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.

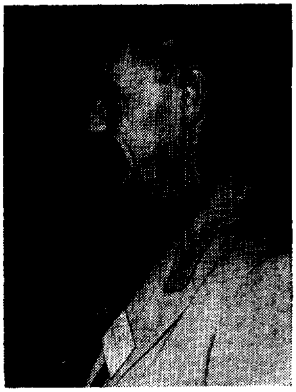

FIG. 5.—D. M. FEREBEE, chairman, registration and reception.

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.

The Triassic Shinarump conglomerate, the Jurassic Entrada sand, the uppermost Jurassic Morrison(?) sand, the Upper Cretaceous Dakota-Graneros sands, and many other Upper Cretaceous sands intertonguing with the Mancos and Lewis shales have a record of oil and gas shows which has not been fully exploited in 90 per cent of the favorable area.

Exploration frontiers associated with sedimentation exist as overlooked variations in deposition, development, and permeability of the Mesozoic sands. Frontiers associated with structure exist with possibility of fault traps, permeability traps, and hydrodynamic traps on low plunging folds with no apparent surface closure. Closure may exist on these folds in the pre-Cretaceous sediments.

The known lithologic variations of the many possible reservoir beds, when combined with known regional structural anomalies, point to many areas of possible production in the sands with a proved record of shows.

22. ARIZONA, A FRONTIER AREA.
SILAS C. BROWN, Consultant, Durango, Colorado.

The state of Arizona is divided into three parts according to its oil and gas possibilities based on present knowledge. This paper gives only a brief mention of the Basin and Range provinces in the southern and western parts of the state and concentrates on the possibilities in the Plateau Province in the northern part.

The major objective formations in the Plateau Province include the Ft. Apache member of the Supai formation (Permian), Hermosa formation (Pennsylvanian) and the Martin formation (Devonian). The presence of a Permian Salt basin in central eastern Arizona may open reef possibilities in the Supai. The Pennsylvanian formations have been disappointing due to the lack of good reservoir beds. Devonian possibilities appear greatest south of the Navajo-Hopi Indian Reservation and in general south and southwest of Holbrook.

The presence of old granite highs and ridges has proved exploration to be dangerous; however, this may be solved by a combination of aerial magnetometer, seismograph, and detailed stratigraphic studies.

23. HYDRODYNAMIC ANALYSES APPLIED TO OIL EXPLORATION AND PROSPECT EVALUATION.
GILMAN A. HILL, Petroleum Research Company, Denver, Colorado.

The common occurrence of hydrodynamic conditions causing tilted oil-water contacts, especially in the Rocky Mountain area, requires the use of new exploration and prospect-evaluation methods. The physical principles of oil entrapment under hydrodynamic conditions are easily understood when explained qualitatively by means of vector-force diagrams. That is, the buoyancy of oil is a vector force acting in a vertical direction, the movement of water in the aquifer produces a vector force acting in a direction approximately parallel with the bedding plane, and the oil-water contact is perpendicular to the vector sum of these two forces. This combination of forces, resulting in a tilted oil-water contact, may (1) cause oil production to extend in the gradient direction beyond the previously assumed limiting contour, (2) force the oil pool away from the highest point of the structure and to the position of minimum potential energy on the flank or nose of the structure, or (3) tilt the oil pool completely out of the structure, leaving it barren of oil production.

When the pertinent forces and structural features are properly scaled, a three-dimensional plastic flow model can be used to study the location and distribution of oil in the structure. In addition, these hydrodynamic scale models can be used to study the effect of local geological factors (faulting, permeability changes, and sand thickness changes) on the hydrodynamic gradient and consequently on the location of the oil pool in the structure.

Electrical and mechanical potentiometric models have been constructed to make regional studies of the potentiometric surface and to evaluate the average hydrodynamic gradient in any specific area of interest. Careful analysis and evaluation of all available data are critical requirements for this study.

It is therefore concluded that in the Rocky Mountain area hydrodynamic gradient analyses must be integrated with structural mapping and stratigraphic studies to properly evaluate all prospects and to find new prospects including nose or flank possibilities on structures previously condemned by dry holes.

24. GEOLOGY OF DISTURBED BELT OF SOUTHEASTERN IDAHO.
MILTON ZENI, Standard Oil Company of California, Salt Lake City, Utah.

The Disturbed Belt of southeastern Idaho is located on the eastern edge of the Cordilleran geosyncline. The structure and stratigraphy are quite similar to that found along the eastern edge of the Cordilleran geosyncline from Canada to southern Nevada. Oil is being produced from a similar structural environment at Turner Valley and Pincher Creek in Canada.

Southeastern Idaho can be divided roughly into parallel zones of structural shortening. Synclinoria, characterized by long, narrow, asymmetrical doubly plunging folds, are separated by anticlinoria which have over-developed into zones of thrusting and imbricate faulting. Overthrusting and imbricate faulting are uncommon in the synclinoria.