side of a basin high on the flanks of a mountain and on the other side at a much lower elevation, a through-going flow of water can occur. When this happens, the effect on oil accumulation is serious. In many cases the oil is completely flushed out of the sand. In others, the pools are merely tilted by the phenomenon described by King Hubbert and Gilman Hill about ten or fifteen years ago.

A great deal can be told about the underground water situation by chemical analysis. The Russians use an interesting water classification which is shown herewith (Fig. 2) and which separates the different geological environments. All those waters which occur in formations where the geological evidence indicates that the water is not in motion occur in the upper right-hand block. These waters are called "*chloride calcium*" waters. Those which occur in what appear to be artesian situations occur in the lower left-hand block. These may be divided into two major classes: the "*sulphate sodium*" and the "*carbonate sodium*" types.

If we examine the chemistry of the water found associated with oil fields in the stagnant situation, we find some very remarkable similarities. In the first place, they are nearly all salty. Usually they are much more concentrated than sea water and sometimes approach saturation. In other respects, they have been substantially altered from sea water. They contain practically no sulphate or carbonate, both of which are prominent in sea water. Almost the only anion is chloride.

In Fig. 3 are plotted random examples of water analyses from southern Arkansas and northern Louisiana. Even though the pools cover a wide area and are by no means connected, in a very long stratigraphic section, it will be noticed that the concentration of the water in thousands of parts per million increases almost linearly with depth. This increase in concentration with depth can be matched with the Woodbine sand of Texas, the Devonian oil pools of Russia, and generally throughout the world where this stagnant situation occurs. Wherever this linear increase in concentration with depth occurs, the water must be completely motionless; if there was any motion at all, it would alter the gradient and probably smear it out altogether.

Numerous studies of dissolved hydrocarbons in oilfield water have been made. Each aquifer appears to have its own pattern of hydrocarbon content which is independent of sands which are above or below. This suggests rather strongly that vertical migration of hydrocarbons does not take place on any measurable scale.

The Russians analyze quite routinely for dissolved hydrocarbons and a number of elaborate maps have been published which are available in the literature. Many authors seem to consider the content of dissolved hydrocarbon an indicator of proximity to an oil field. Their idea is that these hydrocarbons originated in the oil and were spread out into the aquifer by a process of molecular diffusion. It seems much more likely that the oil fields were formed from the insoluble hydrocarbons which were filtered out by the capillary barrier process. The soluble hydrocarbons, on the other hand, were widely distributed by the subsurface water. We therefore ought not to say that dissolved hydrocarbon bases and benzenes were *derived* from petroleum, but that *both* were derived from the same source rocks, probably adjacent to the aquifer in which they are found. The presence of petroleum hydrocarbons, therefore, might be taken as an extremely significant indication that oil was generated and did migrate through an aquifer even though they give no information on how close the well is to an oil field.

Here, right in front of us, in our records and in our files, is an immense amount of interesting information to be used in prospecting. Oil and gas that we drill for are fluids. Why do we then go to great lengths to study the solid structure of the reservoir and pay virtually no attention to the amount, kind, pressures, and chemical compositions of the fluids which they contain? If we understood the fluids and their behavior, we could make much more direct and intelligent use of the geological information we have compiled.

▲ ▲ ▲

March 8, 1965

BEN F. RUMMERFIELD and NORMAN S. MORRISEY, Geodata Corp., Tulsa

"How to Evaluate Exploration Prospects"

Analytical evaluations raise petroleum exploration from the realm of educated guessing to a quantitative decision level that is compatible with modern business techniques. Management and explorationists can thus appraise the merits of an area and/or exploration program and expect to derive optimum results with minimum risk.

All petroleum exploration programs have

one common goal: *To find and exploit reserves of oil and gas at a profit.* Today the economic factors are playing a dominant role in the highly competitive world petroleum situation. In order to justify his existence in the forecast 70-billion-dollar exploration effort set during the next ten years, the scientist must translate his thoughts into terms the nontechnical business man or executive can readily grasp. The obvious common language is dollars and cents in terms of anticipated profits. These economic terms transcend the semantics barrier that normally exists between the executive and the oil finder.

Various methods are discussed to show how geophysicists and geologists can convert exploration factors into anticipated profit-to-risk ratios. The authors include examples.

Significant factors contributing to a successful exploration program are: (1) The exploration and economic analysis must be compatible with, and integrated into, modern business techniques. That is, the analysis must enhance the executive's ability to make decisions. (2) The explorationist must recognize and avoid "marginal ventures," because 60 per cent of the wells completed in the United States are submarginal economically. (3) The laws of probability must be taken into consideration when establishing an exploration program. (4) To insure success, a company must hold risks to a minimum. This can be accomplished, in part, by participating in a large number of potentially profitable ventures, and/or by taking only a part of each drilling venture rather than the entire deal. (5) Anticipated profit-to-cost ratios can be estimated for many areas. Oil companies can use this information in evaluating and accepting wildcat prospects that have at least double the normal odds of developing into a profitable oil field.

The scientist who applies quantitative analyses skillfully will quickly achieve both recognition within his company and the status of a key decision-maker in his company's exploration program.

▲ ▲ ▲

March 15, 1965

LEWIS M. CLINE, Univ. of Wisconsin, Madison

"Geology of the Ouachita Mountains"

The Stanley-Jackfork-Johns Valley-Atoka rocks of the Ouachitas and the Tesnus-Haymond sequence of the Marathons typify what Alpine geologists call black shale flysch. Wild flysch and calcareous flysch also are represented.

In late Mississippian and early Pennsylvanian time a minimum of 22,500 feet of alternating sandstones and shales was deposited in a rapidly subsiding, linear trough. During the cannibalistic stage of the Ouachita geosyncline, (*sensu lato*) the Oklahoma-Arkansas trough probably was but one part of an 1800-mile foldbelt stretching from the Marathons to the Appalachians. Deposition of fine pelitic muds and siliceous shales was interrupted hundreds of times by deposition of quartzose sandstones. The sandstones debouched from a shelf environment exhibit convolute bedding, graded bedding, sole marks and other features now commonly ascribed to turbidity current deposition.

The foldbelt is structurally complex, with several major thrust faults striking parallel to the axis of the foldbelt and thrust toward the craton. Where observed at the surface the thrusts emerge at high angles but some (at least) seem to flatten with depth and probably become bedding plane faults.

The facies patterns and structural characteristics compare closely with those of the Polish Carpathians, Swiss Alps, and Italian Apennines and the characteristic sedimentary features are duplicated in intricate detail in the four mountain systems. Direct comparisons will be made between the Ouachita flysch and that of the classical European areas.

▲ ▲ ▲

March 22, 1965

C. J. MANKIN, W. H. BELLIS, and R. L. KERNS, JR., Univ. of Okla., Norman

"Regional Clay Petrology of Permian Shale in Southwestern Oklahoma"

Permian strata cover an area in excess of 50,000 square miles in the western half of Oklahoma, northern Texas, and southern Kansas. These strata are about 4,000 feet thick, are essentially flat lying, and consist dominantly of shale, mudstones, siltstones, and sandstones. In addition to these terrigenous redbeds, the Blaine and Cloud Chief Formations contain on the outcrop two major evaporite units.

This study and the resulting preliminary report are directed toward the genetic relationships of this redbed-evaporite sequence. Funds for the study are from a two-year National Science Foundation Grant No. G19186 entitled, *Mineralogy and Chemistry*