sures, stratigraphically deeper beds have undergone more "reverse drag" than higher strata. Thus, these reversals of dip adjacent to bounding faults may provide structural traps along the margins of the Albuquerque basin.

Recent deep wells were drilled in the central part of the Albuquerque basin on structural highs, probably intragraben horsts. Most of these recent tests were tight holes, but encouraging hydrocarbon shows were encountered. The margins of the Albuquerque basin have not been tested yet, but there may be numerous traps where "reverse drag" is present. These structures could have trapped hydrocarbons where potential reservoir rocks (mainly sandstones) and source beds (mainly organic-rich marine shales of the Cretaceous and Pennsylvanian, and organic-rich laminated limestone of the Jurassic Todilto Formation) occur.

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Effects of Mississippian Tectonic Movement on Sedimentation and Diagenesis of Greenbrier Group in Eastern Appalachian Plateau

The Greenbrier Group of eastern West Virginia consists of marine carbonates interbedded and mixed with siliciclastics that were deposited on a shallow shelf in the Late Mississippian. The Denmar Formation is the lowest unit of the Greenbrier Group present in east-central West Virginia, and it represents a shallow tidal-flat and platform sequence deposited by a transgressing sea during the Meramecian. This transgression was followed by a regression with progradation of Taggard Formation terrigenous clastics onto restricted tidal flats during the earliest Chesterian.

The Denmar tidal-flat deposits are characterized by pelleted mudstones, limited and depauperate fauna, calcite-filled and dolomite-filled geodes, caliche crusts, fenestral structures, dolomite, burrows, and channel deposits. The platform deposits include more diverse fauna, less micrite, cross-bedded and massive oolitic grainstones, and cross-bedded quartzarenites. Most of the siliciclastics were derived from the north and east of the Appalachian basin. Additional quartz silt, sand, and pebbles were eroded from an uplifted area within the basin and were incorporated into the tidal-flat and platform sediments. This Meramecian tectonic uplift, considered to be part of the 38th parallel lineament, created a subaerial and submarine topographic high that affected sedimentation patterns during the remainder of Greenbrier deposition.

Early phreatic cementation occurred along the flank of the uplift in at least two stages. There is evidence of both penecontemporaneous and later replacement dolomite. In certain strata in the western outcrops, hydrocarbons migrated through permeable layers and filled remaining pores.

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Dolomites and Early Mississippian Bioherms, Leadville Formation, Molas Lake, Colorado

Two dolomite facies that exhibit little petrographic evidence of their original textures are interpreted to be integral parts of two bioherms. A core facies of rugose corals (*Vesiculophylum*), pelmatozoans, cephalopods, and brachiopods in a peloid wackestone-packstone matrix forms two mounds 50 × 40 m and 110 × 75 m in diameter and 7 and 20 m high, resting on a basal unit of foraminiferal (endothyrid) ooid, coated-grain grainstone. These mounds are surrounded and onlapped by a bedded flank facies with relic cross-bedding that forms a halo 15-40 m wide around each mound. The facies consists of very coarsely to coarsely crystalline dolomite, but field evidence shows that it was originally detrital and is coeval with the core facies. It grades laterally away from the core into a distal flank–intermound facies of dolomudstone interbedded with millimeter-thick laminae of dolomite peloid packstone. This facies occurs up to 100 m from the mounds.

Corals in the core facies have been replaced and cemented by nonferroan, nonluminescent sparry calcite at temperatures of at least 200°C. The matrix of micrite and skeletal grains is composed of nonferroan, red-orange luminescent calcite. Diagenetic changes have been modest. In contrast, the two flank facies show obliteration of original textures and replacement by inclusion-rich, nonferroan, red-luminescent, anhedral to subhedral dolomite at temperatures of a least 165°C. Other than appealing to differences in original porosity and susceptibility to subsurface fluids, it is difficult to explain why these closely associated facies have followed such divergent diagenetic paths.

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Piaui Basin, a Jambalaya of Geologic Structures

Although the Piaui basin was the last of the Brazilian equatorial marginal basins to be studied in detail, it is the one that presents the most fascinating structural geology of them all. The superposition of two major tectonic events, quite distinct in nature (rifting and wrenching), produced an abundance and diversity of geologic structures unparalleled by any other Brazilian basin.

The first tectonic event, the rift-stage (early Aptian), created the basin through a series of normal faults predominantly oriented N40°-45°E in the western part, and N75°-85°E in the eastern part. Clastic continental sediments constitute the rift depositional sequence. Continental drifting followed (late Aptian–early Cenomanian), and a thick clastic sequence of transitional to marine sediments was deposited. Wrenching was already taking place, but on a small scale.

During the middle Cenomanian ($\approx$ 95-93 m.y.B.P.) the separation between South America and Africa in this area changed from north-south to east-west along the oceanic Romanche fracture zone. Shear stresses developed. The right-lateral motion, the large bend in the Parnaiba platform, and the different average trends of rift faults from west to east resulted in convergent wrenching. Transpression was greatly enhanced. Rift faults were reactivated as dextral strike-slip faults. Synthetic (N65°-70°W) and antithetic (N20°W and NS) strike-slip faults were formed. Flower structures occurred along the fault trends. Abundant en echelen folds and shale ridges (N20°E) were created. By the time wrenching ceased, a transpressive belt of significant dimensions had emerged in the Piaui basin. Sedimentation resumed in the area during the Oligocene-Miocene.

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Partitioning of Sediments Among Shoreface Transport Paths: Analysis of Sediment Dispersal Patterns Using Empirical Orthogonal Functions

Recent geomorphic evidence from the inner shelf and shoreface to the east of Long Island's barrier island system indicates that reworking of glacial outwash deposits at the inner shelf–shoreface transition, as sea level rises, may be supplying much of the sediment needed to maintain barrier islands to the west. A conceptual model describing sediment dispersal from outwash source areas was developed from this hypothesis. It was reasoned that outwash sediments ranging from silts to coarse gravels would be subject to differential transport paths across and along the shoreface upon reworking. Coarser grain sizes would move onshore toward the intertidal beach, whereas finer sediments would move offshore. Sand of intermediate grain size would be concentrated in the surf zone and move alongshore in wave-generated longshore currents.

To test this model, 400 samples from the beach and shoreface of Long Island were analyzed for grain-size frequency distribution and each grain-size class was examined for frequency of occurrence in the cross-shore and alongshore directions. On a spatially averaged basis, grain-size classes displayed peak abundance in specific zones across the shoreface as predicted by the model, but alongshore trends could not be recognized among the "noisy" data. Therefore, empirical orthogonal functions (EOF) were used to examine uncorrelated (orthogonal) modes of variability in the occurrence of each grain-size class in the alongshore direction. The first function, representing more than 60% of the variability among the data, showed that grain sizes subject to longshore transport in the surf zone increase in frequency in the alongshore direction relative to coarser grain sizes. Results also show that peak concentrations of coarse sediments correspond to zones subject to frequent overwashing. It is concluded that EOF analysis of individual grain-size classes holds promise for extracting trends from noisy data sets.

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Devonian Novaculites as Source of Oil in Marathon-Ouachita Thrust System

The Arkansas Novaculite of southern Oklahoma and the Caballos Novaculite of west Texas (both Devonian) form fractured reservoirs in the Marathon-Ouachita thrust system. These formations were examined to ascertain their petroleum potential.

Findings include the following. (1) The thermal maturity of the thrust system conforms to the maturity of the sequence that it has overthrust, suggesting that this allochthonous facies is not anomalously mature. (2) Shale units within the novaculites contain oil-prone organic matter in sufficient concentrations to constitute source rocks. (3) The composition of oils from Isom Springs field in southern Oklahoma and from McKay Creek field in west Texas is virtually identical and generally resembles Devonian oils in Oklahoma and west Texas.

We conclude that the Devonian novaculites of the Marathon-Ouachita thrust system are self sourcing and do not require a fortuitous juxtaposition of source rocks of a different age to produce a commercial deposit.

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Hydrocarbon-Induced Diagenetic Aureole (HIDA)—Mineralogical and Isotopic Models

The Permian red beds that overlie some giant oil fields in southwestern and south-central Oklahoma have undergone extensive mineralogical and chemical diagenesis. The diagenetic minerals occur within a distinctly zoned aureole that delineates the position of the oil field. The geometries of the aureoles strongly reflect the major structural elements that controlled emplacement of hydrocarbons in the underlying rocks. Calcite, ferroan calcite, manganese-rich calcite, dolomite, ankerite, pyrite, marcasite, and native sulfur are the major diagenetic minerals. The innermost zone of each aureole is characterized by abundant carbonate cementation and generally coincides with a major fault system. Pyrite and marcasite cements are commonly associated with carbonate-cemented zones; these minerals occur also in the bleached sandstones.

δC^{13} values of carbonate cements indicate 3 major sources of carbon: (1) an organic source with δC^{13} values of approximately -32‰ vs. PDB, (2) a freshwater source with an average δC^{13} value of -8.0 ± 3‰, and (3) a hybrid source (freshwater and organic). A mixing model was developed to calculate the proportion of organic carbon in carbonate cement.

δS^{34} values of pyrite and marcasite average 6.1‰ and range from -9 to $+16$‰. The isotopic composition of sulfides is similar to that of oil in the underlying reservoirs. Formation of diagenetic pyrite and marcasite is explained by reduction of iron oxides in red beds by hydrogen sulfide, and by other organic material associated with hydrocarbons.

The HIDA concept can be used in exploration for oil and gas, specifically in structurally controlled reservoirs.

Table 1. Selected Conversions

To Convert:	To:	Multiply By:
	Linear Units	
inches (in.)	centimeters (cm)	2.54
feet (ft)	meters (m)	0.305
miles (mi)	kilometers (km)	1.609
meters (m)	feet (ft)	3.281
centimeters (cm)	inches (in.)	0.394
kilometers (km)	miles (mi)	0.621
	Square Units	
square feet (ft^2)	square meters (m^2)	0.093
square miles (mi^2)	square kilometers (km^2)	2.590
acres	hectares (ha.)	0.405
square meters (m^2)	square feet (ft^2)	10.764
square kilometers (km^2)	square miles (m^2)	0.386
hectares (ha.)	acres	2.471
	Volume Units	
cubic feet (ft^3)	cubic meters (m^3)	0.028
barrels (bbl)	cubic meters (m^3)	0.159
cubic meters (m^3)	cubic feet (ft^3)	35.315
cubic meters (m^3)	barrels (bbl)	6.290
metric tons (MT)	barrels (bbl)	7.34 (approx.)
barrels (bbl)	metric tons (MT)	0.14 (approx.)
	Weight Units	
pounds (lbs)	kilograms (kg)	0.454
kilograms (kg)	pounds (lbs)	2.205
short tons (tons)	metric tons (MT)	0.907
metric tons (MT)	short tons (tons)	1.102
To Convert:	**To:**	**Use Formula:**
	Temperature	
degrees Celsius (°C)	degrees Fahrenheit (°F)	$(°C \times 9/5) + 32$
degrees Fahrenheit (°F)	degrees Celsius (°C)	$(°F - 32) \times 5/9$