facies. In the deeper deposits the sodium chloride facies predominates. The lower total dissolved solids in the ground water in New Jersey indicates that less upward vertical leakage occurs there than in Maryland and Virginia where the shallow deposits contain more concentrated solutions.

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Geochemical Significance of Nickel Complex of Pheophytin

Prophyrin complexes of nickel and other trace metals in petroleum are probably formed from chlorophyll which makes up a minor part of the organic matter from which petroleum develops. Since the chemical and physical environments for the formation of porphyrin complexes must be identical with those for the formation of crude oil, a knowledge of the conditions requisite for the formation of porphyrin complexes is important in defining the conditions under which the associated petroleum is formed. The present study was an investigation of one possible reaction in a likely sequence of reactions leading to the formation of petroleum porphyrins: the complexing of the immediate degradation product of chlorophyll, pheophytin, with nickel. Laboratory experiments were carried out to establish the rate and mechanism of the complexing reaction in the temperature range from 75 to 115°C. in methanol using nickel acetate and pheophytin *a*. It was clear that the reaction mechanism is ionic with the rate depending on the concentration of both nickel ions and pheophytin. The rate of reaction found for the complexing process is sufficiently rapid to indicate a ready formation of the nickel complex of pheophytin in recent sediments, given a reasonable supply of nickel in solution. It was apparent however that the complex is destroyed at sediment temperatures and this precludes the preservation of all but traces of it in recent sediments. It is concluded that the direct reaction between nickel and pheophytin probably does not play a significant part in the formation of nickel porphyrin complexes in petroleum.

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Organic Geochemistry of Cherokee Group in Southeastern Kansas and Northeastern Oklahoma

In southeastern Kansas and northeastern Oklahoma, geological evidence indicates that rocks of the Cherokee group (Desmoinesian) were the source of most of the petroleum which has accumulated in sandstone members and in porous zones along the pre-Pennsylvanian unconformity upon which the Cherokee group was deposited. The Cherokee group in the subsurface is divisible into several cyclothems characterized by nonmarine and marine facies including coal, underclay, sandstone, greenish gray shale, gray (fossiliferous) shale, black shale, and limestone. Although lateral continuity of specific members and cyclothems is evident, the proportion of marine facies is greater in the Cherokee basin than in the adjacent shelf areas.

Organic geochemical studies of the Cherokee group included determination of organic C, hydrocarbons, and saturate-aromatic ratios of the hydrocarbon mixtures. Organic composition, like lithology, shows extreme vertical variability, although principal lithologies have characteristic organic compositions. Greenish gray shales are low in organic C (<0.5%) and hydrocarbons (<50 ppm) with high saturate-aromatic ratios (>1.0); gray shales have intermediate values of organic C (1–3%) and hydrocarbons (100–500 ppm) with low saturate-aromatic ratios (1.0); black shales are high in organic C (5–18%) and hydrocarbons (<2,000 ppm). Despite this internal variability, the organic composition of the Cherokee group as a whole appears to remain uniform over a wide area.

Implications of these results are: (1) organic composition is an inherent property of sedimentary rocks and reflects depositional environment; (2) migration of fluids through shales during compaction has apparently not created compositional gradients or smoothed out primary differences in organic composition; (3) although the uniform character of Cherokee basin crude oils is explicable if the Cherokee group is their common source rock, lack of knowledge on the origin and migration of hydrocarbons poses problems with respect to details of source evaluation.

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Drilling from Floating Vessels in Open Sea

Prior to 1956 offshore wildcat drilling was conducted from fixed platforms or mobile platforms, all of which took their support from the sea floor. Since that time the necessity to work in water depths of 100 feet or more, and the need for cheaper offshore drilling methods in order to make offshore oil competitive in today's market, has led to the development of heavy floating drilling equipment. Up to this time, this type of equipment has been operated in up to 360 feet of water in the open sea. Some of the special features of design of this type of equipment will be shown by slides.

Recently, an engineering study has been completed on the adaption of this type of equipment for very deep water (12,000–15,000 feet) operation. Some of the design problems which have been developed are reviewed.

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Geological Outline of Libya

Cambrian and Ordovician sandstones and quartzites cover the major part of Libya. During Silurian (Gothlandian) time a generally north-south trend from Tibesti through Gargaf to Garian divided the country in two sedimentary provinces, commonly differentiated as "Western-Libya" and "Eastern-Libya."

*Western Libya.*—Divided by a west-southwest—east-northeast ridge in two distinct sedimentary and structural basins which are known to some of the authorities as the "Gadames" and the "Mourzouk" basins. Marine sediments were deposited in both basins during entire Paleozoic time.

At the end of Carboniferous the Hercynic orogeny was very active in the northwestern part of the Gadames basin, where Upper Carboniferous and Permian sediments produced successive transgressions and unconformities. From Upper Carboniferous to Lower Cretaceous gentle subsidence movements governed the deposition in both of the western basins and produced gradation from shallow marine, to lagoonal and to continental deposits.

*Eastern Libya.*—The deposition in the eastern portion of Libya was probably active for the greater part of Paleozoic time. Early Paleozoic sediments are preserved in several areas and also in the Kufra basin, to the south. From Permian to Jurassic time this part

of Libya was possibly uplifted with the exception of the Northern Cyrenaican area.

The Upper Cretaceous produced a large widespread transgression in all of the northern portion of Libya, over an eroded peneplaned surface. The deposition was thin and of a "stable shelf" type with the exception of northern Cyrenaica.

During Paleocene time Western Libya remained stable; however a tilting in the eastern part of Libya produced a large sedimentary basin in the Syrte area, which continued subsiding until Miocene time with its hinge line along the Hun-Misurata main fracture system.

Large portions of Libya are still to be tested by drilling, with the oil strikes localized in general as follows: (1) in the two western Paleozoic basins; (2) in the eastern Syrte Tertiary basin where several unconformities in Upper Cretaceous and Eocene time combined with various movements, resulted in effective favorable conditions for oil accumulation.

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Exploratory Drilling in 1959, United States, Canada, and Mexico

This is the 15th report, based on data gathered by the Committee on Statistics of Exploratory Drilling. It is the 24th annual summary on the subject published in the *Bulletin*. Frederic H. Lahee prepared this statistical analysis and wrote the article for 20 consecutive years. Graham B. Moody prepared the report for 1956. This is the 3d year in which the present author has prepared this exploratory drilling analysis and report.

This report presents a comparison of 1959 data with the number of exploratory holes drilled, and footage drilled during 1958. Also by means of graphs a comparison of 1959 statistics with previous years inclusive of 1944. Ratios of profitable fields resulting from new-field wildcat discoveries are also shown. Trends are indicated by graphs of success ratios for new-field wildcats located on basis of geology, geophysics or the combination of both geology and geophysics. For the 12th time, we are presenting data on Canada and Mexico.

M. A. CONDON, Bureau of Mineral Resources, Geology, and Geophysics, Canberra, Australia

Status of Petroleum Exploration in Australia

No commercial oil field has been discovered in Australia but this must be related to the very small amount of exploration that has been undertaken and the deficiencies in knowledge about the sedimentary basins. Outcrop geology of the sedimentary basins in Australia is known only up to regional reconnaissance detail, and the limits of few basins are precisely known. The complete stratigraphic sequence and its variations are known adequately in few basins and the geological history in none. About 1 million feet of exploration drilling has been completed in the whole of Australia and Papua-New Guinea with a total basin area of about 1,480,000 square miles.

The regional structure is indicated but not precisely established in the Fitzroy basin, Carnarvon basin and Perth basin (W.A.), Sydney basin (N.S.W.), Papua basin (P.N.G.) and the Great Artesian basin. Much of the structure, both regional and local, is of the synchronous type and surface anticlines do not necessarily continue downwards below unconformities. Petroleum source beds and shows are known in many basins but the geological conditions for accumulation have not been established. Much more information is required on the relationships among sedimentation, structure, and possible migration paths of oil.

TOM CULBERTSON, Union Oil Company of California, Midland, Texas

Credit for Discovery

The "basis for location," as used by the A.A.P.G Committee on Statistics of Exploratory Drilling, is inadequate and misleading for any true evaluation of exploratory efforts, and should it be discontinued.

The publication of case histories of typical discoveries, compiled by experienced and representative geologists in each oil and gas district, is proposed as a means of improving our statistical system, and giving proper credit to various exploratory methods, thereby promoting more effective exploration for oil and gas reserves.

The purpose of this paper is to appraise the meaning and use of the statistical column "basis for location." It is also the purpose of this paper to prove that "basis for location" as a statistical classification is inadequate, in its present form, for presenting the geological viewpoints, is unsatisfactory for evaluating our exploration and development efforts, and should be omitted from our annual development papers. It is proposed that committees be appointed in each hydrocarbon producing district to compile annual records in the form of case histories of discoveries, for the purpose of correcting present inadequacies in the classification and improving our exploratory efforts.

BRUCE F. CURTIS, University of Colorado, Boulder, Colorado, and Sandstone Reservoir Committee (C. A. BENGTSON, JULES BRAUNSTEIN, HARRELL BUDD, VIRGIL COLE, RALPH A. DAVIS, BRUCE W. FOX, HARRY GLOVER, PENN L. GOOLDY, T. P. MCCANN, DAVID P. MEAGHER, R. F. MEYER, North Texas Geological Society, KEITH L. RATHBUN, TED R. RUSSELL, F. D. SPINDLE, S. KEITH TUTHILL, R. D. WHITE, JOHN H. WIESE, D. L. ZIEGLAR)

Characteristics of Sandstone Reservoirs in United States

The sandstone reservoir rocks of United States oil and gas fields have been studied by the Sandstone Reservoir Committee in order to learn which kinds of sandstones are most commonly productive and which are most prolific. Information has been gathered concerning the areal extent of sandstones producing in combination and structural trap fields, and concerning genesis of those sandstones constituting stratigraphic traps.

Each of the twenty committee members has been responsible for the assembling of data on an area with which he is familiar. For practical reasons, only large fields (5 million barrels or more gross ultimate production) were considered. This analysis of existing fields should help guide the search for additional production from sandstones.

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Basement Beneath Atlantic Coastal Plain Between New York and Georgia

Basement is defined, for the purposes of this discussion, as the metamorphic and (or) igneous rocks below