Discoveries will come from both structural and stratigraphic traps, with the latter type becoming increasingly important as more well control is made available.

18. EXPLORATION FRONTIERS IN SOUTHWESTERN WYOMING AND NORTHWESTERN COLORADO.
JOHN F. PARTRIDGE, JR., Consultant, Casper, Wyoming.

That part of Wyoming southwest of the Gros Ventre-Wind River-Sweetwater uplift and west of the Rawlins-Sierra Madre uplift and that part of Colorado north of the Uinta-Axial uplift is truly an exploration frontier. The three basins—Green River, Great Divide-Red Desert, Washakie—and the overthrust belt of western Wyoming comprise an area of 25,000 square miles or 15,850,000 acres. This is 22.5% of the area of Wyoming and 3% of the area of Colorado. Practically every acre of this vast area is potential oil land as the basement complex is not exposed within these limits. Yet to date, despite extensive surface mapping, seismic surveys, and almost complete lease coverage, there are only five known oil fields, 13 gas fields, and only one exploratory well per 230 square miles. Rocks of every age from Tertiary to Cambrian are present under all or part of this province and each rock unit is capable of yielding oil or gas. There are abrupt facies changes across this area from the Wyoming shelf to the Cordilleran geosyncline. Structure in this area varies from simple to complex. There are complex folded and faulted rim structure, simple basin structure, basinal uplift structure, and the complex folds and overthrusts in the overthrust belt. Every ingredient for the accumulation of oil and gas is present. It remains for the oil industry to explore and exploit this frontier of the Rocky Mountain region.

19. SOUTH GLENROCK, A WYOMING STRATIGRAPHIC OIL FIELD.
WM. H. CURRY, JR., Far West Oil Company, Casper, Wyoming.

Wyoming, long the stronghold of anticlinal occurrence of petroleum, is now yielding to the stratigraphic trap. South Glenrock, a 1950 discovery on the southwestern margin of the Powder River basin, has developed a 50-million-barrel reservoir in Lower Cretaceous sands of the Dakota and Muddy zones, without the benefit of structural closure.

The term "Dakota" for the lower sand, fits current usage, but the sand is at a different stratigraphic level from other sands of the Wind River basin on the west, also called "Dakota." Dakota oil at South Glenrock is trapped by a westward facies change on a large eastward plunging nose off the prominent anticlinal structure of the Big Muddy oil field. Muddy oil is found in lenticular sands associated with prominent channeling at a point of unconformity, 100 feet above the Dakota zone.

South Glenrock structurally is integrally related to the Big Muddy anticlinal oil field, but produces from different sands. The latter exhibit depositional evidence of being influenced by an ancestral structural feature which was a pre-Laramide incipient "high" at the locale of South Glenrock. This was offset from the younger Laramide anticline which afforded structural accumulation at Big Muddy.

A close study of older sedimentation in other Wyoming localities probably will point to an earlier structural history of local uplifts. The ancestral structures may be offset from their more robust Laramide progeny.

20. PALEOZOIC STRATIGRAPHY OF FOUR CORNERS REGION, UTAH, COLORADO, ARIZONA, NEW MEXICO.
WILLIAM WYMAN MALLORY, Phillips Petroleum Company, Denver, Colorado.

The sedimentary rocks of a region can be organized into (1) units containing similar fauna, (2) units of equal time span, or (3) units of similar lithology. Locally all three unit types may be nearly identical within a sedimentary sequence, but regionally their bounding planes intersect at appreciable angles.

Methods (1) and (2) depend upon paleontological criteria. A major fraction of rocks in the field (and most well cuttings) yields no diagnostic fossils; of fossils recovered, taxonomy and range are, more often than not, moot questions. Methods (1) and (2) are subject therefore to a fair measure of personal interpretation. Organization of sedimentary rocks on the basis of lithology is concrete. This virtue is recognized in the U.S.G.S. definition of a formation as "a mappable lithologic unit." Facies change introduces complexities, but these can frequently be resolved into operational units by diligent effort. The organizational system in this paper is lithologic.

Cambrian sediments of the Four Corners region can be divided into: (1) a transgressive phase composed of a basal sand (Tapeats-Ignacio) followed and overlain in turn by marine shales (Bright Angel-Ophir) and carbonates (Muav-Hartman-Bowman-Lynch), and (2) a thinner regressive phase composed of retreatal sandstones and dolomites.

Time lines cross lithology; hence, at the close of Lower Cambrian time Tapeats sandstone was being deposited in the west Grand Canyon-San Rafael swell region, Bright Angel-Ophir shales in the St. George-Cedar City belt, and carbonates in Nevada. By Upper Cambrian time Tapeats-Ignacio facies had advanced to the Four Corners-San Juan mountain area; Bright Angel facies had been overlapped by carbonates. Latest Cambrian witnessed a rapid marine retreat and clastic offlap.

Ordovician and Silurian rocks have not been identified on the Four Corners region.

Subaerial denudation during Ordovician, Silurian, and Lower to Middle Devonian time developed at least locally a mature topography on Cambrian sediments. Marine invasion of the Upper Devonian

differed from that of the Cambrian in that Devonian seas advanced upon a carbonate terrane, except (1) where valley cutting exposed Tapeats, and (2) in the easterly reaches of Cambrian deposition where Cambrian carbonates never covered the Ignacio conglomeratic sandstone and arkose. The lower part of the Upper Devonian is therefore dolomite contaminated with sands and shales except (1) in valleys where clean sandstone lenses are present in Devonian dolomites, and (2) in the eastern reaches of Devonian deposition where it overlapped exposed Tapeats-Ignacio to lie locally on pre-Cambrian.

Brief marine withdrawal gave rise to a thin gray-green clay zone at the top of the Devonian over which Mississippian carbonate-depositing seas advanced. Distribution of the clean carbonate Madison in the Four Corners region is similar to Devonian.

Cambrian-Devonian-Mississippian distribution patterns were replaced in Pennsylvanian time by new tectonic trends. Crustal mobility supplanted earlier Paleozoic stability. Permo-Pennsylvanian sedimentation exhibits great variation in thickness and lithology. Dominant tectonic elements in the region were the Uncompahgre-San Luis uplift, Zuni-Defiance uplift, Paradox basin, and intervening shelf areas. Excessive rate of crustal subsidence in the Paradox basin produced an evaporite lens nearly a mile thick while normal limestones were deposited on surrounding shelves. Contemporaneous moderate uplift of the Uncompahgre element caused delivery of Paradox basin-marginal arkosic flysch. Climactic uplift in later Pennsylvanian and Permian time spread a thick Cutler arkosic

FIG. 4.—PHIL D. HELMIG, general chairman; H. S. CAVE, Roswell.

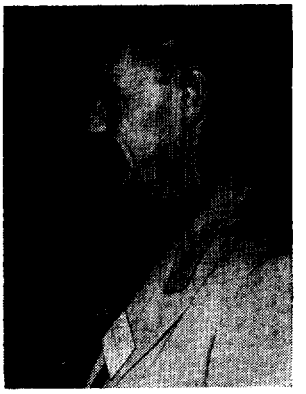

FIG. 5.—D. M. FEREBEE, chairman, registration and reception.

fanglomerate and mixed clastic apron over the central Four Corners region. On its periphery the semiterrigenous Abo-Supai-Hermit-Queantoweap redbed terrane accumulated.

Diminishing Permian redbed deposition was augmented and followed by invasion of light-colored, largely aeolian sands and local bolson evaporites, the Toroweap-White Rim-De Chelly-Coconino-Yeso sequence.

Marine Kaibab-San Andres deposition on the western, southwestern and southern margins of the Four Corners region ended Paleozoic stratigraphic history.

Subsurface stratigraphy of the Four Corners region displays a wealth of possible petroleum exploration frontiers. A few of the most promising include: (1) Devonian channel sands of the Sage Plain-Farmington area, (2) linear Mississippian limestone-dolomite facies change belts flanking the Monument upwarp, (3) Paradox basin-marginal bioherms and associated dolomites, (4) Kaibab limestone and local sand lenses in the Castle Valley-Kaiparowitz region. Emphasis in this region should be strongly stratigraphic, preference going to noses developed on interesting stratigraphy rather than to closures in neutral rocks.

21. EXPLORATION FRONTIERS IN MESOZOIC SEDIMENTS OF FOUR CORNERS REGION.

LEALAND M. KNAPP, The Superior Oil Company, Albuquerque, New Mexico.

The Four Corners region includes 40,000 square miles in New Mexico, Colorado, Utah, and Arizona and is underlain by Mesozoic sediments. Within this area, 21,000 square miles are underlain by sediments at depths favorable for oil or gas production in at least one formation. The present development of oil and gas fields in this area was foreshadowed by shows of oil and gas in early wells, and by seeps in outcrop areas. Much of the present significant production is associated with stratigraphic changes in the formations which produce.