Stanton, Robert James, Jr., Houston, Tex.
(Raymond C. Murray, Andrew Lee Diehl, Robert H. Norton)
Swayne, Lawrence Edwin, Calgary, Alta., Canada
(Don B. Gould, Albert S. Depetris, Lewis T. Braun)
Thomas, Patrick Powers, Midland, Tex.
(Eugene Greenwood, Forrest F. Spry, Menhart L. Feldman, Jr.)
Volz, Edward Richard, Farmington, N. Mex.
(William R. Speer, David M. Thomas, Jr. Marvin L. Matheny)
Webernick, Nelson E., Midland, Tex.
(Calvin S. Smith, Dexter H. Craig, Walter Wayne Roye)
Weist, William G., Jr., Arvada, Colo.
(Stanley W. Lohman, Thad G. McLaughlin, John R. Donnell)
Williams, Floyd Elmer, Albuquerque, N. Mex.
(Chester M. Garrett, Warren A. Bald, Henry W. DeJong)
Witherspoon, Paul Adams, Jr., Berkeley, Calif.
(Parker D. Trask, Alfred H. Bell, Ralph E. Grim)
Yelken, Jack Herbert, Bartlesville, Okla.
(William H. Courtier, Perry M. McNally, Alma J. Hintze)
Zuniga y Rivero, Fernando, Talara, Peru, S. A.
(William E. Denton, Russell B. Travis, Lawrence Weiss)

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
46th Annual Meeting

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS
35th Annual Meeting

ROCKY MOUNTAIN SECTION, A.A.P.G.
11th Annual Meeting

Denver, Colorado April 24–27, 1961

Host Society: ROCKY MOUNTAIN ASSOCIATION OF GEOLOGISTS
General Chairman: Laurence Brundall
General Vice-Chairman and President, RMAG: H. H. R. Sharkey
Vice-Chairman for SEPM: R. Dana Russell

TECHNICAL PROGRAM
A.A.P.G.–R.M.S.

Monday Afternoon, April 24

RESEARCH COMMITTEE SYMPOSIUM

Presiding: JOHN E. KILKENNY, FREDERICK L. STEAD

Introductory Comments: DANIEL A. BUSCH

1. Automatic Data Processing in Geology: W. C. KRUMBEIN, Northwestern University, Evanston, Illinois

Geologists depend increasingly on numerical data to supplement the core of qualitative observations on which the science rests. In subsurface studies especially, the amount of data available on structure, thickness, and composition of stratigraphic units is accumulating at rates beyond the ability of geologists to absorb its full implications. In academic aspects as well, numerical data in sedimentary petrology, paleontology, geochemistry, and virtually all branches of the science are rapidly assuming gigantic proportions. The profession is faced with the need for data storage, retrieval, and processing on a scale unthought of a few decades ago.

Data are stored on punched cards or tape. Retrieval is accomplished by automatic sorting and listing equipment, including devices for plotting data directly on base maps. Data processing may range from simple summaries to more elaborate statistical and mathematical analysis. A wide range of equipment is available for these functions, culminating in present ultra-high-speed digital computers.

The high-speed computer has opened new doors for the extraction of maximum information from geological observations. Studies of interrelationships among rock properties, faunal groups, mappable data, and a host of other kinds of analyses are possible, and are being used increasingly by geologists. An example of trend surface analysis of maps is presented as an illustration. The general problem of setting up "program libraries" for use by geologists, as well as "data centers" for storage, is touched upon.

2. Palynology and Petroleum Exploration: JOHN F. GRAYSON, Field Research Laboratory, Socony Mobil Oil Company

During the past decade, the relatively new science of palynology has generated considerable interest in the field of petroleum exploration. Many geologists have not yet become familiar with palynology and its great potential in stratigraphic, paleogeographic, paleoecologic, and paleoclimatologic studies. After a brief sketch of the development of palynology and the amount of activity in this field at present, some of the basic principles are presented and examined in detail. During the examination of these principles, their potential value to the field of geology is illustrated. Among the important problems facing exploration geologists are the following: (1) age dating of sediments, (2) correlation of contemporaneously deposited sediments, and (3) depositional environment of sediments. Palynology can give valuable data in all three of these areas. Emphasis is placed on some of the recent correlations established on the basis of palynological work as well as some of the recent findings concerning age determinations. In view of the fact that palynology is such a young field, some of the problems confronting palynologists are discussed as well as certain areas of this field that are relatively unexplored.

3. The Geochemistry of Petroleum Migration and Accumulation: BARTHOLOMEW NAGY, Fordham University, New York, N. Y.

Small quantities of a large variety of organic compounds enter the Recent marine sediments before burial. Petroleum, the only major organic and fluid substance in the consolidated rocks, however, contains mainly hydrocarbons. Experiments indicate that hydrocarbon compounds may travel through the sediments with the least restraint during intrastratal fluid flow. Most of the non-hydrocarbon compounds may be removed from the flowing phase by a selective filtration, i.e., chromatographic process.

Chromatography is a physical-chemical method of separation of fluid mixtures in which the components to be separated are distributed between two phases. One is a stationary phase of a large surface area and the other one is the fluid phase that percolates through the stationary phase. Fine-grained mineral particles, organic inclusions and (or) immiscible liquid droplets in sedimentary rocks may constitute the stationary phase. The Martin and Synge chromatographic theory is applied for tracing fluid flow through the sedimentary rock strata.

Petroleum contains colloidal particles, some of which are too large to have flowed through the smaller pore openings. Experiments show that oxidation and some other chemical reactions, taking effect after accumulation, may be responsible for the development of a part of the petroleum colloids. A regional study of the distribution patterns of organic constituents, combined with geological and geophysical data, can be useful information to the exploration geologist.

4. Prospecting for Commercial Fractured "Shale" Reservoirs, Rocky Mountains: BURDETTE A. OGLE, Ogle Corporation, Denver, Colorado

Eighty years ago the first fractured shale production was found in the Rockies. Renewed interest in such objectives, especially in NW. Colorado and NW. New Mexico, has led to several important discoveries during the past five years in particularly the upper Cretaceous Niobrara calcareous shales, which are primarily being considered in this paper.

Fractured "shale" is the general oil-field term used to include not only shale but the generally brittle impermeable rocks ranging from calcareous shale, argillaceous limestone, siltstone to very fine-grained sandstone. In all cases the rocks are more brittle than the usual interbedded plastic shales. At points of abrupt flexure, in planes varying from vertical to horizontal, tensional cracks develop in the brittle rocks on the convex side of the flexure. Typical sites of flexure are sharply folded anticlinal axes and noses, abrupt changes in strike on any structure, monoclinal flexures and sharply folded synclinal axes. Faults also cause fracturing; most open fissures being adjacent rather than in the fault plane. In any case the interbedded plastic shales cause a trapping seal of the fractured brittle shale reservoir resulting in a modified stratigraphic trap which may occur independent of any structural closure. Downdip water is ordinarily absent.

Some factors which have hindered modern-day prospecting for these reservoirs include: the difficulty of evaluating past production histories; the problem of managements in evaluating future potential reserves of this non-homogeneous reservoir (thereby leaving the economics of the prospect and development in doubt); and present-day use of improper and inadequate methods of drilling, testing, completing, and producing these special reservoirs. A review of performance of "Niobrara" fields indicates that recoverable reserves of 5,000 barrels of oil per acre may be expected.

A recommended program for prospecting should include the following.

1. Establishment of the presence of proper brittle objectives in the subsurface at a depth commensurate with cost-productivity—expected return factors. Evidence of shows of oil or indirect indications of fracturing old wells drilled in the vicinity are vital.
2. Localization on an abrupt flexural trend, commonly coupled with cross-faulting.
3. A multiple-well program of evaluation and development to average out variability of fractured reservoirs, the wells being drilled on at least 40-acre spacing.
4. Careful attention to proposed techniques of drilling, testing, completion, and production suited to this special reservoir.

5. Stable Isotope Studies in Solution of Geologic Problems: MILTON WILLIAMS, Humble Oil & Refining Company, Houston, Texas

Geology has long been accustomed to utilizing classical chemical and physical methods in the solution of geologic problems. In recent years still another method having its origin in nuclear science has become available—the use of isotopic abundances and distributions in earth materials. In many cases a knowledge of isotopic compositions of earth materials permits deduction of the histories of these materials and delineation of the various processes to which they have been subjected in the past. Examples of the utility of isotope studies in geology include the use of carbon isotopes in revealing the mechanism by which marine carbonates are formed, the use of magnesium isotopes in investigating dolomitization, the utilization of carbon and sulphur isotopes in relating crude oils of common origin, and the application of carbon isotopes to study of petroleum genesis, diagenesis, and migration. The use of isotope studies as a geologic tool is still relatively new, but holds much promise as an important interpretive method of the future.

6. Interpretation of Dry Holes: JACK W. KNIGHT, Petroleum Research Corporation, Denver, Colorado

Many wells drilled in the centers of some major oil accumulations and wells proved to be at the highest structural positions in many barrier-type traps have been abandoned as dry holes because of large water cuts or water recoveries with minor oil shows. Some of these wells were abandoned prior to the discovery of the commercial pool. In each case, continuous reservoir permeability has been proved between the abandoned water-producing wells and the commercial oil- or gas-producng wells. The common factor is a downdip component of formation-water flow through the producing area coupled with one or more of the following changes in the reservoir: (1) increased reservoir permeability, (2) increased reservoir thickness, (3) increased structural dip, and (4) decreased hydrodynamic gradient.

In some cases, the reservoir around the dry hole has permeabilities comparable with and lithologically continuous with the producing part of the reservoir. Consequently, proper evaluation of fluid recoveries as related to reservoir character and hydrodynamic environment is of the utmost importance in the interpretation of the meaning of a "dry hole." Many of these "dry holes," when properly interpreted, should lead to new field discoveries or field extensions.

Monday Evening, April 24

PANEL DISCUSSION ON RESEARCH SYMPOSIUM PAPERS

Presiding: JOHN E. KILKENNY

Moderator: DANIEL A. BUSCH

Panel: W. C. KRUMBEIN, J. F. GRAYSON, B. NAGY, B. A. OGLE, M. WILLIAMS, J. W. KNIGHT