Shale gas

Ferian Anggara

Outline

- Introduction
- Shale gas resources
- Shale definition and storage mechanism
- Reservoir management overview
- Hydraulic fracturing
- Case studies

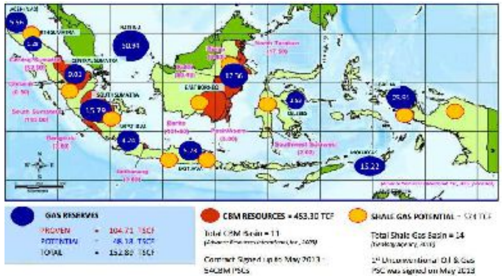
Permen ESDM No. 5 Tahun 2012

- Pasal 1

Dalam Peraturan Menteri ini yang dimaksud dengan:

1. Minyak dan Gas Bumi Non Konvensional yang selanjutnya disebut Migas Non Konvensional adalah Minyak dan Gas Bumi yang diusahakan dari reservoir tempat terbentuknya Minyak dan Gas Bumi dengan **permeabilitas rendah (*low permeability*)** antara lain *Shale oil, Shale Gas, Tight Sand Gas*, Gas Metana Batubara, dan *Methane-Hydrate* dengan teknologi tertentu seperti *fracturing*.

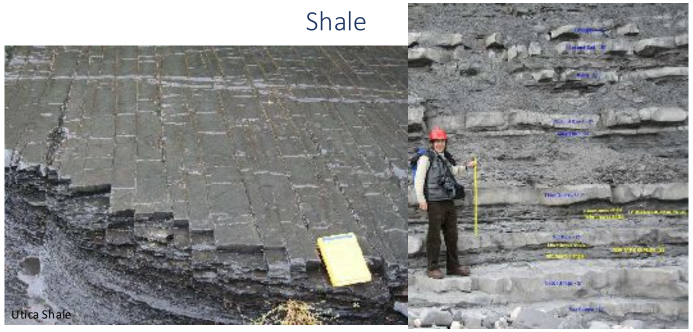
Natural Gas Reserves, CBM and Shale Gas Resources



Estimates of technically recoverable shale gas resources (tcf)

EIA 2011

Shale

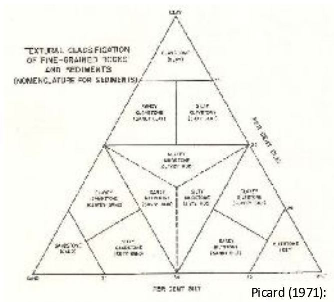


Shale

- Tourtelot (1960): a general term for describing 'laminated clayey rock'
- Twenhofel (1937): a mudstone term is used as general term to include all fine grained detrital rocks, whereas shale was specifically an indurated, fissile, non-methamorphosed, mud.
- Picard (1971):
  - Shale: Structural expression and not depend upon grain size
  - Mudstone: fine grained rock and non-fissile (Wenworth, 1922; Twenhofel, 1937; Shrock, 1948; Ingram, 1953; Dunbar and Rodgers, 1957).

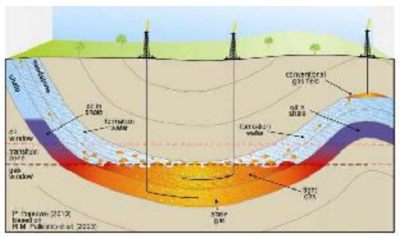
Unindurated	Indurated	After Incipient Metamorphism
	Mudstone	
Silt	Siltstone	Argillite
Mud	Shale (fissile)	
Clay	Claystone	

Twenhofel, 1937

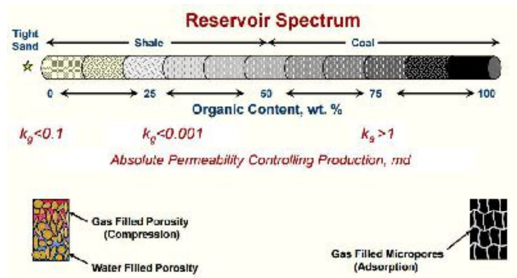


Picard (1971):

Oil and gas formation

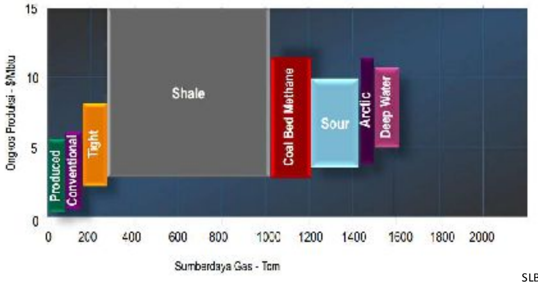


Geni, 2010



Chad, Shale Gas Core Analyses Required for Gas Reserves Estimates

Production cost



SLB Analysis, 2014

Shale gas storage mechanisms

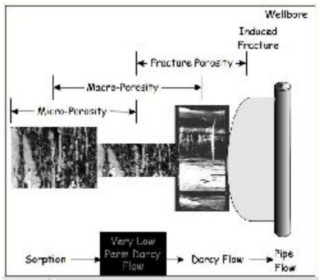
- Adsorption in small pore spaces
- Compression in larger pore spaces
- Solution in water and/or liquid hydrocarbons in larger pore spaces

Triple porosity gas storage

- **Micro- (<2 nm) and Meso-Porosity (< 50 nm)**
  - Gas Storage by *Adsorption*
  - Mass Transfer by Diffusion
- **Macro-Porosity**
  - Gas Storage by *Solution and Compression*
  - Mass Transfer by Diffusion and Darcy Flow
- **Secondary Porosity (Natural Fractures)**
  - Gas Storage by *Solution and Compression*
  - Mass Transfer by Darcy Flow

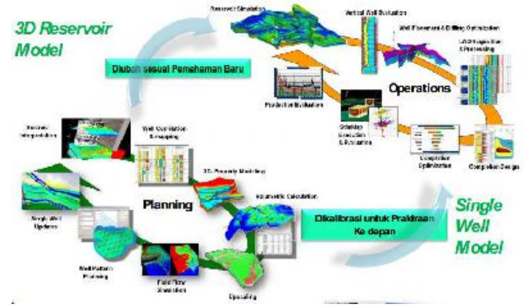
Chad, Shale Gas Core Analyses Required for Gas Reserves Estimates

Shale flow schematic

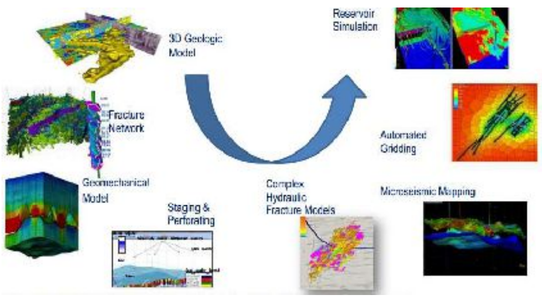


Successful unconventional gas development

SLB Analysis, 2014



SLB Analysis, 2014



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Evaluate	Drill	Complete	Produce
More Knowledge Less Uncertainty	**More Pay Zone Less Rig Time**	**More Reservoir Contact Less Impact**	**More Recovery Less Waste**
- Advanced basin modeling - Integrate core/log/seismic - Seismic sweet spots - Reservoir Quality - Completion Quality	- Longer laterals, faster - Wellbore placement - Integrated BHA/mud - RT fluid analysis - Cuttings and mud logs	- Engineered fracture design - Efficient stim hardware - Green chemistry - Reduce water/proppant - Well integrity	- Manage flowback water - Coiled tubing interventions - Zonal contribution - Optimize pressure / rate - Maximize recovery

SLB Analysis, 2014

Social risks

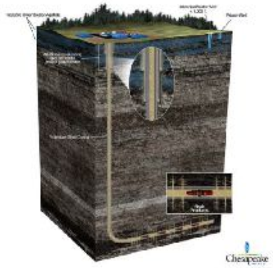
- Air tanah
- Kegiatan Seismik
- Jumlah sumur yang harus dibor
- Gangguan dari operasi
- Intensitas aktivitas operasi
- Banyaknya truk yang lalulalang
- Kebutuhan air dan sumberdaya lain
- Kebisingan

SLB Analysis, 2014

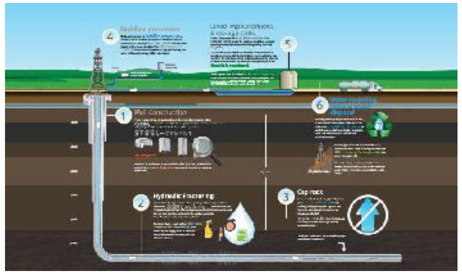
SLB Analysis, 2014

Hydraulic fracturing

- Video

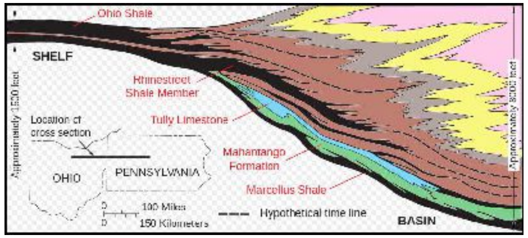


Shale gas production scheme



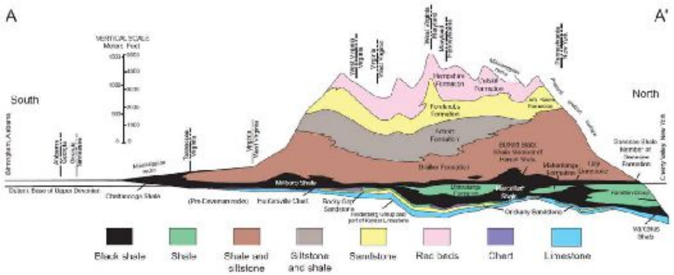
www.api.org/hydraulicfracturing

Marcellus shale



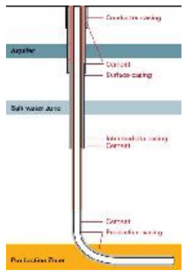
Boughton and McCoy, 2006

Marcellus shale

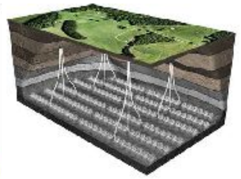


Boughton and McCoy, 2006

Shale gas well design



NETL, 2013

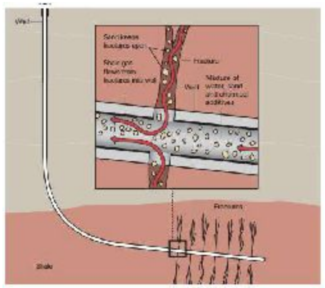


Hydraulic fracturing operations

NETL, 2013

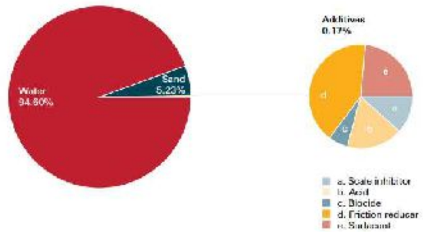
An illustration of hydraulic fracturing

- Fracturing fluids are injected under pressure to stimulate fractures in the shale.
- The fractures are propped open by sand contained in the fracturing fluid so that shale gas can flow out of the shale into the well.



The Royal Society and The Royal Academy of Engineering, 2012

Typical composition of fracturing fluid

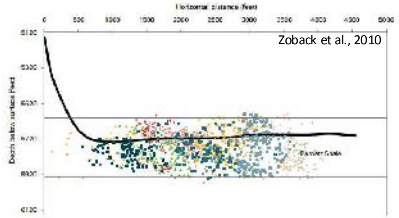


The Royal Society and The Royal Academy of Engineering, 2012

www.api.org/hydraulicfracturing, 2014

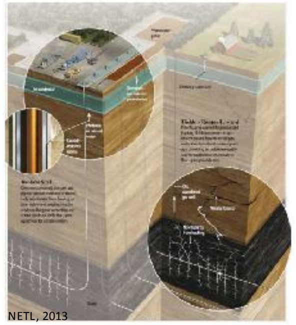
Microseismic monitoring of a typical hydraulic fracturing operation

Barnett Shale, Texas, USA



A displays a horizontal view of microseismic events along the horizontal well. The thick black line represents the horizontal well. Each dot represents a separate microseismic event. Each colour represents a distinct fracturing event.

The Royal Society and The Royal Academy of Engineering, 2012

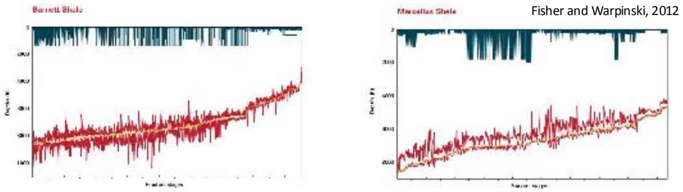


NETL, 2013

Possible pathways for subsurface migration of fracturing fluid/HC

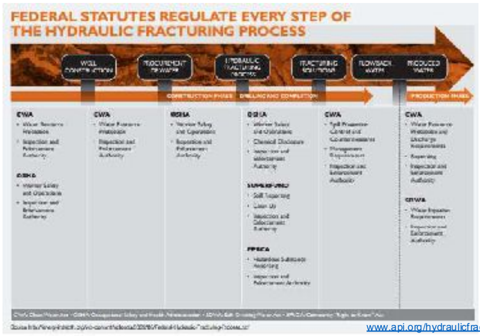
Comparisons of fracture growth and depth of overlying water sources

Fisher and Warpinski, 2012



Figures illustrate fracture height for fracture treatments performed in US shale formation between 2001 and 2010. The depth of each fracture treatment is illustrated by the yellow line and sorted by depth. The red spikes represent the extent of upward and downward fracture growth. The dark blue bars at the top of each figure illustrate the depth of overlying water sources.

The Royal Society and The Royal Academy of Engineering, 2012



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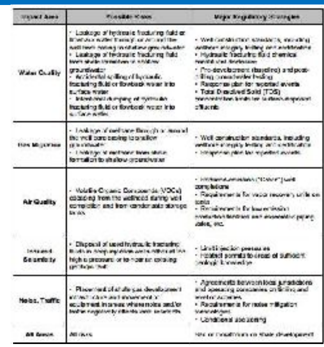
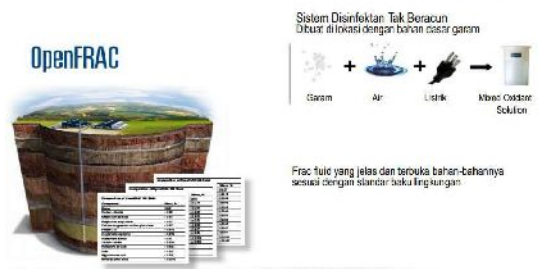
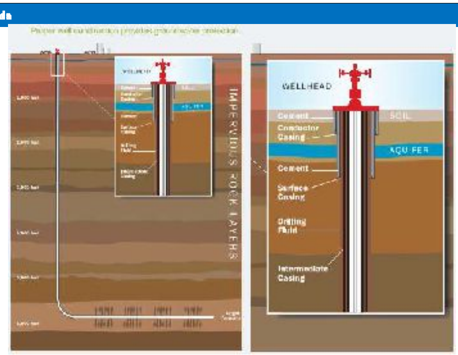


NETL, 2013



SLB Analysis, 2014



www.api.org/hydraulicfracturing

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Well-pad and pad production processing equipment

NETL, 2013

Gas processing facility

NETL, 2013

End