Review on Oil shale data

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-Introduction

Andre Combaz who led the GERB (Groupe d'Etudes des Roches Bitumineuses) in the 1970s gave me several boxes of documents on oil shale. This data with my own file and what I could find on the web is analyzed in this review. Three annexes (A2005, A1999-2004 and A1965-1980) gather most of the data and are attached to this review.

-History

Oil shales are a misnomer being neither shale or oil, in fact an immature source-rock which has not yet generated any oil and needs to be heated at 600 °C to yield oil by pyrolysis. In fact they should be classified with coal and peat. USDOE/EIA reports the oil shale of Estonia in the world lignite production (table 5.4). Most oil shale in Estonia was burned in electric or cement plants. Oil shales are completely different from oilsands (or extra-heavy oils), which are at the end of the oil cycle before being entirely degraded. But many people, even so-called experts (Chevalier) confuse them!

Oil shale has a long past of production, starting in 1837 in France (Autun mines, which were closed in 1957), Scotland 1850-1963, Australia 1865-1952, 1998-2004, Brazil 1881-1900,1941-1957, 1972-, Estonia 1921-, Sweden 1921-1965, Switzerland 1921-1935, Spain 1922-1966, China 1929-, South Africa 1935-1960.

Combaz did in 1975 two good graphs on the past history involving many countries.

Figure 1: different processes from Combaz

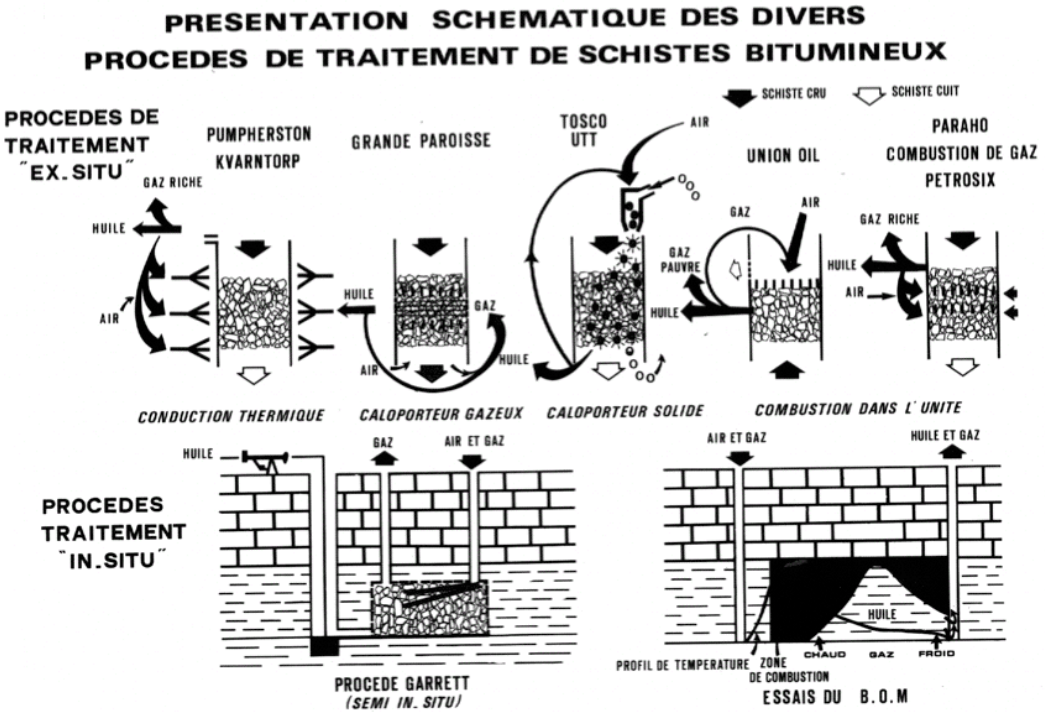
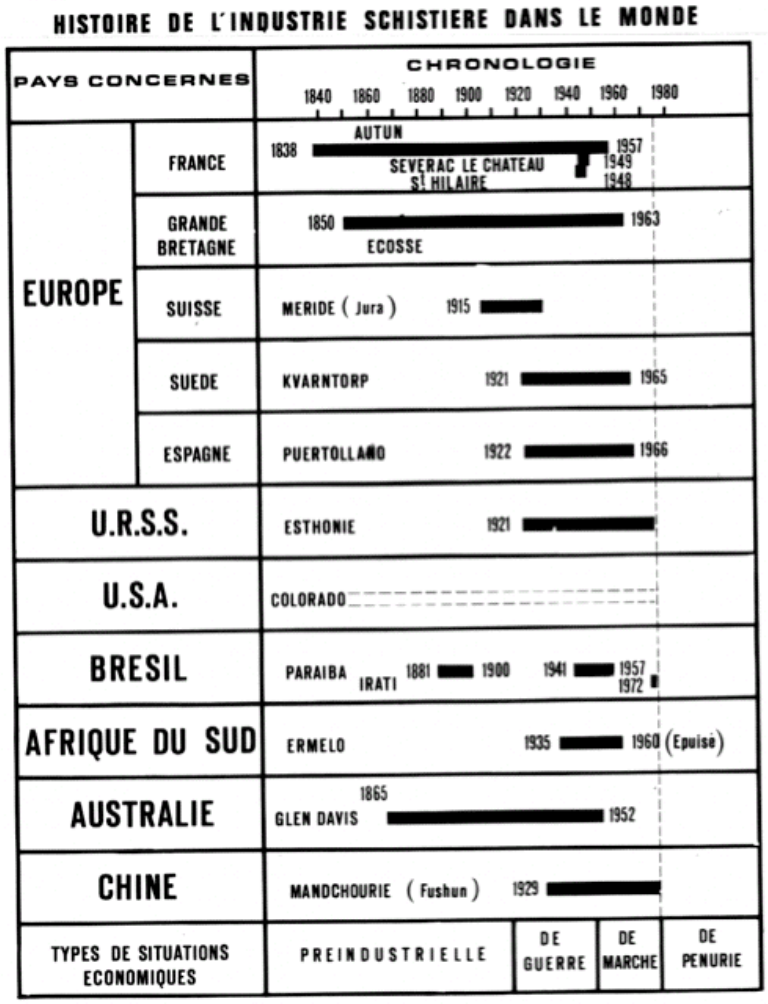


Figure 2: history of oil shale production from 1838 to 1975 from Combaz



-US history

Oil shale has a long history in the US involving many up and downs.

Table A-1. Oil Shale Timeline (Source: Shell Mahogany Research Project, 2004)

1909 U.S. Government creates **U.S. Naval Oil Shale Reserve**
1910 Oil shale lands "claim-staked"
1916 USGS estimates 40 B Bbls of shale oil in Green River formation in CO, WY, and UT
1917 First oil shale retort kiln in DeBeque, Co.
1918 **First oil shale boom begins with over 30 000 mining clams**; lasts until 1925
1920 Mineral Leasing Act requires shale lands be leased through the Secretary of Interior
1929 Test retort at Rulison stops at 3 600 bbls after oil discoveries in CA, TX, and OK
1944 U.S. Synthetic Liquid Fuels Act provides $18 million for experiments at Anvil Points
1950s Gulf Oil and Shell Oil both purchase oil shale lands in Green River formation
1956 Anvil Points operations cease after testing three experimental retort processes
1961 Unocal shuts down Parachute Creek "Union A" retort after 18 months and 800b/d due to cost
1964 Colorado School of Mines leases Anvil Points facility to conduct research on US Bureau of Mines Gas Combustion Retorts
1967 CER and U.S. AEC abandon plans for "Project Bronco" atomic subsurface retort

1972 Tosco, Sohio and Cleveland Cliffs halt Colony oil shale project begun in 1964 after 270,000 bbls of production
1972 Occidental Petroleum conducts first of six in-situ oil shale experiments at Logan Wash
1972 Paraho is formed as a consortium of 17 companies, obtains a lease of Anvil Points facility and builds and operates 24 ton/day pilot plant and 240 ton/day semi-works plant.
1970s Shell researches Piceance Creek in-situ steam injection process for oil shale and nahcolite
1974 Four oil shale leases issued by BLM under Interior's Prototype Leasing Program.
1974 Unocal develops new "Union B" retort process; Shell and Ashland join Colony Project
1976 Navy contracts with Paraho to produce 100 000 barrels of shale oil for testing as a military fuel
1976 Unocal begins planning commercial scale plant at Parachute Creek to be built when investment is economic; imported oil prices reach $41/bbl
1977 Superior Oil abandons plan for Meeker oil shale plant planned since 1972
1979 Shell, Ashland, Cleveland Cliffs and Sohio sell interests in Colony to ARCO and Tosco; Shell sells leases to Occidental and Tenneco
1979 Congress passes Energy Security Act, establishing U.S. Synthetic Fuels Corporation; authorizes up to $88 Billion for synthetic fuels projects, including oil shale.
1980 Exxon buys Arco's Colony interest and in 1981 begins Colony II construction, designed for 47 000 b/d using Tosco II retort process
1980 Congress approves $14 billion for synthetic fuels development
1980 Unocal plans Long Ridge 50 000 b/d plant applying "Union B" retort; begins construction in 1981
1980 Amoco Rio Blanco produces 1 900 bbls of in-situ oil at C-a tract
1981 Exxon begins to build Battlement Mesa company town for oil shale workers
1981 Second Rio Blanco in-situ retort demonstration produces 24 400 bbls of shale oil
1982 Oil demand falls and crude oil prices collapse
1982 **Exxon Black Sunday**: announces closure of Colony II due to cost and lower demand
1982 Shell continues in-situ experiments at Red Pinnacle and labs through 1983
1985 **Congress abolishes Synthetic Liquid Fuels Program after 40 years and $8 billion**
1987 Shell purchases Ertl-Mahogany and Pacific tracts in Colorado
1987 Paraho reorganizes as New Paraho and begins production of SOMAT asphalt additive used in test strips in 5 States.
1990 Exxon sells Battlement Mesa for retirement community
1991 Occidental closes C-b tract project before first retort begins operation
1991 **Unocal closes Long Ridge after 5 MM bbls and 10 years** for operational issues and losses
1991 LLNL plans $20 million experiment plant at Parachute; Congress halts test funds in 1993
1991 New PARAHO reports successful tests of SOMAT shale oil asphalt additive
1997 DOE cedes oil shale lands to DOI/BLM
1997 **Shell tests in-situ heating on Mahogany property**; defers further work on economic basis
2000 BLM seeks public comment on management of oil shale lands
2000 Shell returns to Mahogany with expanded in-situ heating technology research plan (on-going)
2004 DOE Office of Naval Petroleum and Oil Shale Reserves initiates study of the strategic significance of America's oil shale resources.

Walter Youngquist in his 1997 book Geodestinies and in WEC 2001 gave a good review on oil shale booms and bursts. But with the new energy plan, oil shale is back on the agenda of land sales next year. It will be interesting to see who will be buying.

-**Reserve estimate of oil shale**

Many estimates have been published for oil shale reserves (in fact resources), but the rank of countries vary with time and authors, except that US is always on number one over 60 %. Brazil is the most frequent number two. But some appear and disappear, as Zaire = Congo).

World percentage of oil shale resources:

1973		1978		1999		2002		2003		2005	
IFP	%	BP	%	WEC	%	WEC	%	USGS	%	USDOE	%
US	66	US	63	US	61	US	78	US	70	US	72
Brazil	24	Brazil	23	Australia	17	Russia	7,4	Russia	15	Brazil	5,4
USSR	3,4	USSR	3,3	Jordan	11	Brazil	2,5	Zaire	3,3	Jordan	4,2
Congo	3,0	Zaire	2,9	Brazil	4,5	Jordan	1,0	Brazil	2,7	Morocco	3,5
Canada	1,3			Ukraine	3,0	Australia	1,0	Italy	2,4	Australia	2,1
Italia	1,1			Morocco	2,7	Estonia	0,5	Morocco	1,8	China	1,5
China	0,8			Thailand	0,4	China	0,5	Jordan	1,1	Estonia	1,1
Sweden	0,1			Israel	0,3	France	0,2	Australia	1,0	Israel	0,3
Germany	0,1			Turkey	0,1			Estonia	0,5		
Burma	0,1							China	0,5		
								Canada	0,5		
								France	0,2		

-Production data

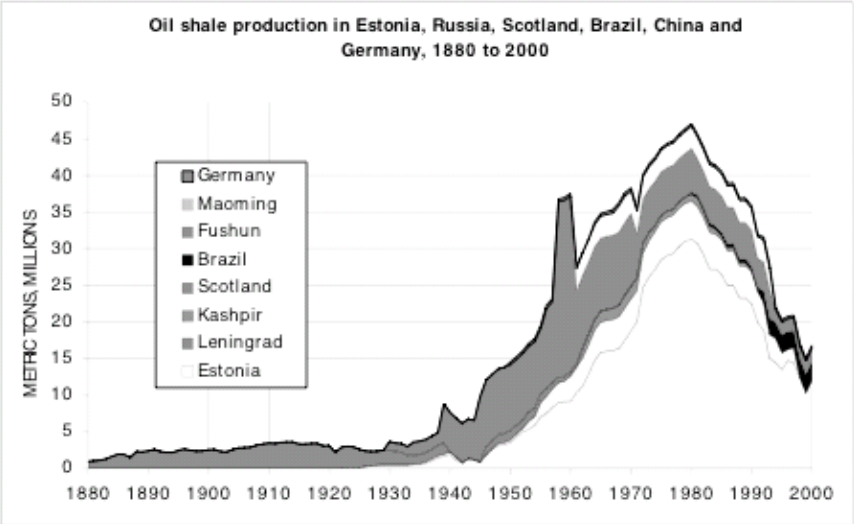
It is difficult to gather production data (given either in shale oil or oil shale in weight or in volume) and few graphs are been issued. There is a large discrepancy between percentages in reserve and in production, because energy-poor countries were developing their only assets.

Percentage of reserves and production in 2002

end 2002	% production	% reserves
Estonia	48	0,5
Brazil	27	2,5
China	17	0,5
Australia	8	1,0
USA	0	78
Russia	0	7
Jordan	0	1,0
France	0	0,2
WORLD	100	100

The best production graph is by Brendow (USDOE 2002) showing a peak of oil shale in 1980 at 50 Mt/a followed by a symmetrical decline (Hubbert curve). It shows that Estonia produces most, peaking at 31 Mt of shales (USDOE 2004) in 1980 but 11 Mt in 1999.

Figure 3: **World** oil **shale production 1880-2000**



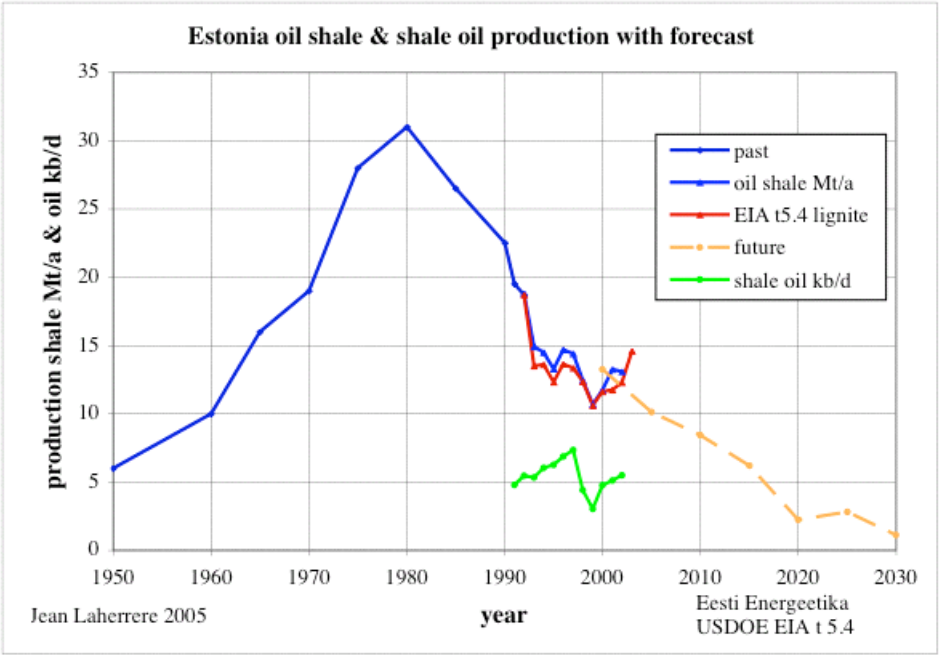
source: Illustration #21 from paper: Origin and resources of some world oil shale deposits, by John R. Dyni, U.S. Geological Survey, Denver, CO, USA, presented at the Estonian Oil Shale Symposium, Tallinn, Nov. 18-20, 2002.

-Estonia

Until recently only 16% of Estonian shales were used for petroleum and chemical manufacturing. But because environmental problems the goal is to decrease sharply oil **shale** production as shown in the governmental forecast of primary energy.

Estonia primary energy 2002 forecasts (Europe scenario) a sharp decrease in oil shale in order to comply with EU rules of no pollution. The production curve displaying a good Hubbert curve for Estonia oil shale, with an unlikely second cycle in the long term!

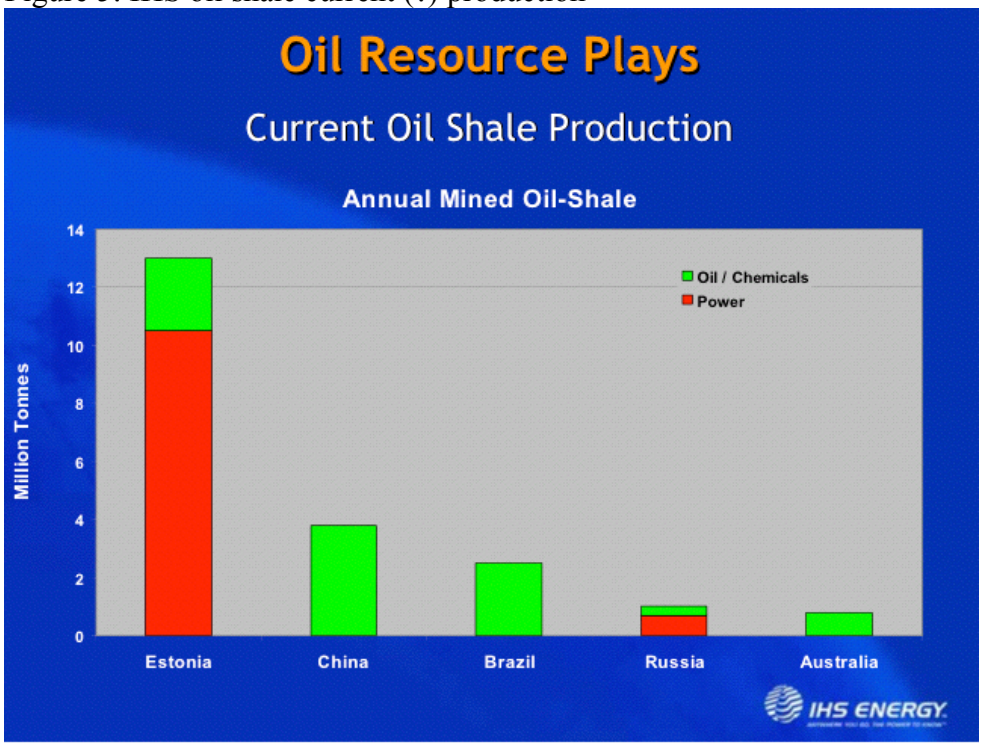
Figure 4: Estoni oil shale production 1950-2030



The production of shale oil was about 5000 b/d for the last 10 years, but it will decrease if the «Europe scenario» is achieved.

-China

Oil shale started production in 1929 in China (Manchuria Fushun) by the Japanese.
1 t of oil was extracted out of 25 t of rocks. In 1961 China was producing one third of its total oil from shale oil, but it is very difficult to find any reliable data on production on a long period.
Ken Chew IHS (OAPEC-IFP 2005 seminar) provides this graph, where China is the largest producer of shale for oil/chemicals!
Figure 5: IHS oil shale current (?) production



But Australia stopped production in 2004!

-Australia

Australia has extracted oil shale from 1865-1952. SPP (Southern Pacific Petroleum) was created in 1968 and was quite active from 1977 to 1986 spending 85 M$ around the world to evaluate oil shale resources and 10 different techniques. In 1980 they sign an agreement with Esso for the Rundle shales deposits for an investment of around 200 M$ to produce up to 200 000 b/d. But the countershock of 1986 killed this agreement. SPP oil shale deposits in Queensland are estimated to contain 20 Gb resources (17 Gb net interest: Corbet 2003). SPP signed in 1995 a similar deal (Rundle was changed into Stuart) with Suncor with their ATP process(for tarsands), which was assumed to be by far the best technology. Suncor, the Canadian tarsand producer, built in 1997 a ATP plant using its oilsands technique in Australia (Stuart oil shale which are very rich with 2.6 Gb reported reserves). The plant has three phases, with the first stage at 4000 b/d and the third stage at 200 000 b/d (reduced at 65 000 b/d). The plant was unable to reach the 4000 b/d level. Suncor left in 2000 (claiming that they have better areas to invest, but admitting in 2005 that it was not commercially viable), writing off the plant investment. From April 2001 to April 2003 Stuart plant produced an average 1000 b/d. The Australian partners having only to take care of the operational cost were unable to finance the plant and the plant was closed in 2004 after having produced about 1 Mb.

-US

During the oil shock of 1973, many pilots were built in the US (together with towns), spending billions of dollars to produce few millions of barrels (Unocal stopped in 1991 after a total production of less than 5 Mb) . The US is reported to contain 2000 Gb out of the 2600 Gb of world resources (USDOE 2004 (Rapport USDOE March 2004 Strategic Significance of America's Oil Shale Resource), mainly in the Green River oil shales.

But to extract oil from the mines, shales must be broken into small pieces, and after heating, the waste is very small fines with a double volume, which are very difficult to store. A very large volume of water is necessary and out of the potential of this dry area. In fact environment problems and furthermore investing more energy than the energy return has killed the pilot plants. It was said to be a question of oil price but it is a problem of energy count.

-Brazil

Brazil started production a long time ago in 1881 and is the second rank after the US for resources (well distributed) and after Estonia for production. They developed the world's largest surface oil shale pyrolysis reactor being the Petrosix 11-m vertical shaft Gas Combustion Retort (GCR). But it seems that the Brazilian success in oil and in biomass to liquids has put oil shale in the shade, as no new plan is found on the web. The production of shale oil dropped from 3900 b/d in 1999 to 3100 b/d in 2002, when the crude oil production was 1.5 Mb/d or 500 times bigger!

-France

France was the first country to start producing oil from shale in Autun in 1837, but production was stopped in 1957. The GERB research group (1973-1978) gathering BRGM, CDF, CFP, IFP and SNEA did some coring in the Fecocourt area in order to make a good inventory of oil shale in France. Samples were pyrolyzed in Germany (Lurgi process). The conclusion was that the resource is large, but production should be marginal and not economical. The Australian SPP requested in 1980 a permit in Fecocourt in order to obtain GERB data.

-Cumulative production of oil shale

The cumulative amount of oil shale can be roughly guessed:

country	peak Mt/a	year	producing period	produced Mt
Estonia	31	1980	1921-now	1200
Brazil	?	?	1880-1900, 1941-1957, 1972-now	500
China	10?	1959	1929-now	300
Scotland	3,3	1942	1850-1963	150
Sweden	2	1944	1921-1965	50
Russia	2	?		50
Spain	1	1960	1922-1966	50
France	0,5	?	1838-1957	25
USA	?	?		20
Australia	?	?	1865-1952, 2000-2004	6
S Africa	0,3	1950	1935-1960	5
world				**2400**

The cumulative production of oil shale is about 2 Gt, representing a production of about 0.1 Gt of oil if all shales were processed and not burnt. It represents a very negligible amount of oil in front of the 150 Gt of oil (liquids) already produced up to now.

-Shale oil

Most of the oil shale were burned and not processed to give shale oil.

Shale oil production was reported by the WEC as

	2002		1999		1996	
	kt/a	b/d	kt/a	b/d	kt/a	b/d
Estonia	275	5 500	151	3 000	343	7 000
Brazil	157	3 100	195	3 900	150	3 000
China	100	2 000	?	?	60	1 200
Australia	46	900	5	100	0	0
world	578	11 600		>5 000	553	11 200

Today oil shale production is about 0,0001 % of the world production. It is completely negligible.

-Future

It is obvious that mining oil shale is either too dirty or too energy negative. Estonia, the world main miner is decreasing its production to almost zero to please the EU. Last mining pilot in Australia was bankrupted in 2004.

In front of mining failures and of huge resources, now hopes are for in-situ project.

But in-situ pilot trying to retort the shale in the ground (Garret process = Occidental pilot reported in the medias to cost only 1 $/b) needs to create some porosity and permeability by fracturing the shale. Combustion was also tested.

Only one in situ project seems to stand, being the Shell project, as it is a in-situ process without retorting, without facturing the shales, waiting for the oil to generate and migrate, but it takes years!

China which is trying hopelessly to find new oil reserves and new oil production, with a long experience on oil shale production, should be the most eager country to promote oil shale progress. But China is very discrete on the subject (maybe because pollution due to coal) and only reported plan is a joint program with Shell ICP in situ project.

But US government is launching a new oil shale program (as they did few years ago on a new hydrate research program) with the **Oil shale development act of 2005** (109th CONGRESS 1st Session S. 1092) to establish a leasing program in 2006 (as in 1974!). Several hearings were given in particular by Shell Unconventional Resources Energy (CEO S.Mut 12 April 2005)

-Shell in-situ pilot

Shell, after a study for in-situ production in the Piceance basin started in 1970, has a pilot since 2000 called Mahogany Research Project. They heat electrically some wells (500-1000' deep) during a long period (several years) to generate oil from the kerogene. To avoid the coming water to disturb the heating, they freeze the formation around the producing area. Shell does not release too much data. The production with 50 workers on site (+100 at headquarters) is rumored to be 10 b/d with an electric bill of 2000 $/d! and the total production is about 2000 b in 5 years They do not expect to decide if the project could be turned into commercial plant before 2008! The goal is to start a small commercial project in 2010.

Testimony of S.Mut

*<<For decades, energy companies have been trying, **without success**, to unlock the large domestic oil shale resources of northwestern Colorado, eastern Utah and southwestern Wyoming.*

***Some 23 years ago**, Shell commenced laboratory and field research on a promising in ground conversion and recovery process. This technology is called the In-situ Conversion Process, or*

ICP. In 1996, Shell successfully carried out its first small field-test on its privately owned Mahogany property in Rio Blanco County, Colorado some 200 miles west Denver. Since then, Shell has carried out four additional related field tests at nearby sites. ***The most recent test was carried out over the past several months and has produced in excess of 1,200 barrels of light oil plus associated gas from a very small test plot using the ICP technology***
This acceleration of natural processes is achieved by drilling holes into the resource, inserting electric resistance heaters into those heater holes and heating the subsurface to around 650F over a 3 to 4 year period.
The process results in the production of about 65 to 70% of the original "carbon" in place in the subsurface
The ICP process is clearly energy intensive as its driving force is the injection of heat into the subsurface. However, ***for each unit of energy used to generate power to provide heat for the ICP process, about 3.5 units of energy are produced and treated for sales to the consumer market.***
<<
Shell claims that the energy return on energy invested is good but it seems that it is only for heating but what about freezing and pumping at the process needs years? The medias after local enquiries report a less optimistic view.

There are many pessimistic views within the industry and official agencies.
-2005 Chevron site www.willyoujoinus.com
Oil production is in decline in 33 of the 48 largest oil-producing countries,
Fossil fuels also exist in unconventional forms—hydrocarbons contained in oil-sands, and even shale are believed to have more energy content than all the oil in Saudi Arabia. The catch is that it may currently take more energy and may cost more to extract and produce oil from some of these unconventional forms than would be gained.

-USDOE/EIA Guy Caruso Administrator « When will world oil production peak? » 10th Annual Asia oil & gas conference Kuala Lumpur June 13, 2005
Oil shales
A huge in-place kerogen resource … but the technology to economically produce large quantities of synthetic oil from them **does not exist and is not likely to in the next decades.**

-2004 Germany BGR P. Gerling "Non-conventional hydrocarbons –where, what, how much"
Oil shale has a high potential, but is **currently absolutely out of economic interest**

As Petrole Informations noticed in 1972: 1 t of coal can give 650 l of oil when 1 t of oil shale can give only 150 l of shale oil. Production of oil shale should start only after that coal is completely depleted! Oil shale is classified by USDOE/EIA within lignite.

Oil shale and shale oil have a very disappointing past and an unlikely future!
Or Youngquist quoted: «Oil shale is the fuel of the future and always will be»

Annexes: detail of the data
-A2005.pdf
-A1999-2004.pdf
-A1965-1980.pdf