Modified Lopatin diagrams were used for detailed maturation modeling of four of the Phosphoria sampling sites. This detailed modeling clearly demonstrates that the thermal effects of overthrusting do significantly influence the maturation history of organic material incorporated in overthrust sediments. Briefly, the result of thrusting is to cool the overriding sheet and warm the sediments being overridden. A unit in the hanging wall of a thrust will not be subjected to high temperatures for nearly as long a time as the equivalent unit in the footwall of the thrust. Comparison between observed reflectance values for the four sampling sites with vitrinite reflectance values calculated from Lopatin diagrams indicates that better agreement between observed and calculated values is obtained when thermal modifications due to thrusting are incorporated within the Lopatin diagrams.

Finally, in the absence of actual geochemical information such as R_o or T.A.I., the models here described appear to be accurate enough to give a reasonable estimate of the thermal maturity of a potential source bed. Such a predictive technique can be of great value in planning an exploration program in previously untested overthrust terrains.

EHRHART, THOMAS P., Mobil Exploration and Producing Service, Dallas, TX

Depositional Environments of Ranger Limestone (Pennsylvanian), North-Central Texas

The Ranger Limestone was deposited on the broad shallow Eastern shelf of the Midland basin during Missourian time. The sequence of alternating carbonate and terrigenous sediments comprising the Ranger Limestone is reflective of the overall cyclicity exhibited by the Canyon Group. An analysis of the interrelationships of the facies produced a framework for reconstructing the depositional history. Earliest carbonate deposition in the Ranger appears to have been initiated on local topographic highs of probable minor relief. Phylloid algae are abundant biotic constituents in the Ranger Limestone and probably played a key roll in the carbonate buildup. The Ranger Limestone is composed primarily of sediments that represent four major depositional environments. The carbonate environments recognized include an inner shelf, a transitional inner shelf, and a restricted inner shelf. These carbonate accumulations are laterally restricted by distal delta-front deposits of the Perrin delta complex.

A multivariate statistical analysis based on point-count data of lithologic and biologic constituents was utilized in the delineation of facies within the Ranger Limestone. On the basis of the detailed petrographic study four facies were defined. These facies are: (1) algal-echinoid-bryozoan wackestone, (2) algal wackestone, (3) lime mudstone, and (4) calcareous shale.

EJEDAWE, J. E., S. J. L. COKER, D. O. LAMBERT-AIKHIONBARE, K. B. ALOFE, and F. O. ADOH, Univ. Benin, Benin City, Nigeria

Evolution of Oil-Generative Window (OGW) in Niger Delta Basin

Assuming a simple model of delta development involving progradation and uniform subsidence to present depths (rate, 500 m/m.y.; 1,640 ft/m.y.), oil-genesis nomographs derived from the TTI method were constructed for various geothermal gradients of the Niger delta (2.2., 2.5., 2.9, 3.2, 3.6, 4.0, 4.4, and 4.7°C/100 m) and utilized in mapping the positions (depth, temperature) of the top of the oil-generative window (OGW) at arbitrarily selected times (40 m.y.B.P., 30 m.y.B.P., 15 m.y.B.P., and the present). About 200 data points were evaluated.

During the active subsidence phase, oil generation within any megastructure was initiated at a temperature of 140 to 146°C (284 to 294°F) and depth of 3,000 to 5,200 m (9,842 to 17,060 ft) within 7 to 11 m.y. after deposition of the potential source rocks. After cessation of subsidence, upward movement of the OGW by 800 to 1,600 m (2,624 to 5,249 ft) was accompanied by a temperature lowering of 23 to 54°C (73 to 129°F). Lower temperatures produced correspondingly heavier crudes.

In some parts of the delta oil generation and expulsion from the lower part of the Agbada Formation predates the cessation of subsidence and structural deformation, while in others it postdates those events. In most parts of the Niger delta, the upper and normally compacted part of the Akata Formation appears to constitute the major source rock.

EKDALE, A. A., Univ. Utah, Salt Lake City, UT, and RICHARD G. BROMLEY, Inst. Historical Geology and Paleontology, Copenhagen, Denmark

Biogenic Structures in Pelagic Carbonates: An Ichnofacies Comparison of Deep-Sea and Shelf-Sea Chalks

As a general rule, pelagic sediment is totally bioturbated, and primary sedimentary structures are rarely preserved. The fabric and internal structure of the sediment are modified post-depositionally by the burrowing activities of the infaunal benthos. However, various aspects of the original depositional environment, such as water depth, sediment type, and substrate stability, may be reflected in the ichnofacies. The ichnotaxa apparently differ in their environmental requirements and tolerances; thus, ichnofacies transitions exist even within the pelagic depositional regime.

Today fine-grained, calcitic nannofossil ooze is deposited beyond the reach of terrigenous sources in water depths of about 2,000 and 4,500 m (6,562 to 14,764 ft). At certain times in the past, however, such as during the Late Cretaceous in northern Europe, fine-grained calcareous ooze was deposited in much shallower depths as well, perhaps as little as a few hundred meters.

Trace fossils aid our understanding of the paleobathymetry and substrate conditions in ancient chalky sea bottoms. Deep-sea chalks differ from their shallow-water counterparts in northwest Europe in their typical lack of abundant shelled megafossils and flint horizons. The European chalks commonly contain a *Thalassinoides*-dominated ichnofacies, which very directly influenced such early diagenetic processes as hardground formation and silica reprecipitation. A deeper water ichnofacies in the European chalks, dominated by *Zoophycos*, is less commonly associated with hardgrounds and flint horizons. In truly deep-sea chalks, *Thalassinoides*, bored hardgrounds, and well-developed burrow flints are very rare; a *Zoophycos-Chondrites-Planolites* association is characteristic.

ELLER, LYNN H., Geological Information Library of Dallas, Dallas, TX

Depositional Environment of Pittsburgh No. 8 Coal Seam

The Pittsburgh No. 8 coal, the basal member of the Monongahela Formation, is considered one of the most important coal seams in Ohio. Maceral analyses and reflectance studies were conducted on four seams to determine its depositional environment. Petrographic analyses of coal from Guernsey, Belmont, and Jefferson Counties, Ohio, show large amounts of vitrinite, varying amounts of exinites, and inertinites. The inertinites, consisting mainly of fusinites and semifusinites are normally present in larger amounts than the sporinites and resinites that make up the exinites. Large amounts of mineral matter, composed of pyrite, carbopyrite, and carbargillite, exist within this high sulfur coal. Vitrinite reflectance studies reveal that all seams rank as high volatile bituminous coal.

Macerals within the coal imply that at the time of deposition the predominant facies was forest moor, occasionally interrupted by the mixed forest-and-reed and reed moor facies. The coal seams were in an upper delta-plain fluvial environment on an easterly building deltaic lobe.

The two westerly seams are thinner, with a higher ash content indicating their proximity to the main delta. They were deposited under brackish water conditions due to the distributary's diluting of the marine sea. The southern and northernmost seams have higher pyritic values reflecting deposition under marine conditions. The southernmost seam's higher pyritic values at its extremes indicate inundations of the sea in that area of the deltaic lobe.

ELZARKA, MOHAMED HOSSNY, Univ. Alexandria, Alexandria, Egypt, and IBRAHIM AHMED RADWAN, Egyptian General Petroleum Corp., Cairo, Egypt

Subsurface Geology of Tertiary Rocks of Northeastern District of Western Desert, Egypt

The lithofacies analysis of the Tertiary rocks reveals two ancient subbasins at the north and southeast of the northeastern district, Western Desert. The southeastern subbasin seems deeper than the northern one as it received relatively thicker Paleocene and early and middle Eocene rocks. The lithofacies of the Paleocene and early and middle Eocene sections are mainly calcareous. The clastic ratio ranges from 0.05 to 1. Shale predominates in the late Eocene rocks. The clastic ratio is more than one everywhere. The Paleocene rocks seem to have accumulated in a lagoonal environment of epineritic depths. Semi-restriction of water circulation at the southeastern subbasin was caused by an elongated ridge, separating the two subbasins. The Paleocene rocks of the northern subbasin indicate accumulation on an unstable shelf, i.e., slow deposition in a rapidly subsiding basin or at least slow deposition in an overall carbonate aerobic environment. Widening of the northern subbasin occurred during the early Eocene. The Paleocene environmental conditions seem to have prevailed during the early and middle Eocene. During the late Eocene, rocks of shallow-water and current-agitated environments accumulated. The lower clastic layers of the Oligocene, having a sand/shale ratio less than one, indicate a clastic shoreline environment-lagoonal subenvironment. The sediments of such an environment are brought down by rivers and reworked by waves and currents. The Oligocene clastics are overlain by a basaltic sheet at the eastern part of the district. The depocenter of the northern middle Miocene subbasin lies farther north. The sand/shale ratio increases to the south, being more than one. The middle Miocene lithofacies indicate rock accumulation in a contemporaneously subsiding basin under lagoonal or delta-front conditions at the southern part of the district. Marine stagnant-bottom-water conditions prevailed during the accumulation of the middle Miocene rocks at the northern parts. The Pliocene shoreline shifted farther northward. The Pliocene rocks seem to have accumulated in lagoons, where the inflow exceeded evaporation and alternating periods of exposure and flooding by either fresh or saline water of poor circulation prevailed. The tectonic instability of the district was initiated by volcancity during the late Oligocene. This volcanic activity was accompanied by uplifting, folding, and faulting of Oligocene and older rocks. The uplifting of the southern part was accompanied with subsidence of the northern one. The subsidence was associated with vertical block movements of the basement rocks. Basaltic magma climbed along faults. The folds are of the brachyanticlinal type, affected by faulting forming a median horst block. This block remained high for a great period of time. The axes of folding are parallel to the fault trends due to their association with the vertical block movements of the basement. The northern flanks of the folds are relatively steeply dipping. The middle Miocene and Pliocene rocks are not affected by faulting. The source lands of those sediments are deduced as nearby low elevated lands affected by the same tectonic events that affected the depositional basin itself during different epochs.

ERIKSSON, KENNETH A., and KRISTIAN SOEGAARD, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA

Storm-Deposited Outer Shelf Facies from Precambrian Ortega Group, New Mexico

The 1,700 million year old Ortega Group in northern New Mexico accumulated in diverse shallow shelf environments under the influence of tidal, wave, and storm processes. Tidal and fair-weather wave reworking dominated the inner shelf but a significant storm overprint is indicated by offshore-directed trough cross-stratification, and winnowed lags and scour channels at the top of tabular units. Storm-surge currents supplied sand to the outer, mud dominated shelf where deposition occurred predominantly under flat-bed conditions. Amalgamated, upward-thickening depositional units of horizontally stratified sandstone comprise 1 to 7 m (3 to 23 ft) thick genetic packages. Based on their position in the progradational shelf sequence, these sandstones are inferred to have accumulated in proximal reaches of the outer shelf. The upper parts of individual 2 to 25 cm (.78 to 9.8 in.) thick depositional units are commonly defined by interlaminated siltstone and mudstone, and the thinner basal sandstones frequently have wave-rippled tops. Scour channels are often present at the top of the sandstone packages. The sandstone:mudstone ratio decreases outward on the shelf with discrete, 2 to 5 cm (.78 to 1.9 in.) thick, horizontally-stratified sandstone beds and rare hummocky cross-stratified beds passing distally into mm-thick horizontally stratified sandstones. Associated lenticular sandstones are exclusively wave rippled. The preponderance of horizontal stratification in outer shelf sandstones coupled with the resemblance of individual depositional units to b-d turbidite beds suggests suspension fallout under conditions of high but waning bed shear. Such conditions may have been related to unidirectional storm surge currents or oscillatory storm waves; the paucity of hummocky cross-stratification may favor the former process. Wave-rippled sandstones developed through fair-weather reworking of the storm-deposited sandstones. In the absence of bioturbation, Precambrian shelf sequences provide an excellent opportunity for studying outer shelf depositional facies and processes.

ESLINGER, E., and V. RANGANATHAN, Cities Service Technology Center, Tulsa, OK

Diagenesis in Stevens Sandstone, a Miocene Deep-Water Turbidite in San Joaquin Valley, California, and Probable Interactions with Surrounding Siliceous Shales

The late Miocene Stevens Sandstone deep-water turbidite in