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* New lecturers and subjects.
[1] Headquarters in London.

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NATURAL GAS: OIL'S PRINCIPAL COMPETITOR

Petroleum gases and liquids, often occurring together, are found in the same types of traps by the same exploratory methods and are exploited and produced in the same manner. Moreover, all crude oil contains some natural gas, but nearly 75% of all natural gases are not associated with crude oil in the reservoir. The two phases of petroleum are highly competitive.

There are important differences in the physics and chemistry of natural gases and crude oil. Natural gases are a mixture of various organic compounds, usually accompanied by smaller amounts of inorganic elements and compounds. Natural gases of commerce are petroleum natural gases, although helium and hydrogen sulfide—also natural gases—may be valuable components. Even carbon dioxide, also a natural gas, finds markets. Physically, natural gases are highly mobile, difficult to contain, and are soluble in both crude oil and water, particularly under pressure.

Chemically, there are marked differences between petroleum natural gases and crude oil. Methane is the simplest, most ubiquitous and principal component of petroleum natural gases. It is often accompanied by much smaller quantities of heavier hydrocarbons. Natural gases are alkanes: paraffinic, saturated, straight chain hydrocarbons. The division between petroleum natural gases and the somewhat more complex, heavier alkanes occurring with them as vapors, is between propane and butane. Butane and heavier paraffinic hydrocarbons can be found both as normal, saturated straight chain or as isomers: saturated, branched chain hydrocarbon compounds. The substantial chemical differences between the simple compounds of petroleum gases and the far more complex crude oils suggest somewhat different modes of origin. An early and multiple origin for methane seems probable, inasmuch as substantial quantities are found in youngest Holocene sediments in swamps and glacial drift, and it is present as part of the atmosphere of several of the planets.

The vastly different physical and chemical characteristics of petroleum gases and crude oil have a great bearing on economics of exploring for, developing and producing them. The phenomenal growth in production of natural gas and in its use as a form of primary energy has been a major factor in the declining growth in the need for crude oil. The two substances are directly competitive for space heating, for domestic uses, and for generation of electricity. Liquefied petroleum gases ("natural gasolines") and lease condensate have further supplanted crude oil. Production of petroleum natural gases, wet, increased from 4,423 trillion BTU in 1945 to 20,121 trillion BTU in 1967, and in 1967 amounted to 36.4% (excluding lease condensate) of production of primary energy, compared to 32.6% for crude oil (including lease condensate). Moreover, according to Winger *et al.*, dry natural gas yields less than 4¢ of every dollar of income from a representative group of companies, the financial characteristics of which have been studied for years by the Chase Manhattan Bank. Although natural gas liquids and lease condensate add somewhat to this amount, natural gas is a much less attractive exploration objective than crude oil.

Most natural gases have been found as a result of the search for crude oil. Under present economic conditions, natural gases alone are not attractive exploration objectives in most areas of the United States. Hence, as demand has continued to accelerate, drilling of gas wells has declined sharply, and ratio of annual production to annual additions to reserves has declined to a dangerous point. Unless this trend is reversed, the next few years may see a shortage of available natural gases—although none exists in nature—simply because of lack of incentive to search for and develop natural gases in the quantities which will be needed.

MASON L. HILL, Whittier, Calif.

NEW GLOBAL TECTONICS RELATED TO WEST COAST STRUCTURE

The current evidence, patterns, and history of sea-floor spreading in the northeast Pacific; the character and history of the San Andreas system of deformation; and some geologic implications of their relations to a worldwide tectonic scheme are reviewed.

The NE-trending East Pacific rise enters the Gulf of California from the Pacific Ocean. The essentially contemporaneous and parallel Gordo and Juan de Fuca ridges lie off the coasts of northern California and Oregon. According to the New Global Tectonics, the SE-trending San Andreas zone is a transform fault which connects these two segments of the World Rift system. Furthermore, according to the rigid-plate concept, the adjoining oceanic and continental blocks are moving northwest and southeast away from the oceanic ridges, and past each other along the San Andreas. On the other hand, according to the new concepts, part of the sea-floor magnetic pattern and the northeast Pacific fracture zones (transform faults) indicate an earlier (10–30 m.y. ago) north-south oceanic ridge trend accompanied by east-west crustal extension. However, since the present crustal dynamics typified by the San Andreas system of deformation has been operative for a much longer time (at least 80 and possible for more than 135 m.y.), some doubt is cast on the interpretation of the San Andreas as a geologically young transform fault. These and other contrasting geophysical data and interpretations from the oceans tested against geologic data and interpretations from the continents serve to emphasize tectonic discrepancies. This approach, versus searching for data and interpretations which tend to confirm the New Global Tectonics, may best stimulate both continental-based geologists and ocean-based geophysicists to obtain critical information leading to the *true* world tectonics.

PETER LEHNER, Shell Development Co., Houston, Tex.

SALT TECTONICS AND PLEISTOCENE STRATIGRAPHY ON CONTINENTAL SLOPE OF NORTHERN GULF OF MEXICO

During a sparker and core-drill program conducted by Shell, salt was cored on 10 prominent structures on the continental slope. Broad salt swells and pillows are typical structures in this region. The Sigsbee scarp appears to be the surface expression of a salt wall. A zone of active down-to-the-ocean faults follows the Texas shelf edge. They appear to be related to the flow of salt at depth away from the advancing clastic wedge.

Upper Cretaceous through Holocene deep-water sediments were cored on the continental slope. East of Brownsville the salt is overlain by redbeds of unknown age. Core holes at the shelf edge found deltaic and shoreline deposits of the Pleistocene low-sea-level stages. Submarine slides and turbidity currents carried sediments down the slope and filled deep synclinal basins between the salt uplifts.

MICHAEL E. HRISKEVICH and JOHN C. RUDOLPH, Banff Oil Ltd., Calgary, Alta.

MIDDLE DEVONIAN REEF PRODUCTION, RAINBOW AREA, ALBERTA

The March 1965 discovery of oil by Banff Oil Ltd. in a Middle Devonian reef in the Rainbow area of northwestern Alberta, sparked a period of intensive exploratory effort which resulted in finding an estimated 1.5 billion bbl of oil and 1 Tcf of gas.[1] The productive trend now referred to as the Rainbow-Zama trend, extends for 110 mi generally north-south and is 20 mi wide at its widest part. Additional discoveries have been made in the Slave Point Formation, Sulphur Point Formation, and Zama Member, all of which overlie the main producing formation—the Rainbow Member reef of the Keg River Formation.

Several unique events have occurred in the relatively short exploration and production history of the Rainbow part of the productive trend. The adaptation of common-depth-point seismic technique to the problem of finding carbonate reefs in an evaporite sequence represented a substantial advance in utilizing the seismic approach in exploration. The feasibility of carrying out overall operations (seismic and drilling) on a year-round basis in the muskeg environment of northwestern Alberta was illustrated.

In the field of reservoir engineering, detailed stratigraphic studies of reef cores were utilized extensively in providing the base for evaluation of secondary recovery schemes using one-, two-, and three-dimensional mathematical models which were constructed to simulate the productive formation and movement of contained fluids. Recovery factors of up to 88% have been accepted by the local regulatory body—the Alberta Oil and Gas Conservation Board. A program of sequential depletion of several separate pools, which have been approved, provides the most economic method of production and conservation.

Several important factors contributed to the drilling of the discovery well at Rainbow. The seismic data on which the location was based were obtained during 1953 to 1955, before the use of common-depth-point techniques in northern Alberta. Seismic interpretation was made difficult by the presence of a severe multiple problem. The selection of the location involved very close coordination between geologist and geophysicist. The availability of high risk capital for an area considered to have essentially sour gas prospects made it possible for the well to be drilled.

Subsequent developments in the field of reservoir engineering also gave rise to close coordination between geologists, reservoir engineer, and the electronic computer.

[1] Canadian Petroleum Association figures, end of 1967.

JAMES O. LEWIS, Consulting Geologist, Houston, Tex.

PRACTICAL COMPUTER USAGE FOR SUBSURFACE GEOLOGISTS

The "success ratio" of the experienced subsurface geologist can be improved by implementing proven subsurface exploration methods with use of the computer.

Techniques for proper use of the computer need to be developed by experienced subsurface geologists thoroughly familiar with the computer programs used in solving exploration problems.

Output from the computer is not the end result, but is the beginning point for the exploration geologist. The "geology" of an area can be displayed in a form acceptable and familiar to the experienced geologist. The amount and quality of the displayed information will give the geologist more information, in an objective form, than has ever been practically available previously. This information, interpreted by the experienced geologist, will result in a higher quality of "decision making" than has been possible.

Use of a computer will not enable the reduction of an exploration staff; but properly used, it will increase the need for experienced geologists and increase the "success ratio."

ROBERT E. STEVENSON, Bureau of Commercial Fisheries, Galveston, Tex.

GROSS TRANSPORT OF SUSPENDED SEDIMENTS OVER CONTINENTAL SHELVES AS ANALYZED FROM GEMINI AND APOLLO SPACE PHOTOGRAPHY

From the manned flights conducted by the National Aeronautics and Space Administration of the United States, about 3,500 color photographs were taken which show features of geologic, oceanographic, or meteorologic interest.

The distribution of suspended sediment is apparent over areas of 2,000–8,000 km^2, in amazing detail, in photographs of waters off major river deltas, such as the Orinoco, Mississippi, and Irrawaddy, where great volumes are introduced into the sea from the streams.

Photographs of coastal waters in the Gulf of Mexico, Persian Gulf, and southwest Africa show suspended sediments distributed by small eddies and rip currents to distances of 30 km from shore.

Where tidal exchange and/or strong offshore winds result in nonperiodic flows from estuaries and lagoons, suspended sediments are visible to distances of 150 km from the shore. As along the Texas coast in the Gulf