more by appearances than extinctions.

Various lines of evidence (seismic, lithostratigraphic, isotopic) indicate that a major, rapid change in abyssal circulation occurred near the end of the Eocene. As modern benthic foraminifera distributions often correlate with modern water-mass distributions, benthic foraminifera may be expected to have responded to the circulation changes. However, the Eocene/Oligocene boundary was not catastrophic for deep-sea benthic foraminifera, and the late Eocene-Oligocene deep-sea fauna evolved in a series of events over several million years. The major faunal abundance change at all depths greater than ~0.5 km (1,600 ft) was the apparently synchronous decrease in abundance of *Nuttallides truempyi* just above the middle/late Eocene boundary (~38.5 to 40 Ma); this pre-dates by 2 m.y. the major ^{18}O enrichment and the change in abyssal circulation regime inferred from seismic stratigraphic studies. The record in deep abyssal locations (paleodepths >3 km, 10,000 ft) shows the greatest changes, for here *N. truempyi* is associated with many endemic deep-water taxa (*Abyssammina, Clinapertina, Aragonia, Alabamina dissonata*, among others) that decrease in abundance and become extinct prior to the Oligocene. In shallower abyssal depths (2 to 3 km, 6,500 to 10,000 ft), a series of first and last appearances occurred in the late Eocene to earliest Oligocene. In lower bathyal depths (~0.5 to 1.5 km, 1,600 to 5,000 ft), a great number of first appearances occurred in the late Eocene through Oligocene.

Oligocene abyssal faunas mark a change from Paleocene (Cretaceous relict) and Eocene taxa (e.g. *N. truempyi, Alabamina dissonata, Aragonia* spp.) to abyssal assemblages that have many taxa in common with modern assemblages. The Oligocene abyssal fauna is dominated by stratigraphically long-ranging and bathymetrically wide-ranging taxa that survived the extinctions of the Eocene. During the middle Oligocene, *Nuttallides umbonifera* became important in deep abyssal locations in the North Atlantic and shallow and deep abyssal locations in the South Atlantic. Shallow abyssal Oligocene faunas throughout the Atlantic differ from Eocene faunas primarily by the absence of *N. truempyi*. Oligocene bathyal (0.5 to 1.5 km, 1,600 to 5,000 ft) assemblages are similar to the Eocene bathyal *Lenticulina-Bulimina-Osangularia* assemblage, although many new taxa appeared in the late Eocene through Oligocene.

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Controls of Deformation Mechanisms and Fracturing on Local and Regional Hydrocarbon Potential in the Central Appalachian Overthrust Belt

In highly deformed fold and thrust belts, strain associated with different deformation mechanisms can significantly alter the porosity and permeability of potential reservoir rocks. In general, mechanisms such as pressure solution, intragranular deformation, and cataclasis reduce porosity, whereas extension fracturing increases porosity, and more importantly, permeability. Since these mechanisms are dependent on parameters such as temperature, pressure, deviatoric stress, lithology, and grain size, they can produce significant regional and local variations in reservoir potential. Thus studies of these mechanisms are important for defining regional limits for exploration and, more locally, for evaluating individual prospects.

In the central Appalachians, exploration is presently confined to the Plateau and Valley and Ridge provinces. However, the regional limits of hydrocarbon potential need to be defined, particularly in light of the recent hypothesis by Harris et al in 1981 of subthrust potential underlying the Blue Ridge in the southern Appalachians. This can be done by combining data on strain and deformation mechanisms with conodont CAI data and estimates of displacements on major faults. Penetrative strain axial ratios (R) range between 1.1 and 8.0 in Great Valley carbonates and between 1.6 and 6.9 in Blue Ridge clastics. In the Valley and Ridge, R is usually less than 1.2. For most reservoir rocks, porosity is completely eliminated for R = 1.5, so that little porosity is expected east of the Valley and Ridge. Conodont CAI data of Epstein et al in 1977 show values approaching 5.0 for the Cambro-Ordovician carbonates and 4.5 for the Silurian-Devonian carbonates along the eastern edge of the Valley and Ridge. These values are at the upper limit for commercial gas production. The North Mountain and Blue Ridge faults, the two major thrusts east of the Valley and Ridge, both have maximum estimated displacements less than 20 km (12 mi), so that subthrust Valley and Ridge-type Silurian-Devonian rocks underlying the Great Valley rocks are fairly limited. Subthrust Cambro-Ordovician carbonates may be more widespread under the North Mountain ramp, but their potential is low because of high CAI and R values. The eastern limit of potential is therefore marked by the North Mountain fault, except for limited areas of subthrust Silurian-Devonian rocks.

The local effects of deformation mechanisms are related to interactions between pressure solution and fracturing, defined by relative timing, lithological characteristics, and structural position. Longitudinal fractures formed early or during the main phase of deformation are often healed or sealed by pressure solution, while transverse fractures, particularly those formed late tend to remain open. Lithological types susceptible to pressure solution, such as impure limestones, are less likely to retain matrix or fracture porosity than pure orthoquartzites. Structural positions with dilational strain, such as fold hinges in competent units, retain more porosity than those undergoing plane strain, such as thinned forelimbs of folds. Brittle deformation zones along splay faults are typically sealed through cataclasis. Consideration of these factors can significantly improve the evaluation of prospects in overthrust belts.

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The Interaction of Natural Organic Matter with Grain Surfaces: Implications for Calcium Carbonate Precipitation

Seawater is a complex solution of inorganic ions and organic molecules in contact with solid phases. Because of its reactivity and sorptive properties, some of the organic matter (OM) will directly affect the kinetics (and possibly the equilibria) of inorganic reactions by modifying the rates and types of reactions occurring between the inorganic ions and the solids. The interaction of natural OM with $CaCO_3$ systems occurs in two ways: (1) adsorption of the OM to $CaCO_3$ surfaces, and (2) complexation or chelation of free cations by dissolved or adsorbed OM. Both processes involve polar functional groups on the organic molecules, with the carboxylate anion ($-COO^-$) being the most likely interacting species, although other functional groups may also be important.

OM associated with a variety of skeletal and nonskeletal $CaCO_3$, including skeletal organic matrix, OM within ooids, and OM extracted from carbonate grain surfaces, was studied for chemical characterization, adsorption phenomena, and cation-binding ability. Skeletal OM is largely protein, whereas ooid and adsorbed OM are humic substances with proteinaceous components comprising about one-third of the composition. Aspartic acid is the most abundant amino acid in both skeletal protein and the humic substances. Conversely, OM associated with noncarbonate sediments is poor in proteinaceous constituents and relatively depleted in aspartic acid.

Aspartic acid-rich protein and humic substances bind or complex with metal ions in proportion to the concentration of carboxyl groups present. Blockage of carboxyl groups to make them inactive destroys the ability of the OM to bind metal ions. Many, if not most, of the carboxyl groups available for metal-ion complexation in both calcified protein and aspartic acid-rich humic substances are on aspartic acid. Thus, this amino acid provides a significant portion of the metal-binding ability of the different types of OM.

Aspartic acid-rich OM is preferentially adsorbed by calcite compared to quartz. Again, the carboxyl group is the likely function to be involved in this adsorption. Blockage of carboxyl groups significantly reduces the ability of humic substances to adsorb to calcite. The similarity in geometry, charge, and composition enables the carboxylate anion ($-COO^-$) to substitute for the carbonate anion ($CO_3^=$) in complexing calcium ion or adsorbing to calcite surfaces.

Competition between organic and inorganic ions for dissolved species and surface adsorption sites is driven by the requirement of the system to remain electroneutral. Concentration variations in dissolved organic and inorganic ions in the pore waters brought about by bioturbation and organic and inorganic diagenesis result in variations in the tendency of OM to affect the chemistry of the system. Most of the $CaCO_3$ formed in the marine environment consists of skeletal material. This $CaCO_3$ contains proteinaceous OM that is thought to be involved in formation of the mineral phase (biological calcification). By analogy, naturally-occurring OM of somewhat similar composition and properties and with identical functional groups may also be involved in the precipitation of $CaCO_3$ in the sedimentary environment (geological calcification).

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Submarine Fan Sedimentation, Ouachita Mountains, Arkansas and Oklahoma

More than 10,000 m (33,000 ft) of interbedded sandstones and shales comprise the Upper Mississippian and Lower Pennsylvanian flysch succession (Stanley, Jackford, Johns Valley, Atoka) in the Ouachita Mountains of Arkansas and Oklahoma. Deposited primarily by turbidity current and hemipelagic processes in bathyal and abyssal water depths, these strata form major submarine fan complexes that prograded in a westerly direction along the axis of an elongate remnant ocean basin that was associated with the collision and suturing of the North American and African plates.

A longitudinal fan system is visualized as the depositional framework for these strata which were deposited in a setting analagous to the modern Bengal fan of the Indian Ocean. Facies analysis of the Jackfork Sandstone indicates that inner fan deposits are present in the vicinity of Little Rock, Arkansas; middle fan distributary channel and crevasse splay deposits occur at DeGray Dam, Arkansas; and outer fan depositional lobe deposits are present in southeastern Oklahoma. Basin plain equivalents are postulated to exist as far away as the Marathon region in west Texas.

Boulder-bearing units (olistostromes) with exotic clasts were shed laterally into the Ouachita basin, primarily from its northern margin. These olistostromes occur throughout the fan succession in all facies (i.e., inner, middle, and outer fan). This relationship may serve as a useful criterion for recognizing similar fan systems in the rock record.

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The Occurrence of *Cycladophora* (?) *davisiana* Ehrenberg in the Gulf of California

The ecological behavior of the radiolarian *Cycladophora* (?) *davisiana* (particularly in high latitudes) has produced a large interest among radiolarian specialists. This species has been considered an environmental indicator, as well as a potential interhemispheric stratigraphic marker.

The geographic and stratigraphic distribution of *C. davisiana* Ehrenberg in the Gulf of California is analyzed in the present study. In the southern part of the Gulf, particularly at the water front formed by the encounter of the California Current and the Gulf water itself, its relative abundance in the surface sediments is comparable to that reported in the Sea of Okhotsk. Below the influence of the water front indicated above, *C. davisiana* has a stratigraphic behavior similar to the one reported in high latitudes.

It was previously hypothesized that the high productivity of *C. davisiana* in high latitudes is favored by water freezing and subsequent ice melting. The Gulf of California has not experienced ice forming processes; thus in this study it is suggested that the productivity of *C. davisiana* is favored by the strong mixing created by the formation of some water fronts.

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The Geomorphic Evolution of the Taylor Black Prairie Between the Trinity and Colorado Rivers

The Taylor Black Prairie is an interesting and complex area that has been, heretofore, relatively ignored as a distinct geomorphic unit. Therefore, the purpose of this study is to describe the region as it exists at the present time and to speculate on its overall evolutionary development.

Based on descriptive geomorphic variables including geology, landform morphology, soil type and distribution, surface gravure, vegetation type and distribution, and land use, the Taylor Black Prairie may be subdivided into three north-to-south trending geomorphic areas. These are, from west to east, the Lower Taylor Prairie, the Wolfe City scarp, and the Upper Taylor Prairie. There is also present, in the southern region of the study area, a relatively distinct small exposure of high gravels located between Little River and Brushy Creek. Because these gravels are geographically restricted within the study area, and because they are dissimilar petrologically from the Cretaceous strata upon which the north-to-south prairies are developed, they constitute a distinct geomorphic area.

The dominant active processes in the Taylor Black Prairie are soil erosion and mass wasting. These are acting under present climatic conditions to shape and modify and topography of this region.

The geomorphic evolution of the Taylor Black Prairie is related to the deposition of Tertiary Uvalde Gravel in the central Texas region. These sediments were carried by major rivers from the edge of the southern High Plains eastward through valleys entrenched in Paleozoic and Comanchean rocks. The less-resistant Gulfian and Tertiary rocks allowed valley widening, thus forming braided alluvial streams that deposited humid alluvial fans.