The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk: Conventional Mining of Oil Shale

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So, there we have all this oil, sitting in these nice thick oil shale beds out West and just waiting to turn some local in Colorado into the next "world's richest person". All they have to do is to figure out how to get the oil out of the ground cheaply enough to make money from it. (And if you remember from the last post on the subject there are over 2,000 patents on ways to do this - if it were that simple there would not be nearly that many). Congress thinks so too, since the Energy Policy Act of 2005 called oil shale a strategically important domestic resource (pdf file). More recently, there is currently a House bill in Committee governing oil shale development.

This is another in a series of Sunday tech talks.

What's the big deal? Drill a hole down there and it flows - isn't that how you get oil out of the ground? Well not in this case. As I said last time the oil is really a waxy kerogen that does not want to flow at all. And there is also a problem with the rock. About 40 years ago a guy called Brace (Ref 1 - sorry I can't find these on the internet) found that the cracks in a rock are related to the size of the grains of the material that make up the rock. A rock with large grains has large cracks, and this gives it a permeability, which is the joining of these cracks to give a path through which oil (or water or gas) can flow through the rock. It also gives the rock its porosity, which are the holes in the rock into which the oil can collect. Unfortunately the grain size of the average particle in oil shale is around 5.8 microns. This is about a tenth of the thickness of a human hair, medium human hair being about 60 - 90 microns wide. As a result the typical oil shale has very poor porosity, and it is only when it has a high oil content (above 50 gallons/ton) that permeability can be easily measured (Ref 2) , below 20 gal/ton it becomes very difficult, because it is so small. The average grade is around 25 gal/ton.

The simple message from those numbers is that oil will not normally flow into any holes that are drilled into oil shale. So where do we go from here? Well if you can't go to the mountain, then the mountain must come to you. In other words, let's mine the oil shale, bring it to the surface, and then get the oil out of it.

That's what they do in Canada with the oil sands, and these beds are thicker. In fact the layers are thick enough so that they can be mined by a number of different ways , including surface mining, what we call room and pillar mining, and then by a third method that I will, for now, call sub-level stoping. Remember that we need to break the rock down into pieces no bigger than 3-inches in size for the retorts.

Union Oil (now Unocal) used the room and pillar method for their mine at Parachute Creek, where mining interest had, for a while, been growing again. Room and pillar mining was also used for the Colony Mine, which was the largest project in hand back in the 1980's . Since there have been a number of reasons suggested for the closing of that project, it might be appropriate to ask you to remember the words I quoted from Harold Carver last week.

> 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.

And then read on:

> Tosco's interest in the Colony project was sold in 1979, and again in 1980, to Exxon Company for the Colony II development. Exxon planned to invest up to $5 billion in a planned 47,000 bpd plant using a Tosco retort design. After spending more than $1 billion, Exxon announced on May 2, 1982, that it was closing the project and laying off 2,200 workers. . . . . . The economic incentive for producing oil shale has long been tied to the price of crude oil. The highest price that crude oil ever reached -- $87/bbl (2005 dollars) -- occurred in January 1981. Exxon's decision to cancel its Colony oil shale project came a year and half later, after prices began to decline and newly discovered, less-costly-to-produce reserves came online. . . . . oil had become plentiful, with about 8 to 10 million barrels per day in excess worldwide capacity, and the trend in rising oil prices had reversed after early 1981.

The failure, in short, at that time became one due to economics, rather than technology.

Using a machine to mine the oil shale poses some problems, since it is much stronger than, for example, the tar sands of Alberta, that can be scooped up with a shovel. Rather the rock has a strength that goes down as oil content goes up to a value of about 13,000 psi with an oil grade of 30 gal/ton, at which point it stabilizes even as the grade continues to increase. This means that the openings for mining can be quite large, as they need to be to achieve the tonnages planned. And there are ways to make them larger.

Rooms mined with the rock were some 55-ft wide, with 58-ft pillars. It also means that the machines to grind the rock from the solid will need, either to be jet-assisted, or of relatively large size. One of the first proposed (for you EROI fans) was designed to produce 17,500 tons per 2-shift day, with an oil content of 40 gal/ton, and with 6.5 operating hours in a shift. Machine power requirements would be 37,500 kwh per working day (Ref. 3).

The advantage of the large mining machines, over drill and blast methods, which remain the most common practice, is that the operation is continuous, with rock being carried away by conveyors, and production need not stop to ventilate away the products from the use of explosives. On the other hand the use of explosives to fragment the rock does provide a relatively effective way to fracture it (though with less size control). One of the questions that I have always had, though, in doing EROI on explosive use is whether to count the energy input as that required to make the explosive, or that liberated when it is set off.

In the days when the industry was last planned, the throughput for single plants was considered to be on the order of 100,000 tons/day. A ton occupies 16 cubic feet (Ref 4) and so if the mine is 30 ft high, a cubic foot of floor space would have 2 tons of rock on it. This would translate into having to mine 2.5 acres of rock per day. The point has been made, however, that underground mining of layers of rock one slice at a time down through the deposit would be inefficient and energy intensive. Further that it would be restricted only to mining the high grade layers.

> The matter of mining, by underground methods, the rich, deep oil shale beds in the center of the basin probably needs little consideration because better methods of producing the resource appear to be at hand. If our civilization has any conscience and if it has any regard for posterity it cannot give serious consideration to any method of production of shale oil from the center of the basin that does not result in substantially complete recovery. Our civilization has passed the stage in which it can kill the whole buffalo merely to consume the tongue and liver as was done in this area less than a century ago.

What he is arguing against is the intent to set up the mine to mine out the rich layers, so that when our grand-children have to mine the rest they must work in the dangerous conditions of a partially mined volume, with only the poorest grades of shale as a reward.

In contrast he argues that the area should be strip-mined since even with a 1,000 ft cover, the thickness of the oil shale would justify the process as a means of recovering the entire volume of oil from the deposit. Part of the problem comes, of course, not only from the fact that a hole a mile in diameter and 3,000 ft deep has been created, but that also all the material that has been mined, has to be stored before being returned. And this is one of the significant problems that mining the deposit either by strip mining or by underground mining generates, that of the waste volumes and condition.

For a long time mining has used some of the waste rock that has been mined to pump back into the mine and fill the holes left. By mixing a small amount of cement with the rock powder it can be made strong enough that the rest of the valuable ore can be mined, and the roof is held up by the newly placed columns. However, when you mine and mill the rock it is broken into small pieces. These bulk in volume by about 60% on average, over the original volume of the rock, and so even with the use of the mine to put back some of the rock there will be about 40% of it left for disposal somewhere else. (Note that this does not include the thermal swelling that occurs when the rock is heated - I will get to that in a couple of posts).

But it should be pointed out that there is already some 50-odd years of experience in dealing with this waste in the area, and while I am not familiar with the problems and their solution, the general mining practice with waste fills is ultimately to cover and seed them so that there is a binding vegetation - unfortunately this, as with some of the other parts of the extraction process, requires considerable water, and that is an issue that we haven't reached yet. But, on the other hand, we don't seem to hear much about the piles that already exist.

Again I am going to pause here, since the post may otherwise get too long, but next time I will talk a little bit about the nuclear option, which might otherwise be forgot.

Ref. 1 Brace W.F. "Dependence of Fracture Strength of Rocks on Grain Size," 4th Symposium on Rock Mechanics, Penn State, 1961,

Ref. 2 Thorne H.M. "Bureau of Mines Oil-Shale Research", First Symposium on Oil Shale, CSM, 1964.

Ref. 3 Hamilton W.H. "Preliminary Design and Evaluation of the Alkirk Oil Shale Miner," Proc. 2nd Annual Symposium on Oil Shale, CSM, 1965.

Ref. 4 Ertl T. "Mining Colorado Oil Shale", Proc. 2nd Annual Symposium on Oil Shale, CSM, 1965.