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 move ment 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 thrustplanes 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 basins. Differentiation between different types of controlling influences may lead to recognition and prediction of a basic and systematic arrangement of structural features. It appears that the controlling factors varied with time.

Faults in the foreland province are of several types. These include primary fractures in the basement complex which control the localization of folds of both major and minor dimensions, faults secondarily related to the growth of folds; faults developed due to local space accommodation; and rather extensive late fractures related to a period of regional tension. Problems arise in attempting to differentiate between systems at any single locality.

The relative age of structural traps in Wyoming influences their effectiveness. Some problems related to time and rate of structural development are: nature and amount of the hydrostatic head

FIG. 3.—Mrs. PHIL D. HELMIG, Roswell; Mrs. MAX L. KRUEGER, Laramie; Mrs. D. M. FEREBEE, Albuquerque.

in aquifers; time of effective closing of a trap; subsequent tilting of a trap; time of faulting relative to accumulation. Criteria for the age of folds should be investigated.

Basic understanding of the mechanics of deformation will broaden the frontiers in exploration. Interpretation of new data is best made on the basis of an understanding of old data. Critical review of the following problems in structural geology is needed to expand our thinking.

(1) Is there a curve which best fits the majority of cross sections of Wyoming foreland folds? (2) Is parallel folding too often assumed in constructing cross sections? (3) Further study of the minor faults and their patterns in folds, and (4) quantitative study of the kind and amount of fracturing in folds relative to the amount of potential reservoir void space developed.

17. POWDER RIVER BASIN, A FRONTIER.

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Although oil has been produced from the Powder River basin since 1889, the basin is still a frontier. The margins are defined by oil fields with the interior parts comprising a vast, virtually unexplored territory. Oil and gas have been found in a variety of traps unexcelled in number by any other Rocky Mountain basin.

The basin is rather simple structurally, with such complexities as exist involving large-scale faulting. The stratigraphy is complicated by numerous north-south and east-west changes in lithology and time span. Cretaceous sediments have accounted for most of the oil produced to date. Jurassic and Pennsylvanian rocks are also important producers. Developments of the past several years have demonstrated that it takes remarkably little to trap oil and gas in this basin and exploration ideas have changed accordingly. Fault-trap production, as demonstrated in Sussex-West Sussex area, and stratigraphic accumulations, such as South Glenrock and Clareton-Black Thunder fields, are typical of more recent discoveries creating great optimism for exploratory work to come.

Future exploration will involve continued geophysical work to search out structural anomalies, particularly in the interior Tertiary-covered parts of the basin. Subsurface work will become increasingly important and surface methods will suffer a gradual decrease in popularity.