Earth's physical resources: extracting coal & oil

Oil in sand and shale

Geoff Brown

These are the Athabasca Oil Sands, one of the world's largest deposits of oil of any type. Every hour, thousands of tons are extracted by ship-sized machines and sent off to the processing works. About 30% of this pile is bitumen, coating the sand grains, and the enormous works is designed not to refine oil, but merely to extract it. This is done in huge steam-filled tumbling drums. The oil sands reside in the drums for about 15 minutes, reaching temperatures of 200°, and gradually the bitumen loosens off the sands. Stones and sand come out at one end and crude oil from the other, but the investment to get this crude oil is enormous. Plants like this cost billions and the amount of processing energy involved is only marginally less than the energy value of the oil produced. But here it works, because the price of oil has been high enough since 1974 for these huge reserves to be extracted economically. There are other substantial reserves of oil sands elsewhere in the world, but there's another potentially important source of oil which occurs in solid form. This is Colorado. These valleys and maces are carved out of this rock. It's finally laminated on a sub-millimetre scale and it consists of brown, muddy bands interleaved with paler, salty, quartz bands. Now, late last century, workers building a railway through this wilderness used rocks like this to surround their fireplaces and they found something quite unexpected. Rather than preventing the camp fires from spreading, they'd actually found rocks that burned. So what those workers had discovered, unwittingly, was one of the world's major oil reserves: the oil shale's of the western United States. In late cretaceous and early tertiary times, a vast inland lake covered the area, which now represents Wyoming, Utah and Colorado, and here lake deposits laid down an 80-metre thick layer of oil shale's, now preserved in two basins. They're capped by limestones, but the whole deposit consists of very fine layers. The thin layers are thought to represent annual variations in the depositional conditions. The dark layers, in fact, are very rich in organic debris, the remains of plant life which flourished in and around the lake during hot seasons. And the paler, silt layers represent sediment washed in from the surrounding land masses during rainy seasons. Now, the organic matter in the sediment probably makes up about 15% of the volume, and it's mainly in the form of long chain sapropelic hydrocarbons of the type that we find in liquid crude oils. Now, how do we get a useful product out of this material? This is all that remains of the first attempt to mine oil back in 1919, but since then research into extraction has continued here and in other places. In Parachute Creek, in the 1960s, for the first time modern equipment was used to mine oil shale's underground and bring them to the surface for retorting. It takes about a ton and a half of oil shale to produce a barrel of oil, so the scale of mining is vast. This is still only an experimental retort which worked for a few years back in the 1970s, but what they did find was that they could get oil. But this plant and other attempts have been hindered by two problems: a simple case of economics; and complex environmental issues. The whole of this valley was required for waste dumping by just one of the smaller proposed mines. Thousands of acres would be needed if surface retorting ever becomes a reality. Barren land is common in Colorado, but water isn't. The planned processing plants required water supplies on a huge scale and they're simply not available in this semi-desert. So other methods of producing the oil shale's have been tried, and the first successful venture lies on the Colorado/Utah border, where Geokinetics Corporation are trying a novel method of in-situ retorting. The oil shale's here are close to the surface and are flat lying. A series of boreholes is drilled in rows across the large tract of land, deeper at one end than the other. Timed explosive charges break up the oil shale, leaving lumps with voids between them; therefore the reserves are now permeable. Air is pumped in at the shallow end and a fire-front started. The first moves through the shale, liberating oil in advance of its passage. This oil trickles down the sloping base of the retorts and collects, and is then pumped to the surface. That's the theory, but what does it look like in practice? This is one of two working retorts. These are the air-pipes which force air in at one end of the retort, down into the expanded oil shale under considerable pressure. The fire-front would have been lit some months ago and is working its way slowly across the retort area, metres below the ground. And at the other end is oil.

Jim Lekas
This shale oil that we're producing here today represents a number of firsts in the history of the state of Utah. Geokinetics is the first company ever to produce significant quantities of shale oil; we're the first company ever to sell that shale oil to a refinery and pay royalties to the state of Utah; and this oil is the first synthetic fuel produced, refined, and marketed within the state. At present, this is the only significant production of shale oil in the United States.

Geoff Brown
So the technique works, but at the moment it's not fully commercial. To improve the yield of oil, many more retorts will be needed. A variety of different environmental problems also needs to be solved, but at least the principle of in-situ retorting has been proved. Using the Geokinetics process there's no problem with water shortage, because during the process water is actually produced. Oil shale production on a commercial scale is being attempted only in the United States, but there are other reserves elsewhere in the world. For instance, back at the turn of the century, Britain had a thriving oil shale industry in the Midland Valley of Scotland, but cheaper supplies from conventional sources made these uneconomic, as has been the case with most attempts to win oil from shale's or sands.