THE STATUS OF THE OIL SHALE PROBLEM

ORLO E. CHILDS

Much has been written about the oil shale deposits of eastern Utah, western Colorado, and southwestern Wyoming. These deposits have been referred to as the largest undeveloped oil reserve in the world. Frequently the reader of oil shale reports is cautioned by the observation that the rock is not really shale and that the organic matter within the rock is not really oil. This basic fact, though often repeated, is also often forgotten; and erroneous conceptions creep into the basic assumptions made during discussions of the problems of oil shale development. The oil shale deposits of Colorado, Wyoming, and Utah are lake-deposited sediments that covered approximately 16,000 square miles. The calcareous muds of the ancient lake floor have been lithified into marlstone, and the organic substance within is in the form kerogen. Although layered in structure, marlstone does not break readily along the layers nor does it possess any natural porosity or permeability. On the outcrop, the marlstone is broken into block-like masses by frequent fractures. Although the system of fractures together with irregular dissolved openings allow some permeability, these important characteristics can be expected to vary greatly from one place to another in the basins. Within the Green River formation, the thickness of oil shale also varies. Along the Green River outcrop, the thickness of the important oil shale interval can be traced from a few feet to well over a hundred feet, and within the basin, wells that have been drilled for oil and gas have penetrated thicknesses up to 1,900 feet. The change in thickness, however, is regular, and within the Piceance Basin where most is known about oil shale there is confidence in expecting certain thicknesses at a given site. In the studies that have been made of the Green River formation, the beds of oil shale are contained within a lower and upper interval of maximum values with an intermediate interval of lesser values. The upper beds have been called the Mahogany zone. If all of the oil shale deposits containing 25 gallons per ton or more are considered, there exist perhaps 600 billion barrels of oil to be derived from marlstone and its included kerogen. If the lower values of 10 gallons per ton are considered, there exist no less than two trillion barrels of oil available, or 25 times the total produced to date within the United States. Perhaps 15 percent of the available petroleum lies within lands either owned or privately leased to companies. The great bulk of deposits lies beneath Federal land and the

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President, Colorado School of Mines.

availability of this land for development is locked in indecision. Although much is known about the technology involved in the retorting necessary to convert kerogen to oil, many consider that this technology is incomplete. Thus, an important need for further research is commonly recognized by those who contemplate the early existence of an oil shale industry. With indecision clouding the availability of lands, with technology considered as incomplete, many consider an accurate assessment of economics as imponderable. Any analysis of the present status of oil shale development must consider the land, technology, and economic problems which face us.

There are many unpatented mining claims which date back to the period before 1920. There are also patented claims which exist around the periphery of the basins where the oil shale outcrops and along stream valleys within the basin. The Federal government owns perhaps 72 percent of the total land beneath which oil shale can be found. Many individually owned tracts of land have passed into the ownership of companies. Since 1920, additional mining claims and the leasing (since 1930) of oil shale have been withheld by the Federal government. However, some areas of the land have been leased as oil and gas leases and, there is now in fact surface production of oil and gas already established under oil and gas leases. Some of this production is undoubtedly from the Mahogany zone of the Green River formation in the subsurface, and eventual multiple-use problems will be introduced should these lands ever be made available under leasing for mining or subsurface retorting in place.

With so much of the known oil shale deposits in government ownership, it has been felt by many that an oil shale industry would not come into existence until a policy was established which would assure oil shale operators of the future disposition of Federal lands. Many people in government and advisors chosen to counsel with government have been considering whether or not this federally owned land should now be made available through leasing. The decision of whether or not oil shale lands are to be made available by leasing is not a simple one. There is even a question as to whether this decision will remain an executive one or become a legislative matter. Whatever the outcome, there will be required broad new basic objectives and policies within government. Recently, the Advisory Board on oil shale to the Secretary of the Interior suggested the following objectives for any new Federal oil shale policy. "(1) To encourage the advancement of the technology of shale oil extraction and the development of a competitive shale oil industry. (2) To encourage wide industry competition and initiative in the development of techniques of mining and recovery. (3) To establish conservation goals and standards for the recovery of the oil shale resource, for the protection of other values in and adjacent to oil shale lands, and for the protection of

public health and related values. (4) To prevent speculative use of leased Federal lands to the detriment of oil shale development. (5) To provide for reasonable revenues to the Federal and State governments from the use of Federal shale lands. (6) To set up whatever Federal program may be decided upon in such a way that it can be administered effectively."

The attitude of many people within government and of many advisors to government seems to be firmly based on the concept that if an oil shale industry is to come into being. it must be a private industry. Opinions vary as to how the development of an oil shale industry might be best stimulated . These opinions vary from one position — that of not making further oil shale lands available — to the opposite extreme of making leases available immediately. The need for further research and further information regarding oil shale is a common factor in the thinking of most people. Those who say oil shale lands should not now be made available base their contention upon the need for extensive research both as to the processes and as to the costs of shale oil production. They call for active research performed by government or government contracts with private organizations for the purpose of establishing complete information regarding the value of oil shale land. The proponents of this approach insist that an extended period of active research would provide sound conservation standards and practices in the extraction of oil shale and at the same time determine the fair market value of oil shale leases; thus, establishing a more precise knowledge of value as a prerequisite for the detailed aspect of leases. They insist there is enough oil shale now in private holdings that this policy will not retard the start of a new industry.

Others propose, and I am in agreement with this proposition, that the Federal government should open selected lands to private leasing upon either the application by interested companies or upon the government's own initiative. This leasing would be carefully controlled, and tracts would be made available for competitive bidding only. as companies make application for specific areas to be put up for bid. Leasing would carry with it firm performance requirements that would make it impossible for a company to hold land indefinitely without developing it, and at the same time it would be impossible to provide specific advantages that might be reminiscent of oil give-away scandals of the past. It seems to me that such an approach, being very comparable to the one now under way off shore in the Gulf of Mexico. would provide the strongest possible incentive to interested industrial companies. Such an approach also would serve to limit the amount of government intervention in the form of tight regulations or threat of production competition. The threat of unknown regulations or the possible entry of the government into production could only retard or eliminate the interest that now exists

on the part of private capital. Some companies have gone ahead with extensive research to determine the processes that are most feasible for developing oil shale holdings. Many companies are working in this field with the anticipation that favorable policies will be established that will continue to make this new industry an attractive one. With all this emphasis upon the value of future research, it must be remembered that it is not possible to do *all* necessary process research and detailed research regarding the geological conditions of a particular land tract *prior to* entering into oil shale development. Research is a continuing need in the process of oil shale development and, therefore, must go hand in hand with the day-to-day problems of development. If the government were to take the position that a certain amount of research is needed before a company has qualified to apply for lease, there is a serious practical problem involved in judging the adequacy of that research. This judgment of adequacy is far more appropriate for the individual company concerned than for an outside organization. Internal as well as external economic considerations faced by a particular company are vital to that judgment.

In the near future, it is hoped that new policies will be established within government which will allow the solution of the many problems which exist regarding the legal status of land holdings and the availability of lands now held by the government. There is truly a period of indecision today, but an area not without hope for tomorrow.

To say that all problems in the technology of oil extraction from oil shale have been solved is an overestimate of present conditions. To say that technological problems are all far from solution is also an overestimate. The kerogen which exists in the marlstones of the Green River formation is of value only after it has gone through processes of retorting. Different systems of retorting have already been studied and perfected. Once oil shale has been mined and crushed, many types of retorts are available. This introduces an entirely new concept in the production of petroleum, when viewed in comparison with the traditional methods of producing oil from wells that have been drilled. The interjection of required retorting makes the development of oil shale akin to expensive production processes in manufacturing. It is a common experience in manufacturing that extensive expenditure of money is needed prior to return on that investment. It is estimated that the mining, crushing, and retorting of oil shale might require an expenditure of perhaps a hundred million dollars to obtain a plant necessary to produce 50 thousand barrels of oil per day from oil shale. This is a magnitude of investment prior to returns which is quite foreign to the thinking and the practice of some oil companies when compared to conventional oil production from drilled wells. The delay of returns on the investment is more common to the practices of mining and manufacturing.

Into this investment also must be worked the plans for conservation which involve an unknown number of dollars. But the problems of handling extensive spent shale from surface retorts, together with the need for protecting the purity of surface and groundwater supplies and the need for protecting the purity of air, all involve unknown but expected costly parts of any planned installation.

Many companies are unwilling to face this kind of costly planning. They feel the future of the oil shale industry is controlled pretty much by the development of successful processes of retorting oil shale underground in place. The technology involved in in-situ retorting and collection of shale oil represents the research area in which progress must be made if some interested companies are going to continue to look for an emerging oil shale industry. Problems in the in-situ method are not simple. It should be remembered the rocks involved do not have any natural porosity, and the permeability is a variable feature depending upon the communication between extensive fracture systems and dissolved openings in the rock. Knowledge in the area of in-situ retorting is the objective of much needed research. Review of the technology of mining, of crushing, or of retorting also indicates that our present knowledge of the state of the art of extracting oil from oil shale is really incomplete.

If oil from oil shale is to find its way into the market place, and if an industry is to spring up based upon the extraction of oil from the deposits of the West, this new industry must face serious competitive forces and important economic limitations involved in that competition. There are still natural reservoirs of oil and of gas that are yet undiscovered in the United States. Although in the past eight years the rate of discovering new natural accumulations of oil and gas has been declining, important new discoveries have been made in recent years. To date, the world-wide exploration and development costs of natural oil and gas deposits occupy a favorable position in competition with the development of oil from oil shale. Oil shale must really be considered as a supplement to natural oil rather than a substitute. In many known fields secondary recovery methods are bringing abandoned oil to the surface. This recovery of additional oil from known structures and known entrapments also occupies a favored competitive position compared with oil shale. Oil is being imported by the United States from foreign oil fields, and the quota of import is an important economic factor as a competitor with possible oil shale development. Any change in the quota of import of foreign oil will have profound effects upon the competitive position of oil from oil shale. Oil is known to occur in tar sands and is known to be a possible derivative of other bituminous rocks. Oil in tar sands stands in approximately the same economic position as oil from the kerogen of oil shales, but the competitive relationship will depend upon future tech-

nological developments of tar-sand derivatives as well. In many places in eastern Europe, oil and gas are developed from the conversion of coal, and although this represents a possible source of oil and gas tomorrow, the competitive position with oil shale is an unknown. All of these competitive sources of oil represent parts of a future economic picture which is not clear; and it is, therefore, very difficult to consider the role of oil shale tomorrow as it must fit into the economic limitations of future sources of hydrocarbon. All of the aspects of the economic climate in which oil shale must find its place must be considered as variable, or perhaps imponderable. In the total energy picture of the United States, perhaps the most accurate position of oil derived from oil shale in tomorrow's industrial picture might best be described as a supplemental role rather than a substitute for known sources today.

The status of the oil shale problem seems to be a forecast of changes that will occur. Expectations are clouded by the indecision of land availability and governmental policy; by the incompleteness in the technology of processes of mining, crushing, and in-situ retorting; and by imponderable economic controls and competition that must be faced by tomorrow's oil shale industry. In the past three years, important progress has been made in all the problem areas. In the next ten years, continued accomplishment may see a new energy industry as a part of the American economy.

Statement made by John R. Donnell, U.S. Geological Survey, after Dr. Childs has left to catch an airplane:

DONNELL: I'm sorry that I didn't have an opportunity to make this comment while Dr. Childs was here. I would like to make a comment on his isopachous map. He stated that the isopach around the margin of the Basin, which was either 50 or 100 feet, represented the thickness of the Mahogany Ledge. He is correct in this statement. However, he did state that the Mahogany Ledge thickened to 1900 feet in the center of the Basin, and he is incorrect in this statement in that the Mahogany Ledge, or the Mahogany Zone, which is the subsurface counterpart of the Mahogany Ledge, is a unit defined on the outcrop. It's a ledging unit which consists of rich oil shale and is bounded both above and below by zones of lean oil shale. As you get to the center of the Basin, it does thicken. However, you still have the lean oil shale boundries both above and below in the center of the Basin. Dr. Childs was referring, I am quite sure, to the total thickness of shale that would average 25 gallons of oil per ton when he stated the 1900-foot section was Mahogany Ledge. I'd just like to insert this in the record.