Des Moines age. Major oil production at Aneth, Ismay, Tohonadla, Gothic Mesa, Anido Creek, and other fields is from algal mounds elongated in a general northwest-southeast direction along the basin shelf. Carbonate reservoirs are closely associated with sapropelic black shales and evaporites, occurring in cyclic repetition in the shelf area and grading basinward into a predominantly salt section.

As far as can be determined all reservoirs are isolated bodies of porous carbonates, mostly limestone. About 30 oil and gas fields in Pennsylvanian rocks have been found in the Four Corners area, about half of which are classed as stratigraphic and the other half as either structural or structural-stratigraphic. In almost all cases it can be demonstrated that the accumulation would have developed even if no structural closure were present, although in many places the occurrence is localized by structural growth.

The Ismay and Aneth fields are selected as examples showing both stratigraphic and structural influence on accumulation, with the latter much more strongly influenced by stratigraphic boundaries than the former.

20. D. L. BAARS, Washington State University, Pullman, Washington

PRE-PENNSYLVANIAN PALEOTECTONICS—KEY TO BASIN EVOLUTION AND PETROLEUM OCCURRENCES IN PARADOX BASIN

A large northwest-trending fault block composed of late Precambrian through Mississippian rocks is exposed in the core of the San Juan Mountains near Silverton, Colorado. The fault block was formed prior to Ignacio (Late Cambrian) time when younger Precambrian quartzites were extensively down-faulted into the older Precambrian basement complex. The structure stood as a high topographic feature during Ignacio to Late Devonian time, but was largely buried by the upper Elbert Formation. Renewed activity occurred in Ouray (latest Devonian or earliest Mississippian) time, when tidal flats developed on the high flanks of the fault block while normal marine waters moved into the graben. The entire structure was high during the Early Mississippian, for the Leadville Formation is preserved only as tidal-flat dolomites and weathering residual blocks within the regolithic Molas Formation above. Pennsylvanian and later movement occurred along the graben, as Hermosa and Cutler strata are now involved in the graben.

With this paleotectonic feature as a model, other areas are more readily understood. A similar ancient fault block is present south of Ouray, Colorado, and extends northwest into the subsurface of the eastern Paradox basin. This structure joins a major northwest-trending pre-Pennsylvanian fault system that flanks each of the major salt anticlines which parallel the adjacent Uncompahgre uplift. Isopachous and lithofacies studies reveal that these structural lineaments were already present in Late Cambrian time, and actively controlled sedimentation through Mississippian time. It is possible that the closely related Uncompahgre uplift had a similar early history.

Pre-Pennsylvanian reservoir facies are best developed along the high flanks of the faults. Late Devonian McCracken sandstones occur in linear bars along the structures, and crinoidal biogenic banks, which are associated with all Leadville production, also occur on the shallower structural flanks. Where paleotectonic relief was too high, however, pre-Pennsylvanian rocks are missing either because of non-deposition or subsequent erosion.

The down-faulted paleotectonic troughs were the site of thick Pennsylvanian salt deposition. When Middle Pennsylvanian to Early Permian clastic wedges from the Uncompahgre uplift initiated salt flowage by differential loading, the fault blocks acted as buttresses which deflected the plastic salt upward. Consequently, the salt anticlines grew along the linear trends created by the Precambrian through Mississippian faults.

21. CHARLES S. TENNEY, Consultant, Casper, Wyoming

PERMO-PENNSYLVANIAN DEPOSITION IN WYOMING

Following truncation of the Mississippian sediments, much of the present State of Wyoming was tilted toward the south. Pennsylvanian seas advanced onto the shelf area of Wyoming both from the southwest and the southeast. In the southeastern portion of the State, a hinge-line developed in the vicinity of the tri-State area. This hinge-line separated a basin deep situated in eastern Colorado from a more stable, restricted bay or gulf which occupied much of eastern Wyoming. An entire sequence of Permo-Pennsylvanian sediments accumulated in this bay, and appears to have occupied an area very similar in outline to the present-day structural configuration of the Powder River basin.

22. DONALD E. LAWSON AND JORDAN R. SMITH, Forest Oil Corporation, Casper, Wyoming

PENNSYLVANIAN AND PERMIAN INFLUENCE ON TENSLEEP OIL TRAPS

Near the close of Desmoinesian time, regional uplift toward the west elevated the Tensleep of the Big Horn basin above sea-level. Broad, low-relief, northeast-trending folds developed during this orogenic uplift. Streams entrenched a well-developed drainage pattern on the exposed Tensleep surface and furnished sediment to the upper portion of the Minnelusa in the east and southeast. During Wolfcampian time, the Phosphoria sea transgressed the area and the incised stream channels were filled with shale and re-worked Tensleep sandstone; later Phosphoria deposition onlapped post-Tensleep hogbacks and low hills.

The majority of the oil that has been produced, and that will undoubtedly be produced, from the Tensleep has been from traps which are structurally controlled. However, accumulation in a significant number of these traps is the result partly or wholly of three stratigraphic variables; (1) an intra-formational change in permeability and(or) lithofacies providing a facies trap; (2) incised channeling with later infilling of basal Phosphoria shale providing a truncational subcrop trap; and (3) a combination of (1) and (2) above with later Laramide anticlinal folding superimposed on or near these primary traps, an effect which commonly causes the effect of tilted oil-water contacts. Either this type of tilt was not great enough to cause secondary migration farther into the fold or the downdip flow of ground water caused a "tar seal" to be formed at the oil-water interface and froze the oil in place.

There seems to be a depth-temperature-porosity relationship in the Tensleep. Thus far in the Big Horn basin, porosities are known to decrease progressively with increasing depth and temperature. Siliceous overgrowths form on the rims of the quartz grains, because of the increased compaction load and temperature, thereby reducing primary porosities. Ground water invading the Tensleep at shallower depths will also cause a similar phenomenon; therefore, the Tensleep will not always be porous even at shallow depths. Possibilities for finding adequate porosity at greater depths will be enhanced in