Precambrian rocks exposed over large areas of Canada collectively form the Canadian shield. The exposed basement is bounded in Alberta and Saskatchewan by overlying sediments. The surface upon which the overlying sedimentary rocks were deposited is warped into a major syncline the steeper limb of which lies in or near the disturbed belt of Alberta and Montana and along the Rocky Mountain front. In this syncline the basement is covered by a relatively thin veneer of sediments except for local areas such as the Williston basin. Petroleum accumulation in the area of thin sedimentary cover is controlled more by stratigraphic than by structural factors.

The area of local exposure of the Precambrian basement includes the Southern Rockies, the Wyoming basin, and part of the Middle Rocky Mountain province. Prior to deformation the basement was thinly covered by sediments. Anticlinal mountain ranges and deep local intermontane basins characterize the region. The site of deformation was localized by the Pennsylvanian structural history. Petroleum accumulation is largely controlled by geologic structure.

The Precambrian basement was deeply depressed beneath the troughs existent in central Utah, western Wyoming, eastern Idaho, western Alberta, and eastern British Columbia during late Precambrian and early Paleozoic time. Deformation of the troughs created the overthrust belt characterized by repetition of the sedimentary sequence in overthrust fault plates. Absence of Precambrian basement rocks in the thrust plates suggests that faulting is localized in the sedimentary sequence. Accumulations of petroleum have been negligible in this division.

The Precambrian basement complex is no longer recognizable in the areas of batholithic intrusion in Idaho, Montana, and British Columbia. The development of granite and granite gneiss in the Idaho batholith, age 100 MY, modified the pre-existing rocks, and substituted a new floor for subsequent geologic history.

Lineaments of primary significance are superimposed across the tectonic divisions. The lineaments have complex geologic histories in which transverse movement was probably important. The prominent lineaments are: Rocky Mountain trench, Montana lineament, Wyoming lineament, and the Walker lineament, all of which separate regions of differing geology.

Volcanically derived materials of Cenozoic age are widely spread across the Rocky Mountain system, and reflect igneous activity of great magnitude. Extensive tectonic adjustment took place by means of normal and reverse faulting both during and subsequent to the deposition of the volcanic products. The extent and magnitude of the late Cenozoic faulting are as yet incompletely understood. Critical discrimination should be made between fault systems of different ages.

2. L. A. Warner, University of Colorado, Boulder
Tectonics of Colorado Front Range

The Colorado Front Range is the largest structural and topographic element in the eastern Rocky Mountains. Its axis parallels the northerly trend of the mountain front through central Colorado. Two additional trends are recognized in the Colorado Rockies. A northwesterly zone of uplifts extends from the Apishapa arch to the Uinta Mountains. A similar, but more vaguely expressed, northeasterly zone localizes a belt of Laramide igneous intrusives. These regional trends constitute the tectonic framework within which the Front Range evolved.

Fragmentary data on the structure of the basement complex suggest a probable relation between Precambrian and later structures. Paleozoic and Mesozoic crustal movements and sedimentation accentuated and modified Precambrian structural trends. In general the sedimentary cover was relatively thin, but locally thicknesses exceed 15,000 feet. Certain positive elements may have persisted from ancestral Rocky Mountain time into the Cretaceous.

Associated with the northeast-trending belt of Laramide intrusives in the central part of the Front Range are northeast- and northwest-trending steep faults that appear to form a conjugate system of shears. Recurrent movements along these faults were complex and displacements noted along the margins of the range are in places opposite to those observed in the crystalline core. Along the northeast flank of the range, the northwesterly faults cut the sedimentary rocks and produce *en échelon* folds.

Except along the northeast flank, the Front Range is bounded by reverse faults and thrusts that dip toward the mountains. The range was wedged upward along these faults, and adjacent sedimentary basins were depressed during Laramide time. Thrusting was most prominent adjacent to and within those areas which had received the greatest thicknesses of pre-Laramide sediments.

3. Gene L. Shaw, American Stratigraphic Company, Denver
Tectonic History of Raton Basin with Special Reference to Late Paleozoic

During early Pennsylvanian time the ancient Apishapa Sierra Grande, a linear mildly positive element trending 45° W. of the present strike of the Sierra Grande uplift, extended across the Raton basin and connected with the strongly positive Front Range element. Seas surrounded the ancient Apishapa Sierra Grande except on the extreme northwest where it connected with the old Front

Range. Marshall Kay's zeugogeosyncline of Colorado and northern New Mexico bounded the west side of the mildly positive ancient Apishapa Sierra Grande and the east side of the mildly positive Uncompahgre. In early Pennsylvanian time relatively small quantities of arkosic clastics were carried into adjacent seas from the ancient Apishapa Sierra Grande and the Uncompahgre. The Front Range, however, yielded vast quantities of arkosic débris toward seas on the east during Atokan and Desmoinesian time. Orogenic activity along the Front Range is recorded in the coarse clastic Fountain formation which grades laterally into early Pennsylvanian marine sediments as well as late Pennsylvanian marine sediments.

Shortly after Cherokee time a major alteration occurred in the tectonic framework of south-central and southeastern Colorado. The Uncompahgre was strongly uplifted along its east side and the ancient Apishapa Sierra Grande subsided to receive coarse arkosic clastics during late Pennsylvanian time. This writer believes the Sangre de Cristo formation in the Raton basin area is Missouri and Virgil in age, representing a near-source clastic deposit with few interfingering marine limestones. Subsidence of the Raton basin area during Missouri and Virgil time was not uniform. A subsiding east-west trough developed along the New Mexico-Colorado border in the Raton basin, connecting with the north-south subsiding Colorado and northern New Mexico zeugogeosyncline. The present configuration of the Apishapa and Sierra Grande uplifts developed during Missouri and Virgil time as linear features bounding the more rapid subsiding east-west trough along the Colorado-New Mexico border.

Uplift on the west side of the Uncompahgre near the close of the Pennsylvanian period caused regional tilting toward the east, producing an unconformity at the top of the Sangre de Cristo formation. Rocks of known Permian Leonard age do not interfinger with arkoses of the Sangre de Cristo formation but rest unconformably on Sangre de Cristo rocks and pinch out by onlap along the west side of the Raton basin.

Except for minor erosion during early Triassic time, the Raton basin area received sediments during the Mesozoic era until the late Cretaceous Laramide orogeny. The Colorado and northern New Mexico zeugogeosyncline was the center of strong Laramide uplift, creating the Sangre de Cristo Mountains, and minor Laramide uplift gave rise to the present Apishapa and Sierra Grande topographic features.

4. John Paul Gries, South Dakota School of Mines and Technology, Rapid City
Tectonics of Black Hills

During the decipherable part of Precambrian history, the Black Hills area was within an undefined geosyncline in which more than 20,000 feet of sediments accumulated. It can be inferred that the axis trended north-northwest, parallel with the isoclinal folding which occurred near the end of Precambrian time. Peneplanation followed the folding.

In early Paleozoic time, the Hills area was part of a stable shelf on the northwest flank of the Sioux arch. Seas encroached from the northwest. Increasing instability in Mississippian time is evidenced by evaporite cycles in upper Mission Canyon and Charles sediments. Post-Madison-pre-Pennsylvanian uplift left the present Hills area as a thumb-like projection extending northward from Siouxia.

With the disappearance of the Central Montana trough at the close of the Mississippian, seas no longer invaded from the northwest.

The Lusk embayment developed in early Pennsylvanian time. Evaporites in the Pennsylvanian sediments testify to instability of the shelf at that time. By late Pennsylvanian or early Permian time, the Black Hills first appeared as a weak but distinct positive element.

Western South Dakota and the surrounding area formed a broad, relatively unstable shelf during the redbed and evaporite deposition of Permian, Triassic, and early Jurassic time. Stable shelf conditions prevailed throughout the upper Jurassic. Local downwarping is indicated by exceptional thicknesses of Jurassic sediments in the southeastern part of the area.

Western South Dakota was near the geographical center of a wide, asymmetrical Cretaceous seaway. The Hills lay along a hingeline, with a wide shelf on the east and a subsiding trough on the west. With brief interruptions, Cretaceous deposition continued over the area through Fox Hills and probably through Hell Creek time.

Laramide doming of the Hills was due primarily to vertical uplift. Folding along the western side, and along the related Old Woman and Cedar Creek trends, suggests some horizontal forces. Effects of primary doming were modified in the Northern Hills by early Tertiary intrusions. By the close of Oligocene time, at least 6,500 feet of sediments had been eroded, and the Hills appeared as a low range of Precambrian rocks nearly engulfed by White River sediments.

Evidence of Miocene and younger folding and faulting occurs south of the Hills. Regional uplifts in the Miocene, Pliocene, and Pleistocene resulted in erosion, reworking, and redeposition of older Tertiary sediments.