

higher primary recovery rates, indicating that this produced water is not all connate, and that the fields are at least in part water-drive fields. Calcite-lined vuggy porosity commonly causes shows in drilling samples to be very difficult to detect in the lower porosity zone. Therefore, if the presence of porosity is indicated in this zone, a drill-stem test is certainly recommended. In many wells, 2½-inch tubing (as opposed to the 2-inch normally employed in this area) and 2¼-inch pumps are required in order to move enough total fluid to attain the oil allowables. However, indicated recovery rates in excess of 200 barrels per acre-foot more than justify the higher resulting production cost.

13. ED L. REED, Consulting Hydrologist, Midland, Tex.

ECONOMIC EVALUATION OF WATER SOURCES FOR WATERFLOODING PROBLEMS

A short history of the development of ground-water sources for waterflooding programs is given. The gradual trend from deep-brine sources to shallower fresh- or brackish-water sources is discussed. A review of the development of the concept of a royalty, or in-place value in acquisition of water rights, is presented. Finally, an analysis of cost data in developing, producing, and transporting water is discussed in relation to present level of delivered prices for fresh and (or) brackish water.

14. G. R. SCHOONMAKER, Marathon Oil Co., Findlay, Ohio

LOOK BEFORE YOU LEAP

Like it or not, petroleum exploration is in the midst of a technological revolution that is spawning whirlwinds of new tools, methods, and thoughts to be evaluated and mastered by the explorationist. The continued sophistication of the abilities and techniques of today's explorationist, as difficult as it is desirable to achieve, will prove an economic boon only when accompanied by careful planning—a look before leaping.

Basically, the explorationist is a businessman applying specialized scientific knowledge to the discovery of profitable reserves. To avoid the costly financial burden and stupefying mental load of seeking new reserves by "brute science," *i.e.*, using every tool and technique extant, he needs a fundamental of any well-ordered enterprise, that of having a working plan for both corporate and personal success. An effective plan of action can not be made until objectives or goals are defined and set. Only then can plans for accomplishment be made, plans that fit the objectives and capabilities of the individual or corporation. Such plans followed by a well-thought-out program, using only those tools, techniques, and mental resources necessary, constitute a "look before leaping" to success.

15. J. M. FORGOTSON, JR., Pan American Research Corp., Tulsa, Okla.

CURRENT USE OF COMPUTERS BY EXPLORATION GEOLOGISTS

Many geologists are beginning to use the computer as an aid in solving exploration problems. The six types of computer applications discussed here are typical of those currently being used.

Industry-supported well-data systems provide large volumes of scout-type data on punched cards or mag-

netic tape which can be filed, sorted, and retrieved rapidly to fulfill specified requirements. The computer also is used to handle large technical data files of individual companies. Micropaleontological data from several thousand wells which penetrated portions of the Tertiary section in the Louisiana and Texas Gulf Coast area are stored on magnetic tape and retrieved by suitable programs, together with related environmental data, for the preparation of isopachous and biofacies maps from which paleogeography may be interpreted.

Correlative electric-log markers or formation tops are recorded on punched card or magnetic tape to allow rapid preparation of structural and isopachous maps using the computer in combination with automatic plotting equipment. Current programs can accept data from wells cut by normal faults and restore to the figures on isopachous maps the thickness of the sections removed by the faults. Maps can be prepared indicating fault patterns, structural data, isopachous values, and isoliths of sandstones and combinations of sandstones. Truncation, onlap, shale-out, and other stratigraphic features coded by the geologist on the input data forms are repeated on printed results and plotted maps to aid in contouring and interpretation. The results of such computations are available in a format suitable for further applications such as automatic contouring and trend analysis.

Computers can be programmed to prepare facies maps from quantified descriptive lithologic information. This use of the computer provides a rapid and economical method of performing the calculations required for a large variety of maps showing various combinations of end members. These maps are used to interpret paleogeography, depositional environments, and trends favorable for the presence of porosity and hydrocarbon accumulation.

Computers are also used for more complex types of statistical analysis, such as factor analysis. By this technique, large numbers of variables can be grouped or clustered into a smaller number of factors, each representing a combination of related variables or samples, retaining essential information and eliminating redundancy. Samples thus grouped into classes or factors have a certain degree of similarity and can be used to define and map facies.

Trend analysis is a statistical technique requiring the use of the computer to separate observed quantitative data into a regional component and a residual component. This technique has proved useful in the interpretation of isopachous and structural maps based on subsurface data, seismic maps, gravity maps, and magnetic maps.

Computer programs designed to compute the gravity effect of a known or postulated structure are useful for interpretation of deep salt-mass configurations. Models of assumed structures can be constructed from seismic or subsurface data and modified until the computed gravity agrees with observed gravity, thus indicating that the final model is a close approximation to the true structural conditions.

16. ARTHUR L. JENKE, Consultant, Abilene, Tex. CASE HISTORY OF CONTAMINATION CONTROL IN HUBBARD CREEK RESERVOIR WATERSHED, TEXAS

The West Central Texas Municipal Water District was created by an act of the Texas State Legislature in March, 1955, with four member cities—Abilene, Albany, Anson, and Breckenridge. Construction of the