Dip-trending sandstones show southeast-northwest trends with a large degree of vertical persistence. Major fluvial axes occur approximately every 40 mi along strike and may also be a reflection of basement structure.

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Sedimentology of Loyalhanna Member ("Big Injun Sand") of Mississippian Greenbrier Limestone

The Loyalhanna is a sparsely fossiliferous, distinctively cross-bedded, sandy calcarenite and calcareous sandstone. It occurs along the outcrop belt and in the subsurface of Pennsylvania and West Virginia where it is less than 100 ft (30 m) thick. In West Virginia, the Loyalhanna has produced more than 200 million bbl of oil, accounting for much of the state's total oil production.

In thin section, Loyalhanna lithologies consist of grainstones with varying proportions of quartz, ooids, fossils, and peloids. Quartz was introduced from a northern source area, and ooids were transported by currents from shoals to the south. Skeletal grains include crinoids, bryozoans, ostracodes, and foraminifera. Peloids are mainly micritized ooids and fossils.

The environmental setting was a high-energy, sublittoral sand flat that extended along the northern coastline of the Mississippian embayment into the central Appalachians. The sediment was deposited as low-relief sand waves with an internal structure of avalanche-style cross-bedding. As the sand built up, the cross-bedded units were capped by horizontal beds. Cross-bedding indicates that sand waves migrated to the northeast under the influence of longshore currents. Minor fluctuations in sea level and sedimentation rate produced a widespread blanket sand.

In the producing areas of West Virginia, porosity development has resulted from early dolomitization. Intercrystalline and moldic porosity is good, typically reaching 15-25%. However, this combination of porosities, which is closely related to original sedimentary textures, has led to only fair permeability and a fair recovery efficiency for the unit.

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PRESTO—A Program for Estimating Oil and Gas Resources

PRESTO (Probabilistic Resource ESTimates, OCS) is a computer program developed to provide resource estimates for offshore areas considered for leasing by the federal government. The program uses Monte Carlo simulation techniques to "drill" prospects that are geologically defined by the user, and then calculates resources using a volumetric formula. Resource estimates are given as probability distributions that reflect uncertainties in the physical representation of the prospects, rather than as single-point values or qualitative assessments. The program also incorporates a number of levels of geologic risk.

Four types of hydrocarbon resources are assessed for each reservoir: oil, associated and nonassociated gas, solution gas, and condensate. All are reported as distributions that can be converted and aggregated to a distribution for equivalent barrels of oil.

Unlike subjective resource estimation methodologies, the program provides reproducible results and can be used in frontier areas as well as mature producing basins. In addition, it provides an analysis of hydrocarbon potential at the zone and prospect levels, which can then be aggregated for basin and planning area estimates.

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Origin of Quartzarenites in Upper Mississippian and Lower Pennsylvanian of Appalachian Basin

Quartzarenites in the Upper Mississippian and Lower Pennsylvanian of the central Appalachian basin have been attributed to fluvial or beach-barrier depositional environments. As part of the USGS basin analysis program, we reevaluated existing data and concluded that quartzarenites were deposited primarily in a high-energy marine environment dominated by tidal currents. These deposits are linear, trend toward the southwest, and are roughly parallel to the axis of the Appalachian geosyncline. Herringbone structures and bioturbation are abundant in the upper part of the deposits and near their margins. The lower and central parts of the deposits commonly display unidirectional festoon cross-beds having amplitudes up to 1 m. Basal contacts tend to be sharp and erosional in the high-energy central parts but are gradational near the margins. The spatial relation of these sandstone deposits to marine facies, their widespread distribution, and their lateral continuity are more compatible with a marine-dominated rather than fluvial origin. Their textural and mineralogical maturity also indicates winnowing typical of a high-energy marine system. Sedimentary structures typical of beach deposits or fluvial systems are rare.

These sandstones were apparently deposited in an epicontinental seaway, which, at times, may have been open at both ends. Because of the configuration of the basin, tidal and geostrophic energies were dominant over wave energy; tidal basin deposits predominated, and wave-energy beach-barrier deposits were rarely preserved. Ebb flow carried the winnowed fines into the southwestern part of the Appalachian basin or into the Ouachita geosyncline. Similar hydrodynamics and sediment transport occur today on the Sunda Shelf, the Bay of Fundy, and in the Bering Sea.

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Mississippian-Pennsylvanian Unconformity near Somerset, South-Central Kentucky

The Mississippian-Pennsylvanian systemic boundary near Somerset, south-central Kentucky, is unconformable. Contact relationships in eastern Kentucky are controversial because of unclear genetic associations displayed by Chesterian(?)-Morrowan Lee Sandstone lobes, which have been interpreted as being of either barrier-beach or fluvial-deltaic origin. The barrier shoreline model stipulates that Meramecian, Chesterian, and Morrowan rocks represent carbonate sediment barriers and carbonate mud islands, offshore clays, quartzarenite barriers, and lagoonal-tidal flat sediments that were penecontemporaneously deposited during northwesterly progradational episodes. The tabular erosion model stipulates that Meramecian, Chesterian, and Morrowan(?) predominantly marine sediments were deposited and lithified as tabular units before and penecontemporaneous with deposition of Chesterian(?)-Morrowan fluvial-deltaic sediments.

Field study of exposures near Somerset indicates that the tabular erosion model satisfactorily explains contact relationships. Tidal flat, tidal channel, and lagoonal lithofacies without barrier sandstones are unconformably overlain by southwesterly progradational fluvial-dominated deltaic lithofacies. Elongate, fining-upward sandstone bodies typically above coal seams, which are oriented parallel with the southwesterly paleoslope, display lag concentrates of carbonized plant debris, epsilon cross-stratification (or apparently lack of stratification), and low-energy ichnofacies, and are enclosed in deltaic lithofacies.

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Structural Styles and Tectonic Implications of Richmond-Taylorsville Rift System, Eastern Virginia

Recent drilling and seismic surveys in the Richmond basin have revealed unexpected results. Alternating episodes of extension and compression have created overprints of structural styles, and generated syndepositional unconformities as sediments were uplifted and rotated. Eroded Triassic sediments from structural highs were redeposited in adjacent synclinal or fault-controlled lows.

In addition, lithologic correlation has revealed the existence of large deltaic complexes prograding across the basins, followed by Mississippi-size meander-belt channel deposits in the subsurface. The early lacustrine-deltaic deposits (Vinita beds, etc) appear to have been deposited in a basin much larger than the apparent outcrop limits of the Richmond or Taylorsville basins. As much as 3,000 ft of these deposits accumulated prior to a compressional event that folded them into enormous anticlines and synclines, as Paleozoic thrust sheets were reactivated and sub-Triassic buried hills grew in height, raising the overlying Triassic sediments by as much as 2,000 ft over a distance of less than 2 mi.

The synclines contain a nearly continuous sedimentary sequence, whereas the anticlines have the uppermost Otterdale Sandstone facies as a blanket deposit over their truncated tips and steeply dipping Vinita beds below the unconformity on their flanks. Extensional events followed the main phase of folding and pulled the limbs of the anticlines apart, causing normal listric faults to form and blocks of Vinita beds to separate into North Sea-type fault-block structure.

Based on maturation and porosity trends with depth, at least 7,000 ft of overburden have apparently been removed from the basins. Either the structural style changed dramatically from listric faults to horst and graben mechanics, thereby dropping the Richmond-Taylorsville sequences below the present erosional level, or an enormous gravity slide from the east covered the basins, and erosion has created windows through this detached Paleozoic thrust sheet into a much larger Triassic rift system below it.

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Mesozoic Biostratigraphic Framework of U.S. Atlantic Outer Continental Shelf

The geologic age of the first marine sediments deposited in the North Atlantic basin is of basic importance in reconstructing the basin's early geologic history. Thus, although the oldest dated marine sediments penetrated on the U.S. North Atlantic margin by DSDP wells are of Callovian age (Blake-Bahama basin), both the Georges Bank and Baltimore Canyon basins include much older Jurassic strata of Bajocian-Bathonian age, as well as an Upper Triassic section. Microplankton provide the basis for a Mesozoic biostratigraphic framework of three basins where drilling has occurred on the U.S. Atlantic outer continental shelf. Studies of closely sampled subsea sections from multiple wells drilled on the Georges Bank basin, the Baltimore Canyon Trough, and the Southeast Georgia embayment, make dating possible by standard age and subage equivalents ranging from Middle Jurassic (Bajocian) to Maestrichtian (Late Cretaceous). This age sequence is documented by dinoflagellate range tops recorded in the offshore Canadian Grand Banks and Scotian Shelf, as well as by reference to ammonite-controlled type localities in northwestern Europe. The age of this sequence is supported from the Callovian to the top of the Maestrichtian by calcareous nannofossils. Additional biostratigraphic markers include a few benthonic and planktonic foraminifers and spores and pollen of age-guide value. The post-Middle Jurassic section in the Baltimore Canyon Trough averages over twice the thickness of the equivalent section in the Georges Bank basin, so that the base of the Middle Jurassic marine section has not been penetrated in the Mid-Atlantic. Georges Bank also has an Upper Triassic section.

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Geologic Evaluation of Leasing on Atlantic Outer Continental Shelf

To date, 9,160 tracts, totaling 51.7 million ac, have been offered for lease in the Atlantic. Of the 506 tracts receiving bids, 410—totaling 2.3 million ac—were leased for a total bonus of $2.8 billion. There have been four Mid-Atlantic sales, three South Atlantic sales, and one North Atlantic sale, with one reoffering sale in the Mid- and South Atlantic.

Resource potential for proposed North Atlantic sales centers around the Georges Bank basin and the Upper Jurassic shelf edge (reef trend). Associated with the reef trend are a series of back-reef anticlines, faults, and pinch-outs. Cross sections indicate post-rift depocenters affected by block faulting and salt movement. Eight exploratory wells, all dry, and two continental offshore stratigraphic test (COST) wells have been drilled in the area.

Thirty-two exploratory wells have been drilled in the Mid-Atlantic in the Baltimore Canyon Trough. Targets have included an intrusive dome, fault blocks, deep-seated diapirs, and the Jurassic shelf-edge reef trend. Two COST wells were drilled, one encountering a show of gas. Five of the exploratory wells tested hydrocarbons, the others were dry.

The Carolina Trough appears to offer the best resource potential in the South Atlantic even though it has yet to be drilled. It has sufficient sediment thickness, a regional salt bed producing a number of diapirs on the seaward edge of the basin, and growth faults associated with the salt flow that may provide other traps.

The Blake Plateau offers some stratigraphic trap possibilities and may contain thermally mature sediments. However, no wells have been drilled in the basin. The Southeast Georgia embayment consists of a thin sedimentary section of mainly Cretaceous continental clastics and Paleozoic metasedimentary basement rocks. Six exploratory wells, all dry, and one COST well have been drilled in this basin.

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Penetration Rates in Drilling Pioneer Salt Wells

The tools and drilling techniques used by early oil-well drillers were developed in this country by salt-well drillers in their search for brine during the 50 years before Colonel Drake's 1859 oil well. The Ruffner brothers drilled the first salt well near Charleston, West Virginia, in 1807, to a depth of 58 ft. Their well, which penetrated 40 ft of the Pennsylvanian Charleston Sandstone at a rate of 4 in./12-hour day, required about 4 months to drill. In 1831, the L. G. Barker salt well was completed in the Mississippian Big Injun sand to a total depth of 820 ft at McConnelsville, Ohio. Penetration rates for various rocks in a 24-hour day were mud rock or shale, 4-10 ft; silty or sandy shale, 2-4 ft; limestone, 1.5-2 ft; sandstone, 0.5-1.0 ft; chert, 2-3 in., and ganister, 1 in. Correlating these drilling rates with the detailed sample log of the Barker well suggests a minimum continuous drilling time of 20 months. In all probability, the well required at least 2-2.5 years to drill considering fishing jobs, repairs to equipment, and similar vicissitudes that beset the early salt-well drillers. Except that he was able to substitute steam power for muscle power, "Uncle Billy" Smith's drilling time of 13 days for the 34 ft of sandy bed rock in the Drake oil well is closely comparable to drilling time for similar shallow salt wells of that period.

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Lithostratigraphic Analysis of Huntersville Chert of Central Appalachians

The Huntersville Chert (Onesquethawan Stage) of the central Appalachians was deposited in a detrital sediment-starved basin where a restricted sea hosted mainly silicisponges of probable Demospongid fauna. The Huntersville Chert grades into the Onondaga Limestone to the west and the Needmore Shale to the east. These Onesquethawan rocks record an initial transgression followed by regression, maximum transgression, and a final regression. Basement sub-blocks as growing structures influenced sedimentation. Differential subsidence of basement sub-blocks and eustatic changes in sea level periodically exposed the basin margins or allowed reworking of low-energy shoreline and shoal sediments. Five mappable stratigraphic units are recognized in the Onesquethawan Stage in the chert-filled basin covering the Rome trough in northern West Virginia, southwestern Pennsylvania, and northeastern Ohio. Shale tongues extending from the east interbed with the chert where the eastern West Virginia arch was low in northern West Virginia and western Maryland, but do not to reach the basin center. Carbonates accumulated over the shelf to the west of the chert basin and periodically over parts of the southern, eastern, and central arches. A moderately steep ramp is interpreted for the facies change from chert to limestone in proximity to the western margin of Rome trough. Are ancient reefs located at this shelf margin? The upper chert lithofacies is the most productive reservoir within the Huntersville.

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Interpretation of Soil Gas Geochemical Anomalies at Rose Hill Oil Field, Lee County, Virginia

Soil gases were recovered with hand-held probes in a survey pattern over the Rose Hill oil field in Lee County, Virginia. The gases were analyzed for lighter hydrocarbon gases (C_1-C_4) plus hydrogen and helium, using a custom-built, dual-column chromatograph. Methane and pro-