made use of this method in studying oil and gas prospects, in addition to structural geology and geophysics.

By use of organic geochemistry there was later developed a new method of semi-direct surveying based on the development of density patterns in the surface soil by analysis for certain inorganic substances. It naturally followed that any radioactive inorganic elements contained in the surface soil would allow the development of a similar concentration pattern which could be mapped by the use of highly sensitive radiation counters.

Serious radiation surveys were begun about ten years ago with the use of an ionization-type instrument of suitable sensitivity and stability. These instruments were built to order and required a considerable period of testing and improvement to prove their reliability.

With the new interest in uranium exploration stimulated by the building of highly sensitive scintillometer devices, these instruments have also become available for oil exploration.

The successful use of all types of sensitive radiation-measuring instruments depends on the proper handling of numerous factors that tend to create false radiation values. Obviously this method, like geochemistry, is not simple. It is the purpose of this paper to attempt to describe and evaluate all factors which must be taken into consideration before a survey can be completed and the correct conclusions reached.

GEORGE B. MANGOLD, Petroleum Engineering Associates, Inc., Pasadena
Differential Thermal Analysis: Correlative Tool Where Other Methods Fail

Differential thermal analysis (DTA) provides a valuable scientific method for determining correlation markers and mineral composition of zones. It is based on the accepted technique of identification of chemical compounds through measurement of thermal reactions as the cuttings or cores are subjected to a controlled temperature rise. The thermal curves, plotted in log form, illustrate changes in formation mineralogy, and graphically point out type and amount of clays, carbonates, oxides, quartz, etc. Mineral trends, breaks, and stringers supply correlative values independent of formation fluids, secondary electrical and radiation properties, and presence of paleontological specimens. Because it depends only on basic mineral composition, DTA can succeed where logs and paleo are not diagnostic. In addition, this technique provides information essential to the full interpretation of in-the-hole logging and of core analysis.

COLE R. MCCLURE, California State Division of Water Resources, Sacramento
Geochemistry and Migration of Meteoric and Connate Waters as Related to Geologic Structure

Data obtained during geologic and geochemical studies in several areas of the Sacramento Valley have suggested correlation between subsurface structure and the occurrence of a type of saline water in the shallow water-bearing deposits. Sufficient data have been collected to permit construction of subsurface contours on the base of fresh water. These contours, which reflect general structure in the Sacramento-San Joaquin Delta area, represent the interface between fresh water and a specific type of saline water. This connate water contains high concentrations of sodium and chloride ions, low concentrations of sulphate and nitrate ions, and approximately equal concentrations of iodide and bromide.

Under hydrodynamic conditions, fresh water in the foothills with considerable head has apparently flushed the saline waters out of a part of the marine sediments. In the Delta area this connate water has been forced upward from the marine sediments to the surface along faults and from truncated marine sediments on anticlinal structures.

There are numerous other ground-water anomalies which may indicate the presence of buried structural features. A characteristic type of water apparently associated with faulting may be noted in the shallow water-bearing deposits. This water commonly has higher temperatures and greater concentrations of silica and boron than the normal ground water. Further geochemical studies of this type may be of value to the petroleum industry.

A. A. HOPKINS, G. R. LAPERLE, J. W. MATHEWS, AND I. T. SCHWADE, Richfield Oil Corporation
Marysville Buttes: Geological and Geophysical Analysis

Marysville Buttes is an extinct complex volcanic plug surrounded by steeply folded and faulted Cretaceous and younger sediments. It occupies a circular outcrop area of approximately 20 square miles, and forms a bold topographic feature rising above the flat low Sacramento Valley.

The Marysville Buttes intrusive developed during post-Eocene time with the piercement and doming of 7,500 feet of Upper Cretaceous and middle and upper Eocene beds by a rhyolite and andesite plug approximately 4 miles in diameter. It is believed later andesite formed the central core and progressively deformed the sedimentary beds. During late Pliocene to Pleistocene, showers of pyroclastics, crudely interbedded with mudflows, were deposited on the denuded dome. This formed a cone, which has subsequently been deeply eroded.

Beneath the valley floor near Colusa, a similar large plug which has been indicated by seismic and well records lies concealed beneath approximately 5,000 feet of Cretaceous and younger sediments. Possible other deep-seated intrusives in the area domed overlying sediments, in some cases resulting in gas accumulations.

The Buttes gas field produces from lenticular Cretaceous sands in a trap which may have been further improved by the Buttes intrusion. Whereas the surface expression of the plug and distorted bordering sediments occupies an area of 20 square miles, the area beneath the surface which is influenced by this volcanic disturbance is at least 120 square miles.

J. P. WOODS, Atlantic Refining Company, Dallas, Texas
Composition of Reflections

When all traces on a seismic-reflection record show about the same deflection at about the same time, the line-up is marked and called a seismic reflection. An important fact is forgotten. The fact is that the reflection seen on the record is almost invariably a composite of the various reflections caused by a set of closely spaced reflecting layers. When the arrangement of the layers in the set changes, the various reflections add together in a different way, and the character of the composite reflection seen on the record changes.

A series of artificial seismic records has been made to show this composition of reflections. The records were made by connecting a standard reflection seismograph to an acoustic model. The model was a 300-foot length of steel pipe with input and output transducers at one end. Records were made for a wedge, a pinch-out, a complex of thin layers, a sand bar, layers corresponding with well resistivity logs, and a regular layer system.

GEORGE C. HEPBURN, JR., Schlumberger Well Surveying Corporation
Geological Approach to Electric-Log Analysis

Use of electric-logging methods to gain more geological information involves knowledge of the lithologic conditions which affect logging measurements. Porosity, interstitial water resistivity, water saturation, permeability, and amount of shale have a definite relation to the recorded curves.

Recent advances in interpretive techniques make possible the determination of water saturation, porosity, and producible oil index by logging methods, even in shaly sands. Qualitative permeability is indicated by the SP curve or microlog-caliper, and under certain conditions can even be determined quantitatively.

Numerous examples are presented which indicate that every permeable formation, no matter how low its resistivity, should be considered potentially oil-bearing until a complete log interpretation has been made.

WILLIAM CARRUTHERS GUSSOW, consulting geologist, Calgary, Alberta
Problems of Oil Migration

Migration and accumulation of hydrocarbons conform with the simple laws of nature and logic. These governing principles are reviewed, both in the physical sense and in the sense of geologic time, and particularly from the standpoint of such concepts as distant source and regional migration, migration paths, differential entrapment, evolution of oils, and the significance of tar belts, interstitial or non-producible oil, synclinal oil, etc.

ROBERT B. SCOTT, The Texas Company, Bakersfield
Geology of North Arvin Field, Kern County, California

The North Arvin field is on the east side of the southern San Joaquin Valley approximately 13 miles southeast of Bakersfield. Production is from the non-marine (Pliocene-Miocene) Chanac formation and the marine (upper Miocene) Santa Margarita sand. A sub-commercial quantity of oil has been produced from the fractured metamorphic Basement Complex (Jurassic?). The thickness of sediments overlying the basement ranges from 5,000 to 7,000 feet, with the depth of wells averaging approximately 6,000 feet. The oil accumulation occurs on a regional southwesterly dipping homocline with closure effected primarily by the lensing of sands and to a lesser degree by faulting. The field was discovered on July 19, 1951, and has undergone almost continuous development from that date.

ROBERT H. PASCHALL, Hancock Oil Company, Ventura
Fourth Dimension in Oil-Trap Analysis

The time is past in which oil geologists needed prompting toward the search for stratigraphic as well as structural traps. However, the contemporary search for oil traps remains primarily a study in geometry. The prime requisite of a wildcat is that it be on a more or less provable closure, which may be either structural or stratigraphic in nature.

California, like many other oil-producing areas, has yielded a depressing collection of non-productive closures. It is evident that there must be a dimension, other than the three of geometry, which is critical in the formation of an oil-producing trap. It is suggested that the fourth dimension is one of time.

Field examples are afforded of two areas where presently mappable structural closures have been