SLIDES: The Elusive Bonanza

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The Elusive Bonanza
Yankee Ingenuity Will Capture the Prize
Chasing a Mirage
Decades of Quiet, Punctuated by Outbreaks of Hoopla and Hype

“An oil shale industry could be initiated by 2011 with initial production of 200,000 b/pd, with an aggressive goal of 2 million b/pd by 2020. Ultimate capacity could reach 10 million b/pd…”

--2004 report funded by the U.S. Department of Energy
‘Colorado Oil Shale Follies’: Long play starring dreamers, hucksters, gullible reporters, deluded federal officials, local boosters, stock swindlers, dedicated engineers and one Black Sunday
Oil riches just out of reach

Shell leads push on shale

Rising crude prices boost hopes for the success of inserting heating rods into layers of rock to extract the West's estimated reserves of 1 trillion barrels.

Part 1 of two stories about prospects for the oil shale industry on Colorado's Western Slope. Part 2 will appear in Tuesday's Denver Post business section.

By Paul Foy
The Associated Press

Meeker — Out in sagebrush country, Kenneth Brown is standing over part of the world's most concentrated energy resource, land that holds up to 1 million barrels of oil per acre.

Too bad it's locked up in layers of rock in some places hundreds of feet underground.

Such is the dilemma presented by the West's oil shale reserves, believed to contain more than 1 trillion barrels of oil — four times the holdings of Saudi Arabia, according to government and industry estimates.

The problem is extraction: Underground layers of shale are as thick as 1,000 feet and were deposited over millions of years by an algae-producing sea. The Green River formation is potentially the world's most bountiful energy source — enough in theory to meet U.S. energy needs for a century — but it is an expensive nut to crack for energy companies. Plus, it could use up a lot of water in an arid region.

Shell Exploration & Production Co. has been out here for nine years, trying to bake shale oil from the ground by using heating
1/10,000th of global energy, much less than animal manure

Figure 19. Production of oil shale in millions of metric tons from Estonia (Estonia deposit), Russia (Leningrad and Kashpir deposits), United Kingdom (Scotland, Lothians), Brazil (Iratí Formation), China (Maoming and Fushun deposits), and Germany (Dotternhausen) from 1880 to 2000.
Is God Brazilian?

Sub-salt at Tupi

Single well costs $100 million; development will take decades
Petroleum Quality

![Diagram showing the relationship between fluid quality (API gravity) and rock quality (permeability in md). The conventional and unconventional areas are shaded differently.]}
Drowning in oil
Pleasure To Burn

GENERAL'S WARNING: Cigarette Contains Carbon Monoxide.
Prudhoe Bay: 15 billion barrels

Shell *already* has rights to $1 trillion of shale...
Petroleum Quality

![Graph showing the relationship between Fluid Quality (API gravity) and Rock Quality (permeability in md). The graph is divided into two main categories: Conventional and Unconventional. The star indicates a specific point on the graph.](image-url)
Petroleum Quality

FLUID QUALITY (API gravity)

ROCK QUALITY (permeability in md)

CONVENTIONAL

UNCONVENTIONAL
North Dakota has produced more oil in the last 15 years than the global oil shale industry has in the last 150 years.
Kerogen Is Not Petroleum, Tons Are Not Barrels

FLUID QUALITY (API gravity)

ROCK QUALITY (permeability in md)

CONVENTIONAL

UNCONVENTIONAL
Immature Source Rock

- **Accumulation of organics and clay**
- **Burial - organic black shale**
- **Deeper burial - kerogen**
- **Oil generation & migration**

Wishing Can’t Make it So
“In reality, so-called ‘oil shale’ is a low-grade, high-ash, hydrogen-rich, sapropellic coal”

--Utah Geology Prof
Energy Content of Fuels

- natural gas
- crude oil
- coal
- cattle manure
- firewood
- municipal trash
- oil shale
- baked potatoes

Million BTU/ton
Cap’n Crunch contains 3 times more energy per pound than oil shale
Raytheon senior principal systems engineer John Cogliandro pulls an RF antenna from a shale sample at CF Technologies in Boston. The antenna transmits radio frequencies that generate heat to melt a waxy substance in the shale called kerogen so that it can be converted into oil.

Zap and extract: Shale yields oil
Nuclear energy is being proposed as an alternative to gas-powered electricity as a heat source for in situ shale oil recovery in the US.


He said nuclear heat could be used to extract the vast US oil shale deposits more economically and in a much more environmentally benign manner than traditional oil shale recovery methods. Forsberg is senior scientist and senior reactor technical advisor for the lab’s Nuclear Science and Technol-
hell’s “\ube oldberg”
Energy Return Will be Very Low
100,000 b/d operation would be the largest single user of electricity on Earth
Climate change starts here
‘Carbon Budget’ must be divided between nations, generations, and *fuels*

Path for 50% chance of avoiding $\Delta T_{avg} >2^\circ C$ (gold) is much more demanding than path for 50% chance of avoiding $>3^\circ C$ (green).
The Ultimate IQ test

Other energy alternatives make much more sense
FAIL
Global Carbon Emissions

- Fossil-fuels
- Land-use Change

Billions of Tonnes Carbon

The New Oil Rush

How sky-high prices have companies tapping into surprising new sources of crude
Red Leaf Resources EcoShale™ Process

- Very low water use
- High Energy Return on Investment
- Pilot test completed
Create electrically conductive fractures (vertical or horizontal)

- Planar heat source more effective than radial conduction from wellbore

Typical simulation
- 150 foot fracture height
- 5-year heating converts 325 feet of oil shalol
- 120-ft fracture spacing,
- 74% heating efficiency
GONE: 65% of U.S. oil has been used. It's history.
Steady State Scenario

OPEC t 35illi b/d

OPEC:

100
80 90
50 60 70
30 40 50

Actual forecast

Non-OPEC - FSU

FSU

OPEC

World peaks at 86 million b/d in 2011

We have \textit{already} begun an energy transition

U.S. using 2 million b/d less oil today than 5 years ago
Remaining Oil
Conventional: 1000 Bb
Tar Sands: 500 billion
Bitumen: 500 billion
Oil Shale: 1000 billion
Coal Liquids: 5000 billion
• Dostoevsky in *Crime and Punishment*:
• “Do you think I care if they talk nonsense? Hogwash! I am a man, therefore I talk nonsense. Nobody ever got a single truth without talking nonsense fourteen times first. Maybe even a hundred and fourteen. That’s all right in its own way. We don’t even know how to talk nonsense intelligently, though!”
Range of heating values for regional coals (maximum, minimum and average BTU/lb)

<table>
<thead>
<tr>
<th>Region</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder River Basin coal</td>
<td>8,220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colorado Coal Active Mines</td>
<td>11,851</td>
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<td></td>
</tr>
<tr>
<td>Eastern bituminous</td>
<td>12,697</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources: Colorado Geological Survey, Colorado Coal Quality Data (Information Series 58); USGS, CoalQual Database; USGS Professional Paper 1625-A.
Energy Content of Fuels

- Natural gas
- Crude oil
- Coal
- Cattle manure
- Firewood
- Municipal trash
- Oil shale
- Baked potatoes

Million BTU/ton
deformation, oil migration & accumulation in a ‘trap’
The Petroleum “Kitchen”

‘Oil window’

‘Gas window’

Changes in molecular composition:
- Original organic chemicals
- Kerogen
- \( C_{34}H_{54} \)
- \( C_{16}H_{18} \)
- \( C_{7}H_{13} \)
- \( C_{3}H_{16} \)
- \( CH_4 \)

Depth (km):
- 0
- 3
- 6
- 9

Relative quantity

Temperature (°C):
- 0
- 75
- 150
- 225

Natural gas

Graphite
• Do we have the time, capital, carbon, and water to pursue this marginal energy resource? Don’t we have better choices? things to do?

• Is oil shale an idea whose time has passed, whose time will never come, whose time never was, whose time has come, or whose time has passed?
I TOLD YOU TO GET A HYBRID!