Shale Oil

PRESENTED BY: ENPPI PROCESS TEAM

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Oil Shale

What is Oil Shale?

Rock
Kerogen
(Oil Shale)

Pyrolysis

- Naphtha
- Jet Fuel
- Diesel
- Nat. Gas
- Hydrogen

Upgrade

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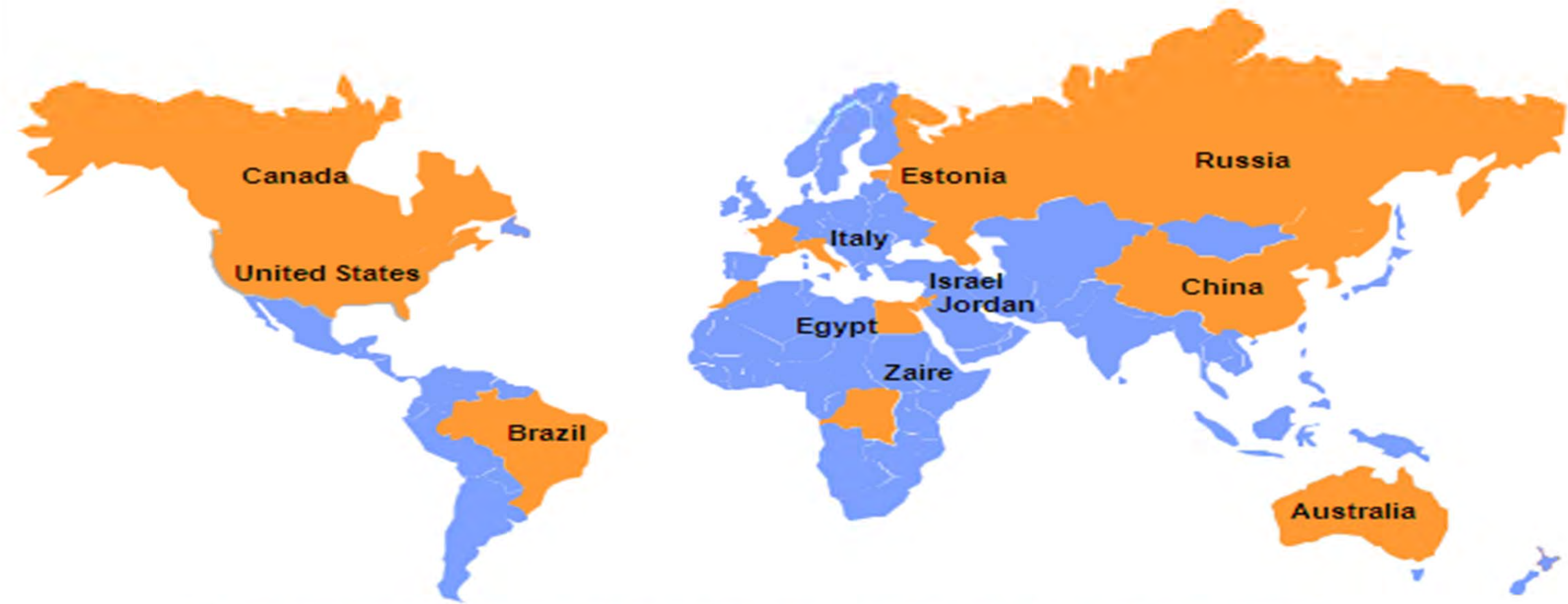
Definition

- **Oil shale**, also known as Rock kerogen, is an organic-rich fine-grained rock from which liquid hydrocarbons called shale oil can be recovered

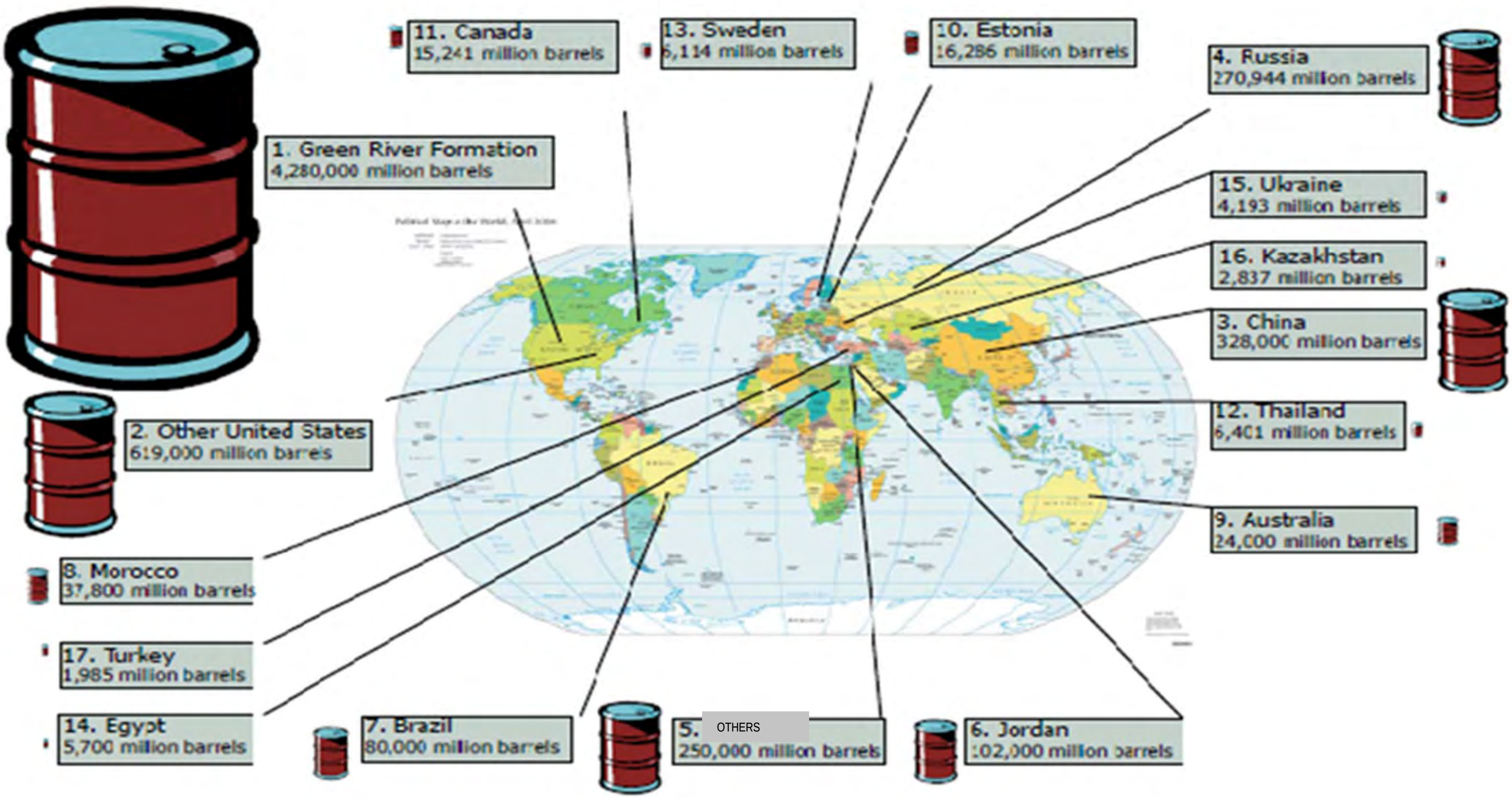
- **Shale oil** is a substitute for conventional crude oil

Reserves Worldwide
10 Trillion Barrels



Countries With Oil Shale Deposits

Global Oil Shale Resources



World Wide Reserves (Barrels)

China	16 Billion
Estonia	16 Billion
Australia	32 Billion
Morocco	53 Billion
Italy	73 Billion
Brazil	82 Billion
Jordan*	90 Billion
Zaire	100 Billion
Russia	248 Billion
United States	6,000 Billion

Source:
United States Geological Survey (USGS), 2005
* Jordan Natural Resources Authority (NRA), 2009

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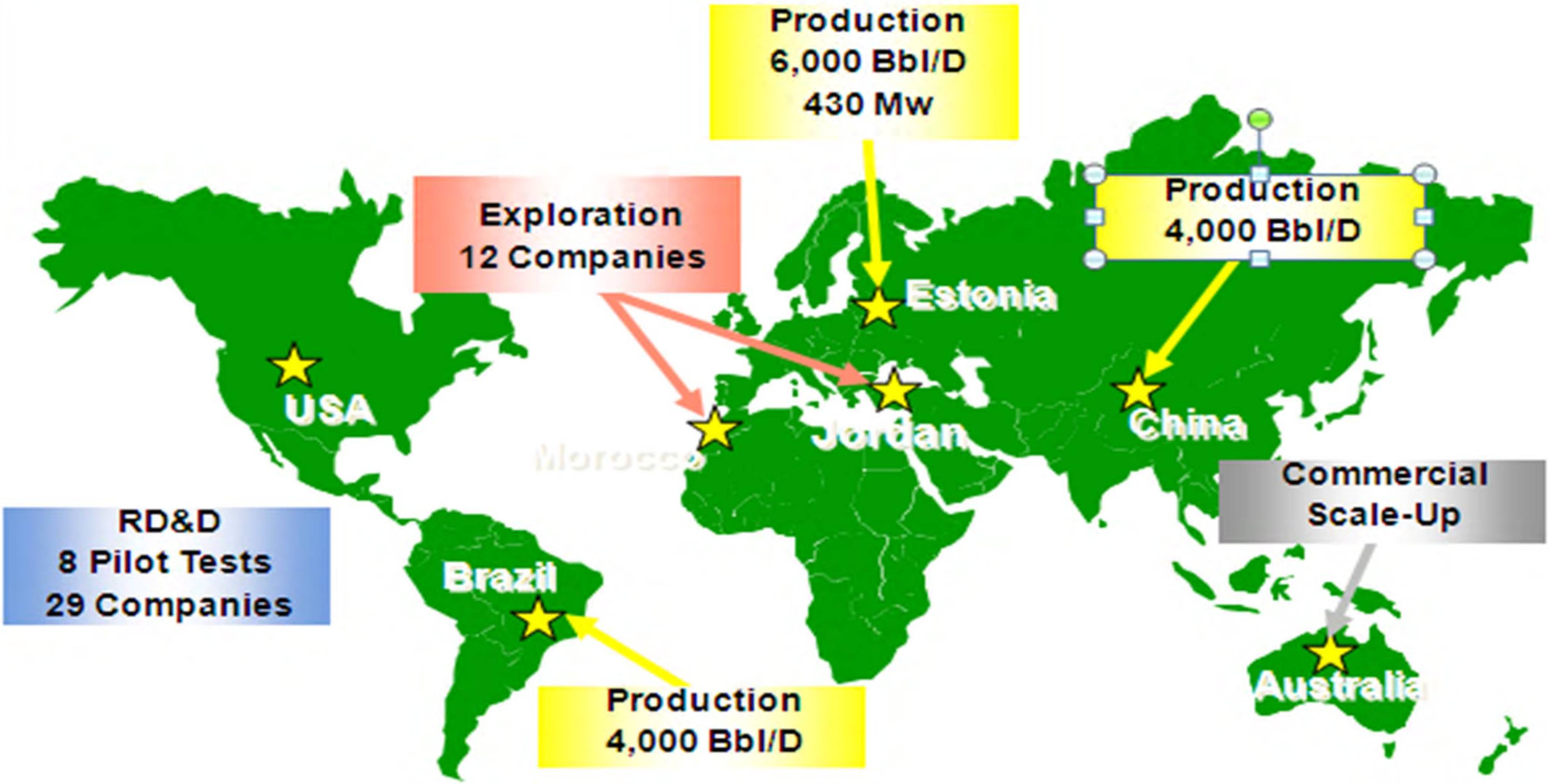
Worldwide Oil Shale Activities



Oil Shale in Jordon

- Jordanian oil shale are high quality, comparable to western US oil shale, although their sulfur content is high.
- The best-explored deposits are El Lajjun, Sultani, and the Jurefed Darawishare located in west-central Jordan
- Jordan has 8th largest oil shale resource in the world.

Oil Shale in Jordon

- Jordan Energy and Mining Limited (JEML) is developing the Al Lajjun oil shale project.
- The project is expected to produce an average 15,000 bpd of refinery-grade oil over a mine life of about 29 years.

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Oil Shale In Egypt

- Oil shale was discovered in 1940s during phosphate mining
- Researches in 1970s showed that Egypt has plenty of Oil shale with shale oil reserves at:
  - Western Desert
  - Eastern Desert

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Oil Shale in EGYPT- Eastern Desert

- Found at the red sea.
- Contains around 4.5 billion barrels of shale oil.
- Only accessible by underground mining methods.

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Oil Shale in EGYPT- Western Desert

- Found at Abu-Tartour.
- Contains around 1.2 billion barrels of shale oil.
- Can be extracted during mining for phosphate and then utilized for power production for use in the mines.

Extraction Technologies

- Extraction Technologies
  - In-Situ Technology
  - Ex-situ Technology

Ex-Situ Processing

- Relies on digging the oil-bearing shale (Oil Shale) out of the ground.
- Crushing it into small pieces.
- Separating the oil-like kerogen from the rock by heating it in a centrally located piece of machinery known as a "retorter".

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Ex Situ Processing Steps

MINING

CRUSHING

RETORTING

OIL UP GRADING

OIL TO REFINERY

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Ex Situ Process Types

- Ex-Situ Retorting:

VERTICAL TYPE	HORIZONTAL TYPE
Fushun Generator (China)	Galoter Retorting (Estonia)
Kiviter Retorting (Estonia)	Alberta Taciuk process Retorting (ATP) Australia
Petrosix Retorting (Brazil)	

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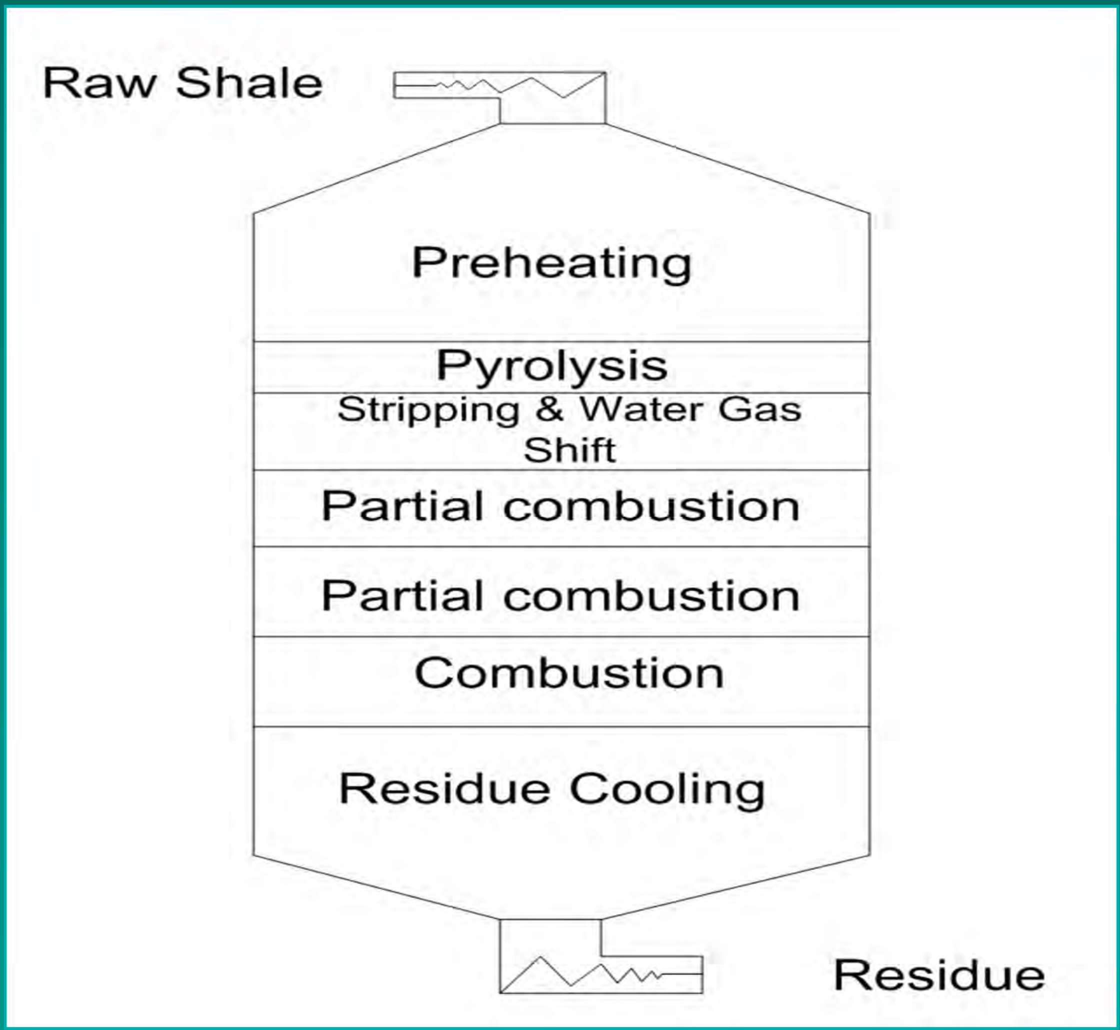
TYPICAL RETORTER



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Horizontal Retorter Suppliers

Retort	Fushun Generator vertical type Retorting	Kiviter vertical type Retorting	Petrosix vertical type Retorting	Galoter horizontal type Retorting	Alberta Taciuk process horizontal type Retorting
Company	Fushun Shale Oil	Viru Keemia	Petrobras	Narva power	SPP
Oil Yield ,%	65	75-80	90	85-90	85-90

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In Situ Processing

- Is the technology for processing oil shale in-situ (i.e. underground).

- The innovation of this process was originally adopted to solve the problems of mining, handling, and disposing of large quantity of material, which is encountered with ex-situ processing.

In-situ Process Steps

DRILLING & FRACTURING

RETORTING

OIL UPGRADING

OIL TO REFINERY

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In-Situ Technologies

a. Shell In Situ Conversion Process (ICP)

b. American Shale Oil Process

c. Conduction, Convection, Reflux (CCR) Process
   Externally Generated Hot Gas
   Chevron CRUSH Process

Shell In Situ Conversion Process (ICP)

- Deep vertical holes are drilled through a section of oil shale.
- Heating underground oil shale using electric heaters placed in the deep vertical holes.
- The entire oil shale is heated over a period of two to three years until it reaches 650–700 °F (340 and 370 °C).

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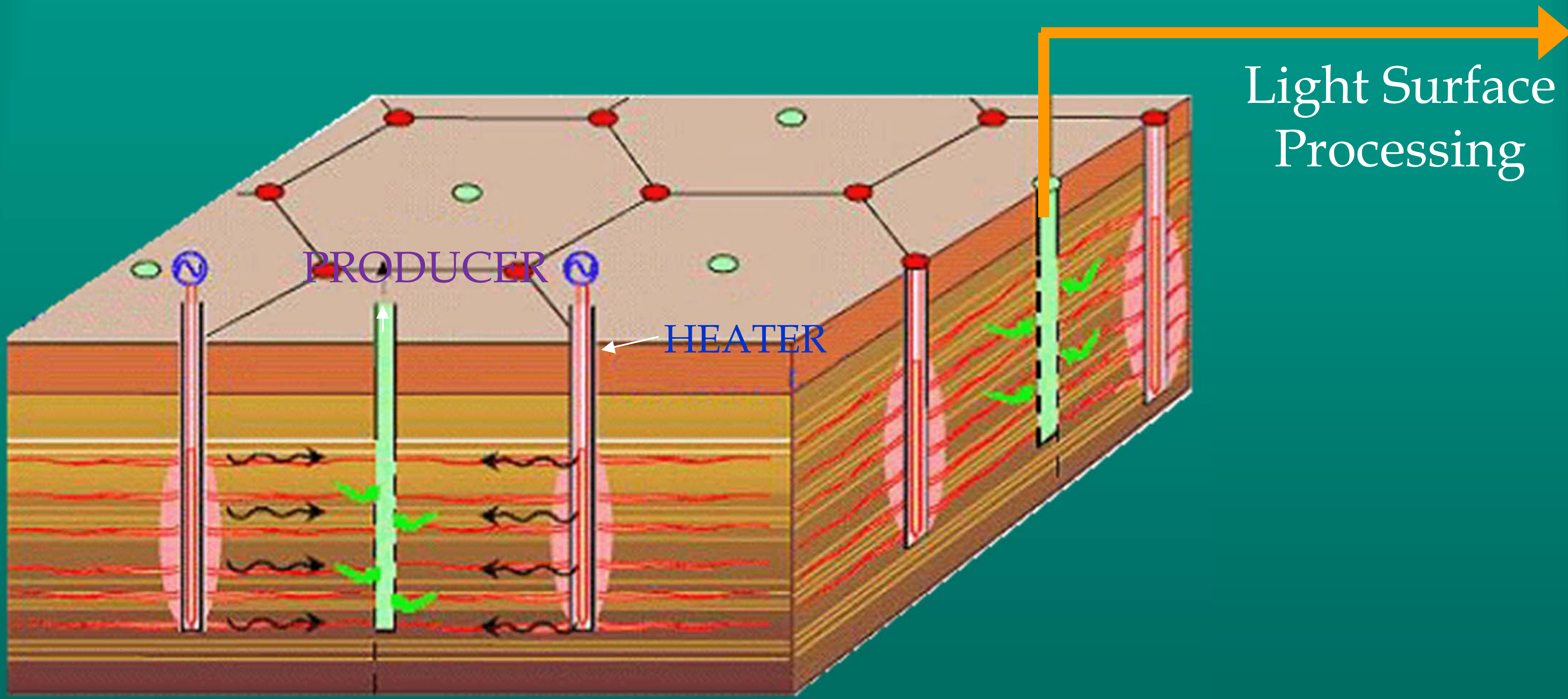
Shell In-Situ Conversion Process (ICP)



Source: US DOE, 2008

Shell's Technique for Ground Water Protection

- Shell's current plan involves use of ground-freezing technology to establish an underground barrier called a "**freeze wall**" around the perimeter of the extraction zone.
- The freeze wall is created by pumping refrigerated fluid through a series of wells drilled around the extraction zone.
- The freeze wall prevents groundwater from entering the extraction zone.
- The freeze wall keeps hydrocarbons and other products generated by the in-situ retorting from escaping from the extraction zone perimeter.

American Shale Oil Process
Conduction, Convection, Reflux (CCR) Process

- Horizontal wells are drilled beneath the oil shale layer.
- Superheated steam or another heat transfer medium is circulated through the horizontal pipes.
- As the organic matter within the rocks boils, it will break the rocks apart and free the oil and gas to be collected.

American Shale Oil Process Technique for Ground Water Protection

- To protect groundwater, the company plans to target deeper layers of oil shale below the basin's aquifer, leaving in place layers of rock above the target zone that will serve as a natural geologic barrier against groundwater contamination.

- The CCR process will consume less energy and require fewer wells, thus minimizing the amount of land disturbed on the surface and reducing the amount of water needed to less than one barrel per barrel of oil produced.

Externally Generated Hot Gas Chevron CRUSH Process

- Controlled chemical explosions.
- Hot gases heated above-ground (such as heated carbon dioxide) and then injected into the oil shale formation via drilled wells.
- Heating the formation through a series of horizontal fractures at the injection well through which the gas is circulated.

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Cheveron's Technique for Environment Protection

- Chevron believes that the CRUSH process will require significantly less energy and water than other in situ methods and will sequester much of the carbon dioxide underground, thus reducing its environmental impact and making it more economical even at lower oil prices.

Environmental Impact

Environmental impact

- Greenhouse gas emissions and global warming.
- Disposal of spent shale (Ex-Situ Processing).
- Production of SOx and NOx .
- Possible Ground Water Contamination with hazardous byproducts.
- Land Reclamation Concern.
- Excessive amount of water requirement in production process (1-3 Barrels of Water per Barrel of Shale Oil).

Economics Overview

Questions and Answers

Question	Answer
• What are the prospects of the oil shale development?	• Massive resources but costly to extract; technology advances are promising, especially with the increasing conventional oil prices
• What is the strategic significance for developing oil shale industry?	• Large economic gains, lower oil prices and new jobs
• What are the critical policy issues surrounding the prospect of oil shale development?	• Resolving technical, environmental, governance issues will determine whether a strategically significant industry will develop

History of investment

- In the 2nd half of the 20th century, oil shale production ceased in Canada, Scotland, Sweden, France, Australia, Romania, and South Africa due to the low price of oil and other competitive fuels.
- In the United States, during the 1973 oil crisis businesses expected oil prices to stay as high as US$70 a barrel, and invested considerable sums in the oil shale industry.
- World production of oil shale reached a peak of 46 million tonnes in 1980.
- Due to competition from cheap conventional petroleum in the 1980s, several investments became economically unfeasible.
- On 2 May 1982, Exxon canceled its US$5 billion Colony Shale Oil Project near Parachute, Colorado because of low oil-prices and increased expenses.

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Economic Estimates & Analysis

- The various attempts to develop oil shale deposits have succeeded only when the cost of shale-oil production in a given region comes in below the price of crude oil or its other substitutes (break-even price)
- The United States Department of Energy estimates that the *ex-situ* processing would be economic at sustained average world oil prices above $54 per barrel and *in-situ* processing would be economic at prices above $35 per barrel. These estimates assume a return rate of 15%.
- The International Energy Agency estimates, based on the various pilot projects, that investment and operating costs would be, that means would be economic at prices above $60 per barrel at current costs.

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Economic Estimates & Analysis

- Yet, according to a survey conducted by the RAND Corporation, the cost of producing a barrel of oil at a surface retorting complex in the United States (comprising a mine, retorting plant, upgrading plant, supporting utilities, and spent shale reclamation), would range between $70–95.
- From this point of view & in order for the operation to be profitable, the price of crude oil would need to remain above these levels.
- The analysis also discusses the expectation that processing costs would drop after the complex was established (Hypothetically, cost reduction of 35–70% is expected after its first 500 million barrels were produced.)

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Economic Estimates & Analysis

- Assuming an increase in output of 25 thousand barrels per day during each year after the start of commercial production, the costs would then be expected to decline to $35–48 per barrel within 12 years.
- In 2005, Royal Dutch Shell announced that its *in situ* extraction technology could become competitive at prices over $30 per barrel. However, Shell reported in 2007 that the cost of creating an underground freeze wall to contain groundwater contamination had significantly escalated.
- As the commercial scale production by Shell does not foreseen until 2025, the real price needed to make production economic remains unclear

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Capital cost

- According to the United States Department of Energy, in 1980s the costs of a 100,000 barrels per day *ex-situ* processing complex ranged from $8–12 billion at 2005 prices. It is estimated that the current capital costs are $3–10 billion at 2005 prices.

Potential Projects

- Because of the losses in 1980s, companies were reluctant to make new invests in shale oil production.

- Currently however, USA, Canada and Jordan were planning or had started shale oil production test projects, and Australia was considering restarting oil shale production.[15][18]

Summary

- Over 10 trillion barrels of in place resource
- Conversion technologies are advancing rapidly
- Estimated reserves of up to one trillion barrels worldwide
- Oil Price is a key driver for its development, at current conventional oil production costs
- Requires concerted effort by the private sector, governments.

Thank You

Economic Concerns*

- EROI is the ratio of energy delivered to energy costs.
- The most reliable studies suggest that the EROI for oil shale falls between 1:1 and 2:1 when self-energy is counted as a cost.
- Self-energy is energy released by the oil shale conversion process that is used to power that operation.
- This places the EROI for oil shale considerably below the EROI of about 20:1 for conventional crude oil at the wellhead.
- Even in its depleted state—smaller and deeper fields, conventional crude oil generates a significantly larger energy surplus than oil shale.

***An Assessment of the Energy Return on Investment (EROI) of Oil Shale by Department of Geography and Environment, Boston University, 2010**

Economic Concerns*

- The larger energy surplus produced by conventional crude oil is due to the fact that kerogen in oil shale is solid organic material that has not been subject to the temperature, pressure, and other geologic conditions required to convert it to liquid form.

- Whereas "upgrade" the oil shale resource is required phase to step-up to the functional equivalent of conventional crude oil.

- This extra step results-in much lower EROI for oil shale.

*An Assessment of the Energy Return on Investment (EROI) of Oil Shale by **Department of Geography and Environment, Boston University, 2010**

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Economic Concerns*

- Firm conclusions regarding the EROI are difficult to establish for a variety of reasons:

  - very few reliable studies of current oil shale operations
  - many studies use a poor or undocumented methodology
  - Some studies exclude important categories of energy inputs that generate inflated estimates of the EROI for oil shale.
  - much of the discussions are regarded as preliminary or speculative because of the very small number of operating facilities that can be assessed.
  - The considerable uncertainty surrounding shale oil production suggests that it cannot yet be "certified" as a clear net energy producer if one includes internal energy as an energy cost.

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Economic Concerns*

- The low EROI for oil shale is closely connected to:
  - retorting process, produces considerable carbon dioxide and other greenhouse gas emissions. (more than conventional liquid fuels from crude oilfeedstock by a factor of 1.2 to 1.75
  - large quantities of energy needed to process oil shale
  - Huge amount of water is required (For every barrel of oil produced in an oil shale operation, between 1 and 3 barrels of water are Required).