The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk: Oil Shale, a Future Source of Oil?

Posted by Heading Out on February 14, 2010 - 8:58am
Topic: Supply/Production
Tags: oil shale, oil supply, tech talk [list all tags]

One of the large numbers that is often quoted in response to the concerns that some of us express over future energy supplies relates to the amount of oil that is present in oil shale. However, there seems to be a general consensus among many that write about world energy, that the 2 trillion barrels of oil potentially available out of the 4 trillion barrels locked in the United States oil shales are not, at the present time, a realistic source of supply. So for the next couple or more weeks these weekly tech talks will be discussing oil shale. The Federal Government is reviewing the leasing process for these lands, and so it might be timely.

To read previous posts in this series of tech talks, click here.

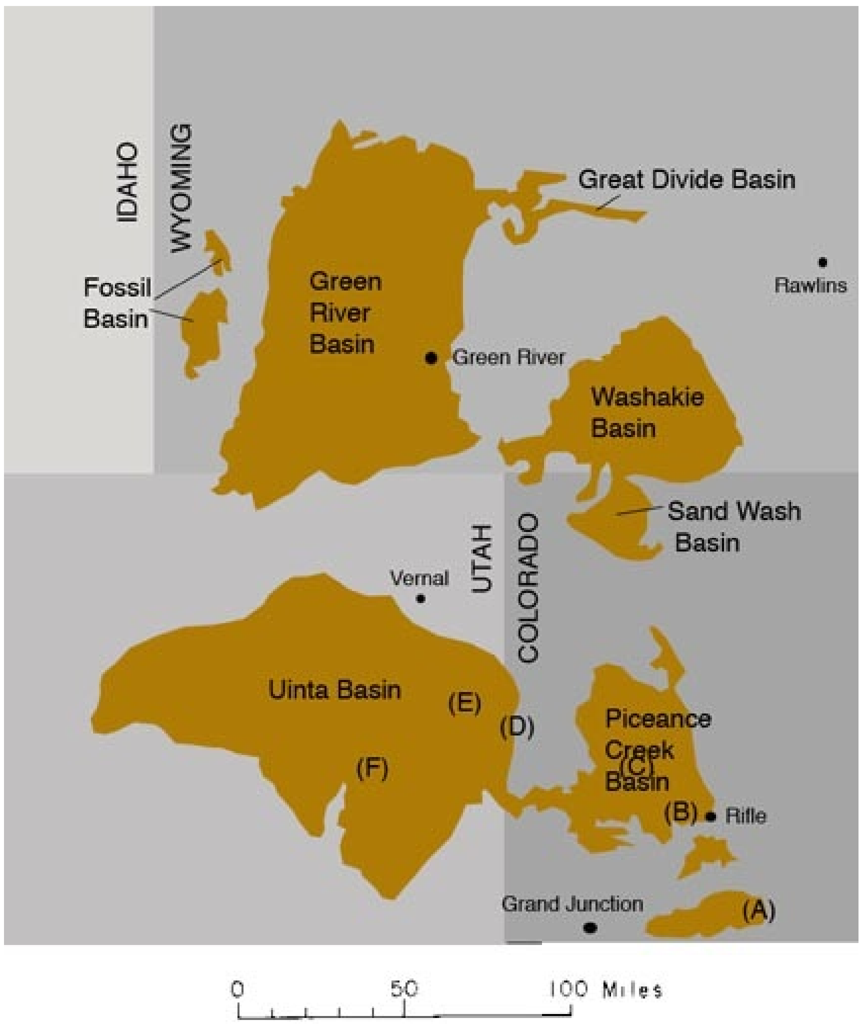
After an eleven year hiatus, Colorado School of Mines reactivated their annual Oil Shale Symposia in 2006, and has been hosting them since then, with the last one being held last October. And the resource is not quite the nonentity that it may at first appear.

> Japan started oil production at Fushun in 1929, and developed, in less than ten years, the world's largest oil shale industry. Shale oil was a principal source of fuels for Japan during World War II. Fushun production continued to expand under Communist China and may be 40,000 bpd presently.

That quote was from a paper in 1964, more recently the USGS have noted an annual production of around 415,000 barrels. it is therefore justifiable to take a little closer look at this whole issue and try to explain some of the technical state of affairs, point out a little of the disingenuousness of some of the statements that have been made, but largely leave the political discussion to others. I will largely, at least initially, deal with deposits in the USA, though there has been a significant industry in Estonia since 1916, though the deposits are anticipated to be exhausted within the next 30 years.

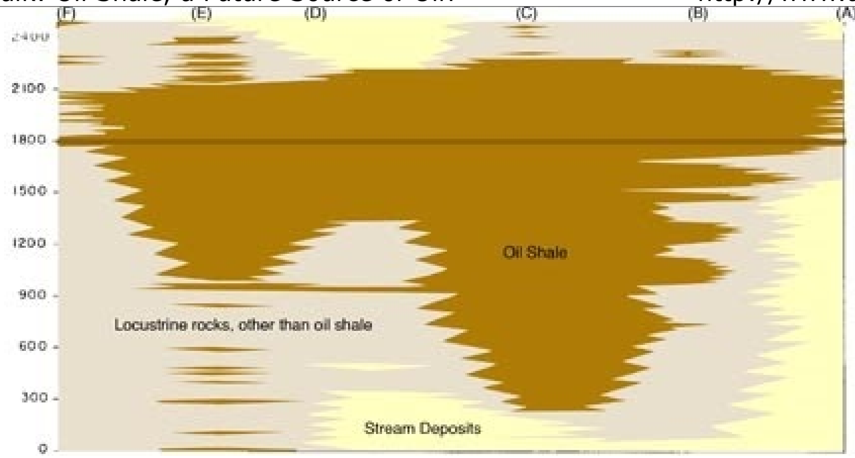
Unfortunately the last time that a serious look was taken at the US resource was back in the 1970s and 1980s, when at one time, under the Project Independence Blueprint, a shale oil production target of 1 million barrels of oil per day was projected, in line with President Ford's State-of-the-Union Message of 1975. That program, in turn, was based on the considerable amount of research that had been carried out, both in the US, and abroad, and on an initial evaluation of practical means to meet the target. But before one looks at that target, and its feasibility, perhaps it is better to look a little more closely at the information which led up to the prediction.

To begin with, while the basic definition of an oil shale suggests the fine-grained rock that is often called shale, and implies it is impregnated with oil that might be easily recovered, unfortunately, in most cases the rock is not a shale, and the organic material that it contains is not yet an oil, and will not run out or separate out with normal treatment. It has been described as a precursor to oil, in that, it was initially formed in the same way, but has not undergone the natural high-temperature and pressure regimes of deep burial in the earth that are needed to turn it into oil. (However, if additional kerogen were to be added to the shale it would through time more likely end up as a coal.) The material is known as a kerogen, and to date the most successful method of removing it from the rock has been to heat the rock until the contents volatize, and then to condense the hydrocarbons back out (in the same fashion that one cracks the oil in a refinery - though there are some significant differences that I will get to later). However, since the initial natural process was not carried as far as with oil, then the amount of energy that is required is generally greater. The greatest deposits of interest are those found in relatively thick deposits around the point where Wyoming, Colorado, Utah, and Idaho come together.



From Donnell, 1st Oil Shale Symposium, 1964. Location of the major oil shale deposits.

A section through the lettered points in the above figure gives:

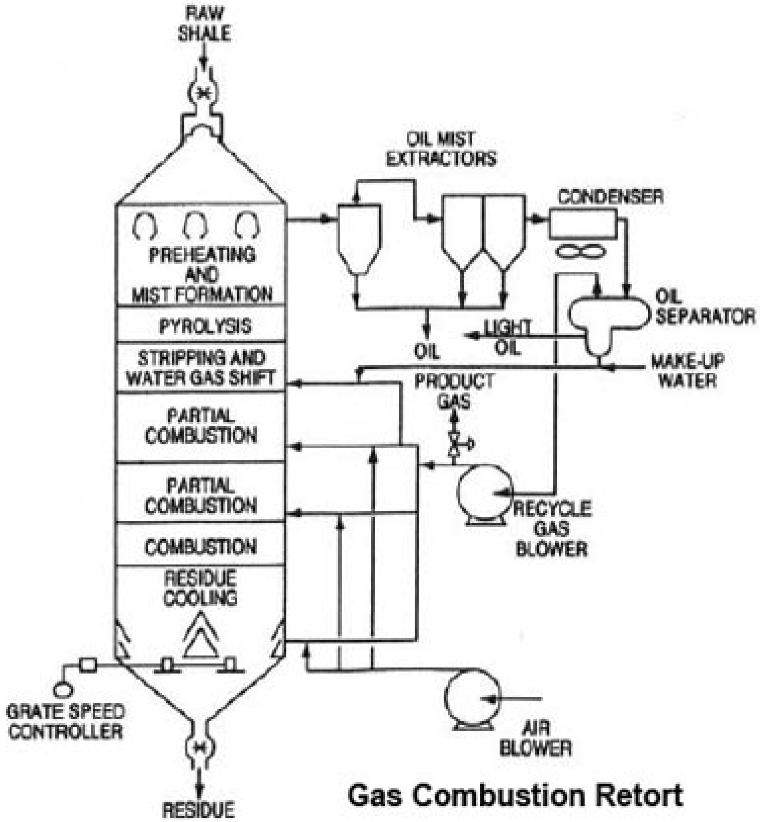


Note that the scale for the vertical section is in feet.

The darker band shown is known as the Mahogany zone in which the Mahogany bed some 100 - 200 ft thick, is considered to be the richest layer, and is a marker for the deposit.

> In oil shale from the Mahogany zone of the Green River Formation in Colorado, the ratio of oil yield to organic matter (weight percent) is 0.659; the ratio of oil yield to organic carbon (weight percent) is 0.818; the ratio of organic matter (weight percent) to oil yield (gallons per ton) is 0.580, and the ratio of organic carbon (weight percent) to oil yield (gallons per ton) is 0.467.

Shale oil has been used as a fuel source in a number of countries around the world, over the past 150 years, but only become of economic significance in the 1920s, as noted above. There have been over two thousand patents issued describing different ways to separate what, for convenience, I will call oil, from the shale (similarly called). Only a few have, however, been demonstrated, and later in this series of posts I will explain some of the peculiar problems that arise in retorting oil shale. But, as an illustration of the type of process that could be used, I will describe the Gas Combustion Process, as developed by the US Bureau of Mines for one of its original experiments. I thought it would be useful to describe this in a little detail, since it points out some of the potential benefits that can come from retorting the material.



Early Oil Shale Processing Retort ([DOE](#))

The retort can be simply thought of as a vertical pipe with the raw shale fed into the top. As it moves down through the retort it passes through four zones. At the top of the retort the shale is cold, and the gasses rising from the lower parts of the process mix with this shale. This has two effects: it pre-heats the shale as it drops into the next zone, while at the same time the oil is condensed into a mist, and the product gasses are cooled. (They are both then collected as they leave the retort.) As the shale continues to move down the retort it reaches, about half-way down, a series of ports that inject air mixed with a portion of the produced gas that has been collected (call this the dilution gas). These two combine to cause ignition and to raise the temperature of the shale (to between 700 and 950 degrees F) so that the hydrocarbon contents vaporize and create the oil and gas combination that rises up out of the retort.

The shale residue continues down the retort, where it is now used to pre-heat a second supply of the collected gas (known as the recycled gas) that is moving up into the retorting zone. This cools the shale as it heats the gas, and the shale residue can then be collected and moved away. By using this form of heat transfer during the process, a relatively high thermal efficiency can be achieved, and the retort can produce about 90% of the original oil in the shale, as well as a secondary volume of gas, beyond that needed to energize the retort. The retort has been shown able to handle shale particles ranging in size from 0.25-inch to 3-inch. By design, it is possible to make sure that the oil mist that is the major product does not condense onto the shale particles that are being fed into the retort. You may note that this separation process does not require any additional external fuel, nor the addition of water to the process.

Using a slightly different method Union Oil Company ran a demonstration plant that ran at rates up to 1200 tons/day, using oil shale from the Piceance Basin. The crude produced was "a waxy, intermediate gravity, high nitrogen and intermediate sulfur crude" where the wax was removed and separately cracked, and the sulfur and nitrogen levels lowered before it could be considered a "commercial shale oil" with properties similar to that of a high quality Utah crude. A feed of crude shale oil at 26,900 b/d would yield 25,000 bd of commercial shale oil, and 500 t of green coke. The oil could then be cracked into 380 bd of lpg; 13,635 bd of gasoline; 1,300 bd of stove oil; 6,700 bd of diesel and 590 bd of fuel oil.

As I said at the beginning of the post, there is an awfully lot of oil shale in the United States. The beds can reach up to 2,000 ft thick, and the oil content can reach 90 gallons/ton. Unfortunately these do not occur at the same time. Rather the highest grade is found in relatively narrow layers in the Uinta Basin, although the oil-shale sequence in the area can be up to 1,200 ft. And unfortunately not all the oil in the shale is made up of the same material, or has the same sort of properties. This can lead both to difficulties both in mining and in retorting.

I will discuss those, and the issue of in-situ retorting, and some of its problems in the next post. But, given what happened, it is perhaps appropriate to close this first post with a comment by Harold Carver of Union at the first symposium.

> It should be quite obvious that if imports to the coastal states and from Canada suddenly increase disproportionately after a shale industry is started, the embryo shale industry would be placed in a severe competitive bind. Unlimited cheap foreign crude imports would make shale oil as well as a large percentage of domestic crude oil production non-competitive. What is needed is assurance that shale oil production will face a stable economic environment in which it can share in the spectrum of raw materials for our future energy needs.

Given what happened later that was quite visionary.

SOME RIGHTS RESERVED This work is licensed under a Creative Commons Attribution-Share Alike 3.0 United States License.