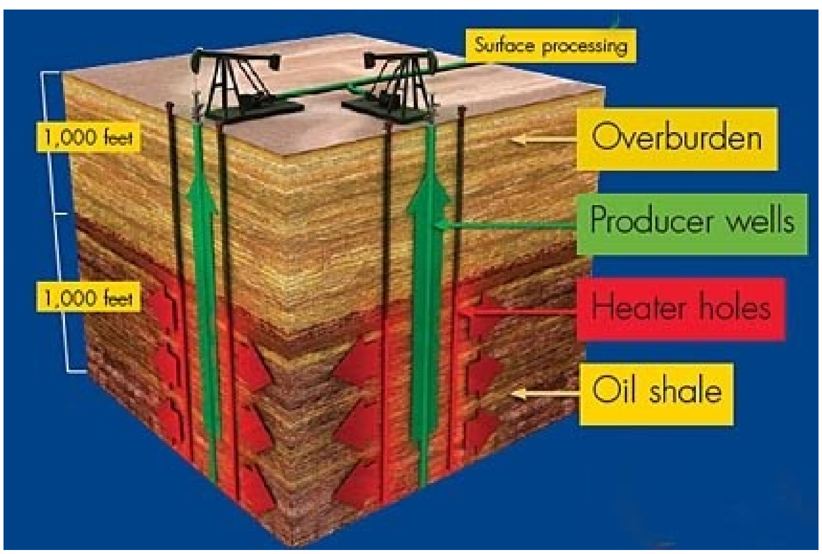
The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk: Using heat to refine kerogen from oil shale

Posted by Heading Out on March 28, 2010 - 11:01am
Topic: Supply/Production
Tags: electric heating, george clark, ground freezing, heating rock, mahogany project, oil shale, shell, tech talk [list all tags]

One of the problems with the oil (kerogen) in oil shale is that it is not mature enough (i.e. close enough to being an oil) that it will easily flow through the rock. In earlier parts of this particular theme, I have written about mining the rock and then heating it in retorts as a way of transforming the kerogen and recovering it for use. I have also, somewhat tongue in cheek, discussed using nuclear weapons to heat the rock so that the transformation can take place without moving the rock, while breaking the rock at the same time, and the unlikely potential for burning some of the oil within the deposit to power the transformation of the rest. While it might work in a heavy oil sand, is not likely to be realistically practical for the finer grained shales. But there are ways of adding somewhat less heat to the rock than using a nuclear bomb, and that will be the topic for today.

This is a continuation of the technical posts that I usually write on Sundays.



While I am largely going to bypass the use of nuclear power (apart from that of providing electrical power) in this piece, the potential use of nuclear power to heat penetrators that allow rapid drilling of weak rock has been partially demonstrated. As I have mentioned previously, Los Alamos National Lab, in looking at different methods for drilling, had come up with the idea of using a small nuclear reactor to provide sufficient heat to a ceramic probe that it would melt its way into the ground, pushing the molten rock to one side, and providing a glass lining to the resulting tunnel.

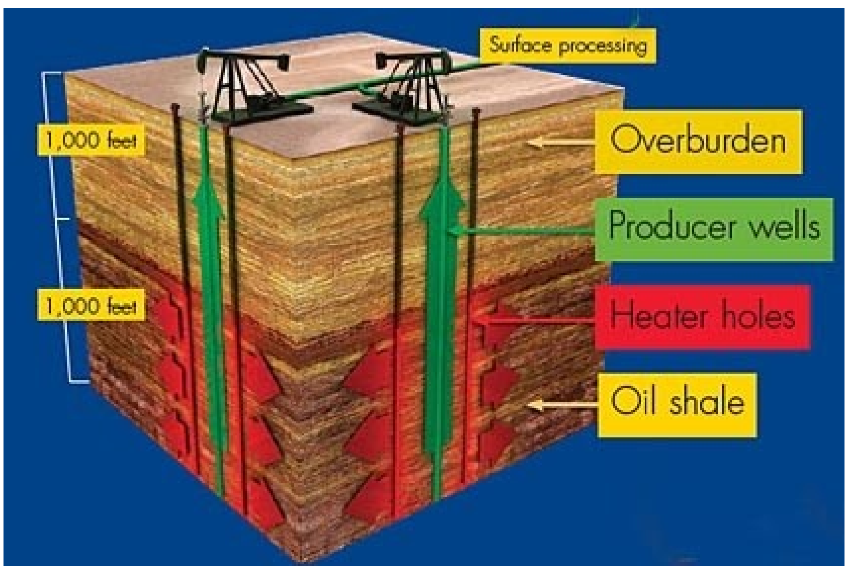
By the way, this has not been used to create the network of tunnels under this country in an idea beloved of some, it has been demonstrated. Not with a nuclear source, but with more conventional heating, Los Alamos drilled drainage holes at the Tyuoni pueblo plaza for drainage in 1973. A total of eight drainage holes were drilled at this archeological site in the Bandelier National Monument.

> The first significant step in the Subterrene technology transfer program occurred when eight water drainage holes were melted with a field demonstration unit at the Rainbow House and Tyuonyi archaeological ruins at Bandelier National Monument in New Mexico in cooperation with the National Park Service. By utilizing a consolidation penetrator, the required glass-lined drainage holes were made without creating debris or endangering the ruins from mechanical vibrations.

At around the same time Dr George Clark, at what was then the University of Missouri-Rolla (now Missouri University of Science and Technology) had used ceramic electrical heaters in rock to raise rock temperatures enough to fracture and break out blocks of granite.

Field tests have therefore been able to take rock up to temperatures that are high enough to melt rock, using electrical heaters placed in holes in the rock. Which is a good introduction to the Mahogany Project in which Shell have been using electrical heaters to heat oil shale in place, to high enough temperatures that the kerogen transforms into a light oil. The investigation has been going on for some 25 years starting in the laboratory, and has progressed through an initial field trial.

Small holes are drilled down through the rock to house the electric heating coils, which slowly raise the temperature of the rock to between 600 and 750 deg F, at which temperature the kerogen will convert, depending on what is there, to a mixture of light oil and natural gas. These fuels can be recovered by drilling conventional wells into the rock, with typical depths at the test site being in the 1,000 to 2,000 ft range.

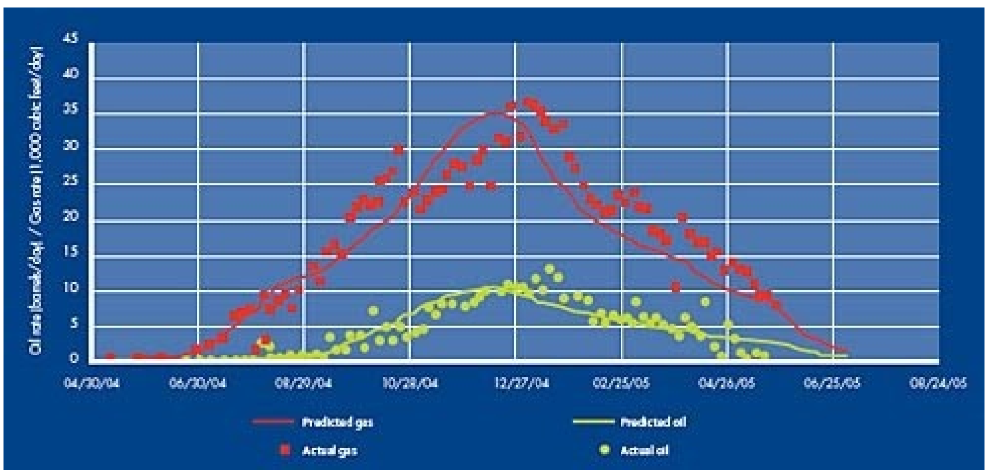


The Shell Mahogany Technology

The field trial placed heaters in a grid over a 30 ft by 40 ft test area and found that a third of the volume produced was natural gas was produced from the lower grade layers of the shale above the layers with the highest concentrations of kerogen (the Mahogany layer) which produced the light oil.

[Array of heaters](#) at a Shell test site

A total of 1,700 barrels of the light oil was recovered during the test period.



[Production from the Shell test wells](#) in oil shale

While the Bureau of Land Management has approved further sites for tests, the program is waiting to see what happens to the price of oil to determine whether or not the program will be sufficiently economically viable to move forward. At present this decision is anticipated to be in the middle of this decade, by which time it may be a little clearer whether the Cornucopians or some of the rest of us have been more accurate in our predictions on the future availability of sufficient oil to meet global demands at an affordable price. But it is the level of that affordable price that will decide whether the oil shale program is viable.

The costs of the project will not just have to cover the heating of the rock. One of the problems with the site is that there is some migration of water through the rock, and this can create two problems. The first is that it pulls heat away from the transformation process and the second is that it can interfere in the overall process itself. To stop the water flow (and concurrently the risk of transformed oil and gas migrating away from the collector wells) Shell has been looking into building an ice wall around the site to hold the water back.

Ground freezing is growing more popular as a tool for dealing with water underground. It has been used, for example, to stabilize the ground while the Boston Big Dig (the Central Artery/Tunnel project) was built and in stabilizing the ground for some of the underground stations in the London Tube network (including the collapse of one of the excavations). It has been used to hold back the water while uranium ore was mined at MacArthur River. Simply described, a dual pipe system is placed in vertical holes, and a freezing solution (usually a brine) is circulated through them, lowering the temperature of the rock to the point that the water freezes. Since the lowered temperature is distributed around the holes, there is no need to intersect any of the fractures, or voids, and the frozen water also helps to strengthen the rock where needed.

For the Mahogany Project test, which began in 2007, the freezing liquid was ammonia, and the test used a pattern of 157 holes drilled eight-feet apart, to a depth of 1,800 ft. The test removed the groundwater from within the well, but did not heat the rock to produce the oil and gas.

It will be interesting to see how this project turns out. It has been suggested that the technology would need a dedicated power source of some 1.2 gigawatts, in order to yield a production of 100,000 bd. Shell estimates it will yield 3-4 energy units for every unit consumed.

Layout of freezing pipes for the Shell Mahogany tests.

As usual with these technical posts, they can only briefly outline a process, if something is not clear please ask in comments, or if there is more information available, we all gain from reading of it.