Meulaboh and Mentawai troughs to the north and the south, respectively.

The Banyak Islands cross-structure is a linear zone of deformation that transects the fore arc obliquely. The continental shelf is narrow and an abrupt change in depth to basement and sediment thickness occurs across a near-vertical fault. The trace of this fault continues onshore in good alignment with a major strand of the right-lateral Sumatra fault system. Offshore, the fault transects the Banyak shelf and appears to intersect the late Pliocene flexure on Nias which is thought to represent the rear edge of subduction-related deformation. Here, it occupies a wider zone of deformation characterized by high-angle reverse faults that probably involve basement. Monoclinal folds and secondary faults have developed in the overlying sedimentary section, and large growth faults with normal separation have developed along the crest of the trench-slope break north of Nias.

Stratigraphic relationships and well data indicate that faulting and folding occurred during Pliocene time. The variation in structural style along strike is indicative of varying crustal structure. The shelf, characterized by rigid crystalline basement with a thin sedimentary cover, exhibits a brittle crustal response, whereas the thick prism of fore-arc basin strata overlies more ductile crust which affords greater crustal mobility.

The wide central Sumatra shelf southeast of Nias does not appear to be related to strike-slip faulting. Seismic profiles show that flat sediments of Miocene and Pliocene age onlap an eroded crustal block of continental character lacking diagnostic structures and obvious trend associations. We believe that this feature existed as a broad, paleobathymetric high that separated the basins early in the history of the fore arc. Buried normal faults, which step down to the trench, offset the basement reflector along the paleoshelf edge. The relatively shallow shelf has persisted as a positive structural element exhibiting a reduced rate of subsidence throughout the Neogene.

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Depositional Environments of Lower Portion of Pottsville Group (Pennsylvanian) in Southern Ohio

Seven sedimentary facies are recognized within the lower members of the Pottsville Group (Pennsylvanian) in southern Ohio which define an overall onlap-offlap sequence. The facies succession, as defined by stratigraphic lithofacies analysis, begins with coarse clastic braided and meandering stream deposits suggesting an aggrading coastal plain depositional environment. The braided-stream facies comprises medium to coarse-grained quartzarenite and pebble to cobble conglomerate and disconformably overlies Lower Mississippian formations. Contained large-scale planar and some trough cross-bedding yield strongly unimodal (west) paleocurrent directions. The overlying meandering stream facies consists of multistoried fining-upward sequences of sandstone, minor conglomerate, siltstone, shale, and coal. Lacustrine and interdistributary bay facies are interpreted to represent a transitional environment from a low-lying coastal plain to a northward transgressing marine embayment. Varvelike laminae of mudstone and claystone of the lacustrine facies grade upward to marine-fossil bearing interdistributary bay and fine delta front facies. Subsequent southerly progradation of a delta system is indicated by interdistributary bay, delta front, crevasse splay, and distributary channel facies.

Fossil plant assemblages suggest that the lower Pottsville Group, in southern Ohio, is entirely Morrowan (Namurian C–Westphalian A) New River Formation age-equivalent.

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Chemical Characterization of Petroleum from a Seep on Slope of Northern Gulf of Mexico

During an extensive coring and geophysical survey of the outer slope of the northwest Gulf of Mexico, a 4-m (13-ft) core recovered from 538 m (1,765 ft) water depth had visible petroleum deposits. The petroleum was extracted and chemically and isotopically characterized. The percent of petroleum soluble in benzene ranged from 4.0 near the surface to 4.5 at 100 cm (39 in.) to 0.1 at 410 cm (161 in.). API gravities ranged between 10.7 and 17.6. GC analysis of the silica gel fractions showed that both the saturated and aromatic hydrocarbon components are highly biodegraded, with the degree of degradation increasing upward in the core. The $\delta^{13}C$ values for the whole oil and the fractions were between -26.2 and -26.7‰ on the PDB scale and showed very little variation among compound classes. Carbonate nodules contained in the oil-rich core had carbon isotopic compositions depleted in ^{13}C, indicating oxidized organic matter is the source of the inorganic carbon. The core is located in an area with large-scale normal faulting which also shows evidence of gas migration. Based on this and the distribution of oil in the core, it is supposed that the oil has migrated upward.

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Monterey Fractured Reservoir, Santa Barbara Channel, California

The South Elwood field in the Santa Barbara Channel is a faulted anticline with cumulative production of 14.5 million bbl from the Monterey Formation as of September 1, 1982. The distributions of pressure, flow rates, and oil-water contacts and the low average matrix permeability of 0.2 md require a fractured reservoir. Within the field, the relation of oil productivity with respect to typical geological parameters of structure or gross lithology is random. However, the present study reveals that the best production is obtained from the wells that penetrate the complete Monterey section, are extensively perforated, and are deviated strongly along structural strike. Observed variations in production as a function of borehole geometry can be quantitatively related to the geometry of fracturing and brecciation.

Core and outcrop studies show a dominant fracture set characterized by vertical, lithologically controlled fractures oriented across strike, and breccias controlled by lithology and structure. Generally, the fracture intensity is unaffected by structural position or bed curvature but is controlled by lithology and bed thickness. Chert, porcelanite, and carbonate rocks are the most intensely fractured lithologies, but the widest fracture openings occur in carbonates. Other varieties of fracturing in the Monterey are related to a protracted history of diagenesis, deformation, and fluid injection.

Three types of tar-bearing breccias occur in the Monterey Formation: stratigraphic breccia, coalescent-fracture breccia, and fault-related breccia. Stratigraphic breccias in porcelanite and chert are attributed to volume decrease owing to silica diagenesis. Coalescent-fracture breccias occur where tar intrudes fractures that lie at high angles to bedding, disaggregating rock adjacent to the fracture. Fault-related breccias commonly are found in conjunction with large-displacement normal faults and rotational strike-slip faults. Formation of breccias probably involves high pore pressures. Because of their polygenetic origin, breccia masses have diverse orientations paralleling bedding or fracture/fault systems.

In conclusion, fracturing and brecciation of the Monterey Formation reflect the interplay between processes of diagenesis, deformation, and fluid dynamics. The most important features of the reservoir in the area of the present study are: (1) vertical fractures oriented normal to the structural trends and inferred to be favorably oriented (to remain open) with respect to the regional minimum horizontal stress; and (2) breccias that are both stratigraphically and structurally controlled and inferred to be related to the interaction of rock stress and fluid dynamics.

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Hydrodynamics of Denver Basin, An Explanation of Subnormal Fluid Pressures

Anomalously low fluid pressures are found in the Lower Cretaceous, Mesozoic, and Paleozoic rocks of the Denver basin. Drill-stem test data and published hydrogeologic information are used to construct a potentiometric map for the Lower Cretaceous sandstones in the area. Normally, one expects the potential surface to be at or near the land surface (0.43 psi/ft). However, the potential surface for the Lower Cretaceous sandstones and underlying Paleozoic rocks is up to 2,500 ft (762 m) beneath the land surface (0.35 psi/ft) in parts of the Denver basin in Colorado and the Nebraska panhandle. The low pressures seem especially anomalous considering the elevation of the outcrops along the Rocky Mountain Front and the Black Hills.

The hydrostratigraphy is defined based on the known regional geology. Structure, isopach, and lithofacies maps are used to estimate the hydraulic characteristics of the rocks in the basin. A numerical model is constructed, based on the hydrostratigraphy, which simulates the regional flow system. Both transient and steady-state flow regimes are simulated. The interaction of the Lower Cretaceous sandstones with overlying and underlying hydrostratigraphic units is investigated. The significance of recharge in the outcrop areas is evaluated. The model is used to define the conditions under which subnormal fluid pressures may occur. The subnormal fluid pressures are reasonably explained as a consequence of regional ground-water flow.

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Importance of Shelf to Trough Black Phosphatic Shales in Mid-Continent

Pennsylvanian black shales containing radiolarian-rich phosphatic nodules, such as are now accumulating on outer shelves and upper slopes of modern tropical seas, are widespread throughout much of Kansas, Oklahoma, and other Mid-continent states.

Conodonts, inarticulate brachiopods, conularids, fish teeth, and radiolarians constitute the main biota of these black shales. Such shales characterize about half the 60 or more known Pennsylvanian cyclothems of Oklahoma and Kansas. These shales, individually approximating about 1 m (3 ft) in thickness in the extensively mined limestone and coal sequences of eastern Kansas and northeastern Oklahoma, have been described by Moore, Branson, Heckel, and others. However, much thicker, up to 8 m (26 ft), coeval zones in the deep Arkoma and Anadarko basins are surprisingly under-reported considering that such highly organic shales may have been the prime source of commercial oil and gas. Furthermore, those coeval black shale wedges that interfinger southward from the Arkoma trough into the red bed- and conglomerate-dominated sequences flanking the southern tectonic borderlands are virtually unreported.

These are the "core shales" of Heckel, the deep stillstand or maximum transgressive facies. Representative black phosphatic shales crossing two or more tectonic provinces include the Desmoinesian sub-Verdigris, Anna, and Nuyaka Creek beds, and the Missourian Mound City and Stark beds.

Dysaerobic (low oxygen) and supposedly slightly shallower water, dark gray concretionary shales adjoin these black phosphatic shales. In many cyclothems the dysaerobic facies represent the deep stillstand facies where the latter is missing. Typically, it features a middle to outer shelf diverse molluscan community, including rapidly evolving goniatites useful for correlations.

These deep-water stillstand indicators are more useful for regional correlations than those for the low water stillstand that include coals, coaly shales, red beds, and paleosols. Carboniferous sea level fluctuations at times probably exceeded 200 m (656 ft), arising from interacting tectonic pulses and glacial-eustatic changes. Recent findings indicating that Carboniferous glacial maxima in southern Pangea exceeded Pleistocene maxima may account for the numerous regressive events on a global scale at that time.

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Changes in Deep-Sea Ostracode Fauna from Eocene into Oligocene

A major change in deep-water oceanic circulation occurred near the end of the Eocene forming the present psychrosphere and basic two-level water-mass system. This event is especially felt in the South Atlantic and Indian Ocean as shown by ostracods found in DSDP cores. Faunas traceable back to the Cretaceous rapidly evolved into the modern deep-sea faunas at this time. Several important ornate genera undergo diachronous changes suggesting that the flooding of the world ocean basins with colder waters happened in stages. The displacement of Tethyan water masses coming from the north by newly formed Antarctic bottom waters can be followed by changes in the ostracods.

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Abnormal Pressures and Their Relation to Oil and Gas Migration and Accumulation

Subsurface water exists in a dynamic state, and the condition of hydrodynamic flow, or potential for flow, is indicated by abnormal fluid pressures. Excess pressures indicate updip flow of water and transfer of hydrocarbons from source rock to reservoir in stratigraphic or structural traps. Deficient pressures most commonly indicate downdip flow, reinforcement of capillary-pressure barriers, and enhanced oil columns in stratigraphic traps. The principles of hydrodynamic flow can be applied in either case for prediction of sites for petroleum accumulation; furthermore, a quantitative estimate can often be made of the amount of oil or gas trapped.

Excess pressures in the Gulf Coast Tertiary section are generated by several mechanisms: (1) nonequilibrium compaction, (2) clay transformation, (3) aquathermal pressuring, and (4) hydro-