reservoir management practices and conventional well spacing. Most of the major Texas oil reservoirs can be grouped into 48 geological plays which account for 71% (32 billion bbl) of all Texas oil production.

Twenty-one of the plays are located in a belt along the Texas Gulf coastal plain and in the East Texas basin. Mesozoic and Cenozoic sandstone reservoirs deposited in fluvial-deltaic and strandplain systems dominate over fluvial sandstones and carbonate reservoirs. The remaining 27 plays extend westward from north-central to west-central Texas. Dolomite is the prevalent reservoir lithology with sandstone and reef-associated limestone being more abundant than chert, conglomerate, and nonreef associated limestone. Reservoir genesis in the north and west Texas plays is diverse and includes a spectrum of clastic depositional environments from fan and fan delta to slope and basin systems. Carbonate reservoirs have been interpreted as open and restricted shelf deposits, platform margin-associated banks and reefs, and deeper water atoll and pinnacle reef systems. Unconformity-related reservoirs in west and east Texas, such as the prolific East Texas field, are grouped into two plays regardless of the depositional history of the reservoir. Recovery efficiencies of the Paleozoic north and west Texas plays are considerably lower than those of the coastal plain and east Texas plays.

The effects of drive mechanism, lithology, permeability, API gravity, and viscosity on reservoir performance are well known. An additional important control on recovery efficiency that has been emphasized by this study is reservoir genesis. Although productivity can be modified by extremes in permeability or hydrocarbon character, it otherwise follows predictable trends based on the known geologic complexity and heterogeneity of the depositional system of the reservoir.

UCHUPI, E., Woods Hole Oceanographic Inst., Woods Hole, MA, and A. N. SHOR, Lamont-Doherty Geol. Observatory, Palisades, NY

Ocean Margin Drilling Project Data Synthesis off Eastern North America

An atlas of geological and geophysical maps has been compiled for the east coast of the North American continent, covering an area from well onshore to the ocean crust, and from 39 to 46°N lat., as part of the Ocean Margin Drilling Project.

Included in the atlas are maps of the depth to continental oceanic basement, depth to the top of Lower and Middle Jurassic (reflectors J_M/J_3 and J_S/J_2, to the top of Jurassic (reflectors J/J_1), to the top of Neocomian (reflector Beta), to the top of Cretaceous (reflector A*), to the top of Paleogene (reflector A_u), and to the top of early Miocene (reflector X). Isopach maps between these reflectors and between them and the sea floor are also included. Contours are two-way travel time with a contour interval of 0.25 to 1 sec.

The atlas also contains a tectonic map of basement, a pre-Quaternary geologic map and lithofacies maps for six time slices.

There are geophysical maps of magnetic and gravity anomalies and compressional wave velocities in sediments and basement.

ULMISHEK, GREGORY, and WYMAN HARRISON, Argonne National Lab., Argonne, IL

Peculiarities of Petroleum Formation in Highly Bituminous, Siliceous, Shaly, Carbonaceous Facies, Timan-Pechora Basin, USSR

Over 50 oil and gas fields with total reserves of about 6 × 10^9 BOE have been discovered in the Timan-Pechora basin, one of the most important Russian frontiers. Almost all the sequence is productive, although major reserves are confined to two stratigraphic intervals beneath regional seals. Principal source rocks are the so-called Domanik facies, 25 to 150 m (82 to 492 ft) thick, represented by rapidly alternating black shales, chert, marls, and siliceous and organic limestones. Exclusively sapropelic organic matter averages 5 to 7% and reaches 20% or more. Soluble bitumen is very abundant (1 to 2 wt. %) and contains all the components characteristic of crudes: from light oils to heavy tars and typical high-molecular asphaltenes. These characteristics exist even on the basin's periphery where Domanik facies are only marginally mature. In other areas, Domanik facies are mature; they are probably overmature in the deepest troughs. Outside the area covered by Domanik facies, pools and even significant shows are absent.

Deposition of this prominent facies began during the end of early Frasnian time in a wide stagnant sea that covered the eastern edge of the Russian platform. Beginning in the late Frasnian, shallow-water carbonate sedimentation resumed along the basin's edges and on uplifted blocks. Condensed Domanik deposits continued to form in the gradually deepening sea on the east side of the basin. Barrier reefs and clastic terraces that prograded basinward formed along the northern and western boundaries. The deep-water trough was finally filled by thick clastics at the end of early Tournaisian time.

The unusual composition of Domanik facies and their exceptional enrichment by sapropelic organic matter result in their peculiarities as petroleum source rocks. Lithology of the rocks, particularly the abundance of huge carbonate concretions fully or partly replaced by silica, suggests a long delay in lithification and the relative importance of the late diagenetic stage of oil generation. This explains the presence of immature oils in underlying Devonian clastics and their absence elsewhere in the sequence. On the other hand, Domanik facies, owing to significant silicification that trapped giant amounts of bitumen in the rocks, became a "natural repository" of oil during geologic history. This oil migrated because of fracturing, especially during stages of tectonic activity. Spatial distribution of oil types and deposits of solid bitumen in traps having different ages of formation, clearly shows predominance of pulse-like vertical migration. Migration of oil from the Domanik continued during late stages of geologic history along with block uplifting, cooling of the sedimentary cover, and absence of sedimentation. Thus, methods of applied geochemistry that invoke models of heating should not be applied to Domanik-type rocks and more geologic data are required to assess their role as oil sources.

UNDERWOOD, MICHAEL B., Univ. Missouri, Columbia, MO, S. B. BACHMAN, Cornell Univ., Ithaca, NY, and D. G. HOWELL, U.S. Geol. Survey, Menlo Park, CA

Influence of Accretionary Tectonics on Sedimentation and Diagenesis: Paleogene Yager Formation of Northern California

The Yager formation of Humboldt County, California, comprises well-bedded mudrock, sandstone, and conglomerate of Paleogene age. These strata are much less deformed than coeval broken formations and melange of the Coastal Belt Franciscan. We infer that deposition occurred within slope, slope-channel, and trench-slope-basin environments, in an overall subduction or transpressional tectonic regime.

The following observations suggest that Yager basins were both restricted in size and elongate in shape: (1) feeder-channel and mid-fan facies associations are common within the Yager; however, outer-fan depositional-lobe sequences are both rare and poorly developed, and basin-plain deposits are absent. Sandy mid-fan deposits typically grade into thin-bedded and poorly cyclic fan-fringe turbidites. It is likely that "normal" distal-fan facies associations failed to develop because of restricted basin geometries. (2) The regional distribution of turbidite facies and facies associations indicates that basin-fill sequences generally maintain good continuity along strike (northwest-southeast); the facies changes occur along transverse sections, and are, at least in part, temporally controlled. Thus, the basin-fill sequences appear to be elongate in a northwest-southeast direction, parallel with the dominant structural grain. (3) Thick sections of complexly folded mudrock are common within the Yager. These fine-grained strata, which include both hemipelagic shales and silty or muddy turbidites, are interpreted as slope deposits and are typically cut by lenses of coarse-grained, thick-bedded channel fill. The slope and channel sequences are nearly as prevalent as the sandy basin-fill sequences, which suggests that the Yager basins were not only restricted in size, but probably perched on an inclined, mud-covered slope.

Analogs for the Yager formation can be found along many modern subduction zones, where small, elongate basins typically form on the lower trench slope behind thrust-bounded or anticlinal ridges. Uplift of the ridges causes sediment-transport conduits (submarine canyons and slope channels) to become blocked; coarse detritus is thus trapped behind the ridges in a manner somewhat comparable to the salt diapirs which confine intraslope basins in the Gulf of Mexico.

Mean vitirinite-reflectance values for Yager shales near Garberville, California, are as high as 0.79%. Burial depths of as much as 6,000 m (19,700 ft) are indicated, using a geothermal gradient of 2°C/100 m. However, the depositional overburden associated with Neogene shallow-marine sediments of the Wildcat Group is estimated to be only about one-third the amount required. The additional overburden apparently resulted from mid-Tertiary thrusting along the Garberville thrust, a fault which marks the tectonic contact between Yager strata and melange of the Franciscan central belt terrane.

UPSHAW, CHARLES F., Amoco Production Co., Tulsa, OK

Research Trends in Biostratigraphy

Paleontology, as applied in biostratigraphy, has long been an indispensable part of petroleum exploration. However, rapidly improving technology in many disciplines and the limitations of traditional biostratigraphy based on tops and zones dictate the need for an improved technology. In response to this need new approaches have been suggested, including probabilistic stratigraphy, geohistory diagrams, no-space graphs, isotopic and fission track dating, radiometric geochronology, tephrochronology, magnetostratigraphy, paleo-oceanographic geochemistry, and graphic correlation utilizing composite standards.

One example of a research program for the 1990s and beyond includes the development of a paleontologic composite standards and the interactive capability for their use by graphic correlation; the development of computer data bases for morphologic, taxonomic, paleoecologic and paleogeographic research and the interactive capability for synthesis, analysis and display; and, the development of time-based primary sedimentary models for prediction of geologic conditions ahead of the drill. Refined and stable taxonomic data supplied by highly capable paleontologists are a prerequisite for success. Such a program clearly requires management commitment of manpower and resources necessary to develop the technology, and it requires the development of effective technology transfer mechanisms to implement the results in exploration programs. The reward for success will be multifold improvement in our understanding of geologic conditions and history.

As with all exploration sciences, the present and future of biostratigraphy is the intelligent application of good paleontology to the solution of increasingly difficult geologic problems by constantly improving technology.

UZIEMBLO, NANCY, and HARRY PETERSEN, Reservoirs, Inc., Houston, TX

Diagenetic Components Within Woodbine Formation, East Texas

The Upper Cretaceous Woodbine Formation contains diagenetic components in the form of cements and clays which can cause problems in drilling, completing, and stimulating a well. These diagenetic components are present in pore systems of the rocks deposited within various Woodbine depositional systems ranging from fluvial to deep marine. Fluvial environments were present in the northeast area of the East Texas basin, and changed to deltaic-marine systems to the south and southwest. Deeper marine sediments are represented by a thickening clastic wedge deposited over the Edwards reef trend as channels, interchannels, and submarine fans. It is necessary to identify mineral types, crystal morphologies, and modes of occurrence of the diagenetic components within pore systems of rocks formed in these various depositional settings so that proper drilling, completing, stimulating, and/or acidizing programs can be conducted.

Calcite, dolomite, ankerite, and quartz are important cements which reduce porosity and affect reservoir quality of the Woodbine Formation. Carbonate minerals occur as isolated patches or extensive cement within the intergranular network. Quartz cement is commonly observed in the form of euhedral overgrowths. The storage capacity of the reservoir and productivity of a well can be hindered where these cements reduce and isolate primary and secondary pores. During completion, stimulation, and possibly acidization, calcite may cause further problems through reaction with hydrofluoric acid and precipitation of formation-damaging calcium fluoride. Iron hydroxide precipitates may also form when iron-rich calcite, dolomite, and ankerite are contacted by HCl, HF, and HCl/HF acids. These precipitated gels can block pores and reduce production.

Important clay components found within the pore network of the Woodbine Formation are kaolinite and chlorite. Kaolinite commonly displays a pseudohexagonal "book" and platelet morphology. It is relatively stable with respect to acids; therefore, acidization should have minimal effect on the kaolinite. A problem of migration of fine particles can arise when these "books" and platelets are loosened from framework grain surfaces. Turbulence within pore networks, caused by fluid movement during stimulation and production, especially near the wellbore or a fracture face, can cause the kaolinite fines to move and block pore throats. This could result in formation damage. Chlorite occurs as well to moderately crystalline platelets which reduce porosity by lining and filling pore areas. If the chlorite is iron-rich and contacted by HCl, HF, and HCl/HF acids, a problem of iron hydroxide precipitation can occur.

Other clays within the Woodbine Formation include illite and smectite. Authigenic illite is found as incipient growths on chlorite platelets. The smectite has a honeycomb morphology and occurs as a grain coating. These components can cause problems if present in significant amounts within Woodbine reservoirs. If relatively fresh water is allowed to contact the formation, illite can "mush" and the smectite can swell, both damaging the formation.

Drilling, completing, stimulating, and acidizing programs can