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 noncar-