Reefs and banks form stratigraphic traps which hold more than 40 per cent of the total petroleum production in the world. They are of special importance in the Permian basin exploration. Yet there is much confusion concerning the classification and terminology of these skeletal deposits. It is the purpose of this paper to attempt to define these structures on a genetic and morphological basis and indicate their exploration potentials.

Following Lowenstam (1950) and Nelson *et al.* (1962), the writer applies the terms "reef" and "bank" to denote the origin of the structures, whereas the terms "bioherm" and "biostrome" are used to designate the shape of the structures and their relation to the associated layered facies.

A *reef* is a structure built by the in-place growth of organisms which have the ecological potential to act as frame-builders. It is a wave-resistant, prominent structure on the sea floor and, therefore, influences, and modifies sedimentation in its vicinity.

A *bank*, in contrast, consists of organisms which did not have the ability to erect a rigid three-dimensional frame-work. Banks may be formed in place or by mechanical build-up following transport of the skeletal remains. Banks also are wave-resistant. They may or may not be prominent structures on the sea floor or influence the sedimentation around them.

According to their formation, banks are subdivided into (1) mechanical and (2) biogenetic accumulations. Biogenetic accumulations are subdivided further into banks resulting from (a) biogenetic baffling of sediment, (b) biogenetic binding of sediment, and (c) gregarious local growth of organisms without erecting prominent structures.

Thus, reefs and banks are distinctly different types of accumulations. In a reef, ***in situ*** growth of organisms is more important than sediment trapping and binding, and the organic productivity of the frame-building organisms alone is sufficient to elevate the structure above the surrounding sea floor. Frame builders in general are organisms that cement themselves to the substratum and form a rigid mass. Cementation appears to be very important in the resulting structure. Colonial hexacorals, stromatoporoids, calcareous sponges, rudistids, and crustose $CaCO_3$-secreting red algae can act as frame builders in a reef.

In contrast, in banks, the sediment-baffling and binding functions of the organisms are the main sources of sediment accumulation. Tetracorals, tabulate corals, bryozoans, crinoids, phylloid algae, pelecypods, gastropods, and brachiopods are organisms that can not erect a rigid framework. However, they can actively trap sediment and form banks. Furthermore, their local gregarious growth may lead to bank-type accumulations.

A ***bioherm*** is a massive, mound-shaped structure which is in discordant relationship with the surrounding layered facies of different lithologic types. A *biostrome* is coarsely layered and grades concordantly into the surrounding layered sediments.

According to these definitions, a reef, according to its shape and geological setting, represents a bioherm. A bank, however, may take the form of a bioherm or biostrome. Mechanically accumulated banks and biogenetic banks resulting from the sediment-baffling activity of organisms generally have the form of bioherms. Banks resulting from biogenetic binding of sediment may have the form of either bioherms or biostromes. Local gregarious growth of organisms usually leads to accumulations of the biostrome type. The fact should be stressed that the shape of a fossil structure is not necessarily the same as its shape at the time of formation. Differences in compaction capabilities of skeletal deposits *versus* clay or carbonate-mud-rich deposits tend to exaggerate the relief of the organic build-up.

Examples of various types of Recent and ancient reefs and banks are illustrated and discussed. Recent coral reefs of the Florida Keys reef trend and Cretaceous rudistid reefs in Sierra El Abra, Tampico region, Mexico, are examples of true reefs. Little Molasses Reef, Florida Keys, is interpreted as a bank which was formed by mechanical accumulation of skeletal debris. Rodriguez Key, Florida Keys, and mud mounds in Florida Bay are examples of banks representing biogenetic accumulations resulting from the sediment-baffling functions of organisms. Phylloid algal mounds from the Hueco Tanks area (West Texas), Dry Canyon near Alamogordo, New Mexico, and Marble Canyon, Alamogordo, New Mexico, are ancient counterparts of these biogenetic banks.

Algal stromatolites are representative of banks formed by the sediment-binding action of organisms. Cretaceous oyster beds are indicative of bank accumulations by local gregarious growth of organisms.

It is very important to emphasize the fact that structures, which superficially appear to be very similar, may, in fact have formed in very different environments and, therefore, require different genetic interpretations.

11 A. L. PORTER, New Mexico Oil Conservation Commission, Santa Fe, N Mex.

OIL AND GAS CONSERVATION IN NEW MEXICO

Oil has been known to exist in New Mexico for more than 50 years, but significant production did not begin until the completion of the second well in the Hobbs pool in 1930. The Hobbs pool, developed during the time when the law of capture prevailed elsewhere, stands today as an example of the wise application of sound conservation policies.

For several years the development of oil and gas resources in New Mexico has been the state's biggest business, and has added much revenue to its economy.

The conservation act and laws passed by the state's legislators, creating the New Mexico Oil Conservation Commission, charged this commission to prevent the waste of oil and gas and to protect correlative rights.

The commission can point with pride to its conservation record and, as a regulatory body, its performance in the public interest reflects its flexibility in bringing about needy changes as technology improves.

12. FRANK SPIVA AND A K. DOSS, Consultants, Abilene, Tex.

PALO PINTO LIMESTONE OF WESTERN RUNNELS COUNTY, TEXAS

The Palo Pinto Limestone (lower Canyon Series) of western Runnels County, Texas, is generally found at depths of 3,800-4,200 feet. The two productive porosity zones are in the upper 50 feet of the formation. The lower is by far the more productive. The Palo Pinto can produce from structural traps alone but the best producing fields are those in which stratigraphic pinchouts are associated with low-relief structures. Several of the presently productive fields produce 30-60 per cent water together with the oil; history now shows these fields to have considerably 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