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) hydrocarbon generation. These mechanisms operate at different depths and temperatures, but may, in some cases, operate together to produce hydrodynamic flow. The result of flow is development of secondary porosity by dissolution of grains or cement and by hydrocarbon migration. Oil and gas accumulate in local, low-potential volumes of reservoir rock in which the pressures can be either slightly or greatly in excess of normal hydrostatic pressures.

Deficient pressures in Rocky Mountain basins are caused by uplift, exposure, and recharge of aquifer systems by meteoric waters. Downdip hydrodynamic flow results in oil columns of unusual height in which the oil trapped by flow greatly exceeds that which can be trapped by capillary-pressure barriers alone. These basins may have locally excess pressures due to clay transformation, or hydrocarbon generation, or locally deficient pressures due to gas blockage in fine-grained rocks.

The principles of flow are well established but not widely applied, and there is a need for better documentation of causes for abnormal pressures and the effects of flow. Knowledge of fluid-pressure regime can often be determined from relatively few points of subsurface control for a better understanding of fluid-migration history. Such knowledge is essential to oil and gas exploration in both poorly tested and mature basins.

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The Age of the Eocene/Oligocene Boundary is ...

In the construction of geologic time scales and the related exercise of discussing the chronology of chronostratigraphic units and boundaries, it is important to clearly distinguish between radiochronologic, biochronologic, magnetochronologic, and magnetobiochronologic input to their formulation. Failure to do so has, in some places, led to the confusion which surrounds the discussion and uncritical acceptance of some of the variant scales now being used. A brief critical examination will be made of several of the currently used Cenozoic chronologies and their bearing on the age of the Eocene/Oligocene boundary.

Current age estimates of the Eocene/Oligocene boundary range from about 32 to 38 Ma based on the assessment of various (predominantly glauconitic) radiometric dates, poleontological control of varying reliability, and quality and paleomagnetic chronologies employing different calibrations. High temperature radiometrically dated polarity stratigraphy in the middle Eocene (polarity chron 20-21 interval) and the latest Eocene-early Oligocene (chron 15/16-12 interval) in North American continental sections with mammalian faunas provide the framework for much needed calibration points in the mid-Cenozoic and for a revised Cenozoic time scale. This also provides constraints on age estimates of the magnetobiostratigraphically determined Eocene/Oligocene boundary in deep sea and continental marine sections. The Eocene/Oligocene boundary (biostratigraphically linked with the LAD's of the *Globorotalia cerroazulensis-cocoaensis* group, *Hantkenina* and *Globigerapsis*, and the rosette-shaped discoasters, *i.al. Discoaster barbadiensis* and *d. saipanensis*), is situated within the reversed interval between marine magnetic anomalies 15 and 13 with younger and older boundary estimated age values of 37.24 and 35.87 Ma, respectively. Our best estimate of the age of the Eocene/Oligocene boundary (subject to minor changes as a result of further magnetobiostratigraphic studies) is 36.6 Ma.

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Paleozoic Lithofacies in Southwestern Sinai and Their Depositional Environments.

Major breaks in sedimentation, accompanied by well-developed paleosols, have been successfully used to subdivide the 600 m (1,968 ft) of Paleozoic sandstone and shale sequence of southwestern Sinai, Egypt, into five smaller facies association units (i.e., formations). The lowest unit (the Araba Formation) is dominated by 1 to 10 m (3 to 32 ft) thick coarsening-up sequences of parallel-bedded, varicolored, fine-grained arkosic sandstone and muddy sandstone with abundant *Skolithos* burrows and in places *Cruziana* traces. This is the deposit of a low-energy prograding sandy coastal plain complex that grades upward into a thin, fining-up channel-overbank deposits with poorly developed paleosols. The overlying Naqus Formation scours deep into the Araba, and is characterized by lenticular, coarse to medium-grained, cross-bedded quartz sandstone with only a few clayey intervals. Well-rounded vein quartz and quartzite pebbles are scattered in the lower half, but form lenses in upper half. Cross-beds are common. The Naqus is interpreted as alluvial fan-braided stream deposits. A 15 to 20 m (49 to 66 ft) thick, conspicuous dark brown, ferruginous shale, ochre-yellow dolomitic sandstone and fossiliferous gray siltstone sequence, persistent all along the Qabeliat valley, overlies the Naqus and represents lagoonal deposits laterally equivalent to the shallow marine shale-dolomite sequence of the Um Bogma Formation farther north. The upper few meters of this unit developed into a paleosol. Basal fluvial channel sands of the succeeding Ataqa Formation cut into the Um Bogma paleosol, and grade upward into the fossiliferous green-red marine shales and subordinate sandstones in shoaling-upward sequences. Laterally, these shallow marine beds grade into coastal swamp deposits of carbonaceous shale and coal. Excellent paleosols developed at the top of the Ataqa Formation which in turn is deeply channeled by a thick succession of fining-upward, lenticular fluvial channel-sand-overbank paleosol facies of the Budra Formation. Southward in the Qabeliat valley, a parallel-bedded sequence of thick green shales and thin brown sandstones, both nonfossiliferous, intervenes in the middle of the Budra Formation and represents ephemeral lake deposits related to the fluvial system. Although the repetition of facies associations in the Paleozoic sequence of southwestern Sinai points to the repetition of events, each lithofacies shows characters of its own sufficient to assign it to a specific environment. Marked asymmetry in the facies sequences suggests spasmodic character of the events.

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Fan-Delta Deposition in Lower Cotton Valley Group Sandstones of Northeast Texas

Fan deltas have been defined as progradation of alluvial fans into a standing body of water from a proximal highland area. Sedimentary environments associated with fan delta complexes have been described in detail in Holocene examples. The subaerial fan is composed of braided channels, gravelly beaches, flood plains, and marshes. The subaqueous fan includes tidal lagoons, channel-fill complexes, marginal islands, breaker bars, and is also characterized by steep slopes and submarine channels where mass-gravity processes may dominate.

Few fan delta complexes have been recognized in the subsurface. The Cotton Valley Taylor "B" Sandstone is interpreted as the distal part of a prograding fan delta based on the vertical sequence in cores from Kildare field, Cass County, Texas. Three