11. FRED S. HONKALA, Montana State University, Missoula, Montana, and KENNETH P. MCLAUGHLIN, Montana State University, Missoula, Montana, "Central Montana Tectonics."

The major tectonic elements of Central Montana include: (1) the Little Belt-Big Snowy-Porcupine anticlinorium, (2) the northern High Plains region with its igneous intrusions, (3) the Sweetgrass arch, and (4) a southern area that consists of the Crazy Mountain syncline, Lake Basin fault zone, and the northern end of the Bighorn-Pryor uplift. The economic and academic significance of these features and their important subdivisions are reviewed.

The literature is reviewed in an effort to present a picture of the geological development of these tectonic elements. In order to do this, outstanding contributions including those by Erdmann, by Sloss, and by other geologists have been slightly modified by use of new information available at this time. Revised isopach maps and generalized lithofacies maps are presented for central Montana for the Madison-Colorado shale interval.

The effect or significance of certain features or conditions is discussed. These include: (1) the generally positive Sweetgrass arch, (2) the generally negative Beltan (Montana) trough-Big Snowy axis, (3) shallow and deep-seated igneous intrusives of the High Plains, (4) *en échelon* faults in central Montana, and (5) thrust faulting east of the main Rocky Mountain front.

12. PAUL J. LEWIS, Billings Geological Service, Bismarck, North Dakota, "Ordovician of the Williston Basin."

The discovery of oil in sediments of Ordovician age in the Williston basin has required detailed analysis and correlation of various recognizable units. The outcrop areas on the fringes of the basin show Champlainian and Cincinnatian sediments.

The central area of the Williston basin contains a much greater thickness of Ordovician sediments. Possible correlations of the central area and the outcrops are discussed. Change of facies within the carbonate formations are noted.

The textural characteristics of the producing section and other zones are presented by microphotographs.

13. MILES T. RADER, JR., U. S. Smelting, Refining and Mining Company, Billings, Montana, "Silurian Carbonates in the Williston Basin."

Following a brief discussion of the history of the recognition of the age of these beds in the basin, isopach and cross sections are presented in an effort to delineate their present extent and to infer their original extent. A description of the rocks is followed by an attempt to explain the environment of their deposition. Fields in which these beds produce (or produced) oil are noted and discussed.

14. ANDREW D. BAILLIE, Manitoba Mines Branch, Winnipeg, Canada, "Devonian System of the Williston Basin Area."

The Devonian system in Manitoba, Saskatchewan, North Dakota, and eastern Montana comprises four major lithologic units of group rank that are named in ascending order: Elk Point, Manitoba, Saskatchewan, and Qu'Appelle. Isopach, lithofacies, tectonic, and environmental maps are employed to present the gross lithologic character and depositional history of each group.

The Elk Point group consists principally of carbonate and evaporite strata and exhibits marked tectonic differentiation into shelf and basin areas. The shelf areas are characterized by normal marine carbonate deposition that includes biohermal-type reefs. The basin area, sharply delineated by isopach and lithofacies patterns, consists of strata that include salt and anhydrite (Prairie evaporite) as much as 600 feet thick. The thickness of the Elk Point group exceeds 700 feet in the basin and thins to a few feet in peripheral areas on the south where near-shore and transitional deposits are recognized.

The Manitoba group consists predominantly of normal marine carbonate strata with several thin persistent argillaceous zones and beds of anhydrite. A basin of limited areal extent contains as much as 300 feet of salt and anhydrite (Davidson evaporite) in central Saskatchewan. Repetitive lithologic sequences suggest a cyclical type of deposition and rhythmic environmental changes. The lowest complete cycle is named the Dawson Bay formation. The group ranges in thickness from 200 to 800 feet.

The Saskatchewan group consists of shelf-type carbonate strata as much as 1,000 feet thick. Two fragmental and reefoid units exhibit marked lateral persistence throughout the area. The upper reefoid unit is correlated with the Nisku member of the Winterburn formation of central Alberta.

The Qu'Appelle group consists of an assemblage of red argillaceous siltstone and dolomitic shales in the east and becomes anhydritic in the west. A persistent silt zone marks the base of the unit. The upper contact is placed at the base of a widespread black bituminous shale that constitutes the lowest black shale zone of the Exshaw formation.

15. H. MACK COX, consultant geologist, Billings, Montana, "Williston Basin—Mississippian Reservoir Characteristics—and Proved Reserves."

Since the Clarence Iverson Madison discovery in December, 1951, the Williston basin has indi-

cated proved reserves of nearly 200 million barrels from the Mississippian formation alone. This is almost twice the combined new reserves of all other Rocky Mountain areas for the same period. It is predicted that by the end of 1955 the Mississippian reserves will be more than ½ billion barrels, or approximately ⅓ the present reserves of Oklahoma. Basis for this prediction is the variety of favorable reservoir characteristics of the Madison-Charles. Production is obtained from fractured limestones, granular-type limestone with pin-point porosity, and fossiliferous vuggy limestone within rich source beds. Accumulation is not entirely dependent on structure or large amounts of closure as in most other Rocky Mountain areas.

16. T. R. BARNES, Shell Oil Company Billings, Montana, "Case History of Pine Unit, Little Beaver, Richey and Southwest Richey."

Contour maps showing original data on which wells were drilled are compared with contour maps based on available well data. A brief résumé is given on drilling and production characteristics for each field.

17. KEN R. PARSONS and CARL W. KLAENHAMMER, Williston Oil and Gas Company, Casper, Wyoming, "The Glendive Area, Cedar Creek Anticline, Dawson County, Montana."

A presentation of the generalized stratigraphy, structural interpretation, initial development, and producing zones of this local part of the Cedar Creek anticline.

A structure-contour map (Red River-Ordovician) and stratigraphic and structural cross sections are included, together with Silurian, Devonian, and Mississippian isopachs which demonstrate the principal structural evolution of this feature prior to the advent of the most recent Laramide deformation.

18. GLENN M. FEDDERSON, Murphy Corporation, Denver, Colorado, "East Poplar Unit, Roosevelt County, Montana."

The East Poplar Unit is located on the west flank of the Williston basin in T. 28 N., R. 51 E. and T. 29 N., R. 51 E., Roosevelt County, Montana.

The East Poplar Unit includes an area of 34,134 acres of which 98 per cent has been unitized. The unit is controlled by the Carter Oil Company, Murphy Corporation, Phillips Petroleum Company, and Placid Oil Company. Murphy Corporation is the unit operator.

Structurally, the East Poplar Unit is located on an anticlinal closure on a broad regional nose.

The discovery well, the Murphy Corporation East Poplar Unit No. 1, C., SW., NE., Sec. 2, T. 28 N., R. 51 E., was completed March 12, 1952. The discovery well was drilled to the total depth of 9,163 feet into Ordovician quartzite. The well was completed dually from two zones of porosity in the upper part of the Madison formation for an initial production gauge of 325 barrels of oil per day through 8/64-inch tubing choke and 390 barrels of oil per day through 12/64-inch casing choke.

To date, eighteen oil wells and three dry holes have been completed in the Unit area.

Two areas of production have been established within the Unit area. Neither area has been fully delineated. Approximately 3,200 acres are considered proved productive at this time.

19. KINGSLEY W. ROTH, Amerada Petroleum Corporation, Williston, North Dakota, "Development in the Nesson Anticline Area, North Dakota."

This paper deals with oil discovery and developmental activity on the Nesson anticline of northwestern North Dakota. Structural and stratigraphic data resulting from the activity are reviewed and interpreted. Various items of interest pertaining to production are included.

20. C. G. STRACHAN, Gulf Oil Corporation, Tulsa, Oklahoma, "Case History, Pincher Creek Structure and Field."

The Pincher Creek structure lies in the southern part of the Foothills Belt of Alberta. Seismograph operations started in the area of the structure in 1943 as a part of the survey being carried on in the region and has been carried on periodically into 1953. The shooting was partly by the refraction method.

The discovery well is the Pincher Creek No. 1, LSD 15, Sec. 24, T. 3, R. 29 W. 4. Subsequently successful wells, the Marr No. 1 and the Bonertz No. 1, were drilled 7½ and 4½ miles, respectively, and in that order northwest of the discovery. The Schrempp No. 1 was drilled low on the structure in an attempt to find oil but only had a short section of the pay zone above the gas-water line. The Huddleston No. 1 is the most recent completion. It has modified somewhat previous ideas of the nature of the structure and has made a local change in the extent of the reservoir.

The pay zone is in Mississippian dolomites and limestones with a stratigraphic sequence similar to that at Turner Valley. The gas is in intergranular porosity zones and in general permeability occurs as the result of fracturing in the reservoir. Most of the entire productive section has been cored with consequent good control of reservoir factors.