source of carbonate and of the energy required for sulfate-reducing bacterial activity is therefore problematic.

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Organic-Matter Preservation in Chattanooga Shale: Revised Late Devonian Correlations, Kentucky and Tennessee

Continued interest in the carbon-rich shale of Devonian and Mississippian age in Kentucky is reflected by intensive leasing and drilling to evaluate the potential reserves of oil shale. Hydrocarbons and heavy metals are associated with layers rich in organic matter (OM). Thicker accumulations of shale suitable for surface extraction lie along the flanks of the Cincinnati arch in both the Illinois and Appalachian basins. Distribution of the OM-rich shale is not uniform, but is controlled by subtly defined lithostratigraphic units. The shale tends to thin across the Cincinnati arch by an order of magnitude (100 versus 10 m, 330 versus 33 ft), and individual units disappear entirely. Key beds have been used with mixed success in tracing these changes.

Recognition of these key beds in cores provided by a recently completed 70-core drilling program in and near the outcrop is the basis for revising earlier suggested correlations. One key bed, marked by the occurrence of the alga? *Foerstia* (*Protosalvinia*), occurs in the lower part of the lower (Huron) member of the Ohio Shale in the Appalachian basin. The Huron Member is overlain by a lithostratigraphic marker, the Three Lick Bed. The *Foerstia* Zone has been traced in core and outcrop to the upper part of the uppermost (Clegg Creek) member of the New Albany Shale in the Illinois basin.

Discovery in this widespread continuous biostratigraphic marker at the top of the upper (Gassaway) member of the Chattanooga Shale near the designated reference section in Dekalb County, Tennessee, suggests that the Three Lick Bed of the Ohio Shale does not correlate with the middle unit of the Gassaway Member of the Chattanooga Shale as thought. Field relations indicate that the Three Lick Bed is absent by nondeposition, and starved-basin conditions prevailed into Early Mississippian time in this part of Tennessee. These stratigraphic revisions become significant in a regional synthesis of the anoxic-basin depositional model of OM—rich shale and syndepositional tectonics during Late Devonian time in Tennessee and Kentucky.

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Paleozoic and Mesozoic Stratigraphy and Oil Potential of Western Desert

The depocenter of the Paleozoic basin in western Egypt lies in the northwestern part of the Western Desert. The sediments are primarily terrigenous (with two minor phases of vulcanicity) laid down in an epicontinental sea. The depositional axis of the basin, where thicknesses in excess of 2,800 m (9,200 ft) have been recorded, has a northwesterly trend to the vicinity of the Siwa Oasis. A less well-defined shallower basin with a northerly trend lies to the southwest. The facies show such similarities to those found in the Ghadames and Murzuq basins that the same formational names are applied. Farther east, a possible Paleozoic basin lies in the Abu Gharadig area where 1,300 m (4,265 ft) of sediments were drilled. The limits of this presumed basin are questionable since basement was not reached.

Following the deposition of the Paleozoic section, there was a marked hiatus; the time of Hercynian movements for Permian and Triassic beds is absent. Uplift and the presence of volcanics dated in Permian-Carboniferous time are indicative of Hercynian tectonic activity. Only in Early Jurassic time did the seas again begin to encroach upon the Western Desert area from the Salum basin in the northwest and the Wadi Natrun basin to the east and northeast. This process continued, until by the time of the Oxfordian transgression maximum there was a relatively uniform carbonate cover to about lat. 29°N over the Western Desert.

Further tectonic uplift accompanied by faulting and marine regression is dated from late Kimmeridgian time to the beginning of the Cretaceous, when transgression began once again. The pattern of transgression, however, differs from that of the Jurassic; the two basins, the more westerly Matru basin and the easterly Alamein basin, both have north-northeasterly trends, although by Aptian times they are less clearly distinguishable.

The dominant feature, new in the Western Desert, was the development of an east-west extensional basin, the Abu Gharadig basin, in Cretaceous time. It was bounded on the north (30°N) by the Rabat Abu Rivash ridge, which persisted through the Cretaceous. The trough became less distinctive in Cenozoic times when a further trough, the Tiba basin, developed north of the ridge.

Production from the northern Western Desert until recently has been disappointing. Exploration results from the Paleozoic Section have yielded little, but the existence of a marine section suggests that the area northeast of Siwa still has potential. The thick deeply buried Jurassic marine sequence in the Western Desert may be the source for at least part of the production from Cretaceous horizons in the Abu Ghradig, Alamein, and Razzak oil and gas fields.

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Central Arctic Foothills, Alaska: A Unique Challenge in Frontier Exploration

Chevron U.S.A. has under lease nearly 2 million acres (800,000 ha.) of Arctic Slope Regional Corporation lands in the foothills of the Brooks Range between the Chukchi Sea and Canning River. In the central foothills, between the National Petroleum Reserve-Alaska and the Alaska pipeline, Chevron has conducted extensive field programs and air photo mapping, recorded 3,000 km (1,865 mi) of seismic data, and drilled three exploratory wells.

The Brooks Range foothills are underlain by complex thrust plates and associated foreland folds which contain deformed rocks ranging in age from Devonian to middle Cretaceous. Main thrusting occurred in latest Jurassic to Albian time, corresponding to an arc-continent collision possibly associated with the widening of the Canada basin. First orogenic pulses are recorded by Upper Jurassic turbidites and olistostrome units which reveal a southern clastic source, a major reversal in source direction from older sedimentary units. Lower Cretaceous foreland turbidites show progressive northward migration of underthrusted imbricating plates.

In the thrust belt, the primary reservoir objective is Lisburne limestone and dolomite, Mississippian to Permian in age. Seismic data identify a variety of structural styles of Lisburne plates ranging from complex stacks of imbricates to a single leading-edge plate underthrust by Lower Cretaceous foreland clastic units. Pore space in dolomitic Lisburne is filled with solid bitumen nearly everywhere on the surface in the central foothills, suggesting that extensive amounts of oil have migrated through 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