the rocks, and in at least one area, accumulated in older traps. Rich, oil-prone source beds and oil shales occur in rocks ranging from Devonian to Early Cretaceous in age. These rocks are typically mature or post-mature on surface thrust plates in the heart of the thrust belt, but become significantly less mature to the north along the leading edge thrusts.

In the fold belt, the primary objective is Lower Cretaceous sandstone. Surface and seismic mapping reveal numerous open folds, whose location is controlled by more deeply seated thrust fault geometry. Cretaceous shale units are typically gas-prone and organic-lean, but the Umiat field demonstrates that oil has migrated into shallow structures, perhaps from a significant distance. Also, residual oil shows are common in many wells throughout the fold belt. The relationship of the source of the Umiat oil to the fold and thrust belt and its implications for exploration potential are yet to be fully understood.

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Hurricane Influence on Holocene Sediment Accumulation in Sarasota Bay, Florida

Sarasota Bay is a shallow, somewhat ovoid-shaped coastal bay located landward of a Holocene barrier complex on the west-peninsular, microtidal coast of Florida. Sediments presently accumulating in the bay consist of: (1) fine to very fine quartz sand contributed by littoral drift and reworking of older deposits, (2) fine to coarse quartz and phosphatic sand contributed by Tertiary carbonates and Pleistocene terrace deposits, (3) biogenic carbonate debris which is produced within the bay and/or derived from the nearby Gulf of Mexico, and (4) clay minerals derived from weathering of nearby carbonates and shales. Vibracoring throughout the bay has enabled recognition of six subsurface facies: protected bay, open bay, tidal delta-overwash, storm, sand bar, and marsh. Bedrock beneath the bay ranges from 0 to 8 m (26 ft) below present sea level and is largely responsible for the present aerial configuration of Sarasota Bay.

Intense storms (hurricanes) played a prominent role in the Holocene history of the bay. At least three of these extreme events are recorded in the strata that lie beneath the present bay. The storm facies is characterized by fining-upward units of shelly quartz sand each of which ranges up to 1.6 m (5 ft) in thickness. Individual storm deposits may cover as much as 80% (38 km^2, 15 mi^2) of the bay. These deposits are stratigraphically bracketed by the protected bay and/or open bay facies, which are the other laterally extensive facies present. Washover phenomena and the opening and closing of inlets are also documented in Holocene history and can be related to specific storm units.

The typical stratigraphic sequence of storm and related facies shows the protected bay facies overlain by the storm facies and capped by a combination of the protected bay and open bay facies. Tidal inlet-related facies occur proximal to the barrier and are associated with the storm and protected bay facies, whereas the distal areas are dominated by open bay facies which is reworked, storm-deposited sediment.

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Oil Shale Perspectives

The worldwide oil shale resources are extremely large. As an example, the calculated recoverable oil from just the Green River Formation in the tri-state area of Colorado-Utah-Wyoming is as large as the estimated ultimate total conventional oil production from the entire world. In addition there are significant resources in other parts of the USA and in other countries.

Despite the great potential, the pace of western oil shale development took a general downturn in 1982 because of a combination of factors led by an uncertainty concerning short to intermediate term pricing for crude oil, a lesser demand for petroleum products, and increased projected costs for development. An example is Exxon's announcement that the Exxon/TOSCO multi-billion dollar project would be discontinued and most of its support equipment sold.

Other western developers that are progressing with their projects include Union Oil of California in the Piceance basin of Colorado and Geokinetics Inc. of the Uinta basin of Utah.

In the eastern part of the county, Paraho decided not to move its project to Kentucky unless additional financial support could be obtained.

On the international front, Brazil and Morocco are actively developing oil shales in their countries, and feasibility and background studies are being conducted in other areas of the world.

The industry, from a future commercial development standpoint, and the government, following its policy to promote high-risk, long-range, high-return energy projects, should accelerate their efforts in oil shale research and development. A lead time of 3 to 5 years is necessary from the planning stage to the first barrel of shale oil production. Using a 10,000 bbl/day plant as a minimum goal, modular development of several competing processes and technologies should be conducted in the near future. These plants should be modular in nature, so that the more favorable processes could be replicated to provide for future demand.

The U.S. Department of Energy current oil shale support efforts are pointed toward process technology research rather than monetary support of industry pilot projects.

Federal government support for commercial oil shale development is a function of the Synthetic Fuels Corporation which provides price support guarantees to companies who are willing to build plants which can produce a minimum of 10,000 bbl/day of shale oil.

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Sandstone-Carbonate Repetitive Alternations: Butterfield Peaks Formation (Middle Pennsylvanian), Oquirrh Group, Central Utah

The Butterfield Peaks Formation is an impressively thick (up to 2,000 m, 6,600 ft, or more) example of alternating siliciclastic and carbonate deposition. In the Provo area, it exhibits several prominent facies of sandstone and carbonate, as well as intermediate gradations. The sandstones are quartzose, generally very fine and fine-grained, and are best separated into facies on the basis of sedimentary structures. These include tabular cross sets interpreted as eolian in part, and a variety of other marginal to shallow-marine facies. Trace fossils of the *Cruziana* facies occur in some units of most of these sandstones except the subaerial ones. They are also common in the carbonate rocks.

The carbonate rocks can be separated into facies on the basis of composition and texture. The fossiliferous carbonate rocks, predominantly wackestone and packstone, contain diverse marine fauna dominated by brachiopods, bryozoans, and echinoderm ossicles. Rarer fossiliferous carbonate facies include spiculitic dark mudstone to wackestone, and fossil grainstone.

In sandy carbonate rocks, the content of siliciclastic grains ranges from support of the rock (grading into sandstone with interstitial carbonate), to a sprinkling of silt grains in micrite or microspar. Much of the sandy carbonate is "wackestone" and "packstone," some with poorly organized lamination probably resulting from wave action. Many sandy carbonate units lack internal structure or exhibit only bioturbation.

In the Provo area, Butterfield Peaks Formation sandstone deposition appears to have been dominated by eolian processes and shallow marine currents related to the Pennsylvanian trade wind regime. Paleocurrent indicators (mostly sandstone foresets) show a strong unimodal pattern from north to south in present coordinates, which corresponds with expected Pennsylvanian trade wind directions from published paleomagnetic paleolatitude reconstructions. Subaerial and marginal-marine deposition seems to have been dominated by siliciclastic sand, with carbonate deposition limited, for the most part, to open marine environments. This contrasts with the Butterfield Peaks section 70 km (43 mi) south in the southern East Tintic Mountains. Much less siliciclastic sand is present there, both as sandstone and as a component in carbonate rocks. Marginal marine carbonate facies, such as mudstones to wackestones with fenestral fabric and brecciated textures, are present. Apparently a less-abundant supply of sand allowed the development of these facies instead of overwhelming them, as seems to have been the case farther north.

Despite the repetitive nature of the clastic-carbonate alternations, and widespread Middle Pennsylvanian cyclic deposits in other areas, stepwise Markov chain analysis suggests that true cyclic successions cannot be demonstrated mathematically in the Provo-area Butterfield Peaks Formation. The semi-ordered succession present appears to be a function of the interaction of glacio-eustatic sea level fluctuation, tectonically induced rapid episodic subsidence, high rate of carbonate production, and facies shifts between carbonate and clastics partly controlled by wind-influenced delivery of siliciclastic sand and silt.

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Peat Deposits in the Mississippi River Deltaic Plain

Buried peat zones represent former marsh and swamp surfaces formed by cyclic sedimentation processes. They originate approximately at mean sea level and provide modern analogs for coal-forming environments.

To better understand variations in stratigraphy and organic and mineralogical properties between peats in different deltaic settings, two basins were chosen for study: Vermilion Bay and Barataria basin. The first area represents a blanket-peat-forming environment; the second exemplifies interdistributary peat accumulation.

The stratigraphy of the upper 4 m (13 ft) of the western Vermilion Bay area is that of a freshwater swamp (> 35% organic matter and abundant cypress wood fragments). Due to marine inundation, the present surface is covered with a saline marsh. The swamp deposit at 1 m (3 ft) depth possibly correlates with a marsh deposit at the same depth in eastern Vermilion Bay, where three depositional cycles, each containing blanket peats, can be recognized in the upper 9.5 m (31 ft) of the subsurface. The Barataria interdistributary basin displays a great horizontal and vertical organic matter variability. Hence, stratigraphy cannot be determined, but organic-rich pockets up to 4 m (13 ft) thick are known to exist. In addition, the Pleistocene surface deepens from −2 m (−6.6 ft) in western Vermilion Bay to −50 m (−165 ft) in Barataria basin as a result of differential subsidence and surface irregularities.

Characteristically, the peats average 90% moisture, 80% organic matter (20% ash), and a bulk density of 0.12 g/cm^3, the latter two numbers based on dry weight. When these data are related to depth, it appears that compaction during the first few thousand years after deposition is minimal. The frequency distribution of organic matter percentage ranges, for all sediments, shows that in eastern Vermilion Bay 15% of the material is peat; by comparison, in Barataria basin, 5% of all material is peat.

Preliminary results from mineralogical and elemental analyses of fresh and brackish peats indicate the presence of clay minerals, quartz, pyrite, gypsum, siliceous spicules, and smaller amounts of the trace mineral rutile. Minerals appear to vary with the type of peat. Elemental inorganic compositions also vary with depositional setting and post-depositional salt-water encroachment.

Peat deposits in the deltaic plain show a great variability in stratigraphy and characteristics due to four conditions: (1) difference in depositional setting; (2) depth to the Pleistocene; (3) intermittent interruption of marsh growth by influx of detrital clastics; (4) marine inundation of freshwater peats.

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Coastal Barrier and Inner Shelf Lithosomes Related to Shoreface Erosion

Along the Atlantic coast of Delaware lies a lagoon-barrier, headland, and spit complex which has transgressed landward during the Holocene Epoch. The shoreface is relatively steep with major erosion occurring from 0 to −10 m (−33 ft). In addition, erosional recession of the lagoon barrier and headland coast varies from 1 to 3 m (3 to 10 ft) per year averaged over the past 150 years. The inner shelf from −10 to −30 m (−33 to −100 ft) is also undergoing modification as the transgression continues. The net result is a sequence of Holocene depositional lithosomes in the valleys of the pre-Holocene (late Wisconsinan age) land surface. These valleys were cut by the ancestral Delaware River and its tributaries. Extensive surveys of the Delaware inner shelf with high-resolution seismic profiling tied in with vibracoring have allowed delineation of the three-dimensional character of the Quaternary erosional and depositional events controlling the Holocene coastal units. The separate and distinct sedimentary environmental lithosomes of the various coastal environments form irregularly shaped depositional units that are in some places presently undergoing erosion in the shoreface and in other places are being buried by thin transgressive sands on the inner shelf. Erosion during storm periods occurs to depths of greater than 30 m (100 ft), as evidenced by outcrop of Pleistocene sedimentary units along the former pre-Holocene interfluves that have been transgressed and are now exposed on the inner shelf.

Forty-two vibracores were drilled in the shoreface in water depths of 2 to 10 m (6.6 to 33 ft). These cores encountered a great variety of stratigraphic units including Holocene Epoch barrier sands, lagoons, spits, and marshes, as well as Pleistocene sediments of the pre-Holocene headlands, originally deposited in similar coastal sedimentary environments. The present depositional shoreface sands range in thickness from 20 cm to 1.5 m (8 in. to 5 ft). In some areas, slumping or soft sediment flow is indicated.

Thus, the ravinement surface along the Atlantic coast of Delaware underlies extremely thin depositional sands in the shoreface and adjacent inner shelf. Potential preservation of coastal lithosomes in this setting is highly variable, dependent on pre-Holocene topography in many places. The transgressive sequence studied is the result of migration of coastal environments from a position near the axis of the Baltimore Canyon trough geosyncline approximately 50 km (31 mi) to the east at a