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 groundwater 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 magnetic 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

Hubbard Creek Reservoir began in 1962. A single U.S.G.S. hydrologic station below the present damsite indicated that water acceptable by U.S.P.H.S. standards would be impounded. However, an increase in chloride load was noted beginning in 1958 and continuing into 1961. Consultants were employed to ascertain the source of the contamination, inasmuch as the watershed is located in one of the most intensively drilled areas in the nation, with more than 13,000 known holes. The consultants' report, submitted in May, 1962, established that the watershed was naturally clean and that contamination originated primarily from salt water disposal pits, improperly plugged wells, and water escaping to the surface as a result of repressuring by waterfloods.

Remedial work, including plugging leaking wells, a no-pit order for the watershed by the Texas Railroad Commission effective March 1, 1964, the establishment of additional U.S.G.S. hydrologic stations, and a general clean-up by the oil industry significantly reduced the chlorides reaching the reservoir. These remedial measures, however, were insufficient to reduce chlorides entering the reservoir to less than 50 ppm.

A second intensive study was submitted by the consultants in January, 1966, and isolated eight remaining contaminated areas. This study also recognized salt-water charged alluvium as an important source of contamination. These findings were supported by U.S.G.S. data. It was found that 4 per cent of the watershed area contributed up to 40 percent of the total chloride load reaching the reservoir. This area, just west of the city of Albany, Texas, contains numerous shallow waterfloods and very old production dating to the 1900s. As a result of continuing pollution originating here, the Railroad Commission held a "show cause" hearing in Albany in August, 1966, during which operators were given an opportunity to show cause why offending leases should not be shut down.

The results of the consultants' contamination studies in this watershed emphasize that geological responsibility today goes far beyond the search for petroleum reserves. Geologists must be prepared to point out unmistakably to their employers and clients the many potential hazards that lie ahead—perhaps many years ahead—as a result of poor completion practices. These matters are of concern to the geological profession and should be considered definite geological responsibilities whose importance will increase in years to come.

17. MAX E. CURRY, Curry Engineering Co., Midland, Tex.

OLD IDEAS INTO NEW DOLLARS—PREPARATION AND EVALUATION OF REMEDIAL PROBLEMS

The total value of an oil and gas property may be affected greatly by the timely performance of remedial work. A simplified method of evaluating the economics of such work, utilizing the skills and practices of a petroleum geologist, is presented, using actual field case histories.

18. PATRICK J. F. GRATTON AND WILLIAM J. LEMAY, Consultants, Roswell, N.Mex.

GROUND RULES FOR SAN ANDRES EXPLORATION

Interest in the San Andres of New Mexico currently is running at a high level with an average of 8 wildcats and 30 field wells active within the 44 townships of the play. The play centers on the common corner of Chaves, Roosevelt, and Lea Counties. In this general area on the north flank of the Tatum basin and the south flank of the Matador uplift, oil and gas is being found in the San Andres under hydrodynamic conditions where permeability pinchouts cross anticlinal noses. Most of the medium-gravity oil has been found between 3,000 and 5,000 feet in fractured dolomite of the Slaughter zone of the San Andres. Almost all of the 10 commercial San Andres fields in the report area have been found within the last 8 years. During this period the petroleum industry drilled about 150 exploratory wells and more than 550 San Andres field wells. The 10 fields ultimately should yield at least 100 million dollars gross revenues from the sale of oil and gas.

On the average this is 10 million dollars per field, which is the approximate equivalent of 4 million barrels of oil. An average productive well will generate approximately $200,000 gross revenues during the life of the property. This compares with an average dry-hole cost of $30,000 and $55,000 for the average producer.

Because of the very low porosity of the Slaughter reservoir zones, drill-stem tests and conventional logging procedures generally are inadequate to evaluate the San Andres properly. This paper reviews several of the guide lines or rules which should assist in finding and evaluating San Andres traps.

CORRECTION TO CERTIFICATION PROCEDURE NOTICE

Active members desiring certification, who have a minimum of *eight* years' experience in petroleum geology (including graduate study and teaching) will receive an application form, on request, from AAPG Headquarters (Box 979, Tulsa, Oklahoma 74101). The completed form with application fee attached should be returned to Headquarters, where letters from sponsors and references are to be directed.

The complete application file is forwarded to the District Representative, who serves as the local certification committeeman. The file is then forwarded to the Board of Certification for processing. Following thorough research, the file is forwarded to the Executive Committee with an appropriate recommendation. After a complete review of the application file, the Executive Committee awards or withholds certification.

The application processing routine may take 5–6 months, because of the number of persons involved. With certification comes a certificate suitable for framing and the eligibility to lease an embossing seal or stamp.

For details regarding the requirements and procedures of AAPG certification, refer to the April, 1965, *Bulletin*, page 486.

The preceding reprint of the certification procedure is a correction of the paragraph published on p. 2494 of the November, 1966, *Bulletin* which directly quoted the report of the Professional Standards Committee cited. Executive committees require *eight* years of experience in petroleum geology to qualify for certification application, one year more than the minimum of seven years recommended by the Professional Standards Committee.