

## Shale gas

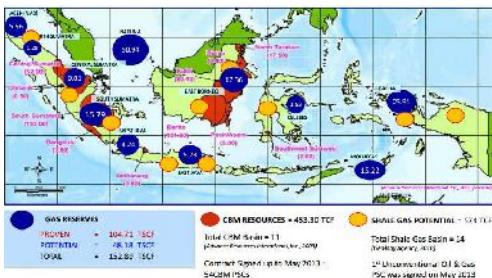
Ferian Anggaran



*Shale gas* 1

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

## Outline



Management Reserv

*Shale gas- 4*



Shade gas- 2

Permen ESDM No. 5 Tahun 2012

- Pasal

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 tertutu seperti fracturing.



Management Reserves

Shale gas- 6

Shale

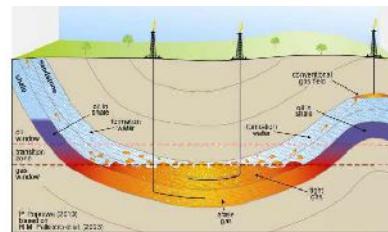
- Tourtelot (1960): a general term for describing 'laminated clayey rock'
  - Twenhofel (1937): a mudstone term is used as general term to include all fine grained detrital rocks, whereas shale was specifically an indurated, fissile, non-metamorphosed, mud.
  - Picard (1971):
    - Shale: structural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

Unindurated	Indurated	After Incipient Metamorphism
	Mudstone	
Sh.	Siltstone	
Bed.	Shale (fusile)	Argillite
Fls.	Chlorite	

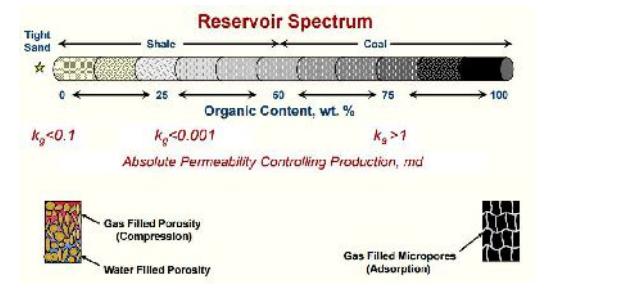
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## Oil and gas formation



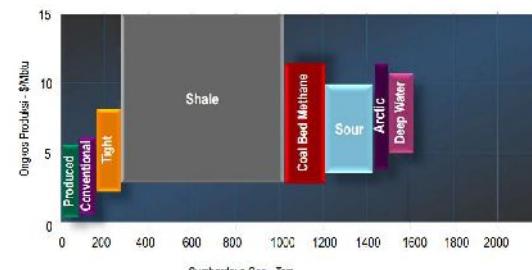
Geni, 201



100

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## Production cost



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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

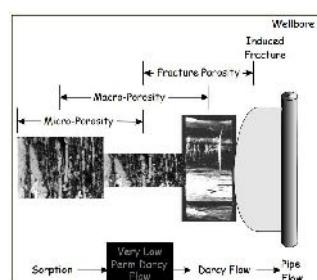
## Triple porosity gas storage

- ❖ **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 gas 12

## Shale flow schematic



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Shale gas 13

## Successful unconventional gas development



SLB Analysis, 2014

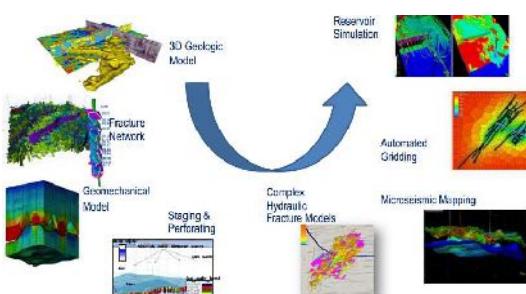
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## 3D Reservoir Model



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SLB Analysis, 2014

Evaluate	Drill	Complete	Produce
<b>More Knowledge Less Uncertainty</b>	<b>More Pay Zone Less Rig Time</b>	<b>More Reservoir Contact Less Impact</b>	<b>More Recovery Less Waste</b>
<ul style="list-style-type: none"> <li>- Advanced basin modeling</li> <li>- Integrate geophysical seismic</li> <li>- Seismic survey spots</li> <li>- Reservoir Quality</li> <li>- Completion Quality</li> </ul>	<ul style="list-style-type: none"> <li>- Longer lateral, faster</li> <li>- Wellbore placement</li> <li>- Integrated 3D/4D</li> <li>- RT fluid analysis</li> <li>- Cuttings and mud logs</li> </ul>	<ul style="list-style-type: none"> <li>- Engineered fracture design</li> <li>- Efficient slurry hardware</li> <li>- Green chemistry</li> <li>- Reduce water/proppant</li> <li>- Well Integrity</li> </ul>	<ul style="list-style-type: none"> <li>- Manage flowback water</li> <li>- Cyclic tubing interventions</li> <li>- Zonal contribution</li> <li>- Optimize pressure / rate</li> <li>- Maximize recovery</li> </ul>

SLB Analysis, 2014

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## Social risks

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



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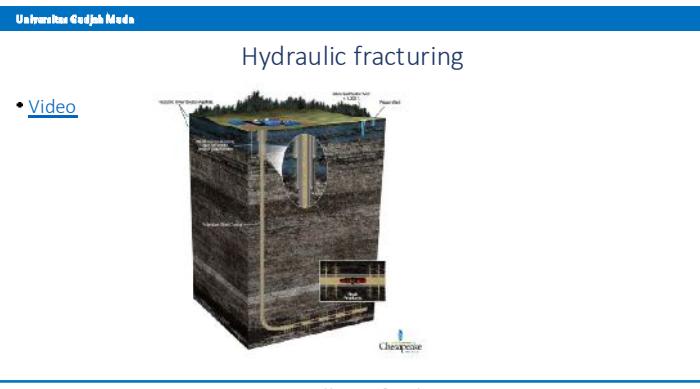
Management Reservoir



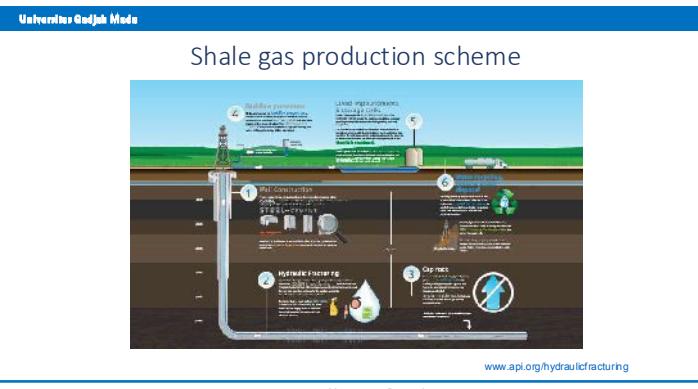
SLB Analysis, 201



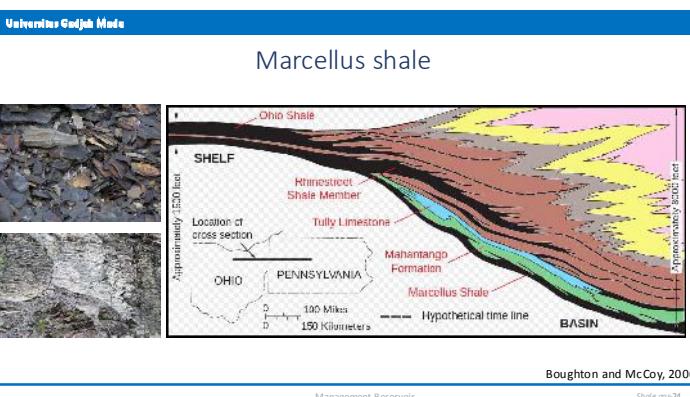
SLB Analysis, 201



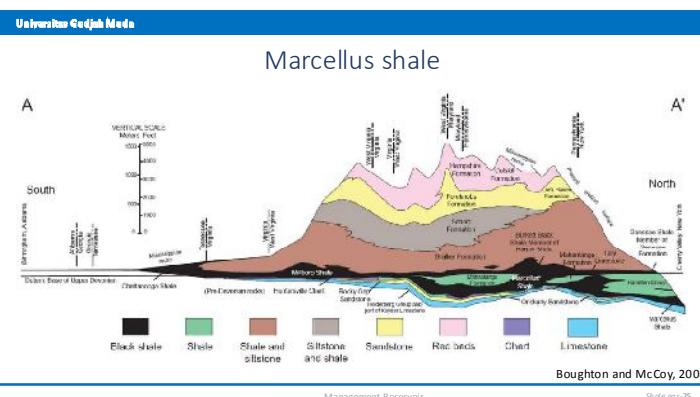
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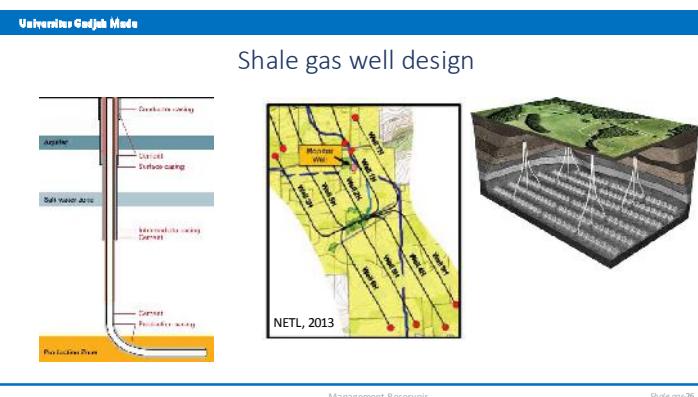
[www.api.org/hydraulicfracturing](http://www.api.org/hydraulicfracturing)



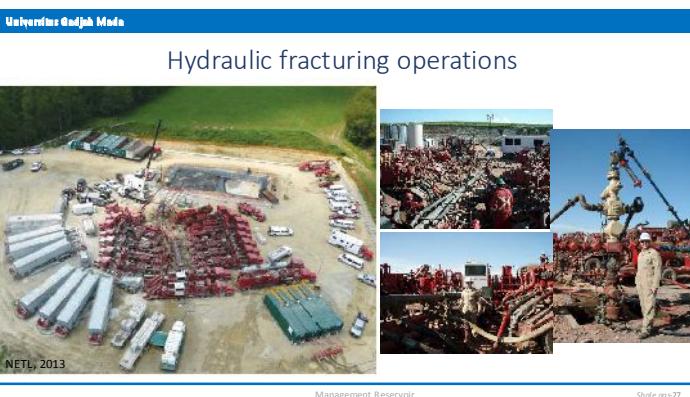
Management Resources  
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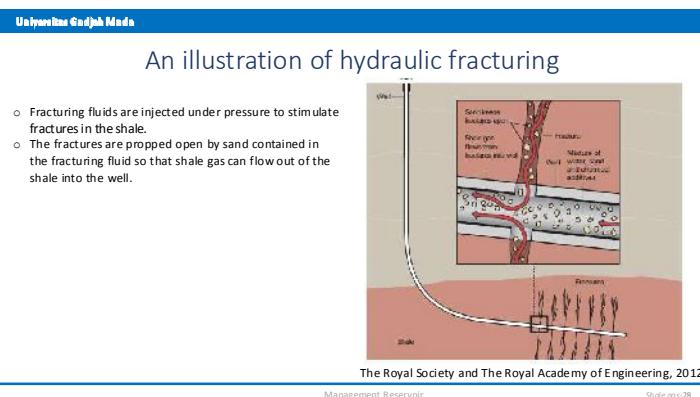
Management Reservoirs Slide one-25



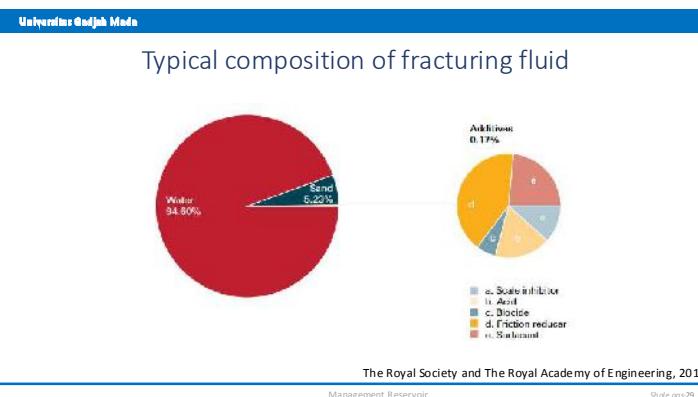
Management Resources  
Shabir et al. 2016



Management Reservoir Shale gas 27



Management Reservoir Shale gas-28



Management Reservoir

The fracturing mixture consists primarily of high water mixed with some sand and a small proportion of common chemicals.

0.5% CHEMICAL ADDITIVES		
<b>90% WATER</b>		<b>9.5% SAND</b>
Spill salt		Laundry detergent
Thread or resinous		Dr. Salt
		Sand by weight per volume used
		Seal additive
		Emulsion

[www.api.org/hydraulicfracturing\\_2014](http://www.api.org/hydraulicfracturing_2014)

Possible pathways for subsurface migration of fracturing fluid/HC

NETL, 2013

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, 2011

Management Reservoir

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**FEDERAL STATUTES REGULATE EVERY STEP OF THE HYDRAULIC FRACTURING PROCESS**

PHASE	REGULATIONS
WELLSITE PREPARATION	EISA • Water Resources Protection • Importation and Exportation Authority
TRANSPORTATION	GWA • Clean Air Act • Resource Conservation and Recovery Act Authority
CONSTRUCTION PHASES	BISHA • National Oil and Gas Well Construction Rule • Resource Conservation and Recovery Act Authority
FRACKING	OSHA • Worker Protection • Fracturing • Resource Conservation and Recovery Act Authority
FLOWBACK / WATER MANAGEMENT	CWA • Water Pollution Prevention and Control • Resource Conservation and Recovery Act Authority
PRODUCTION	CWA • Water Pollution Prevention and Control • Resource Conservation and Recovery Act Authority  GWIA • Water Pollution Prevention and Control • Resource Conservation and Recovery Act Authority

Source: U.S. Environmental Protection Agency, "Hydraulic Fracturing and the Safe Use of Water," available at [www2.epa.gov/hfstudy/safewater.html](http://www2.epa.gov/hfstudy/safewater.html).

[www.apl.org/hydraulicfracturing](http://www.apl.org/hydraulicfracturing)

Impact Area	Possible Risks	Major Resiliency Strategies
Water Quality	<ul style="list-style-type: none"> <li>Lossage of Potable drinking water due to damage to pipes or valves, which will result in water loss and water quality reduction.</li> <li>Lossage of Potable drinking water due to damage to pipes or valves, which will result in water loss and water quality reduction.</li> </ul>	<ul style="list-style-type: none"> <li>Water distribution system, including water tanks, piping, valves and pumping stations, must be designed to withstand flooding.</li> <li>Proven design standards and practices must be followed.</li> <li>Resilient water storage systems must be developed to withstand flooding.</li> </ul>
Power Generation	<ul style="list-style-type: none"> <li>Failure of power plants caused by flooding, which will result in power outages.</li> <li>Failure of power lines caused by flooding, which will result in power outages.</li> </ul>	<ul style="list-style-type: none"> <li>Water distribution system, including water tanks, piping, valves and pumping stations, must be designed to withstand flooding.</li> <li>Proven design standards and practices must be followed.</li> <li>Resilient power generation systems must be developed to withstand flooding.</li> </ul>
Air Quality	<ul style="list-style-type: none"> <li>Health Effects: Decrease in VOC levels due to flooding, which will result in health effects.</li> <li>Indirect air pollution due to flooding, which will result in health effects.</li> </ul>	<ul style="list-style-type: none"> <li>Proven design standards and practices must be followed.</li> <li>Resilient air quality recovery systems must be developed to withstand flooding.</li> <li>Proven design standards and practices must be followed.</li> </ul>
Animal Safety	<ul style="list-style-type: none"> <li>Death of animals due to flooding, which will result in significant economic impact.</li> <li>Habitat loss due to flooding, which will result in significant economic impact.</li> </ul>	<ul style="list-style-type: none"> <li>Use of proven design standards and practices must be followed.</li> <li>Resilient animal habitats must be developed to withstand flooding.</li> </ul>
Road, Traffic	<ul style="list-style-type: none"> <li>Reopen road of all the lost development areas due to flooding, which will result in significant economic impact.</li> <li>Reopen road of all the lost development areas due to flooding, which will result in significant economic impact.</li> </ul>	<ul style="list-style-type: none"> <li>Proven design standards and practices must be followed.</li> <li>Resilient infrastructure must be developed to withstand flooding.</li> <li>Resilient traffic management systems must be developed to withstand flooding.</li> <li>Proven design standards and practices must be followed.</li> </ul>
All Areas	All risks	<ul style="list-style-type: none"> <li>No risk conditions can be developed.</li> </ul>

**OpenFRAC**

Sistem Disinfektor Tak Beracun  
Dibuat di lokasi dengan bahan-cara garam

Garam + Air + Listrik → Klorin Oksider Solution

Frac fluid yang jelas dan teruak bahan-behaninya  
sesuai dengan standar buku lingkungan

Properti	Properti	Properti	Properti
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997	998	999	1000

Well-pad and pad production processing equipment



A



B

NETL, 2013

Management Reservoir

Shale gas-39

Gas processing facility



NETL, 2013

Management Reservoir

Shale gas-40

End

Management Reservoir

Shale gas-41