In mature exploration areas the ability to rapidly evaluate acreage for further exploration and development has previously been restricted by the vast amounts of data that must be analyzed. To efficiently evaluate selected areas it becomes necessary to subdivide such areas into workable tracts based on the amount of data and time available. Regional attempts at exploration in many places become too manpower-intensive for many energy companies.

Through utilization of computer data bases it is possible for a small group of individuals to effectively evaluate significant amounts of acreage. In mature provinces, this capability lets individuals rapidly develop exploration recommendations which previously could be made only by geologists who were already knowledgeable about that part of the province.

Two approaches which have been successfully applied to recent exploration efforts are (1) mapping of exploration potential/development potential values and (2) statistical mapping of structural trends. The exploration potential/development potential concept assigns arbitrary values to pertinent tests of specific geologic horizons. By using automatic contour mapping programs it becomes possible to define areas of exploration potential as well as areas of development potential.

The second application involves residual and trend surface analysis mapping of selected geologic horizons to define regional paleostructures. In the example to be presented, both seismic and well control indicated that sedimentary onlapping occurred during Lower Cretaceous time on the flanks of basins; these onlaps were located by computer-drawn contours. Significant potential hydrocarbon plays lie within these onlap zones.

COLEMAN, J. M., and D. B. PRIOR*, Louisiana State Univ., Baton Rouge, LA

Deltaic Influence on Shelf-Edge Instability Processes

Large river systems deliver significant quantities of fine-grained sediment to continental shelf regions. In specific areas off deltas, deposition rates are rapid and the sediment may be involved in a variety of mass movement processes on the subaqueous slopes (slumps and slides, debris flows, and mudflows) causing rapid sediment accumulation at shelf-edge depths and resulting in active progradation of the shelf edge. Seismically, the deposits appear as large-scale foresets and are commonly composed of in-situ deep-water deposits alternating with shallow-water sediments transported by mass movement. On electric logs, sands within these units are sporadic and display sharp basal planes and blocky shapes. Progradation of the shelf-edge deposits is generally accompanied by oversteepening and large-scale instability of the upper shelf-edge slopes. Deep-seated and shallow rotational slides move large volumes of sediments and deposit them on the adjacent slopes and upper rise. Extensive contemporaneous faults commonly form at the shelf-edge. Continuous addition of sediment to the fault scarps, particularly by mass movement from nearby delta-front instability, causes large volumes of shallow-water sediment to accumulate on the downthrown sides of the faults, mostly forming large-scale rollover structures. Continued movement along the concave-upward shear planes commonly results in compressional folds and diapiric structures. Contemporaneous accmulation of shallow-water mass movement deposits may occur in association with these structures.

Massive retrogressive, arcuate-shaped landslide scars and canyons or trenches can also form at the shelf edge owing to slumping and other mass-movement processes. Such canyons and trenches can attain widths of 10 to 20 km, depths of 800 m, and lengths of 80 to 100 km. The creation of such features by shelf-edge instability results in exceptionally large volumes of shallow-water sediment yielded to the deep basins in the form of massive submarine fans. The infilling of depressions by deltaic progradation is rapid, forming large foresets near the canyon heads. The low strength of the rapidly infilled, underconsolidated sediments causes downslope creep or reactivation of failure mechanisms, resulting in multiple episodes of filling and evacuation.

COMER, J. B., Univ. Tulsa, Tulsa, OK, and H. H. HINCH, Amoco Production Co., Tulsa, OK

Petrologic Factors Controlling Internal Migration and Expulsion of Petroleum from Source Rocks: Woodford-Chattanooga of Oklahoma and Arkansas

Upper Devonian-Lower Mississippian Woodford-Chattanooga black shales are oil source beds throughout Oklahoma and much of western Arkansas. Diagenesis in the Woodford-Chattanooga source section proceeded through the following relative time sequence: (a) silicification, chiefly by recrystallization of radiolarians, which probably followed the reaction conversion of amorphous opal-A to opal-CT to chert; (b) dolomitization of deep-basin opal or chert and shallow-platform carbonate laminae; (c) tectonic faulting, folding, and associated fracturing and stylolitization predominantly associated with the late Paleozoic Arbuckle and Ouachita orogenesis; (d) late silicification and mineralization along fractures contemporaneous with (e) generation and expulsion of petroleum.

The principal expulsion mechanism for these Upper Devonian-Lower Mississippian oil source rocks is whole-oil migration through coarser grained matrix pores, stylolites, and fractures, rather than diffusion on a molecular scale. Diffusion migration does occur but appears only to affect internal migration over a few millimeters within the source rock, and thus cannot account for expulsion of large volumes of oil. Preliminary calculations based on source rock extract data indicate that approximately 147 billion bbl of oil have been generated within Woodford shales in the 23,000 sq mi (60,000 sq km) geographic area of southern and western Oklahoma underlain by the Woodford Formation. Minimum relative oil-expulsion efficiency appears to have been approximately 18 to 19% of the oil generated. Thus, at least 27 billion bbl of oil have been expelled from the Woodford into adjacent formations in southern and western Oklahoma while 120 billion bbl of oil remain unexpelled in the source rock.

COOK, E. E., L. J. MCCLURE, and N. S. NEIDELL*, Zenith Exploration Co., Inc., Houston, TX

Now You See It, Now You Don't—Seismic Expressions of the Subtle Trap

Exploration geologists and geophysicists have much in common in terms of tools and vocabulary when it comes to searching for hydrocarbons, but there are clear differences in approach. Certain occurrences of hydrocarbons are subtle in terms of their geologic setting. Others may be obvious in terms of geology, but subtle in their seismic expression. Little has been written about such traps other than what has appeared in works on stratigraphic applications for seismic data. It is also important to distinguish between subtle seismic expressions of traps and complicated seismic expressions. The complicated seismic expression, while difficult to interpret, is not often overlooked. Noting subtle seismic signature in the first instance is another matter. A challenge is presented when both geology and seismic expression entail subtlety. These problems are encountered frequently and often are treated with great success. Detection of fracture porosity in carbonate rocks is an example.

Bounds and nature of seismic visibility and detectability are developed for families of lithologies of exploration interest. Geometric considerations are examined in the context of subsurface definition. Tools and techniques currently available for treating seismic data for the subtle trap are described, and uses for these tools and methods are given. In reconciling geologic and geophysical views toward the subtle trap, a more complete definition of the concept and a still larger family of exploration targets are provided.

COOK, HARRY E., and ROBERT M. EGBERT, U.S. Geol. Survey, Menlo Park, CA

Carbonate Submarine Fan Facies Along a Paleozoic Prograding Continental Margin, Western United States

Mass-transport deposits, though common in carbonate basins, normally occur as widespread sheets or debris wedges, as in the Devonian of Canada and elsewhere, or in modern interplatform troughs of the Bahamas.

Reexamination of a seaward-prograding Cambrian and Ordovician continental margin section in central Nevada reveals a 150-m thick interval whose facies resemble current models of submarine-fan deposition. The upper 100 m of sediment is assigned to an inner-fan setting and is characterized by submarine slides and several entrenched channels 10 m deep and 500 m wide. The channels are filled with disorganized boulder-bearing conglomerates but are not arranged in any well-defined thinning- and fining-upward sequences. Stratigraphically below this interval are thinning- and fining-upward organized, pebble to cobble-bearing channelized conglomerates, 30 to 50 m thick. These channels are 1 to 5 m deep, 20 to 100 m wide, and rapidly coalesce laterally and vertically. The conglomerates grade laterally into and are interbedded with thin and discontinuously bedded ripple-laminated and graded calcarenites, similar to detrital overbank-levee and interchannel deposits. These sedimentary units probably represent a system of braided channels in a mid-fan position. Below the braided channels are 10 to 20 m of thickening- and coarsening-upward cycles of virtually nonchanneled beds; beds in the cycles are composed of calcarenites exhibiting Bouma divisions. These carbonate sand sequences are interpreted to represent prograding outer-fan lobes.

The recognition of carbonate submarine-fan sequences raises several questions. (1) What sedimentologic and tectonic conditions are conducive to fan development in carbonate provinces? (2) Do these conditions resemble those for clastic-fan development, or do carbonate provinces have unique requirements? By recognizing carbonate submarine fans and the geologic conditions that control their sediment dispersal patterns, areas of maximum sediment accumulation may be predicted as an aid in exploring for petroleum reservoirs of deeper water carbonate environments.

CORLISS, BRUCE H., Woods Hole Oceanog. Inst., Woods Hole, MA

Distribution of Recent Deep-Sea Benthonic Foraminifera from Southwest Indian Ocean

Deep-sea benthonic foraminifera from the Crozet, Madagascar, and Mascarene Basins of the southwest Indian Ocean were studied (9-45°S, 45-80°E) to determine faunal-water mass relations. Principal component analysis of the faunal data reveals distinct trends related to depth and bottom-water potential temperature. Principal component 1 represents an average of all the faunal data. Negative values of principal component 2 reflect the importance of *Epistominella umbonifera* and are found generally south of 35°S latitude in the Crozet Basin and on the flanks of the Madagascar, Southwest Indian, and Southeast Indian Ridges. These negative values are associated with bottom-water potential temperatures ranging from -0.1 to 1.2°C with the high relative values (≤ -0.4) associated with potential temperatures $\leq$0.8°C. Positive values of principal component 2 reflect the importance of *Planulina wuellerstorfi,* rare species ($\leq$ 3%), *Globocassidulina subglobosa,* and *Astrononion echolsi,* and are found on the Central Indian and Madagascar Ridges where bottom-water potential temperatures are 0.4 to 1.2°C. High relative values of principal component 2 ($\geq$ 0.4) are found with potential temperatures of 1.2°C. High negative values of principal component 3 reflect the importance of *G. subglobosa* and high positive values reflect the importance of *Epistominella exigua, P. wuellerstorfi,* and *Pullenia bulloides.*

COSSEY, STEPHEN P. J., Conoco Inc., Ponca City, OK, and HAL FRANK, Conoco Inc., Falls City, TX

Uranium Mineralization in Eocene Point-Bar Deposit, South Texas

An Eocene point-bar deposit was exposed by open-pit mining near Conoco's uranium mill in Karnes County, Texas. Two oxidation cells within the 1-mi-wide point bar are closely associated with the sedimentary facies. One oxidation cell with a subtle color difference was wedge shaped, confined by the steeply dipping accretion sets of the point bar. Color differences between oxidized and unoxidized sediments are very subtle. The front of oxidation was in basal point-bar sediments immediately below a sandy channel fill sequence. This sequence contains the second or upper oxidation cell, which is tube shaped and is only 50 ft (15 m) wide and about 20 ft (6 m) thick. Abundant clay galls within the sandy channel fill prevented the encroachment of oxidation along lateral boundaries of this oxidation cell and, therefore, controlled the distribution of local crenulations in the front. Trough cross-bedding and ripples indicate a south to southwesterly paleocurrent direction within the point bar. The orientation of the upper oxidation cell suggests that oxidizing fluids flowed in an easterly direction. Therefore, mineralization developed substantially later than sediment deposition, after uplift and a change in ground-water flow direction.

COWAN, DARREL S., and MARK T. BRANDON, Univ. Washington, Seattle, WA

Contrasting Facies in Upper Mesozoic Strata of Pacific Northwest

Upper Jurassic to Lower Cretaceous sedimentary rocks in the San Juan Islands, Washington, can be grouped into two facies that are represented elsewhere along the Pacific margin from southeastern Alaska to California. The eastern facies comprises well-stratified volcaniclastic turbidites depositionally overlying mafic to felsic volcanic rocks resting on a mafic-ultramafic igneous basement. Sedimentary breccias derived from the basement and pelagic radiolarian argillites are locally