

for appraising deposits and means of recovering the minerals. Work can be started immediately after authorization on samples now available. It can then be expanded to other deposits by procurement of samples held by the Geological Survey and private companies and by new core drilling.

B. Study the metallurgy of the minerals, devise processes for extracting the valuable ones in conjunction with the production of shale oil, and develop methods for converting the extracted minerals to basic industrial chemicals.

1. Amenability of unretorted oil-shale minerals to chemical extraction. The possibility of recovering the valuable minerals before retorting will be investigated in order to cover all possible facets. Minor effort will be expended here.

2. Determine amenability of retorted oil-shale minerals to chemical extraction. All plausible techniques for extracting alumina and soda from retorted shale will be investigated. Studies will be based on optimum retorting practice for oil extraction to take advantage of chemical and physical properties imparted during retorting. Testing will include oil shale both hot from retorting and cold after storage. Effect of moisture from open storage will be determined.

3. Determine effects of changing oil-shale retorting practice on extracting alumina and soda from oil shale. Optimum retorting practice for oil recovery may not yield the most suitable material for extracting other valuable minerals. Assuming alumina and soda are coproducts with oil, optimum processing for the total system of oil retorting and mineral extraction will be determined. Additional work under this element will include investigation of processing techniques in which, simultaneously, oil will be removed and minerals rendered readily extractable by subsequent chemical action.

4. Evaluate laboratory data and determine most feasible processes. Results of investigations for research phases 1, 2, and 3 will suggest the most promising processing routes. Additional investigations will be required to determine the optimum sequence of operations for processes based on best methods of extracting alumina and soda from oil shale. Optimum process for recovering final alumina and soda products will be based on most economic sequence of operations, not the best means of extraction alone.

5. Develop pilot-plant design data by large-scale laboratory study of the more likely processes. Design and sizing of process equipment and flowsheets will require substantial investigation to establish material and energy balances, materials of construction, and probable effect of recycle streams in large-scale operations. Effective operation under this element will give information to narrow choices of possible processes and give data required for a well engineered pilot plant.

6. Evaluate large-scale laboratory data to choose optimum process for pilot-plant study. This research phase will consist primarily of estimating capital and operating costs for the better processes to select the least expensive for development in pilot plant. Also included will be technical evaluation to expose possible areas of operating difficulty in the pilot plant and to point out areas where additional investigations might provide techniques to lower costs.

7. Design and construct pilot plant. Design of pilot plant will be based on process information provided by research phases 5 and 6.

8. Conduct pilot-plant investigation to develop optimum process for treating appropriate types of oil shale. Pilot plant study will develop the single most promising process and provide a base for possible commercial demonstration efforts. In addition, suitability of process to varying types of oil shale from other horizons as disclosed by concurrent phases of oil shale program will be demonstrated.

9. Final evaluation of pilot plant data. This work element will complete the process-development package by providing accurate estimates of capital and operating costs for a commercial plant and by resolving technical problems uncovered in the pilot plant.

C. In cooperation with geologic appraisals of the deposits under resource appraisal, study the extent, character, and resources of the minerals.

D. Evaluate the economics of commercially extracting the minerals, as well as shale oil, from the deposits and their conversion to industrial chemicals.

Concurrent with part C above, a minor research effort will be conducted as necessary to provide additional information relating to varieties of oil shales disclosed as geologic and mining investigations progress.