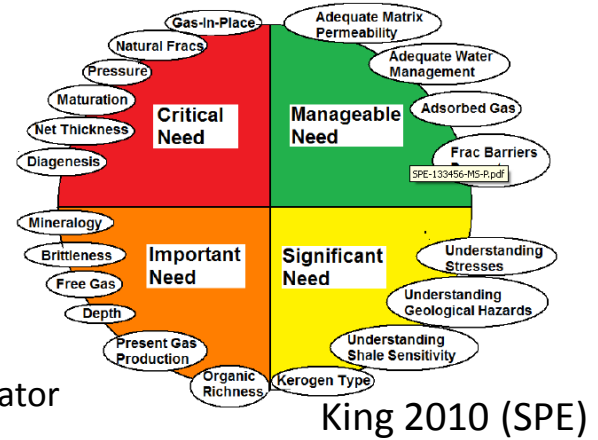


# Shale reservoir characteristics

- The properties of the rock determine whether it will be commercially viable
- There are many characteristics that need to be assessed by drilling exploration boreholes and testing the boreholes



## Żarnowiec IG-1 well Poland



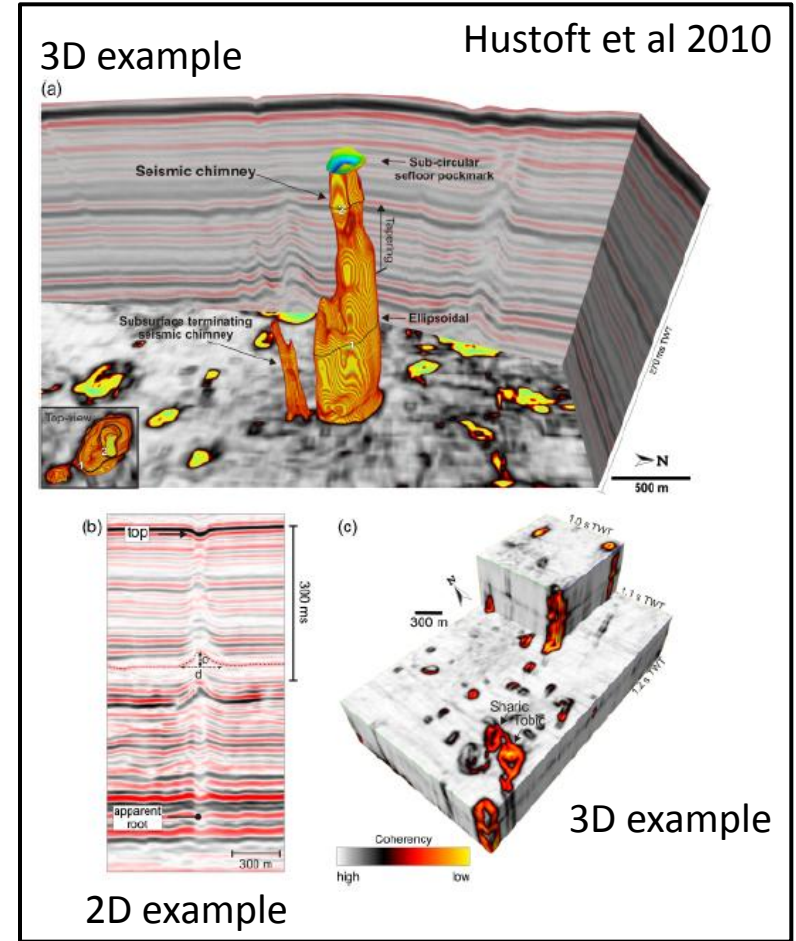
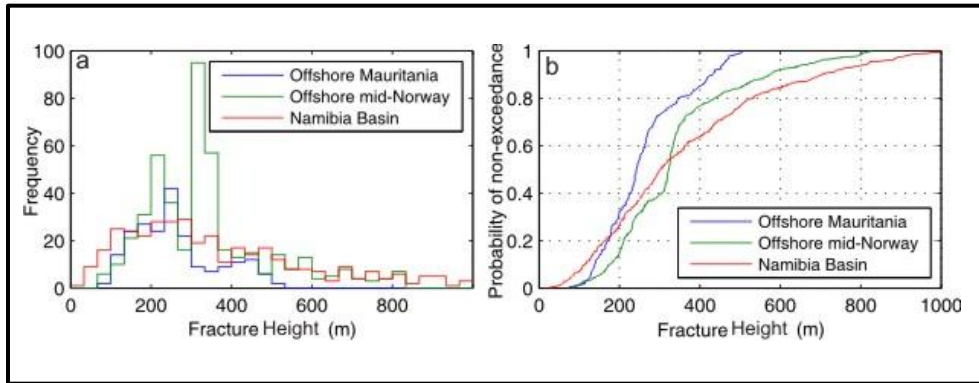
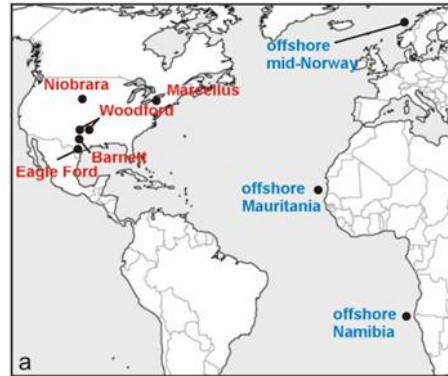
Core of Silurian shale, Poland

# Natural hydraulic fractures ('Pipes')

1170 measured from 3 regions and imaged with seismic data

Caused by naturally developed pressure.

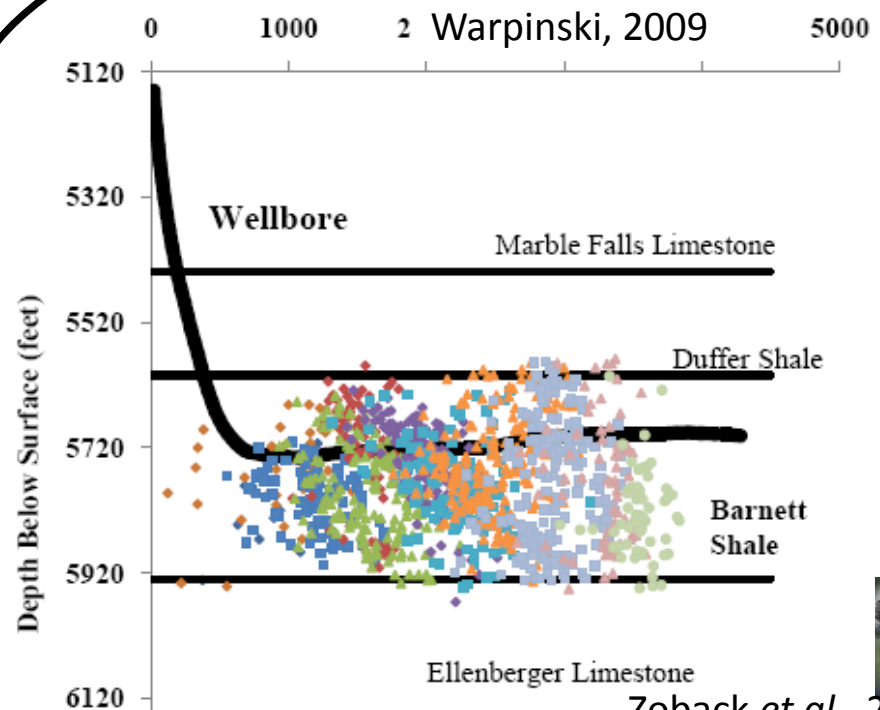
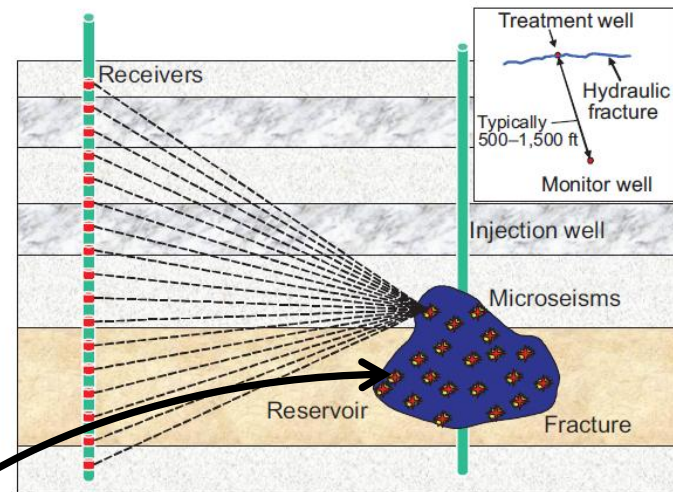
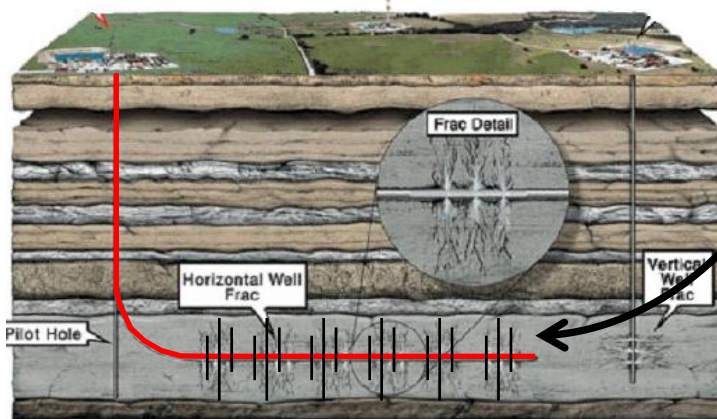
Probably consist of hydraulic fractures and allow migration of gases, oil and water



Davies, R.J., Mathias, S. A., Moss, J., Hustoft, S., and Newport, L., in press Hydraulic Fractures: How Far Can They Go? *Marine and Petroleum Geology*.

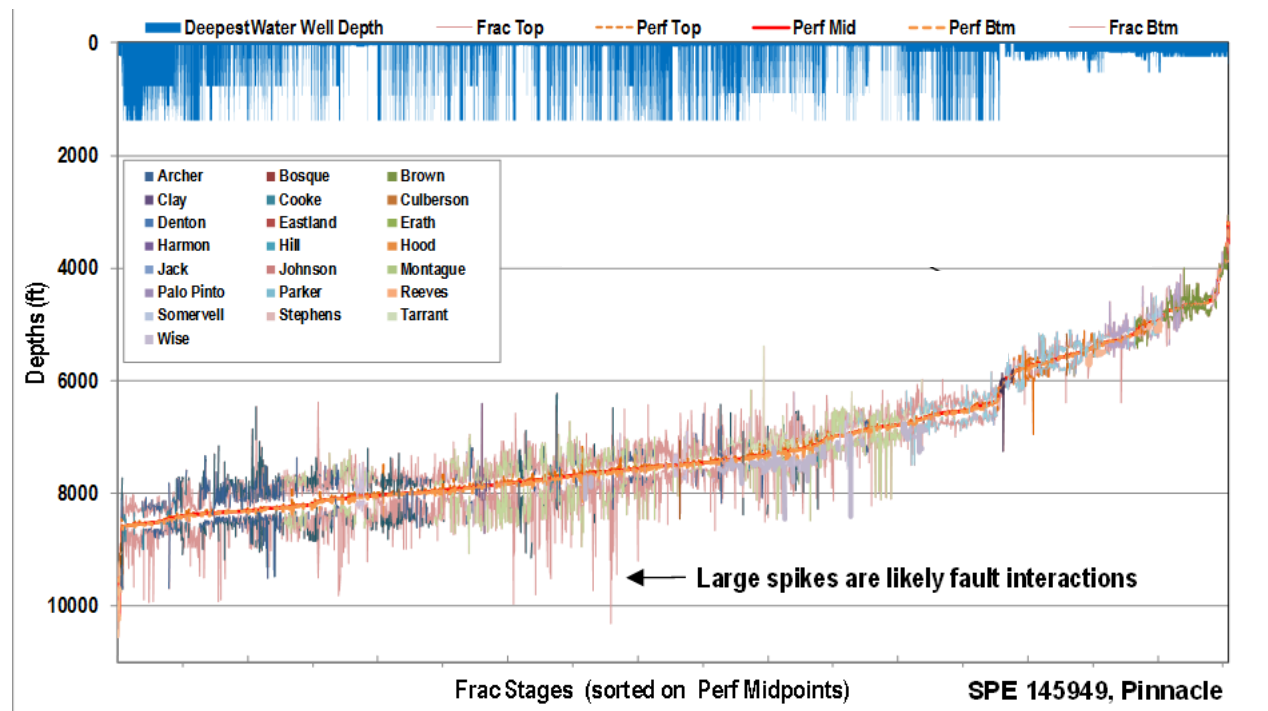
# Monitoring hydraulic fractures with micro-seismic

- As hydraulic fractures propagate, swarms of micro-earthquakes are generated locally.
- The 3D map of induced micro-seismic events can then be used to infer the spatial extent and location of the fracture network zone.



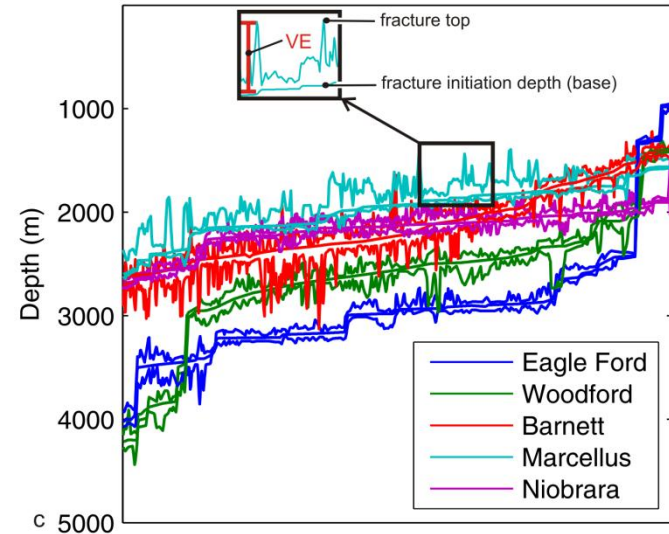
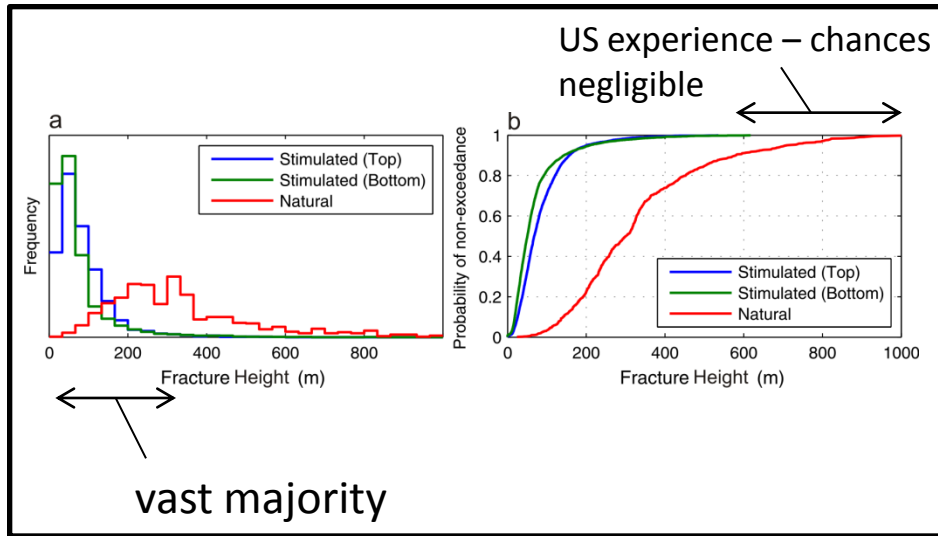
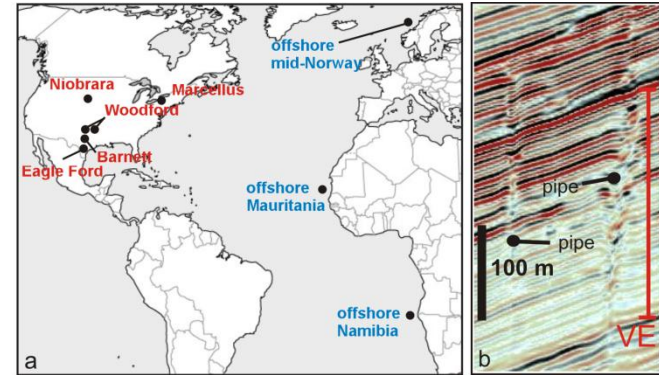
# Barnett shale (Texas) – data from Halliburton

- 1000s of hydraulic fracturing operations completed
- Done with slickwater (~ 98% water)
- Spikes on the graph are fractures that grew upwards and downwards
- Tallest spikes due to link with faults



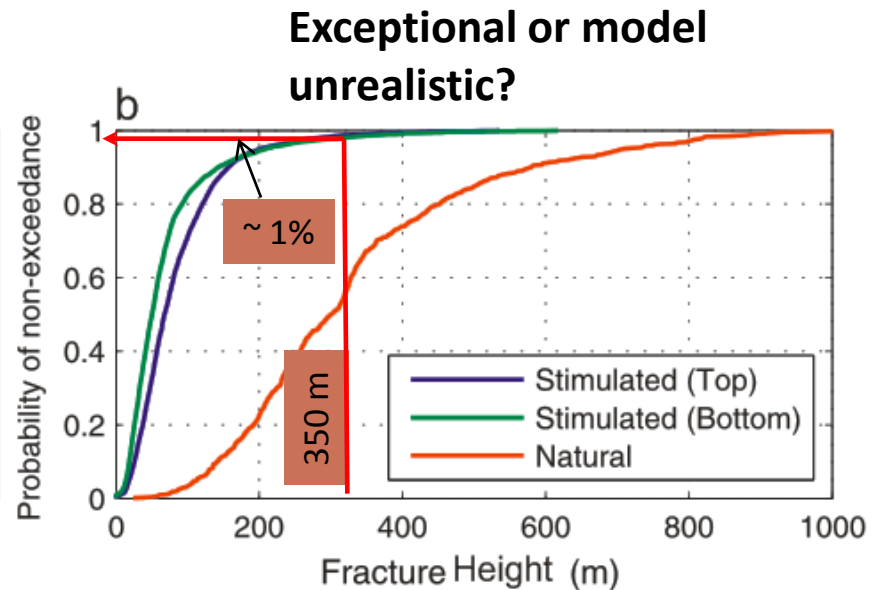
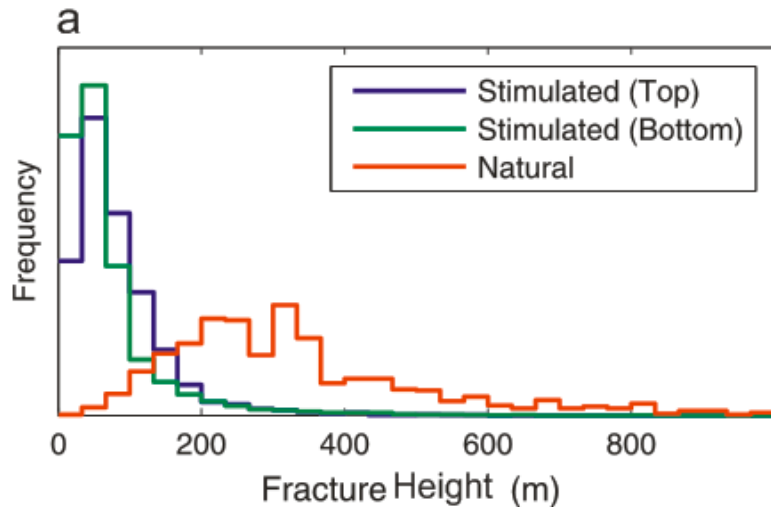
# Measuring vertical extent (VE)

- Digitised the graphs for 5 shale gas provinces in the USA. 4 in public domain, 1 unpublished from Halliburton
- Produced frequency vs height graphs
- Produced probability vs height graphs





# Summary : how far can they go?



Exceptional or model unrealistic?

- 1000s of stimulated hydraulic fractures
- 1170 natural hydraulic fractures
- **Chances of stimulated hydraulic fracture extending > 350 m is ~ 1%.**

Davies, R.J., Mathias, S. A., Moss, J., Hustoft, S., and Newport, L., in press Hydraulic Fractures: How Far Can They Go? *Marine and Petroleum Geology*.

# Shale Gas - Safe Vertical Separation Distance

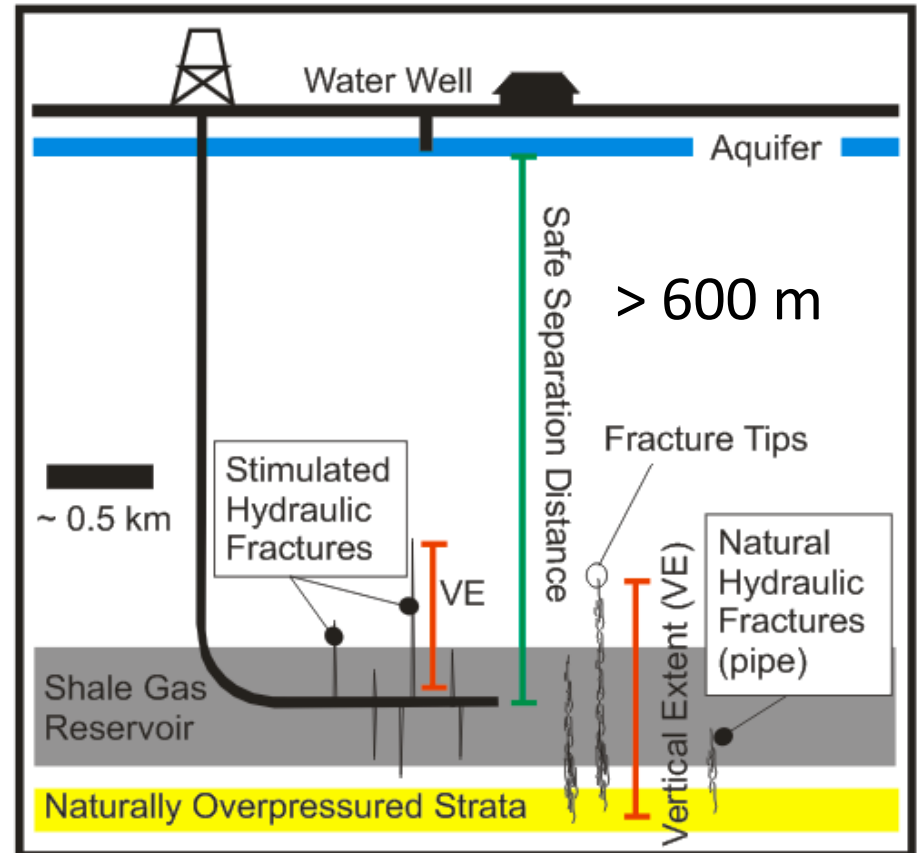
Maximum reported height of an upward propagating hydraulic fracture from USA is ~ 588 m.

Of the 1170 natural hydraulic fracture networks offshore of West Africa and mid-Norway it is ~ 1106 m.

Based on these data, probability of stimulated fracture extending vertically > 350 m is ~ 1%.

But data comes from Paleozoic of USA. All rocks different and different stress regime.

**Recommendation more data collection. For new areas safe separation > 0.6 km**



# Key initial areas of study

- **Fracture height**
  - ✓ Probabilistic assessment completed. Keep building database – 1<sup>ST</sup> STAGE COMPLETED
- **Natural contaminants of groundwater**
  - ✓ Literature search and analysis to get regional baseline
- **Exceptional seismicity**
  - ✓ Why do we get exceptional seismicity due to hydraulic fracturing (Eola Field, USA and Lancashire, UK)?
  - ✓ Is it important?
  - ✓ What geological conditions?
  - ✓ How can it be mitigated?
- **Long term fate of fracking fluid**
  - ✓ Percentage that reacts
  - ✓ Infiltrates matrix
  - ✓ Resides in permeable formations
- **Subsidence**
  - ✓ Model the magnitude of land subsidence
  - ✓ InSAR and LiDAR to detect subsidence
- **Flowback water disposal in Europe**
  - ✓ For cleaning – composition of residual sludge (e.g. radionuclides)

