Our major oil shale reserves are in Colorado, Utah and Wyoming. The areas are well defined and we are confident that the largest reserve is in Colorado's Piceance Creek Basin. Utah has some areas that may be developed at reasonable cost by open-pit mining but much of its oil shale is deeply-buried and cannot be economically produced with technology now available.

Wyoming has only marginal oil shale prospects despite a large area of Green River formation, but additional exploration is needed especially with regard to associated minerals. I will have more to say on these other minerals later.

A figure of 1.744 trillion barrels was given recently for the oil shale potential of Colorado, Utah and Wyoming.[1] This estimate is based on the 15–15 definition (at least 15 gallons per ton in beds at least 15 feet thick) but such a figure is meaningless since much of this oil is not now nor is likely ever to be economically recoverable. Dr. Wayland pointed out in his testimony that only "about 80 billion barrels of shale oil is considered recoverable by demonstrated mining and retorting methods", or less than 10% of the total reserve. According to Dr. Wayland's figures, 21.1% of the reserve is in private hands or a recoverable reserve of about 16 billion barrels.

Eightly billion barrels or even 16 billion barrels is a lot of oil, well worth going after, but these numbers are a far cry from the trillions of barrels that lead people to think in terms of paying off the national debt with oil shale royalties or of the oil shale owners hoarding hundreds of years of oil supply. I am confident that ultimate recoveries of shale oil will be higher than Dr. Wayland's figures but decades will pass before the leaner, less-accessible oil shales become a part of the "recoverable" reserve. Any figures that do not take into account losses and uneconomic low-grade zones are misleading and have done much to confuse the real issues of the oil shale problem.

## THE TECHNOLOGY

I would like to dispose of the subject of technology without involving you in details of the various techniques for producing the oil. The two suggested approaches for the recovery of shale oil are (1) mining/aboveground retorting and (2) retorting in place or *in situ*.

Shale oil has been produced for more than 100 years by mining/retorting and this is the only production method in use today. Russia and China both have sizeable industries. Current research and development in the USA is aimed mainly at improving these earlier mining/retorting techniques and applying modern engineering concepts and equipment to the job. Good results have been achieved, a sound technology is available and we are now in the prototype phase of testing some of our new ideas. This technology can and probably will be applied commerically by the early 1970's.

The *in situ* technique has many proponents, among them:

Oil people who would like to apply their background and experience to shale oil production.

Naturalists who look on mining as a despoiler of the aesthetic value of the landscape.

Proponents of nuclear technology who would like to develop peaceful uses for atomic explosions.

Engineers who think there ought to be a better way to get the oil from oil shale than to move hundreds of thousands or even millions of tons of rock every day.

All have some logic to support their position, but unfortunately research has not yet come up with a feasible *in situ* production method. The reasons are several but prominent among them are:

Oil shale has no permeability or porosity and in most areas little or no communication exists between holes even a few feet apart.

The rock must be brought to a high temperature to form oil before it can be produced.

The oil is waxy, viscous and flows with difficulty at ambient rock temperatures.

The nuclear concept that seeks by a massive explosion to create a rubble zone of broken oil shale is no cinch to work and the efficiency of oil recovery by a

[1] Dr. Russell G. Wayland, Acting Chief, Conservation Division, U.S. Geological Survey, before the Subcommittee on Antitrust and Monopoly of the Senate Judiciary Committee, April 18, 1967.