sive limestone cliffs up to 500 ft thick are present in southwestern New Mexico and southeastern Arizona.

Horquilla reefs, 1,200 ft thick, were described and photographed by Zeller in the Big Hatchet Mountains. The reef started growing in Desmoinesian time and grew into early Wolfcampian time. Numerous reefs in West Texas and southeastern New Mexico grew at the same time and have produced billions of barrels of oil.

Porous Epitaph Dolomite is visible in the Big Hatchet Mountains, reefs are present in the Mustang Mountains, and lagoonal evaporites are present in the Whetstone Mountains of Cochise County, Arizona. Presence of backreef evaporites up to 200 ft thick lends evidence that the Leonardian-age Epitaph Dolomite could be analogous to the prolific Abo production of southeastern New Mexico.

Lower Cretaceous beds contain rudistid, coralline, algal, bioclastic banks up to 500 ft thick in the Big Hatchet Mountains and 200 ft thick in the Mule Mountains of southeastern Arizona.

The large Pedregosa basin contains more than 25,000 ft of sedimentary rocks. For most of Paleozoic time, the basin had a history of environment and structural evolution similar to the Permian basin of West Texas and southeastern New Mexico. Billions of barrels of oil and tens of trillions of cubic feet of gas have been produced in the Permian basin. I believe a like amount will be found in the Pedregosa basin.

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Oil and Gas Potential—Paradox Fold and Fault Belt, Colorado and Utah.

(No abstract submitted)

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Planktonic Foraminiferal Test-Porosity as Paleotemperature Indicator

(No abstract submitted)

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Early Permian Unconformity in Southeastern Wyoming and North-Central Colorado

Evidence for the existence of an unconformity in southeastern Wyoming and north-central Colorado between rocks of the Goose Egg Formation, the Owl Canyon Formation, or the Lyons Sandstone and the Casper or Ingleside Formations is provided by reworked basal sandy zones and conglomerates, truncation of underlying cross-strata, local relief, possible "duricrust" or caliche zones in subjacent rocks, and an isopach description of the configuration of the erosion surface.

Subjacent strata range from Wolfcampian to pre-Desmoinesian age. The subcrop becomes older from east to west. Superjacent strata belong to 3 units ranging from early to late Leonardian. In the southern and central Laramie Range and most of the Laramie basin, the Owl Canyon Formation forms the supercrop. It thins to a zero edge northward and westward by depositional onlap and fills in relief on the underlying unconformity. The Opeche Shale Member of the Goose Egg Formation constitutes the supercrop in the Shirley basin, the northern Laramie Range, and probably most of the western study area. It thins northward slightly in the Shirley basin and the northern Laramie Range and fills in relief on the underlying erosion surface. The Lyons Sandstone forms the supercrop on the southwest margin of the Laramie basin.

Stratigraphic relations in southeastern Wyoming are in accord with an interpretation of the growth of an extensive land area and its transgression in the Rocky Mountain and western Mid-Continent areas in Early Permian time.

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Hydrocarbon Distribution in Casper Formation (Permian-Pennsylvanian) of Laramie and Shirley Basins, Wyoming

Hydrocarbon production from the Casper Formation in the Laramie and Shirley basins of southeastern Wyoming is exclusively from sandstones on closed Laramide structures. Total recoverable reserves are approximately 8 million bbl, half of which is found in the Quealy Dome structure of the southern Laramie basin. The presence of closed structures which are barren of Casper oil suggests that factors other than the present structural configuration are important in controlling the oil distribution in the Casper Formation.

Subsurface data from 137 wells indicate that the present distribution of Casper oil and oil shows is a complex function involving pre-Laramide structural growth, the configuration of the post-Casper unconformity, sandstone porosity (and permeability) patterns in the upper part of the Casper Formation, and the development of Laramide structure. The relative paucity of Casper oil may be related to an extreme distance of migration from the source rock and the presence of major permeability barriers in the upper Casper Formation along the paths of early migration.

Prospects for major accumulations of Casper oil do not appear to be good although stratigraphic traps similar to those found in the eastern Powder River basin are possible.

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Depositional Dynamics of Upper Cretaceous Sandstones, Rocky Mountain Region

Throughout the Rocky Mountain region, numerous Upper Cretaceous intervals display a sequence of deposits, from the base upward, of (1) marine and/or lagoonal shale, (2) barrier-island sandstone, (3) marsh-mudflat deposits, (4) lagoonal-bay deposits, and (5) alluvial–coastal plain sediments. These sequences record seaward progradation of coastal plain, transitional, and nearshore marine deposits in response to a large sediment supply and continuous subsidence.

Barrier-island sandstone units display a characteristic upward sequence of infra-surfzone, surfzone, and beach deposits which reflect depositional regressions. The vertical succession of sedimentary structures in a barrier-island sandstone records building up of the sea floor until a segment emerged and a barrier beach formed.

Sand enters the sea through deltaic distributaries and tidal passes and is transported downcoast by longshore currents and littoral or beach drift to nourish and prograde barrier-island sand bodies. The geologic record is strongly biased toward preservation of case histories

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.

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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.

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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.

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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