youngest stratigraphic units. This lithology, typical of the Key Largo Limestone of the northern keys, is interrupted by a single thick horizon of mollusk-rich quartz sand derived from paleo-highlands to the north. On Big Pine Key, the youngest stratigraphic unit grades laterally from an ooid grainstone (Miami Limestone) in the northwest to a skeletal-peloid packstone/grainstone (Key Largo Limestone) to the southeast. The latter facies also characterizes older underlying units which are again defined by paleo-exposure surfaces.

Vadose diagenesis during sea-level lowstands has largely resulted in alteration of the sediments to low-Mg calcite, but minor amounts of aragonite remain in the youngest stratigraphic unit. Pervasive development of secondary moldic and irregular dissolution porosity has accompanied this mineralogic transformation. Submarine cementation is insignificant, and freshwater phreatic lenses, if and where present, have failed to leave a distinctive petrographic imprint.

Overall, the Florida Keys (as manifest by the youngest stratigraphic unit) represent relatively high-energy deposits which accumulated on a slight but significant break in slope. Water depths were not great, and it is unlikely that a major contemporaneous reef barrier lay seaward at that time.

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Comparative Organic Geochemistry of Shales and Coals from Cherokee Group and Lower Part of Marmaton Group of Middle Pennsylvanian Age, Oklahoma, Kansas, Missouri, and Iowa

Mid-Continent middle Pennsylvanian rocks are a complex assemblage of coal-cyclothem lithologies. Organic-matter-rich rocks in the section include coals (33 to 76% organic carbon—org. C), marine, dark-gray to gray-black shales (1 to 8% org. C), and laminated, phosphatic black shales (4 to 28% org. C). Organic matter in these rocks came mostly from peat swamps, as shown by similarities between coal and shales in organic petrography, hydrogen (H) and oxygen (O) indices (Rock-Eval pyrolysis), pyrolysis-gas chromatographic analyses, and gas chromatographic analyses of saturated hydrocarbon fractions of $CHCl_3$ extracts. A halocline, resulting from the river waters that transported the dissolved and fine particulate organic matter from the extensive swamps, may have been the principal mechanism for restricting circulation in the shale-depositing environments.

Some organic geochemical properties vary significantly within and between the coal and shale lithologies, reflecting inferred differences in intensity of depositional and diagenetic anoxic conditions and degree of thermal maturation. For shales with comparable thermal maturities, deposition and diagenesis under more intense anoxic conditions result in higher org. C, P, U, Se, Mo, V, Ni, Ag, and Cr contents, H indices, saturate/aromatic and NSO/asphaltene ratios in $CHCl_3$ extracts, and lower O indices, pristane/phytane ratios, and organic carbon $\delta^{13}C$ values (more negative by 1 to 2 per mil). H and O indices in coals resemble those of shales deposited under the most intense anoxic conditions. In contrast, saturate/aromatic, NSO/asphaltene, and pristane/phytane ratios in coal extracts, trace- and minor-element contents, and organic carbon $\delta^{13}C$ of coals resemble shales deposited under relatively oxic conditions. A few coals are overlain by black phosphatic shales and have been subjected to more intense anoxic diagenesis. These coals have higher U, Se, Mo, V, Ni, and Cr contents, lower pristane/phytane ratios, and more negative (~ 1 per mil) organic carbon $\delta^{13}C$ values. When normalized to n-C_{18}, most pristane/phytane variability in all rock types appears to be related to variation in amounts of pristane, phytane content remaining relatively constant. With increased degree of thermal maturity, (1) H and O indices decrease in both coals and shales; (2) total bitumen/org. C and pristane/phytane ratios increase in shales but decrease in coals; and (3) saturate/aromatic ratios increase significantly only in shales that were subject to high levels of anoxic diagenesis. The black phosphatic shales contain extractable organic matter that is most similar to Cherokee crude oils from northeast Oklahoma and southeast Kansas.

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Mesozoic Paleo-Oceanography of Atlantic and Western Interior Seaway

Mesozoic oceans were filled with warm, salty water formed in marginal seas in the arid zones, rather than by cold water from polar sources as is the modern ocean. The early Atlantic and Gulf of Mexico were sites of significant salt extraction, serving as evaporative basins refluxing dense brine to the world ocean. As connection with the world ocean became better established, salt deposition in these basins ceased but sea level rose in response to growth of the mid-ocean ridge system, resulting in extensive flooding of the continents. Marginal seas and that part of the seaway through the Western Interior of North America lying in the arid zone then became sites of formation of plumes of dense, warm, salty, oxygen-poor water. These dominated the structure of the adjacent oceans. Periodic filling of individual basins by especially dense warm salty bottom water caused partial overturning and high productivity, followed by temporary stagnation and oxygen depletion, with the result that organic carbon-rich sediments were preserved. Because such "anoxic events" were dependent on local climatologic factors they were not necessarily synchronous in different basins.

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Continental Lower Cretaceous Stratigraphy, Sweetgrass Arch Area, Southern Alberta and Northern Montana

An integrated regional scheme of lithostratigraphic nomenclature is proposed to encompass the Lower Cretaceous strata on both sides of the international border. The Blairmore Group, defined in the southern Alberta Foothills, is extended to encompass the entire Sweetgrass arch area. The informal Cut Bank sandstone member of northern Montana is raised to formation status and extended into southern Alberta. The Cut Bank Formation is correlated with the Cadomin Conglomerate of the Alberta Foothills.

The Mannville Group formerly was extended to the Lower Cretaceous continental strata of the southern Alberta plains. This name is now restricted to strata occurring north and east of the Sweetgrass arch area which resemble the type Mannville. The Kootenai Formation (Group?) nomenclature, formerly used in Montana, is discarded because of continued confusion with the older, formally defined Kootenay Group of the Alberta Foothills. Most of the informal members defined in various oil fields should be confined strictly to the areas in which they are defined.

The present configuration of the Sweetgrass arch is the product of Late Cretaceous–Early Tertiary Laramide deformation, but the presence of a paleotectonic high coinciding with the present arch trend can be documented from the early Paleozoic. Sedimentation and erosional patterns were greatly affected by the ancestral arch and produced marked stratigraphic variations around it resulting in independent Canadian and American schemes of stratigraphic nomenclature being proposed.

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The Colony Shale Oil Project

For many years, the oil shale "boom" in western Colorado has been just around the corner. Now, the Colony Shale Oil Project, a joint development of The Oil Shale Corp. and Exxon Corp., is under full construction and will be the nation's first full-sized commercial shale oil project. The Colony operation, located in Garfield County in northwestern Colorado, is targeted for production at a rate of 47,000 bbl/day of synthetic oil in early 1986. To support the plant, it will be necessary to produce 66,000 tons/day of oil shale from a conventional room-and-pillar mine.

The shale will be hauled from the mine in 85-ton trucks and crushed to −9 in. (229 mm) in a 72 × 109 in. (1.8 × 2.8 m) gyratory crusher. The coarse ore will then be transported by a 72 in. (1.8 m) conveyor belt 5,000 ft (1,525 m) to the secondary crushing station where it will be further reduced to − ½ in. (13 mm) by eleven impactor crushers. The finely crushed shale will enter six Tosco II retorts, each capable of processing 11,000 tons/day. When heated to 900°F (482°C) in the pyrolysis drum, the kerogen vaporizes and is separated from the spent shale. The oil shale vapors are then condensed, fractionated, and upgraded by hydrotreating before entering a pipeline to be transported to a conventional refinery. By-products ammonia, sulfur, and coke will be recovered from the upgrading process.

To mitigate the impact of a large work force on the sparsely populated Western Slope, Colony is developing the Battlement Mesa community on the Colorado River 15 mi (24 km) south of the project site. When completed, the community will house approximately 25,000 residents in a variety of housing types, and will be the second largest town in western Colorado. Colony is providing the equivalent of interest-free loans to local organizations for the establishment of schools, a fire station, and other needed facilities.

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Variation in Depositional Systems Along Shoreline Embayments—Modern and Ancient Examples

The stratigraphic record of strandline depositional environments shows a systematic change along shoreline embayments in response to changes in the ratio of wave-energy flux to tidal-energy flux. Waves diminish in size and tidal ranges increase from the entrances to the heads of such embayments.

A depositional model for shoreline embayments emphasizing sand bodies shows the following: *embayment entrance*—wave-dominated deltas, microtidal barriers, abundant washover fans, and flood-tidal deltas in lagoons; *mid-zone*—mixed-energy deltas, mesotidal barriers, numerous inlets, back-barrier tidal-channel sands; and *embayment head*—tide-dominated deltas, offshore tidal sand ridges, no barriers, extensive marsh/tidal flat systems.

Two ancient shoreline embayments, along the Carboniferous shoreline of the southern Appalachians and the Late Cretaceous shoreline of Wyoming and Colorado, illustrate the model. Both examples illustrate a change in sand-body geometry from microtidal, wave-dominated barriers at the entrances to mesotidal, inlet-dominated barriers farther inside the embayments.

Thus, subsurface exploration for sand bodies containing economic deposits should focus on strandline-parallel sands with lagoonward building washovers and flood-tidal deltas at embayment entrances, and strand-perpendicular tidal sands at embayment heads. Exploration in the mid-zones of the embayments would be the most difficult, because of the complexity brought about by the migration of tidal inlets at the shoreline and tidal channels in the back-barrier area.

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Diagenetic Model for Carbonate Rocks in Mid-Continent Pennsylvanian Eustatic Cyclothems

Diagenetic patterns in cyclic Mid-Continent Pennsylvanian carbonates are readily explained in terms of a predictive diagenetic model derived logically from the eustatic depositional model for widespread Pennsylvanian cyclothems. Transgressive shoal-water calcarenites are characterized by overpacking of grains, discernible neomorphism (with excellent preservation of structure) of originally aragonitic grains (ooids, green algae, mollusks), and ferroan calcite and dolomite cement, which indicate movement from the marine phreatic environment of deposition and diagenesis into the low-oxygen deeper burial connate zone, with substantial compaction before any cementation. Offshore invertebrate calcarenites associated with offshore ("core") shales also are characterized by overpacking of grains and ferroan carbonate cements, which indicate a similar diagenetic history. Regressive shoal-water calcarenites show a much greater variety of diagenetic features, including early marine cement rims and large-scale leaching of originally aragonitic grains, commonly with subsequent collapse of micrite envelopes, grain fragments, and overlying material in samples insufficiently stabilized by early cement rims. This was followed by pervasive cementation by blocky calcite before much further compaction, then by ferroan calcite, and finally ferroan dolomite in remaining voids. This pattern indicates replacement of depositional marine phreatic water by meteoric water, which dissolved unstable carbonate grains and then deposited stable carbonate cements in environments that eventually became increasingly oxygen-depleted and otherwise chemically changed, probably as mixing-zone and deeper connate water moved back into the rock and replaced the meteoric water during and after the succeeding transgression. Trends in calcilutites are essentially similar to those in calcarenites of equivalent phase of deposition, with evidence of subaerial exposure and meteoric vadose soil formation in strata at the top of many regressive limestones. It is apparent that with the regression of the sea and emergence that terminated deposition of a cyclothem, meteoric water penetrated the permeable parts of the regressive carbonate and left its distinctive diagenetic patterns of early leaching and cementation before much compaction occurred, but rarely did meteoric water penetrate the impermeable offshore shale, which acted as a seal and allowed associated deep-water and underlying transgressive carbonates to become more deeply buried and substantially compacted before cementation, with unstable grains undergoing slow neomorphism in the absence of leaching.

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Facies Associations in Slope-to-Shelf Transition: Precambrian Miette to Lower Cambrian Gog Group, Kicking Horse Pass, Southern Canadian Rocky Mountains

In the eastern Kicking Horse Pass, Miette sediments consist of