along the western edge of the Central Basin platform exceeded 12,000 feet. Shelf limestones were deposited on the marginal shallows, but turbidites and flysch poured in to practically fill the basin during the Wolfcampian. Subsidence continued during the Leonardian, which is characterized by bedded sands, dark limestones and dark shales. In the Guadalupian, the reef-bordered marginal limestone shelves began encroaching on the semi-starved sand and shale floored basinal area. This fore-stepping was checked when reef growths sealed off the seaward opening to the basin. Upper Permian, Ochoan, evaporites furnished the final filling for the structurally negative Delaware basin. Overlying Triassic terrestrials and Cretaceous shelf limestones show no evidence of a buried deep basin in the area.

20. JOHN C. OSMOND, Consulting Geologist, Salt Lake City, Utah

GEOLOGIC HISTORY OF SITE OF UINTA BASIN, UTAH

The Uinta basin in northeastern Utah includes an area of 9,300 square miles. The differential vertical movements which created the basin and its rim began in Paleocene or Eocene time, during the deposition of the Wasatch Formation. The synclinal axis of the basin trends easterly and is slightly convex northward. The basin is asymmetric with a broad gently-dipping south flank and a north flank which is up to 10 miles wide with beds near vertical and locally overthrust.

The configuration of the Uinta basin is controlled in part by pre-existing structures and geologic trends, but much of the present rim is the result of Tertiary tectonics.

The dominant tectonic factor in the development of the basin is the rise of the Uinta Mountains block and the simultaneous subsidence of the synclinal axis of the basin. This major flexure in the crust probably conforms to the edge of the late Precambrian trough in which the rocks of the Uinta Mountains block were deposited. This belt of Precambrian rocks was essentially dormant until Eocene when it began to rise from depths of about 16,000 feet below sea level to elevations of 7,000 to 13,000 feet above sea level.

During lower Paleozoic the Uinta basin area was on a stable crust just east of the Cordilleran geosyncline. In the Pennsylvanian Period the Uncompahgre uplift formed a mountain range part of which now underlies the southeastern part of the present basin. This major tectonic feature had a northwest trend, and several small folds or faults with similar trends developed in the eastern part of the basin. These structures were gradually masked by Mesozoic sediments. Slight Tertiary upwarping and differential compaction allow some of these structures to be reflected as folds plunging into the eastern part of the Uinta basin.

In Cretaceous time the Rocky Mountain geosyncline occupied the region and received clastic sediments from the Cordilleran geanticline in western Utah. In Late Cretaceous time easterly directed compressive forces resulted in folding and over thrusting at the western edge of the Uinta basin area and possibly also caused slight arching of the eastern edge.

During Tertiary time western North America was elevated above sea level. Concurrent with this epeirogeny the mountain ranges and basins of the Rocky Mountain Region were developed by differential uplift. To the west of the Rockies the Basin and Range province was also elevated, and tilted fault-block mountains and valleys were created. This difference between the Rockies and the Basin and Range province reflects the difference in the Paleozoic between the stable block and the geosyncline.

The Uinta basin was outlined in Tertiary time by the central part not being elevated as high as its rim. The northern sector of the rim was the most active in pushing upward. The eastern and southern sectors of the rim were formed by the stable elements supported by the Douglas Creek arch and part of the Uncompahgre block. The southwestern sector of the rim was formed by the San Rafael swell, a Tertiary anticline formed by subsidence of adjacent areas and probably localized by an upper Paleozoic positive trend.

The western sector of the rim of the Uinta basin was created by the interplay of tilting of fault blocks above the eastern margin of the Paleozoic geosyncline and north-trending faults that developed over Mesozoic troughs which, in turn, were superimposed on the margin of the geosyncline.

The structure of the Uinta basin is the result of regional uplift of a heterogeneous area of the crust which incorporated both the sturdy and the weak, or weakened, products of prior deformations. The absence of intrusive igneous rocks is striking.

21. C. A. MARTIN, Continental Oil Company, Durango, Colorado

DENVER BASIN

The Denver basin is one of the largest structural basins in the Rocky Mountain area and extends across portions of Colorado, Nebraska, and Wyoming. The basin is typically asymmetrical with its axis paralleling and close to the Front Range. The deepest portion of the basin lies near Denver, where more than 12,500 feet of sediments are present.

Recently discovered outcrops suggest that during pre-Pennsylvanian time, the Denver basin area was a normal marine shelf receiving sediments from early Paleozoic seas. Post depositional uplift along Siouxia exposed this area to deep erosion removing nearly all the early sediments.

In Early Pennsylvanian time, transgressive seas entered the Denver basin area from the Anadarko basin, depositing a predominantly clastic terrane. Near the end of the Atoka, the first major pulses of the Ancestral Rockies occurred. This uplift reached maximum proportions during the Des Moines. Clastic material eroded from the uplifted mountains was deposited contemporaneously with marine sediments deposited in the expanding seaway. This expansion reached its maximum during the Missourian and was followed by a slight Virgil regression. Continued Permian regression left a full suite of environments and facies ranging from normal marine through an evaporitic sequence to terrestrial deposits. Late Permian and Triassic sediments indicate the Ancestral Rockies were weakly positive and supplied sediments to a shallow hypersaline sea. Non-depositional conditions persisted from Upper Triassic through Lower Jurassic, and into Mid-Jurassic time. During Middle and Upper Jurassic time, transgressive seas fluctuated across the basin from the northwest. As these seas regressed at the close of the Jurassic, a broad inland flood plain developed.

Early Cretaceous seas inundated the area from the north and south reworking earlier sediments and obscuring the Jurassic-Cretaceous boundary. Initial basin-forming movement occurred at this time. Fluviatile material from exposed areas to the east and northeast developed a complex deltaic pattern as it interfingered with marine sediments basinward. Deltaic deposits also extended into the area from the southwest merging with sediments from the east. Another cycle of transgression and regression developed similar depositional patterns. It is within these two Early Cretaceous sedimentary cycles that significant reserves of oil and gas have been discovered. In the Upper Cretaceous, a major transgression joined the northern and southern seas into a large seaway crossing the downwarping basin, and lapping against the uplifted Front Range. This Laramide tectonic activity reached its peak during the Eocene with the basin acquiring its present configuration.

22. LEONARD E. THOMAS, Marathon Oil Company, Casper, Wyoming

GENERALIZED HISTORY OF SEDIMENTATION AND STRUCTURAL DEVELOPMENT OF BIG HORN BASIN

The Big Horn basin of northwest Wyoming is primarily a Laramide structural basin. The area has been a portion of larger sedimentary basins throughout most of geologic history.

The basin is located on the eastern shelf of the Cordilleran geosyncline, east of the hinge line separating the shelf from the former deep parts of the syncline.

Local structural deformation on the sites of several Laramide anticlines in the basin is suggested by slight thinning noticeable in strata of Ordovician age. Local structural influence upon the present-day basin, however, is not evident until at least as late as the beginning of Upper Cretaceous.

During the pre-Laramide eras, periods of regional movements indicate a "see-saw" action with repeated northerly tilting, deposition, emergence and erosion which resulted in truncation of the Ordovician, Devonian and Mississippian sediments from north to south. There is a complete absence of Silurian sediments.

During Pennsylvanian, Permian and Triassic, the area of the present-day basin underwent southerly tilting, deposition, erosion and truncation that resulted in the formations thinning from south to north.

Jurassic and Lower Cretaceous formations show an increase in thickness from south to north. They also show the development of a low-relief structural arch that appears to be the buried, northwest-plunging nose of the Casper arch and Laramide Range in south and central Wyoming.

By the beginning of Upper Cretaceous time the embryo of a structural basin may have been present which affected some of the basal sands of the Frontier Formation.

Later transgressions and regressions of the Upper Cretaceous seas continued until the Laramide Orogeny came into strong evidence at the beginning of Fort Union time. The period of intense movement continued into Eocene with thrust faulting followed by deposition and partial erosion of volcanics on the western margin of the basin.

This movement resulted in peripheral mountain building, pronounced unconformities at the margins of the basin, the development of conglomerates in the Tertiary beds, and the development of the intense anticlinal folds preserved today.

23. BERNARD E. WEICHMAN, Superior Oil Company, Casper, Wyoming

GEOLOGICAL HISTORY OF THE POWDER RIVER BASIN, WYOMING

Precambrian igneous and metamorphic rocks underlie the Powder River basin. Their distribution is uncertain because of lack of subsurface control.

For the purpose of this paper the geologic section is divided into eight rock units. Some of these rock units cross time boundaries between periods.

Rock Unit 1 includes Cambrian and Lower Ordovician sediments deposited by a sea that began transgressing eastward during Middle Cambrian time and regressed at the close of Lower Ordovician time. Following this regression all sediments in Rock Unit I were eroded from the extreme southeastern part of the Powder River basin.

Rock Unit 2 is bounded by the "St. Peters Break" of post-Lower Ordovician time at the base and the Upper Silurian unconformity at the top. The sea in which these beds were deposited transgressed southward from the Williston basin. Sediments of this unit thin southward due to Upper Silurian erosion.

Rock Unit 3 includes the predominantly carbonate rocks of Devonian and Mississippian age. Four unconformities can be mapped within this unit; one at the top of the Devonian, one between the Lower and Middle Mississippian, one between the Middle and Upper Mississippian and one at the top of the Mississippian. Widespread karst topography characterizes the upper surface of the unit at the top of the Mississippian.

Rock Unit 4 includes the Pennsylvanian and Lower Permian rocks. Lower Permian tectonics and erosion breached folds subsequently buried under Unit 5.

Rock Unit 5 includes the Permian and Triassic redbeds and associated carbonates and evaporites. Large-scale uplift and erosion prior to Jurassic formed an unconformity at the top of this unit.

Rock Unit 6 includes all Jurassic rocks and the transition sediments at the base of the Cretaceous.

Rock Unit 7 begins with the transgression in Early Cretaceous time and the deposition of a dominantly shale sequence subdivided by four economically important regressive cycles. The top of Rock Unit 7 is the top of the Cretaceous, a major and early pulse of the Laramide orogeny.

Rock Unit 8 includes all beds of Tertiary age. The present-day configuration of the Powder River basin and the major structures and fault systems were formed at this time (Laramide orogeny). Tertiary sedimentation was controlled by the present basin outline. Previous sedimentation was related to tectonic features of a much broader area than the Powder River basin.

24. S. B. ANDERSON and C. G. CARLSON, North Dakota Geological Survey, Grand Forks, North Dakota

SEDIMENTARY AND TECTONIC HISTORY OF NORTH DAKOTA PORTION OF WILLISTON BASIN

The Williston basin is a structural and sedimentary basin which covers 51,600 square miles in North Dakota and contains sedimentary rocks of every geologic period from the Cambrian through the Tertiary. The maximum known thickness is 15,128 feet in a well in McKenzie County in Western North Dakota.

The Upper Cambrian to Lower Ordovician Epochs are represented by the Deadwood Formation which represent stable shelf deposits extending eastward from the Cordilleran geosyncline. The Williston structural basin began in Middle Ordovician time with a relatively thin clastic sequence (Winnipeg Group) followed by predominantly carbonate deposition (Red River, Stony Mountain and Stonewall Formations). Carbonate deposition continued through Lower and Middle Silurian (Interlake Formation) followed by a period of erosion marked by a major unconformity.

During the Middle and Upper Devonian Epochs the Williston basin was a part of the larger western Canada basin of deposition which was marked by predominantly carbonate deposition with a thick evaporite in the lower part (Prairie Formation) and cyclical carbonates with some thin clastic and evaporite beds in the upper part