

Surface structures are known, especially in the western part of the state, and also around the Black Hills and along the Missouri River. Some structures have been drilled.

In comparison with the great potential area for oil finding in South Dakota, only scattered drilling has so far been accomplished, and few wells have tested the deeper possible oil and gas zones.

At present more wells are being drilled, seismic information is being accumulated, and surface parties are evaluating the areas of exposed Cretaceous and Tertiary rocks. Interest is high and this frontier may soon become another oil state.

### 13. SWEETGRASS ARCH, GEOLOGIC FRONTIER.

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The Kevin-Sunburst, Pondera, Cut Bank, and Bannatyne oil fields are located along or across some part of the Sweetgrass arch. Oil has been produced from these fields since the 1920's. Relatively little is known and clearly understood of the importance stratigraphy and subsurface geology play in the accumulations of oil and gas in this province. Numerous wells have been drilled and are still being drilled in the continued search for oil and gas in this area. However, few electric or radioactive logs are run and few if any samples of the cuttings are taken for geologic study. Consequently, much valuable geologic information is going to waste.

East-west stratigraphic cross sections show a pre-Middle Jurassic positive area east of the present Sweetgrass arch in the Chinook-Bearpaw mountain area. Between Middle and Upper Jurassic time

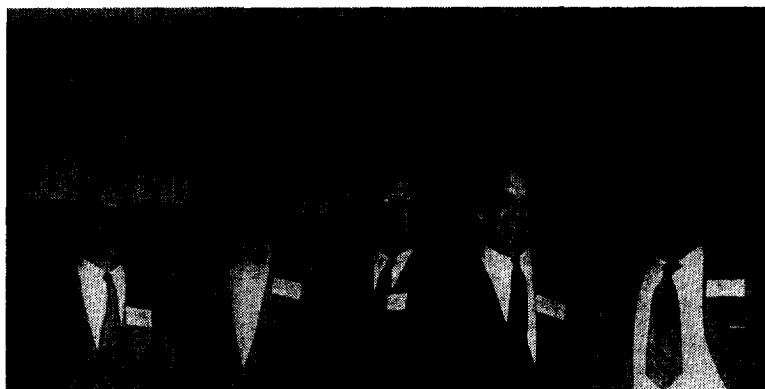


FIG. 2.—Radio-panel members: E. W. ELLSWORTH, business manager, A.A.P.G., Tulsa; FRANK D. GORHAM, JR., Pubco Development, Inc., Albuquerque; A. I. LEVORSEN, Tulsa; MAURY GOODIN, Petroleum Information, Denver; SHERMAN A. WENGERD, University of New Mexico, Albuquerque.

this positive area was depressed and the Belt Island positive area came into being. The present northwestward plunge of the Sweetgrass arch was probably established at this time.

Periods of erosion and truncation of sediments followed by redeposition have caused numerous wedge belts of porosity in sediments from Lower Mississippian to Lower Cretaceous. Changes in facies from the predominantly clastic sediments of the Big Snowy group (Upper Mississippian) into the limestone and dolomites of the miogeosyncline west to the present Sweetgrass arch offer multiple stratigraphic trap possibilities for the accumulation of oil and gas. Relatively little has been done to explore these stratigraphic traps or wedge belts. The wedge edge of the Middle Jurassic Sawtooth sandstone and limestone remains unexplored. Changes in tilt and hydraulic gradient may have caused oil accumulation off the top of structurally high areas forcing a re-evaluation of formerly condemned structures. The area is further complicated by thrust faulting along its western margins.

The Sweetgrass arch area offers a challenge to the petroleum geologist to solve its stratigraphic and structural complexities. Rewards will be high—the oil is here, find it!

### 14. CEDAR CREEK ANTICLINE, EASTERN MONTANA.

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The Cedar Creek anticline is an elongate northwest trending flexure approximately 100 miles long and 10 miles wide located in eastern Montana on the northwest flank of the Williston basin.

As expressed in surface beds of Upper Cretaceous age, the structure is an asymmetric fold with

the steep side on the west. Minor structural closures occur along the axis. The general appearance is one of a long, narrow flexure typical of the compression-type Rocky Mountain anticlines.

Increased exploration for oil since the discovery of the Glendive field in late 1951, has made available geologic data which reveal a considerably different structural development than most geologists expected. The preparation and interpretation of isopachous maps, paleogeologic maps and cross sections indicate that the Cedar Creek flexure is not the result of compressive forces, but due to a sequence of events, i.e., vertical uplift and eastward tilting, normal faulting, extreme truncation, and finally rejuvenation. The growth commenced in early Mississippian time and continued intermittently into Eocene time. The present structure is the resultant of several stages of structural movement which in many ways is similar to the structural development of the Nemaha ridge of Oklahoma and Kansas.

Until 1936 when the first discovery of oil was made in the Williston basin by the Montana Dakota Utilities Company near the south end of the Cedar Creek anticline, the trend was thought of as gas-producing only. Gas was first discovered in 1913 on Gas City dome about 10 miles south of Glendive, Montana. Since this date, approximately 350 gas wells have been drilled. Most of the gas is being produced from the Judith River sandstone at an average depth of 900 feet. According to Petroleum Information, the present gas reserves on Cedar Creek anticline are approximately 60 billion cubic feet. Several of the wells had an initial potential of 25 million cubic feet of gas daily.

The 1936 oil discovery is reported to have flowed at the rate of 125 barrels of oil per day with a small amount of water from the Madison limestone at a depth of 6,800 feet. The test was finally abandoned because of water trouble. Four other deep tests were drilled prior to 1951. All of the tests had good shows or actually produced some oil from either the Mississippian or Ordovician carbonates, but were soon abandoned because of water shut-off difficulties. Altogether, several thousand barrels of oil were produced from these five tests.

It was not until the discovery by The Texas Company, late in 1951, that impetus was given the Baker-Glendive area. Since that time 50 tests have been drilled, of which 37 have been successful. These tests have revealed a thick stratigraphic column of potential reservoirs which includes the Winnipeg sandstone, Red River dolomite, and Gunton dolomite of Ordovician age; Interlake dolomite of Silurian age; Jefferson dolomite of Devonian age; and limestone and dolomite of the Madison group of Mississippian age. Discoveries have been made in the Charles and Mission Canyon formations of Mississippian age, the Interlake group of Silurian age, and the Gunton and Red River formations of Ordovician age. Currently most of the production is from the Red River formation.

At present seven of the several surface or seismic structures have been found productive. Numerous possible traps have not been tested and it is probable that during the next few years more discoveries will be made.

#### 15. 1953 WYOMING HIGHLIGHTS.

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Exploration drilling in Wyoming in 1953 has shown a moderate increase over 1952. Drilling activity, both exploratory and development, has largely been concentrated in the Powder River and Big Horn basins. The hub of activity has been in the Powder River basin, resulting from the basinward extension of Newcastle sandstone stratigraphic trap. Isolated discoveries in the Wind River, Laramie-Hanna, and Green River basins have been very encouraging; therefore, exploratory drilling in Wyoming in 1954 should be broader in scope and continue at an accelerated pace.

#### 16. STRUCTURAL PROBLEMS PERTAINING TO PETROLEUM EXPLORATION IN WYOMING.

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Two structural provinces exist in Wyoming. These provinces are the overthrust belt of western Wyoming marginal to an earlier trough, and the mountain range and intermontane basin province over the old foreland. The tectonic provinces were outlined by Cambrian time, and reflected in the later depositional history.

The attitude of the major fault planes within the overthrust belt is a major problem. The attitude near the toe of the thrust is known locally but at depth is hypothetical. Attitude of the thrust planes will affect the amount of lateral displacement of rock masses in relation to their original sites and environments of deposition, and hence their potential as a source of petroleum. The amount and direction of displacement will affect the degree of cementation to be anticipated in reservoir rocks. Continuity of reservoir rocks and their hydrostatic systems have been interrupted by the thrust planes. The extent of available areas for free migration of hydrocarbons is dependent upon structural conditions.

The foreland province of Wyoming covers a large area and contains the majority of the state's oil fields. Localization of the major tectonic features in the province has been controlled by several factors such as: pre-Laramide fracture systems, possibly as old as pre-Cambrian; heterogeneity in the crystalline basement; and Laramide flexures independent of inherited control. Lesser structural features localize as the result of adjustment of rocks to available space in the developing intermontane