lifts and monoclines that generally face southwesterly. The southwestern part includes the minor basins (Henry, Kaiparowits, Black Mesa, and Blanding), the broad Mogollon slope, and uplifts and monoclines that generally face eastward.

The "salt" anticlines, piercements, and graben of the Paradox basin are the most special structures of the Plateau. Their folding and piercement began in Permian time, continued intermittently through Triassic and Jurassic time, and culminated in Laramide time. Subsequent collapse may be partly related to Cretaceous loading, partly to Laramide folding, and partly to solution of the salt.

In addition to the elongate, tangentially compressed uplifts such as San Rafael, Circle Cliffs, or Zuni, there are several domical uplifts due to the stock and laccolithic intrusions such as the La Sal, Abajo, or Ute centers. These centers fall on three nearly parallel, northwesterly trending lines.

The earliest tectonic events that appear to have influenced the present structure occurred during late Paleozoic time. Three northwesterly trending Permo-Pennsylvanian positives developed on and adjoining the Plateau. From northeast to southwest, these are the Front Range, Uncompahgre, and Zuni. All appear to have been asymmetrical toward the southwest where they were immediately adjoined in order by the Colorado, Paradox, and San Juan sags or basins. During Triassic and Jurassic time, local folding occurred in the Paradox fold belt and elsewhere and broad, slight epeirogenic sagging developed in a northwesterly direction between the Uncompahgre and Zuni positives. In late Jurassic time, the southern rim of the Plateau was generally tilted northward. During late Cretaceous time, the Plateau was markedly depressed and slowly tilted northward as it became a part of the Rocky Mountain geosyncline.

Despite the fact that the descriptive tectonics of the Plateau are fairly well known, there still remain several problems concerning the cause, nature, and history of deformation and the character, nature, and history of fluid movement. Among these problems are (1) influence of the Precambrian structures on later deformation, (2) Paleozoic and Mesozoic diastrophisms as interpreted from stratigraphy, (3) cause and nature of Laramide movements especially in relation to the formation of the adjoining Rockies belts, (4) significance of the fracture systems, (5) Cenozoic erosional history and basin sedimentation, and (6) paleodynamics of the rock fluids.

12. WILLIAM LEE STOKES, University of Utah, Salt Lake City
Tectonics of Wasatch Plateau and Near-by Areas

The Wasatch Plateau of south-central Utah is a large table-like remnant of high ground not yet destroyed by the general erosion of the Colorado River system. The basic structure is monoclinal with a regional westward dip that is gentle on the east and steep on the west. Superimposed on the basic structure is a broad anticline, the Monument Peak uplift, consisting of two folds that plunge slightly east of north into the Uinta basin. These folds, in turn, are modified by a north-trending system of fault zones which fall into the North Gordon, Pleasant Valley, and Joes Valley zones. The Joes Valley zone is largest, having a total length of about 75 miles and an average width of 2 miles. It and the other zones are splintered by numerous small faults and the downward displacement reaches a maximum of 3,000 feet.

The regional westward dip of the Plateau is related to the origin of the San Rafael Swell. The greatest folding of the Swell must have been post-Cretaceous pre-Eocene by analogy with the Waterpocket fold on the south. Since the Monument Peak uplift shows structural alignment with the Swell, it probably originated at the same time.

The complex fault zones are obviously of later origin. They are tensional features and cut all surface rocks including Pleistocene moraines. They are related to the deep-seated Wasatch monocline and probably to subsidence and solution effects in the salt-bearing Jurassic rocks below. The western flank of the Wasatch Plateau is complex with numerous faults, unconformities, and landslides. This complexity may be due to growth and collapse of salt structures.

13. W. W. MALLORY, Phillips Petroleum Company, Denver
Tectonic Development of Cordilleran Region

The Cordilleran region of Western United States is a segment of the Cordilleran geosyncline. Its western and eastern borders are the Pacific Coast Ranges and the Wasatch or Teton line. The Cordilleran geosyncline differs from its cratonic neighboring regions, the Colorado Plateau and the Rocky Mountains, by (1) containing extreme thicknesses of sedimentary and volcanic rocks and by (2) having experienced true orogeny. Like its counterpart, the Appalachian geosyncline, it has dual facies expression. An inner (cratonward or miogeosynclinal) belt has thick sediments lithologically similar to cratonic rocks; an outer (seaward or eugeosynclinal) belt has very thick graywackes, volcanics, and other lithotopes.

It is convenient to describe the tectonic development of the geosyncline in four stages, each of which exhibited a distinctive tectonic pattern. Stage I, comprising only the Cambrian period, was essentially simple failure of the continent margin by subsidence behind a progressively inward migrating hingeline. Sediment source was cratonic.

Stage II was a complex interplay of orogeny, volcanism, and deposition with long duration. It opened in Ordovician time with development of a midgeosyncline hinge (the Manhattan line) which introduced the dual facies aspect. Dark, poorly sorted clastics in the outer belt were derived from tectonic island chains which rose within the belt itself (autocannibalism) while normal carbonates and clean sandstones accumulated in the inner belt. Folding and volcanism commenced in the Klamath Mountain area. Silurian and Devonian tectonic patterns resembled Ordovician.

During the Carboniferous, intensified tectonic activity was expressed as folding and thrusting on the approximate site of the old Manhattan hingeline to produce an uplift (Manhattan geanticline of Eardley) which shed conglomerates into both belts. Folding, volcanism, and deposition of clastics continued in northern California.

Further intensification of tectonic action occurred in the Permian, Triassic, and lower Jurassic periods. Profound subsidence of the outer belt accompanied deposition of autochthonous volcanics of regional extent and extreme thickness. A composite maximum of 70,000 feet (12 miles), centering in the California-Nevada area, dominated the entire outer belt. In addition, (1) strong tangential stresses produced local dynamometamorphism in the Sierra and Mohave areas of California in Permian time, (2) basic plutons were emplaced in central Oregon in Triassic time, and (3) ultrabasic intrusions of lower Jurassic age were injected in the Klamath area. These and earlier tectonic events indicate existence of a so-called Klamath tectogene in Washington, Oregon, and California. During the Mesozoic, midgeosyncline lands crowded the inner belt eastward, finally causing extinction.

Stage III was climactic orogeny involving not only folding and thrusting but regional dynamometamorphism and large-scale batholithic intrusion. Beginning in upper Jurassic time, batholithic emplacement in the Klamath tectogene reached proportions unequalled in North America since the Precambrian. Repeated impulses of folding and thrusting marched eastward during late Jurassic and Cretaceous time to culminate as thrusts of major magnitude (Lewis, Bannock, Strawberry, Muddy) at the Teton-Wasatch line.

Apparent post-orogenic relaxation of Stage IV caused collapse of the orogenic highland in the Great Basin. Extensive block faulting plus actual subsidence produced a Tertiary-Recent depositional basin (comparable with the Triassic of the Appalachian belt) which to-day exhibits internal sediment supply, and which in future may acquire a depositional history of some magnitude. Eventual broad, regional, epeirogenic uplift of the Cordilleran belt with associated erosional planation is predicted.

14. ARMAND J. EARDLEY, University of Utah, Salt Lake City
Thrust Belt of Northern Utah, Southwestern Idaho and Western Wyoming

The thrust belt of western Wyoming and adjacent parts of Idaho and Utah is arcuate eastward with the major thrust sheets having been overthrust toward the east. The northern end is crowded against the Teton—Gros Ventre—Wind River tectonic unit and the southern end against the Uinta Mountains mass. The distance between the buttressing elements is 180 miles. One thrust, the Absaroka has been traced the entire length of the belt; others are fairly long, and most have branch faults. The thrust sheets of the forward or eastern part of the belt are stacked in shingle fashion on each other, and for the most part dip fairly steeply at outcrop, although it is evident from stratigraphic displacements that horizontal movement has been considerable in a number of places. The imbricate thrusts of the eastern part of the belt involve mostly Mesozoic strata at the surface. In the back part of the belt is a master thrust called the Bannock, and it involves both Paleozoic and Mesozoic strata. The original view has recently been questioned that it is a great horizontal shallow thrust sheet that was later folded and eroded through in one place. Instead of one master sheet it may be a complex of several imbricate thrusts.

Sharp anticlines and synclines either in front of, or within, the Bannock thrust sheet have attracted the attention of petroleum geologists, and have been drilled without success. A disturbed belt in front of the thrusts involving Cretaceous and early Tertiary strata has been proved productive of oil and gas in several places. Considerable attention is now being given this belt. South of the La Barge oil field the thrust sheets are extensively covered by the lower Eocene Knight formation, and this renders exploration difficult.

15. HOWARD R. RITZMA, Southern California Petroleum Corporation, Denver
Structural Development of Eastern Uinta Mountains and Vicinity, Colorado, Utah, and Wyoming

During Proterozoic time an east-west trough along the site of the present Uinta Mountains, received 20,000 or more feet of sediments, the source of which was in uplands east and north. These sediments, the Uinta Mountain group, are mainly sandstone and quartzite in the eastern part of the range. They form an homogenous shallow-rooted "pod" imbedded in the earth's crust which has tended to act as a unit in subsequent orogenic events.

No known important orogenic events disturbed the area from Cambrian through most of Mesozoic time. Commencing during the deposition of the Mesaverde formation in late Cretaceous time and continuing into Paleocene time, a low north-south uplift, the present Douglas Creek arch and south end of the Rock Springs uplift, was folded across the Uinta "pod." In Paleocene and early Eocene time the Uinta arch, roughly coincident with the "pod," was cross-folded normal to the