

shale oil is derived from kerogen by heating the rock to a high temperature, a process known as retorting. The two major approaches for extracting oil from shale are (a) retorting of mined shale and (b) *in situ*, or underground, retorting.

First as to retorting of mined shale, the potentially commercial oil shale contains inert rock in the range of 80 to 85 percent by weight. This means a relatively large volume of rock must be mined, crushed, passed through a retort vessel, and heated to temperatures sufficient to break down the kerogen and produce raw shale oil.

With regard to *in situ* retorting, we have here a process whereby the oil shale would be heated underground to break down the kerogen. The hydrocarbon vapors generated in the form of raw shale oil at the surface. This process would eliminate the mining, crushing, and disposal of large volumes of rock. To date, however, the possible application of the *in situ* process is based mostly on theory, and little has been proved regarding practicability. There has been much talk in government and industry about utilizing a nuclear blast to create a large underground zone of broken rock. This rock would then be heated in place, and the shale oil recovered at the surface. The nuclear concept is dramatic, but we believe the possibility for development of a practical system is remote.

Even though the *in situ* process provides desirable objectives and will continue to attract research attention, we believe that the mining and retorting approach offers the best promise for the development of a shale oil industry in this country.

After retorting, the complex process of upgrading still remains. The raw shale oil is not a suitable refinery feed-stock; it must be converted to a synthetic crude oil by adding hydrogen and by removing the undesirable elements of nitrogen, sulfur, and oxygen. The upgrading operation requires elaborate high-pressure and high-temperature equipment.

Now, turning to the role of private industry in this effort, many companies have made significant commitments of capital and technical resources for the development of an oil shale industry. One example is the retorting research operations financed and conducted by several companies, including my own, at the Bureau of Mines experimental facilities in Anvil Points in Colorado.

Humble has been engaged in land acquisition and research program for several years. We have spent more than \$15 million on oil shale since 1963. I would hazard a guess that in recent years private industry has spent over \$100 million in similar efforts. But even more important, private industry has demonstrated that it is capable of and willing to finance and conduct the necessary research and development to bring shale oil into commercial production.

The Senate Antitrust and Monopoly Subcommittee recently concerned itself with questions of monopoly and antitrust in connection with development of the federally owned oil shale deposits. Although this concern is understandable, the Mineral Leasing Act of 1920 contains provisions which insure against the possibility of a monopoly. The act provides that no lease can exceed 5,120 acres and that no person, association, or corporation can hold more than one lease. Considering the large amount of public land involved, it is difficult to