ciently well preserved or studied in sufficient detail for construction of even general facies maps. One obvious exception is the Green River Formation of Paleocene(?) to Eocene age, the most extensively studied lacustrine rock unit in the world. In the Green River Formation, the general facies pattern in northeast Utah and northwest Colorado is one of marginal coarse clastics and centralized organic-rich mudstone; a general basinward increase in carbonate rock is also notable.

Most lakes pass through more than one cycle of expansion and retreat. The resulting vertical sequence is a composite of many complete and incomplete cycles.

Lacustrine rocks display a variety of allocyclic sequences: glacial and nonglacial varves, transgressive-regressive cycles, and various composite groupings represented by bundles of varves or other cyclic deposits.

POOLE, FORREST G., THOMAS D. FOUCH, and GEORGE E. CLAYPOOL, U.S. Geol. Survey, Denver, Colo.

Evidence for Two Major Cycles of Petroleum Generation in Mississippian Chainman Shale of East-Central Nevada

Marine Chainman Shale from drill cores in Railroad Valley and from outcrops in several mountain ranges of east-central Nevada contains a mixture of marine-sapropel and detrital terrestrial-plant organic matter. The organic matter ranges from immature to supermature in thermochemical evolution as indicated by organic geochemical data on kerogen and on hydrocarbon extracts and oil, by vitrinite reflectance, and by alteration colors of palynomorphs and conodonts. Hydrocarbon contents (<30 to 2,000 ppm) and organic-carbon contents (<0.1 to 7 weight %) vary widely. A discontinuity in thermochemical maturity has been identified between Paleozoic and Paleogene rocks in uplifted terranes, whereas a more continuous kerogen-maturation profile exists across the Paleozoic and Paleogene boundary where deeply buried beneath Neogene rocks. A two-cycle model of petroleum generation is proposed to account for these variations.

The first cycle of petroleum generation began probably in early Mesozoic time when the Chainman was buried beneath upper Paleozoic and lower Mesozoic rocks. Depth of burial and hence the degree of thermochemical maturation varied with late Paleozoic and Mesozoic folding, faulting, and erosion.

Organic matter in the Chainman is supermature in many localities where higher paleotemperatures were related to subcrustal hotspots or deeper burial. Analyses of surface and subsurface data indicate that although Chainman rocks were subjected to thermochemical degradation and generated some hydrocarbons in Mesozoic time—as evidenced by oil of varying viscosities trapped in fractures, voids, and invertebrate-fossil cavities in dense limestone concretions and beds—organic matter was not completely transformed into petroleum where buried at moderate depths. Uplift of buried Chainman Shale prior to the late Mesozoic arrested the first cycle of petroleum generation in thermochemically immature and mature rocks.

Many organically immature and mature Chainman rocks in this region are now undergoing a second cycle of thermochemical degradation and renewed oil generation in Neogene basins where adequate fill and temperature increase have occurred. Rocks of the Chainman Shale probably are a major source of petroleum in Railroad Valley where oil has accumulated in fractured, welded ash-flow tuffs of Oligocene age. Oil accumulations are inferred to occur in other valleys in eastern Nevada where similar geologic conditions exist.

PORTER, LORNA A., Peppard-Souders and Associates, Denver, Colo.

Laramie-Hanna-Shirley Basins—Future Petroleum Potential

The Laramie-Hanna-Shirley basins are three contiguous intermontane basins between the Laramie (Front Range) Mountains and the Sierra Madre and Rawlins uplifts. All of the current major production was discovered prior to 1960. In the last 4 years only 20 wildcats have been drilled in the area, which includes approximately 5,000 sq mi (13,000 sq km).

Hydrocarbon production in these basins is primarily from the Muddy, Cloverly, Sundance, and Tensleep. Lesser amounts of production have been indicated from the Lewis, Mesa Verde, Steele, and Frontier. All of the production in the area, with the exception of one field, is associated with surface and subsurface anomalies. In areas where the Cretaceous and Jurassic are productive, stratigraphic traps are usually associated with these anomalies.

Subsurface and outcrop data indicate that the Laramie-Hanna-Shirley basins have potential for purely stratigraphic entrapment in Cretaceous and Jurassic units. Delineation of facies for these units has indicated areas of best potential for stratigraphic entrapment. In addition, potential exists in the Laramie-Hanna-Shirley basins for entrapment on structural anomalies which have not been tested to deeper objectives.

RICE, DUDLEY D., U.S. Geol. Survey, Denver, Colo.; GARY L. NYDEGGER and CHARLES A. BROWN, Kansas-Nebraska Natural Gas Co., Lakewood, Colo.

Bowdoin Dome Area, North-Central Montana—Example of Shallow Biogenic Gas Production from Low-Permeability Reservoirs

Natural gas is currently being produced from shallow, low-permeability, low-pressure reservoirs in the Bowdoin dome area, Phillips and Valley Counties, Montana. Most of the gas is stratigraphically entrapped in thin, discontinuous siltstones and sandstones that are enclosed in a thick sequence of shales of Late Cretaceous age. There is some structural influence on the accumulations in more porous zones. The reservoirs and the associated shales were deposited on a shallow marine shelf and thus present different mapping and recovery problems from most low-permeability reservoirs which are of nonmarine origin. The shales enclosing the reservoirs were the source of the early generated biogenic gas.

Natural gas was first discovered at Bowdoin in 1913