

Detailed facies analysis of Holocene marsh deposits in coastal Delaware reveals a variety of environments of varying organic composition. An understanding of the depositional environments and early diagenetic histories of these sediments is necessary to evaluate their potential as source rocks.

Distributions of marsh facies are related to sea-level changes, compaction, shoreline configuration, drainage, sediment supply, and other factors. The overall factor controlling marsh deposition in coastal Delaware is relative sea-level rise. This produces a transgressive sequence of fresh- to brackish- to salt-marsh deposits. Three typical stratigraphic sequences are developed: broad marsh-continuous barrier sequence, broad marsh-discontinuous barrier sequence, and tidal-river marsh sequence. The first two sequences contain predominantly high- and low-marsh sediments. The tidal-river sequence contains thick sections of brackish-marsh sediments. Freshwater and salt-marsh sediments may contribute significant and relatively equal amounts to that sequence.

Degradation of plant fragments can be related to surface conditions in depositional environments as well as to changes that occur with depth. Some marsh sediments are better potential source rocks than others. Carbon values are largest in detrital organic facies, large in brackish-marsh facies, variable in high-marsh facies, and small in low-marsh facies. Noncarbonate carbon values range from 2.33 to 10.9. Premaceral compositions show small amounts of preresinites, presclerotinites, and fusinites, and large amounts of premicrinites. The largest previtrinitic, preresinitic, premicrinitic, and presclerotinitic compositions occur in brackish-marsh facies. Kerogen typing suggests these sediments might produce hydrocarbons with both humic and lipid compositions.

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Deep Basin, Alberta

The Deep Basin, Alberta, is the site of a major gas accumulation which will have a profound impact on the North American energy scene. Approximately 20% of the total western Canadian drilling activity over the past year has been within the limits of the Deep Basin.

Hydrocarbons have been found in 20 rock units ranging in age from Permian to Late Cretaceous. The majority of the reserves are contained within the Lower Cretaceous Spirit River Group and the Jurassic Nikanassin formation. Spirit River sediments were deposited in a series of transgressive and regressive cycles which can be mapped by gross lithologic characters and verified by sedimentologic and paleontologic criteria. The most favorable reservoirs are developed in chert-granule and fine-pebble conglomerates and associated medium-grained sandstones which are characteristic of a beach environment. Finer grained, poorly sorted sandstones of the foreshore facies form the reservoir for tight-formation gas. An even larger resource of tight-formation gas is found in the fluvial sandstones of the Nikanassin which present the same technologic challenges to economic development as their Spirit River equivalents.

Detailed petrophysical studies have been utilized in the design of drilling and completion programs and the interpretation of potential pay horizons.

The current oversupply of gas in western Canada will result in the deferment of tight-sand gas production until additional markets become available.

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Tectonic Significance of Microstructures in Idaho-Wyoming Thrust Belt and Hinterland

Mechanics of foreland thrust belt development can be explained using paleostress orientations from dynamic analyses of microstructures in quartz, calcite, and dolomite. Deformation in the hinterland must also be considered since the two basic models—gravity spreading and lateral tectonic compression—predict substantially different stress fields in this region.

Petrofabric studies in the Meade plate show that compression was dominantly layer-parallel, trending approximately east-west. On overturned fold limbs, compression at 50-80° to bedding suggests a locking angle which agrees well with existing theoretical and experimental analyses of kink-folding. Observed kink-fold geometries may be a necessary result of ramp configurations in the decollement thrust surface. These data are in accord with either of the two principal models.

Dynamic analyses at scattered localities in the southern Idaho hinterland show primarily layer parallel or subparallel, east-west compression in all demonstrably allochthonous rocks at all structural levels. Fold vergence and local overturning indicate eastward translation along the undated, but probably Mesozoic, younger-over-older thrusts characteristic of this region. Near metamorphic core complexes, Tertiary thermal events may have affected preservation of older microstructures. Parautochthonous Precambrian metasediments between foreland and hinterland record compression at high angles to bedding. The age and origin of these microstructures are unknown at present.

These studies indicate that maximum compression was nearly horizontal and oriented approximately east-west throughout southeastern Idaho during thrust belt activity. Therefore, the lateral tectonic compression model is favored.

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Permian Trace Fossils of Western Wyoming and Adjacent Areas

Burrows are common to abundant in much of the Permian Phosphoria Formation and correlative units in western Wyoming and adjacent states. Surface traces are rare. Coarse phosphorite units are characterized by straight, full-relief traces with fine-grained fillings. They are commonly horizontal but some are vertical. Sandstones contain burrows varying greatly in orientation and regularity. Carbonate rocks and certain cherty units typically contain burrows similar to those of modern crustaceans; the burrows are filled with skeletal material, fine-grained carbonate rock, phosphorite, or chert.

Absence of primary sedimentary structures in certain units is probably due to bioturbation. Units with high concentrations of burrows near the top suggest rapid deposition. Straight vertical burrows in certain marine sandstones may be insect burrows in barrier-island environments.

Cylindrical, irregular chert nodules are characteristic of most carbonate units. Some nodules are isolated but others coalesce into beds. The carbonate matrix in many places has flow structures around the chert nodules suggesting relatively early lithification of the chert. Some cherty beds contain irregularly cylindrical carbonate bodies. The cylindrical bodies, both chert and carbonate rock, are interpreted as burrow fillings. Burrows filled with material coarser and more permeable than the host sediments were sites of chertification. In beds in which the opposite conditions prevailed, the interburrow material was silicified. Because large burrows with coarse-grained fillings are abundant and in many places penetrate less permeable sediments, they may have functioned as important fluid conduits during early diagenesis.

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Thermal Evolution of Sedimentary Basins Along Atlantic Continental Margins of United States

The subsidence of the ocean floor subsequent to its formation at an ocean ridge can be predicted quantitatively using a simple one-dimensional cooling model and assuming isostasy. The evolution of a passive continental margin is in many ways similar to the evolution of the seafloor. A model for the subsidence and thermal evolution of continental-margin sedimentary basins can be obtained from a similarity solution to the one-dimensional heat-conduction problem. Continuous sedimentation and the subsequent compaction of the sediments are included in the analysis. Good quantitative agreement is obtained with subsidence record obtained from the COST B2 well in the Baltimore Canyon. The present measured thermal gradient is also in good agreement with the predicted value. The thermal evolution obtained is used to predict the petroleum potential of the area. It is found that optimum conditions for the generation of petroleum occur between depths of 6 and 8 km. Petroleum occurrences at shallower depths would presumably require an upward migration of petroleum.

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Fresh Look at Some Ouachita Problems

Numerous new geologic and geophysical data collected in recent years in the Ouachita province by industry, government, and academic institutions allow an updated synthesis of events that shaped the southern margin of North America in the Paleozoic.

Some new key observations include: (1) radiometric data indicate both Devonian and late Paleozoic metamorphic events affected the core areas of the Ouachita Mountains; (2) long-suspected pre-Desmoinesian orogenic uplift that supplied detritus into the foreland basins of the Ouachita system is well displayed on seismic

data and has been confirmed by the drill. Weakly deformed Desmoinesian and younger, shallow marine to continental successor basin sediments overlie with angular unconformity the folded and thrustured Ouachita facies rocks beneath the Gulf coastal plain as far south as the Sabine uplift; (3) high-quality field work, especially in Arkansas, has yielded ample data that support a polyphase deformation in the core areas of the Ouachita Mountains. Movements consisted of at least one north-vergent thrust and fold phase primarily of Pennsylvanian age. Initial folding and thrusting were followed (probably in Permian time) by a south-vergent overturning of previous geometries, additional folding and thrusting, and the development of north-dipping cleavage; and (4) plate tectonic reconstructions of the opening and closing of the Iapetus Ocean and the formation and breakup of Pangea have added to the understanding of the events that led to the origin of the Ouachita system. Nevertheless, big data gaps remain.

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Ophiomorpha From Upper Bathyal Eocene Subsea Fan Facies, Northwestern Washington

Trace fossils with a burrow morphology characteristic of *Ophiomorpha nodosa* Lundgren occur in upper bathyal subsea fan deposits of the Eocene in northwestern Washington.

The burrows average 2 cm in diameter and branch profusely. Swollen turnabout chambers occur at branching points. Horizontal burrows are most common at the base of sandstone beds. Burrow walls exhibit surface ornamentation including scratch marks and pellet lining, although most burrows are mud-lined and smooth surfaced. These morphologic features conform to those characteristic of *Ophiomorpha nodosa* Lundgren.

Abundant *Ophiomorpha* burrows occur in the sandstones and associated siltstones of the lower Eocene "Sandstones of Scow Bay" and upper Eocene Quimper Sandstone and Marrowstone Shale, Marrowstone and Indian Islands, northeast Olympic Peninsula.

The burrows occur in a sandstone-shale sequence with sedimentary features characteristic of subsea fan deposition. Lithofacies are classified using Mutti and Ricci Lucchi's 1972 turbidite facies criteria. *Ophiomorpha* occurrences are: 14 in Facies B—lenticular channel sandstones; 68 in Facies C—tabular sandstones with shale interbeds ("classical turbidites"); 17 in Facies D—shales with numerous sandstone interbeds; and 4 in Facies E—shales with few sandstone interbeds. *Ophiomorpha* is most abundant in facies associations consisting of positive megasequences (thinning upward—fining upward) characteristic of channel filling in middle fan-lobe environments.

Paleoecology of foraminiferal assemblages from interbedded shales suggests upper bathyal (200 to 1,200 m) water depths. The in-situ fauna consists of abundant specimens of bathyal hyaline foraminiferal superfamilies (Buliminacea, Cassidulinacea, and Discorbacea), keeled and compressed cassidulinids, numerous species of *Gyroidina*, and bathyal species of *Cibicides*. Forms