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

> See OIL SHALE on 5E

Mining oil reserves with heat

The oil industry is considering using heat technology to mine the West's oil shale reserves, which are believed to contain more than...
Oil Price

Canadian tar sands

ethanol

GTL

CTL

1975 1990 2005
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

FLUID QUALITY
(API gravity)

ROCK QUALITY
(permeability in md)

CONVENTIONAL

UNCONVENTIONAL

(78x36 to 546x756)
Drowning in oil
Prudhoe Bay: 15 billion barrels

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

Conventional Quality

Unconventional Quality

Fluid Quality (API gravity)

Rock Quality (permeability in md)
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.

![Graph showing fluid quality vs. rock quality with conventional and unconventional areas](image-url)
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, sapropelic coal”

--Utah Geology Prof
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

GREENPEACE

CLIMATE RESCUE
‘Carbon Budget’ must be divided between nations, generations, and fuels.

Path for 50% chance of avoiding $\Delta T_{\text{avg}} > 2^\circ C$ (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
The New Oil Rush

How sky-high prices have companies tapping into surprising new sources of crude
hell’s
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 shalo
  - 120-ft fracture spacing,
  - 74% heating efficiency
Home Delivery

Rock That Burns
U.S. OIL PRODUCTION 1900 TO 2050

PEAK 1970

GONE: 65% OF U.S. OIL HAS BEEN USED. IT’S HISTORY.

2001

DOWN THE OIL “OFF RAMP”
Steady State Scenario

OPEC t 35illi b/d

OPEC's tays ~ 35 million b/d

World peaks at 86 million b/d in 2011

Actual forecast
We have *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

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**Wringing Out the Oil**

Skyrocketing fuel prices have made it feasible to extract oil from solids like shale and coal, in processes that were previously deemed too costly. So-called unconventional oil is expected to make up 35 percent of the world’s supply by 2015.

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**The Rising Price of Crude**

- March 3, 2003: $35.88
- April 28, 2003: $25.49
- March 3, 2004: $35.88
- April 13, 2006: $69.32
- August 30, 2005: $69.81

Source: U.S. Energy Information Administration.
• 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)

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
- $C_{34}H_{54}$
- $C_{16}H_{18}$
- $C_7H_{13}$
- $C_3H_{16}$
- $CH_4$

Depths:

- 0 km
- 3 km
- 6 km
- 9 km

Temperatures:

- 0°C
- 75°C
- 150°C
- 225°C

Relative quantity:

Graphite

Natural gas

Oil

Oil window

Gas window
• 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?
RESOURCE QUALITY AND UNCONVENTIONALS

FLUID QUALITY (API gravity)

ROCK QUALITY (permeability in md)

- OIL FROM MATURE SOURCE ROCKS
- OIL SHALE
- EXTRA-HEAVY OIL/BITUMEN
I TOLD YOU TO GET A HYBRID!