where large sediment supplies are recorded by seaward progradation of deltas and barrier islands.

Widespread sheets of sandstone and conglomerate, like the Ericson Sandstone of the Rock Springs uplift and the Castlegate Sandstone of eastern Utah, represent braided piedmont plain deposits of sand and gravel spread beyond the bases of newly uplifted areas under conditions of humid to subhumid climates. These are commonly underlain and overlain by meander belt deposits consisting of broad silty-shale floodplain deposits and narrow channel sandstones and conglomerates. The upward sequence of braided alluvial sheets of sandstone and conglomerate and predominantly shaly meander-belt deposits records progressive headward erosion of tributaries and consequent expansion of drainage basins.

JACKA, ALONZO D., Geol. Dept., Texas Tech College, Lubbock, Tex.

Principles of Cementation and Porosity-Occlusion in Sandstones

Widespread, porosity-occluding vadose cementation is restricted to hot arid and semiarid regions where carbonate (caliche) is concentrated, and to hot regions with wet-season, dry-season climates (savannah lands) where iron and aluminum hydroxides and oxides (laterites and bauxites) are concentrated. Rapid evaporation-triggered precipitation of carbonates, hydroxides, and oxides results in initial precipitation of finely crystalline grain-coating cement films (which separate grains) and in later replacement of grains by cement to form increasingly enriched concentrations. Textures and structures of caliche, laterite, and bauxite are homologous and uniquely reflect vadose processes. The mechanism by which ions are concentrated as vadose cement is upward diffusion from the water table through moist soil following periods of infiltration, and evaporation-triggered precipitation in water films during drying intervals.

Cementation below the water table or in water-filled voids (aqueous cementation) in fresh water or seawater, occurs slowly and, because large crystals have time to grow, the cement is coarsely crystalline. Soon after burial silica is precipitated as epitaxial overgrowths on quartz grains at shallow to moderate depths under conditions of low temperature and slightly acid pH. At greater depths silica precipitation is followed by calcite precipitation and replacement of quartz under higher temperature and pH. Silica mobilized at depth by replacement and solution of quartz, diffuses upward and carbonate diffuses downward where it precipitates as optically continuous or polycrystalline overgrowths on available calcite "seeds" deposited with sands or with intercalated calcareous shales or limestones. Transportation of cementing materials by opposed diffusion gradients, through very slowly moving or static interstitial water, overcomes inadequacies inherent in the supposition that they were transported upward by abnormally large volumes of water, required to transport cementing materials, expelled from compacting clays below depths where clays continue to undergo significant compaction.

In Upper Cretaceous sandstones of the Rocky Mountain region faceted silica overgrowths were precipitated at shallow to moderate depths of burial on sands which accumulated as braided alluvial sheets (piedmont plains), extending outward from newly created uplifts, point bars deposited in channels of meandering rivers on swampy coastal plains, deltaic distributaries and barrier islands, consisting of lagoonal, backshore beach, foreshore beach, surfzone, and infrasurfzone sands. Silica overgrowth molding and merging formed loosely cemented sandstones, but did not occlude porosity. Concentrations of oyster shells in lagoonal and backshore sands and concentrations of *Inoceramus* in distal extensions (infra-surfzones), where sands intermesh with calcareous offshore marine shales, provided calcite "seeds" upon which porosity-occluding calcite cement crystals were precipitated as epitaxial and polycrystalline overgrowths at considerable depths by downward diffusion of carbonate.

KENT, D. M., Saskatchewan Dept. Mineral Resources, Regina, Sask.

Stratigraphic and Sedimentologic Analysis of Mississippian Madison Formation in Southwestern Saskatchewan

Rocks of Mississippian age in southwestern Saskatchewan consist of a sequence of relatively similar carbonate rocks ranging from 340 ft to 1,030 ft thick. A vertical change in lithologic character not generally reflected on a geophysical log permits an informal division of these rocks into a lower, generally sparsely fossiliferous argillaceous or bituminous limestone unit, and an upper, commonly fossiliferous nonargillaceous limestone unit. The lower unit shows some lateral variations from locally developed bituminous limestone to argillaceous limestone. Red ferric oxide coloration is common in the argillaceous rock, as is glauconite, particularly in the basal part. The upper unit is characterized by a preponderance of crinoid remains generally in the form of alternations of particle-supported crinoidal limestones and micritic limestones with varying percentages of crinoid columnals. Bryozoa, brachiopods, and solitary corals also are concentrated in this sequence of rocks.

The variable thickness of Mississippian rocks is probably related to the effects of regional erosion on the post-Mississippian–pre-Jurassic erosion surface which have resulted in removal of progressively older beds in a northwesterly direction. A paleotopography having a distinct northeast-southwest grain was developed on the erosion surface. Local paleotopographic relief is in the order of 100 ft and regional relief is approximately 400 ft from west to east.

At present oil in commercial quantities is obtained from only 1 well in the study area. This oil accumulated in a dolomitized crinoidal limestone that subcrops on the western slope of a paleotopographic ridge. The ridge is on the easterly plunging Battle Creek anticline. The prospects of discovering additional hydrocarbon accumulations in the Mississippian rocks of southwestern Saskatchewan are enhanced greatly by the presence of excellent local source rocks as represented by the bituminous limestones of the lower carbonate unit.

LAND, COOPER B., JR., Colorado School Mines, Golden, Colo.

Stratigraphy of Cretaceous Fox Hills Sandstone, East Flank of Rock Springs Uplift, Sweetwater County, Wyoming

The Upper Cretaceous Fox Hills Sandstone on the east flank of the Rock Springs uplift is a regressive sequence of sandstone and siltstone which was deposited in shallow neritic and estuarine environments. It overlies, and intertongues with the marine Lewis Shale, and is overlain by, and intertongues with the nonmarine Lance Formation.

Exposed Fox Hills strata consist of littoral and shallow neritic, very fine-grained sandstone and siltstone which commonly are overlain, with marked disconformity, by fine- to medium-grained sandstone deposited in estuarine environments. The origin of these widespread erosion surfaces is believed to be related to the lateral migration of estuary and tidal channels behind prograding barrier-island shorelines.

In the subsurface east of the outcrop, the stratigraphic position of the Fox Hills rises, in an east to southeast direction, over 400 ft in a distance of 15 mi. Subsurface shoreline trends in this area are north to northeast, and appear to form a large embayment across the present Wamsutter arch. North and east of this area, in the vicinity of the North Desert Springs field, the typical Fox Hills Sandstone and uppermost Lewis Shale pass laterally into a thick sequence of siltstone and shale interpreted by Asquith to be a major delta.

Small amounts of oil and gas have been produced from the Fox Hills, and numerous shows have been reported from wells on the east flank of the Rock Springs uplift. The optimum targets for future exploration appear to be porous Fox Hills shoreline and estuarine sandstones, where they interfinger in an up-dip direction with shales of the Lance Formation.

LIVO, GEORGE, Gulf Mineral Resources Co., Denver, Colo.

WOLLASTON LAKE URANIUM HUNT, NORTHERN SASKATCHEWAN, CANADA

(No abstract submitted)

MAIONE, STEVEN J., Colorado School Mines, Golden, Colo.

STRATIGRAPHY OF FRONTIER SANDSTONE MEMBER OF MANCOS SHALE (UPPER CRETACEOUS) ON SOUTH FLANK OF EASTERN UINTA MOUNTAINS

(No abstract submitted)

MEISSNER, FRED F., Shell Oil Co., Denver, Colo.

DEPOSITIONAL PATTERNS IN MIDDLE PERMIAN STRATA OF CENTRAL WESTERN UNITED STATES

Sedimentary strata of Middle Permian age (Guadalupian—uppermost Leonardian?) in the central western United States (Montana-North Dakota to Arizona-West Texas) contain a variety of rock types, including carbonates, evaporites, and terrigenous clastics. These strata include such group or formational units as Phosphoria, Park City, Goose Egg (Wyoming); Taloga, Whitehorse, Blaine (Kansas, Oklahoma); Artesia, San Andres (West Texas, New Mexico); and Kaibab (Arizona). These sediments were deposited on a broad cratonic shelf which underwent differential subsidence and which was bounded by a continental upland on the east and by deep-water seas on the west and south. Lithologic patterns within the strata are characterized by profound lateral facies changes and cyclical repetitions in vertical sequence. Lateral lithofacies changes are related to a broad range of depositional environments and processes, many of which may be identified. These lithofacies changes control the accumulation of major quantities of oil and gas. Cyclic repetitions of lithology in vertical sequences of the strata are related to periods of transgression and regression produced by changes in sediment productivity and sea level. These changes may have been controlled by both global tectonic instability and polar glaciation. Regional correlations based on the cyclicity of the strata seem reasonable and suggest that several of the major depositional cycles identified in widely scattered parts of the central western United States may be synchronous.

MORGAN, J. T., and D. T. GORDON, Marathon Oil Co., Littleton, Colo.

INFLUENCE OF PORE GEOMETRY ON WATER-OIL RELATIVE PERMEABILITY

The interrelation of pore geometry, rock properties, and water-oil relative permeability is illustrated with photomicrographs and relative permeability curves of reservoir rocks. Data are shown to be very similar within a given rock type. This fact emphasizes the need to determine the various reservoir rock types and their distribution. Effects of core handling, calculated versus observed waterflood performance, and data-collecting procedures are important factors to consider.

NELSON, T. W., and DAYTON CLEWELL, Socony Mobil Oil Co., New York, N.Y.

FUTURE EXPLORATION IN ROCKY MOUNTAINS

(No abstract submitted)

OLMORE, STEPHEN, Univ. of Utah, Salt Lake City, Utah

LOWER TRIASSIC MARINE FACIES: AN INDEX TO TECTONIC TRANSPORT IN SOUTHEASTERN NEVADA

A detailed regional facies analysis of the lower part of the Moenkopi Formation (Triassic) is helpful in understanding Sevier tectonic transport along the shelf-miogeosyncline transition in southeastern Nevada. The Virgin Member represents deposition during the last pulse of marine transgression in the Cordilleran geosyncline from the basin onto the shelf in southeastern Nevada and adjacent Utah and Arizona. Because facies changes and corresponding thickness changes assume linear trends along the transition zone, the post-depositional translation and distortion of facies can be determined.

The stratigraphic section in an area comprising the North Muddy Mountains east to Lake Meade is an apparent autochthonous sequence which is not logically underlain by a regional thrust with scores of miles of displacement. The distance measured perpendicular to depositional strike from true shelf facies to the basinward margin of the transition facies is about 35 mi. Included within this span is a thick evaporite sequence that is equivalent to beds deposited in an open marine setting in the basin on the west. On the north, between the Beaver Dam and the Mormon Mountains, the span between the same 2 facies is about 10 mi. The apparent facies change on the north in the area of the Mormon Mountains is ascribed to a major sole thrust that has displaced facies about 20 mi toward the shelf. The areas are separated by an approximate east-west shear zone that has a minimum right-lateral displacement of about 12 mi.

I believe that attractive oil and gas possibilities exist in the North Muddy Mountains–Lake Meade area which was previously interpreted to be a major allochthon.