crease in annual production to approximately 900 Bcf by 1990 and this production level should continue to the year 2000.

Estimated undiscovered oil resources range from 2 (95% probability) to 8 (5% probability) billion bbl with 4 billion bbl the most likely quantity. The most promising area for future discoveries (barring bandwagon psychology!) is the thrust belt with an estimated range of 600 million to 3 billion bbl and a most likely estimate of 1.5 billion bbl. Future discoveries in the thrust belt will be in structural traps in Mesozoic and Paleozoic formations.

Close behind the thrust belt in estimated undiscovered oil resources is the Powder River basin with a range of 500 million to 3 billion bbl and a most likely estimate of 1 billion bbl. Future discoveries should be in Pennsylvanian and Cretaceous rocks, in stratigraphic traps, within the central, deeper part of the basin.

Other parts of Wyoming have a wide variety of possible traps and potentially productive formations. There is a long-shot chance for giant oil or gas accumulations in Permian-Pennsylvanian stratigraphic traps in the Wind River and Green River basins, similar to the Cottonwood Creek field in the Bighorn basin. These will be deep!

Estimated undiscovered gas resources range from 35 (95% probability) to 100 (5% probability) Tcf with 56 Tcf the most likely quantity. Future major gas discoveries will be in Tertiary, Cretaceous, and pre-Cretaceous rocks in the Green River and Wind River basins. These basins have an average range in potential from 11 to 47 Tcf and a most likely estimate of 21 Tcf in each basin. The Wyoming portion of the thrust belt has an estimated range in potential of 8 to 20 Tcf and a most likely estimate of 12 Tcf undiscovered, but these estimates are subject to considerable change as developments continue.

A significant portion of the gas potential is in "tight" sandstones that have less than 1 md permeability. Greatly increased wellhead prices and improved fracturing technology would permit ultimate gas production to be larger than the most likely estimates.

HAUSEL, W. D., Wyoming Geol. Survey, Laramie, Wyo.

Powder River Basin Uranium Deposits; History and Production

The historical significance of the Powder River basin uranium deposits is twofold: (1) the first economical Tertiary uranium deposits in Wyoming were discovered in the Pumpkin Buttes area of the Powder River basin, and (2) the surface to near-surface exposure of these ores provided the basic information needed to develop exploration models for prospecting in similar Tertiary basins in Wyoming.

The first commercial production of uranium within the Powder River basin began in 1953 and continued until 1965. Most of this early production came from mining operations concentrated along high-grade (as high as 15% uranium and nearly 3% vanadium) concretionary deposits limited in size and extent. Because of the size of these deposits, only small tonnages were realized, and as many as 55 separate mining operations were reported within the first 15 years. A second uranium boom began in the early 1970s with the discovery of several low-grade disseminated roll fronts near Pumpkin Buttes and in the southern Powder River basin. Production from the low-grade disseminated deposits has totaled nearly 180 times more ore tonnage than that produced from the high-grade concretionary deposits. Total ore production within the basin amounts to more than 5 million tons of ore, and increased production is expected over the next several years.

HAUSEL, W. D., Wyoming Geol. Survey, Laramie, Wyo., and M. E. MCCALLUM and T. L. WOODZICK, Colorado State Univ., Fort Collins, Colo.

Update on Exploration for Diamonds in Colorado-Wyoming Kimberlite Province

The discovery of diamonds in kimberlite diatremes in 1975 led to a joint effort by Colorado State University and the Wyoming Geological Survey to explore for additional kimberlite occurrences within Colorado and Wyoming. Presently, more than 90 separate kimberlite localities are known in the Colorado-Wyoming State Line district and the Iron Mountain district of Wyoming. Additionally, an isolated kimberlite pipe is present west of Boulder, and there is a kimberlite dike in the Estes Park area of Colorado, extending the known kimberlite occurrences in a roughly north-south trend over approximately 120 mi (192 km). Diamonds have been recovered only from diatremes in the State Line district, except for an isolated occurrence of placer diamonds recently identified in stream-sediment concentrates from the Medicine Bow Mountains.

Exploration continues with the examination of the Front Range by available remote-sensing imagery. Target areas given highest priority are those showing apparent relations and similarities to known kimberlite districts. Drainages in these areas are systematically sampled for heavy mineral indicators (i.e., pyrope garnet, magnesium ilmenite, chrome diopside), and the heavy mineral "trains" are traced upslope to potential kimberlite sites. Detailed ground surveys are conducted over several miles around all new discoveries, with special emphasis placed on associated linear trends (faults, dikes, joints, etc). Limited soil and alluvial geochemical sampling has been used with variable success.

Several geophysical methods have been used, but electrical resistivity and magnetics appear to be the most useful. Electrical resistivity methods show that weathered kimberlite is highly conductive (80 to 250 ohm-ft) compared to the enclosing Precambrian granitic host rocks (300 to 7,400 ohm-ft) and that magnetics are variable, showing only small dipolar anomalies ($\pm$ 30 to 150 $\gamma$).

HEGNA, EARL T., Hegna, Kerns & Traut, Consulting Geologists, Casper, Wyo.

Hartville Uplift—New Look at an Old Area

The Hartville uplift of eastern Wyoming is a structural arch connecting the Black Hills uplift with the Laramie Range. It displays several periods of tectonic activi-

ty—Late Pennsylvanian, post-Wolfcamp–pre-Leonard, post-Triassic–pre-Late Jurassic, pre-Cretaceous, and post-Paleocene.

Early structural exploration along the southeast Powder River basin rim resulted in several oil and gas discoveries, notably Lance Creek field with pay zones of Cretaceous, Jurassic, Permian, and Pennsylvanian ages. Recent exploration has resulted in stratigraphic discoveries in Cretaceous and Pennsylvanian rocks. This rather sparsely drilled area appears to have excellent potential for additional stratigraphic traps in Cretaceous and Pennsylvanian sandstones.

HENDRY, H. E., G. N. SUTHERLAND, and S. J. C. WING, Univ. Saskatchewan, Saskatoon, Sask.

Relations Between Sedimentary Facies and Diagenesis in Frenchman Formation (Maestrichtian) of Southern Saskatchewan

The Frenchman Formation of southern Saskatchewan is a fluvial deposit which ranges in thickness from only a few meters to over 70 m in a distance of about 50 km. The detritus was derived from the Cordillera mainly on the west and southwest. The rocks and sediments of the Frenchman Formation are arranged in fining-upward sequences, typically with the following arrangement of sedimentary facies from bottom to top of each sequence: large-scale trough cross-bedding in medium to coarse-grained silty sand; trough cross-bedding with individual sets topped by ripple lamination or parallel-laminated silt with plant remains; ripple cross-lamination in fine sand and silt; parallel-laminated fine-grained silty sand or alternating sand and carbonaceous material; interbedded purple, green, and silty clays. Single sequences are up to 40 m thick. The sands are interpreted as channel-fill deposits and the clays as overbank deposits; the ratio of channel to overbank deposits ranges from 0.2 to 5.3. Where exposures permit and the formation is thick enough, sand bodies can be traced for up to 4 km. However, some sands clearly are lenticular and persist in outcrop for less than 1 km. Many parts of the Frenchman sands are cemented with calcium carbonate and the distribution of the cement shows a close relation to the sedimentary facies. In the coarse-grained sands with large-scale cross-bedding, patterns of cementation have been influenced strongly by the anisotropy of permeability; preferred directions of cement development are parallel with the trough axes of cross-bedding and parallel with the dip of foresets in cross-bedding, and cementation in such zones commonly occurs to the extent that an expanded fabric has developed. In the finer grained sands and silts, development of cements is related principally to the overall direction of bedding, and cements are concentrated in spheroidal concretions whose planes of maximum projection parallel the bedding.

HOBDAY, DAVID K., and DAWN G. MCKALIPS, Bur. Econ. Geol., Austin, Tex.

Nonmarine Depositional Environments and Uranium Exploration in Lower Cretaceous Antlers Formation, North Texas

Detailed geologic and geochemical investigations of the Sherman quadrangle for the National Uranium Resource Evaluation (NURE) program have included fluvial deposits of the Antlers Formation which are exceptionally well exposed in cliffs along the shores of Lake Texoma, Grayson County, Texas. These deposits accord with the classical mixed-load, meandering-river model, with erosively based pebbly sandstones grading upward into silty sandstones and carbonaceous mudstones with sporadic lignitic material. Lateral-accretion bedding of presumed point-bar origin is inclined at angles up to 10°. Thickness of these lateral accretion units permits estimates of channel depth of as much as 12 m. Distinct channel forms, some of which are clay filled, are up to 100 m wide, but substantially lower estimates of channel width are obtained from dimensions of the point-bar stratification. Flanking and overlying the in-channel sands are inclined levee deposits, chutes and chute bars, proximal to distal crevasse splays, and organic-rich backswamp clays.

Preliminary radiometric analyses show low to very low readings for the major channel sands, with a general trend of increasing radioactivity with decreasing grain size, decreasing bed thickness, and increasing organic content. Thus the most distal, or sediment-starved, overbank facies composed of dark laminated clays and lignites show the highest values. These analyses indicate substantial local epigenetic enrichment, but the deposits encountered to date are too small to be considered a potential resource.

JACKSON, TIMOTHY J., and FRANK G. ETHRIDGE, Colorado State Univ., Fort Collins, Colo., and ALV D. YOUNGBERG, Dept. Energy, Laramie, Wyo.

Flood-Plain Sequences of Fine-Grained Meander-Belt System, Lower Wasatch and Upper Fort Union Formations, Central Powder River Basin, Wyoming

Models of fine-grained meander-belt systems generally emphasize the coarser sandstone facies of channel origin and neglect the relatively fine-grained overbank sediments of the flood plain. This emphasis is unfortunate because of the volumetric importance of the flood-plain sequences in many ancient stratigraphic successions such as the Tertiary coal and uranium-bearing rocks of the northern and central Rocky Mountain and Great Plains provinces. An appreciation of the processes of formation, and lateral and vertical successions of these deposits can provide valuable information for mining and reclamation activities.

Macroscopic and microscopic studies of 18 continuous cores through the lower Wasatch and upper Fort Union Formations in a 4-sq mi (10 sq km) area of southeastern Campbell County, Wyoming, allow recognition of six flood-plain environments associated with point-bar sequences. These flood-plain sequences, recognized on the basis of primary and secondary sedimentary structures, presence and type of bioturbation, organic content, and presence or lack of preferred vertical and lateral successions, include lacustrine, lacustrine delta fill, well-drained and poorly drained swamps, crevasse splay, levee, and abandoned channel. Recognition