tional), and irreducible water saturation.

The state of knowledge regarding reservoirs is such that, in some cases, rock and reservoir properties can be related directly; in other cases, they can be related empirically or only through speculation and surmise.

After a petroleum-bearing reservoir has been discovered, it can be cored, logged, and studied first-hand. Such a study then should guide field development through primary and secondary production. This type of study also can aid materially in shaping an exploration approach in search of similar reservoirs and in influencing a wildcat drilling program.

Each of the following examples of geologic reservoir studies was directed toward a different specific reservoir problem.

1. A large anticline in Wyoming produces from several reservoirs of different age and genesis; each reservoir has a separate set of production characteristics and problems.

2. A pair of structural-stratigraphic traps in Illinois, although similar in some properties, have different origins, internal geometry, heterogeneity, and recoverable reserves.

3. A gas-condensate reservoir in Oklahoma, where a combined petrographic-relative permeability study led to the installation of a dry-gas repressuring plant and a marked increase in recoverable reserves.

Although these examples are all from United States oil fields, the principles and methods of study are applicable in any petroleum province. Best conservation practices require the integration of geologic reservoir studies into drilling, logging, completion, stimulation, and primary or supplementary recovery operations.

20. W. S. FREDERICK, SR., Phillips Petroleum Co., Bartlesville, Oklahoma

Abnormally High Formation Pressures at Borehole and Beyond

Presented are examples of the effects of abnormally high formation pressures on drilling wells and illustrations of routine techniques of data handling, *i.e.*, identifying, documenting, and predicting abnormal formation pressures. High-pressure anomalies occur in large, mappable volumes and are present in Rocky Mountain basins. They cause serious drilling problems and add considerably to wildcat and development-well drilling costs.

Examples are compiled from data from the Rocky Mountain area and other areas.

21. GEORGE V. KELLER, Colorado School of Mines, Golden, Colorado

Electrical Prospecting Methods in Oil Exploration

Electrical-prospecting methods may be used in an exploration program in one of three ways. (1) They may be used to determine the depth to resistant basement rock. (2) They may be used to detect directly the presence of oil. (3) They may be used to map variations in texture associated with lithologic traps.

Electrical-prospecting methods are being used extensively in some parts of the world for mapping major structural features within sedimentary basins, but in the United States seismic methods have proved to be far more effective for such studies. Electrical-prospecting methods have been used in the past to detect increases in resistivity caused by the presence of oil, but such applications have been limited to very shallow occurrences. The direct discovery of oil by electrical methods at greater depths would require great improvement in techniques. Electrical methods have been little used in the study of lithologic changes in a sedimentary column associated with oil traps. The Department of Geophysics at the Colorado School of Mines has been investigating such an application, using both well logs and field surveys from the Denver basin.

22. H. B. EVANS, JOHN C. HARMS, AND PHILIP W. CHOQUETTE, Marathon Oil Company, Littleton, Colorado

GRAPE*—Device for Continuous Porosity Determinations

A rapid, accurate, and continuous method for measuring porosity or bulk density of cores from boreholes has been developed. The method is based on gamma-ray scattering.

The principal technical advantage of this porosity-measuring device is that variations in porosity encountered by a moving, pencil-size, gamma-ray beam are recorded continuously, whereas other methods yield only an average porosity for a particular core piece.

Basically, this device consists of a variable-speed drive system to move geologic material between a shielded gamma-ray source and a shielded detector, an optical caliper to measure the sample thickness, and a computer to calculate density and porosity from the measured parameters. The measured thickness and the computed density and porosity of the sample are recorded on a strip chart. Because the sample and the recorder chart are driven at the same speed, a direct comparison between the recorded parameters and the actual sample is possible.

Excellent agreement exists between porosity values of common sedimentary rocks measured by this method and by other conventional methods.

The system is designed for either field or laboratory use and only one operator is required. The device handles cores 1–4½ in. in diameter, conventional core plugs, and slabbed cores at drive speeds more than 3 in./min. At this speed, 100 ft. of core can be analyzed for density and porosity in about 6 hrs.

The device was designed primarily for density and porosity evaluation of sedimentary rocks obtained in oil exploration and development. Other applications of this system are possible. They include porosity measurements of unconsolidated recent sediment samples, determining oil content of oil-shale samples, measuring the ore content of metalliferous deposits, and estimating acoustic wave velocities or average density for geophysical purposes. Porosity profiles measured by the gamma-ray device for a variety of rock types illustrate uses of these results.

23. JOHN P. HOBSON, JR., Cities Service Oil Company, Tulsa, Oklahoma

Cyclic Sedimentary Sequences in Frontier Formation (Upper Cretaceous), Casper Arch Area, Wyoming, and Some Stratigraphic and Possible Paleoenvironmental Implications

The Frontier Formation is generally about 1,000 ft. thick in the Casper arch area and consists of a series

* Gamma-Ray Attenuation Porosity Evaluator.