outlines of the depression may have been formed in Miocene(?) time, but its present configuration is chiefly the result of late Pliocene(?) deformation. Structurally, the depression is a series of north-trending grabens arranged en echelon north-northeasterly.

Slides showing possible thickness and distribution of the Cambrian-Ordovician-Silurian, Devonian-Mississippian, Pennsylvanian, Permian, and Triassic-Jurassic-Upper Cretaceous in the area are presented; also a schematic stratigraphic section north-south across the area and a map showing Laramide and younger tectonic features.

6. SIGNIFICANT EXPLORATORY DEVELOPMENTS OF 1953.
PHILIP C. INGALLS, Socony-Vacuum Oil Company, New York City.

Within the United States there are extensive little-tested areas believed to offer untold potentialities for the development of truly big oil and gas production. Outstanding in this respect are the Rocky Mountains, the Great Plains, and the southeastern states. But not to be overlooked are the apparently thoroughly prospected areas with "bottomless" sedimentary basins, and areas where complex faulting, numerous wedge-outs, or rapid lateral facies changes have slowed the accumulation of information needed for scientific wildcatting.

The year 1953 saw the completion of many wildcat discoveries in the United States which further

FIG. 1.—ROBERT H. DOTT, executive director, A.A.P.G., Tulsa, Oklahoma; GRAHAM B. MOODY, vice-president-elect, A.A.P.G., San Francisco, California.

broadened and brightened exploratory thinking. Some of these discoveries were in the wide-open spaces, others hugged or were within areas of big production; some were completed as significant producers, others made only small wells but afforded a positive indication of an area's potentialities.

7. EXPLORATION FRONTIERS IN WESTERN CANADA.
W. B. GALLUP, Royalite Oil Company, Limited, Calgary, Alberta.

This paper stresses problems concerning exploration in the western part of the Western Canada sedimentary basin, especially in the Alberta syncline and foothills belt. Some reference is made to certain problems elsewhere in the basin.

The area is seen as a true frontier both with respect to geography and geologic thinking. Problems of access and various exploration techniques peculiar to the wilderness areas are described. Geological thinking with respect to the syncline and foothills is changing rapidly and these approaches are also discussed.

8. WILLISTON BASIN DEVELOPMENTS, 1951–1953.
RAY L. HARRISON, JR., Lion Oil Company, Bismarck, North Dakota.

The phenomenal rate of development in the Williston basin can best be visualized by remembering that at the end of 1950 there was not one producing oil well within the basin parts of North Dakota, South Dakota, Montana, Saskatchewan, or Manitoba. During three years of unprecedented exploratory drilling which followed the first commercial production of oil in the Williston basin (Virden field, T. 10 N., R. 28 WPM., Manitoba, Canada), 55 oil fields, 20 field extensions, and 4 gas fields have been discovered. During this period, production has been established from 16 different formations. One of the most spectacular discoveries during this period came in August, 1953, when

flush production at 2,100 feet was developed in the Lodgepole (Mississippian) in the Roselea field, 56 miles north of the North Dakota line in Manitoba. Subsequent wells in the Roselea field have reported initials as high as 2,500 barrels of oil per day. The lack of sufficient well information makes it impractical to calculate the reserves represented by the fields thus far discovered; however, the most conservative estimate places this figure between 500 million and 1 billion barrels of recoverable oil.

The year 1953 witnessed the completion of the 300,000 barrels per day Interprovincial Pipe Line from Edmonton, Alberta, to Sarnia, Ontario, and marked the beginning of construction of three new refineries in North Dakota, which on completion will process 33,500 barrels of basin crude daily. 1953 also saw the completion of the 100,000-barrel-per-day common carrier Service Pipe Line from the Beaver Lodge-Tioga area to Mandan, North Dakota, the beginning of construction of a natural-gasoline plant at Tioga, North Dakota, and the completion of Stanolind's products line from Mandan to Fargo, North Dakota. There remains, however, an urgent need for additional marketing facilities before the full economic potential of the basin can be realized. Judged from recent official and unofficial announcements, plans to create new facilities are under way and the next five years should show marked progress in this direction.

With geophysical activity maintaining its record-breaking pace, and millions of acres of leases approaching one year closer to the expiration date of their primary terms, it is expected that 1954 will witness an unprecedented wildcat and field development program in the Williston basin. Excellent shallow production in Manitoba, the discovery of the first commercial oil in South Dakota, plus continued success in Montana, North Dakota, and Saskatchewan will serve as an incentive to substantiate this 1954 prediction.

9. MISSISSIPPIAN OIL ACCUMULATIONS IN NORTHERN MONTANA.
JACK W. NORDQUIST, Phillips Petroleum Company, Billings, Montana.

Mississippian reservoirs in northern Montana have produced oil in an amount almost equal to the combined total from all other producing zones. Six important fields, four in the Sweetgrass arch area and two in the Williston Basin, currently yield a total of over 350,000 barrels of oil monthly. Without exception, the producing zones are carbonate reservoirs which contain either intergranular, vuggy or fracture porosity. A discussion of each field is presented to illustrate that stratigraphic variations are equally, if not more important, than structural closure in governing accumulation. The stratigraphy of the Mississippian is treated briefly to show regional correlation of the producing zones.

10. WILLISTON BASIN PALEOZOIC UNCONFORMITIES.
W. S. MCCABE, Stanolind Oil and Gas Company, Casper, Wyoming.

The Williston basin is primarily a Paleozoic basin. Regional Paleozoic unconformities are present in the basin at the base of the following: Cambrian, Ordovician, Middle Devonian, Lower Mississippian, Middle Pennsylvanian, and Middle Permian. The unconformity at the base of the Mississippian is the most pronounced of the regional unconformities. Regional stratigraphic sections and ispach maps are used as illustrations.

11. EXPLORATION FRONTIERS IN NORTH DAKOTA.
CHARLES TALLARD, Continental Oil Company, Bismarck, North Dakota.

Most of the fields in North Dakota were located by a combination of surface mapping and the reflection seismograph. Detailed surface mapping in southwestern North Dakota will be very valuable in locating other structural anomalies; however, the essentially flat Tertiary and Upper Cretaceous beds and the glacial débris north and east of the Missouri River hamper this method of exploration.

Other fields have been located by a combination of seismograph and subsurface studies, and in the future this combination will become a much more valuable method of exploration.

12. WILLISTON BASIN IN SOUTH DAKOTA, AN OIL FRONTIER.
FRANK W. FOSTER, Ohio Company, Bismarck, North Dakota.

No oil in commercial quantities has been found in South Dakota. The geology, however, is replete with the promise that oil will be found in this state. The north-plunging Lemmon syncline, that is, the south end of the Williston basin, occupies the west half of South Dakota. Paleozoic sediments, the source of oil in North Dakota and in adjacent areas in Montana, are known in the subsurface of South Dakota and comprise 37,000 square miles. Cretaceous sediments, which produce oil in Nebraska, occur throughout the state, over an area of about 77,000 square miles. Mesozoic and Paleozoic sediments may range up to 10,000 feet in thickness.

Cross sections indicate the wedging-out of formations of Ordovician, Silurian, Devonian(?), Mississippian, and Pennsylvanian age. These wedge-ends should form porosity traps and be prolific sources of oil. A pre-Jurassic unconformity overlies the truncated edges of most, if not all, of the older formations. Oil reservoirs may be found here. Isopach maps indicate a wide areal distribution of several potential oil-bearing formations.