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.

COUSMINER, HAROLD L., WILLIAM E. STEINKRAUS, and RAYMOND E. HALL, U.S. Dept. Interior, Minerals Management Service, Vienna, VA

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.

DELLAGIARINO, GEORGE, and EDWARD RUIZ, U.S. Dept. Interior, Minerals Management Service, Reston, VA

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.

DE WITT, WALLACE, JR., U.S. Geol. Survey, Reston, VA

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.

DONALDSON, ALAN C., West Virginia Univ., Morgantown, WV, and DALE SKOFF, Hydrocarbon Exploration, Buckhannon, WV

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.

DRIVER, EDGAR S., and ROBERT V. BRODINE, Independents, Wexford, PA

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 propane concentrations were separated into regional and anomalous values and contoured along with values of C_3/C_1. Analytical techniques developed to discriminate gas-prone areas from oil-prone areas confirmed the oil-prone nature of this field.

Geochemical anomalies were interpreted in the context of surface fracture distributions and areas of good production. Geochemical anomalies correspond with areas of optimal production from fractured reservoirs having mostly a north-northeast orientation. For this area a predominantly vertical leakage path from reservoir to surface is inferred. Geochemical prospecting using probes can identify oil versus gas-prone areas and can suggest which among many fracture directions are most likely to contain petroleum concentrations.

DULONG, FRANK T., and C. BLAINE CECIL, U.S. Geol. Survey, Reston, VA

Arsenic Concentration Variability and Inorganic Affinity for Selected Coal Beds of Central Appalachian Basin

The mean arsenic concentration on a whole-coal basis, for 613 complete channel samples representing 34 coal beds from the central Appalachian basin, is 14.0 ppm (standard deviation, s.d. = 14.9). An F-test for variance equality and the appropriate t-test on the means can separate stratigraphic units into three categories: (1) Kanawha Formation, which has a mean of 5.04 ppm; (2) New River, Pocahontas, and Monongahela Formations, which have means of 10.1, 10.9, and 12.4 ppm, respectively; and (3) Allegheny Formation, which has a mean of 18.1 ppm.

Data from 40 complete channel samples of the Upper Freeport coal bed (Allegheny Formation) were used for statistical evaluations (F- and t-tests as applied in the stratigraphic comparison) of the regional (western Pennsylvania) versus local (within mine) arsenic variation. The arsenic concentration and variation in whole-coal samples are greater on a regional scale (mean = 40.8 ppm, s.d. = 30.6, n = 21) than on a local scale (mean = 23.8 ppm, s.d. = 18.7, n = 19).

Nine channel samples of the Upper Freeport coal bed were subjected to a 21-part size-gravity washability study. A mean of 86 wt. % of the coal floated at a specific gravity of 1.6. The mean arsenic concentration (6.05 ppm) in this float recovery is 55% less than the mean arsenic concentration in the unprocessed samples (14.3 ppm). The mean arsenic concentration in the remaining 14 wt. % of the coal was 123 ppm. The float-sink analysis verified an inorganic affinity of arsenic and indicated that arsenic is associated with pyritic sulfur in the Upper Freeport coal bed. Three samples with a mean arsenic concentration of 4.20 ppm had a mean of 36.4% reduction of pyritic sulfur, while 6 samples with a mean arsenic concentration of 19.3 ppm had a mean of 63.8% reduction of pyritic sulfur. Concentrations of arsenic in complete channel samples above some threshold, approximately 10 ppm for these samples, appears to be associated with removable pyrite.

EDSON, GARY M., U.S. Dept. Interior, Minerals Management Service, Vienna, VA

The Mid-Atlantic Mesozoic Paleoshelf Edge: Carbonate Buildup or Reef?

An Atlantic Mesozoic paleoshelf-edge reef has been inferred from seismic profiles and Scotian Shelf petroleum exploration. The hypothetical reef forms a discontinuous offshore linear trend from Florida to Nova Scotia.

Data from recent Mid-Atlantic deep-water exploration drilling reveal the local nature of the paleoshelf-edge rim. Lower Cretaceous limestone was encountered at anticipated depths. Visual examination of drill cores and petrographic analysis of core thin sections show bioclastic grainstone, packstone, wackestone, floatstone, and rudstone, as well as a small amount of possible boundstone.

The bioclasts are mostly rounded, coarse sand and have thick or thin rinds. The abundant varieties of bioclasts include sponge, coral, echinoderm, bryozoan, bivalve, and algae fragments, with foraminifera, ostracods, calpionellids, and tubiphytes. Some intervals contain large (several centimeters), lobate stromatoporoids, which may be reefal framework elements.

I conclude that some intervals represent carbonate debris buildups and others represent reefal bioherms. Bioclastic debris intervals may result from in-place destruction of fragile calcareous reefal biota.

EGGLESTON, JANE R., U.S. Geol. Survey, Reston, VA

Pennsylvania Anthracite Mining Industry: A Past—and a Future?

The anthracite region in north-central Pennsylvania was one of the earliest areas of coal mining in the United States. Anthracite was used by blacksmiths in Wilkes-Barre as early as 1769, and by 1808, coal was in demand for home heating and industrial markets. Anthracite production reached a peak of 99.6 million short tons in 1917, but has declined to only 4 million short tons in 1983. Reasons for the decline, during a time when energy demand has generally been increasing, include availability of cheaper fuels, unreliability of anthracite supply, labor-intensive mining, difficulty in mechanization of mines because of geologic conditions, depletion of the more accessible coal beds, and cost of correcting environmental problems.

Many energy analysts believe that the Pennsylvania anthracite industry is facing extinction. The remaining reserves are, however, extensive; a 1984 study funded by the U.S. Bureau of Mines estimated 19 billion tons of anthracite resources, including a reserve base of approximately 7 billion tons. The cost of anthracite leaving the preparation plant is at least 50% higher than that of bituminous coal mined in the East. However, the anthracite region is closer to major eastern markets, so transportation costs are less for anthracite. Because anthracite has a low sulfur value, the costly scrubber equipment required at power plants using higher sulfur bituminous coal usually is not necessary for anthracite-fired plants. Most mining research has been directed toward the bituminous coal industry in the past; similar research is needed in the anthracite industry to develop mechanized, high-productivity mining methods and to improve economic competitiveness.

EICHER, RALPH, Terra Information Processing Services, Ltd., Dulles Airport, VA, GENE TOLBERT, MAPSS Corp., Manassas, VA, WILLIAM SMITH, GeoGraphics, Inc., Champaign, IL, and WILLIAM G. MURRAY, Johnston & Associates, Inc., Haymarket, VA

Microcomputers in Earth Science

Earth scientists and engineers are well advised to consider their long-term repetitive needs for computer support before making a heavy financial commitment in computer hardware. Powerful work stations can now be designed around a personal computer (PC) or microcomputer.

Success with microcomputers results from development of VLSI (very large-scale integrated) circuits and the 5¼-in. diskette (floppy) drive. The latter allows computers with limited memory to swap data rapidly and economically between memory and a storage diskette. Microcomputers benefit from advances in electronic technology and are approaching capabilities of mainframe processors. Equally important to the success of these hardware improvements is the acceptance of common operating systems between machines assembled by different manufacturers and the implementation of compilers for major computer languages. Accompanying compiler development is the development of more powerful, multitasking, multi-user operating systems.

Examples of powerful PC and super-micro systems that are of particular interest to those working in the earth sciences and mineral resource assessment will be presented, as well as improved peripheral equipment such as graphic printers, communication modems, digitizers, and specific software programs.

Such developments in hardware and software, which offer improved speed and responsiveness, are the real keys to improved productivity when microcomputers are used. They permit better management and analysis of data, more meaningful formatting of information, greater alternatives for problem-solving, and with a well-designed system, time and money saved.

ENGLUND, KENNETH J., and ROGER E. THOMAS, U.S. Geol. Survey, Reston, VA

The Richlands Channel—Part of an Early Pennsylvanian Depocenter in East-Central Appalachian Basin

Investigations of Lower Pennsylvanian coal-bearing rocks for the central Appalachian basin analysis program have delineated a broad sinuous channel extending for 30 mi northwestward from Richlands, Virginia.