thrust the West Texas crustal block against the Delaware block, with local denudation of the uplifted edge and eastward-directed backthrusting into the Midland basin. Later in the Permian, the area was the center of a subcontinental bowl of subsidence—the Permian basin proper. The disturbed belt formed a pedestal for the carbonate accumulations which created the Central Basin platform.

The major pre-Permian reservoirs of the Permian basin lie in large structural and unconformity-bounded traps on uplift ridges and domes. Further work on the regional structural style may help to predict fracture trends, to assess the timing of oil migration, and to evaluate intrareservoir variations in the overlying Permian giant oil fields.

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Potiguar Basin: Geologic Model and Habitat of Oil of a Brazilian Equatorial Basin

The Potiguar basin integrates the eastern part of the Brazilian equatorial Atlantic-type margin. The rifting stage of this basin occurred during the Neocomian and Aptian. The drifting stage and sea-floor spreading began in the Late Albian. The rifting stage clearly was intracratonic during the Neocomian and is recognized as a mosaic of half-grabens trending mostly northeast-southwest and filled with syntectonic lacustrine siliciclastics. The half-graben pattern exhibits rotation of beds into the major fault zone, and the preserved uplifted margins display either paleostructures or paleogeomorphic features with hydrocarbons. A regional pre-Aptian unconformity preceded the Aptian proto-oceanic rifting stage which was characterized by syntectonic fluvio-deltaic sediments. The Aptian tectonics were represented by reactivation of former lineaments superimposed by predominant east-west normal faulting. Structural highs during this stage are so far the most prolific oil accumulations. The most important source beds and reservoir rocks are both Neocomian and Aptian sediments. Geochemistry and hydrodynamics have shown that hydrocarbon migration was driven through fracture or fault zones in both Aptian or Albian plays. Lithofacies maps support this interpretation because pools occur whenever adjacent downthrown blocks present a high shale content.

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New Method in X-Ray Quantitative Mineralogical Determination of Sedimentary Rocks

A new method in quantitative x-ray diffractometry has been developed which uses no "standard" minerals for calibration. Thus, this new method is diametrically different from the classical internal method of Klug and Alexander, which requires the similarity (in chemical composition, crystallinity, and degree of preferred orientation) of minerals used as "the standards" and in the unknowns. The method is based on the interrelationship between the weight percentages of constituent minerals in a rock and relative intensities of x-ray peaks arising from these minerals.

If the concentration in percent of mineral m in sample s is denoted as X_{ms}, the mass absorption coefficient as μ_s, the intensity of a diffraction peak as I_{ms}, and the instrumental (including structural and compositional characteristics of the constituent minerals) constant as K_m, then the weight percentages of minerals in a rock can be obtained easily through a least-squares analysis, $X_{ms} = K_s / I'_{ms}$, where $I' = I_{ms} / \mu_s$. The μ_s can be measured readily from the Compton scattering intensity with an x-ray spectrometer.

Examples from a synthetic mixture, carbonate rock, and mudrock illustrate this new approach.

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Sedimentation in a Transgressed Interdistributary Bay on Mississippi-Lafourche Delta Lobe

Caminada Bay is a shallow south Louisiana bay, located between the distributary levees and beach-ridge plain of the late Lafourche Mississippi delta (900-500 y.B.P.) on the west and the Bayou Des Familles levees (3,000-2,000 y.B.P.) on the east. Small distributaries traversed the region of the present-day bay, probably during both early and late Lafourche time. The Lafourche delta actively prograded until about 500 y.B.P. when it was abandoned by the Mississippi River; the area of the present bay then entered its transgressive phase. Grand Isle, which separates Caminada Bay from the Gulf of Mexico, was subsequently built by sand derived from local distributary-mouth bars and erosion of the Lafourche beach-ridge plain to the west. As a consequence of the cutoff in fluvial sediment supply and continued subsidence, the lower delta plain of the Lafourche lobe is currently being transformed into the rapidly expanding Caminada Bay.

Visual description, x-ray radiography, and resin peels of 23 vibracores (4 to 8 m, 13 to 26 ft, in depth) reveal the following vertical succession of sedimentary units beneath the bay: (1) basal paleobay deposits, (2) an intermediate unit representing Lafourche delta lobe progradation, and (3) upper transgressive bay deposits.

The deepest unit penetrated (paleobay deposits) consists of mottled or bioturbated very fine sand and clay and shell beds. The intermediate unit (delta lobe) consists of intricately interlaminated very fine to fine sand, silt, and clay. It features lenticular, wavy, and flaser bedding. The upper transgressive unit consists of banded organic-rich clay with in-situ and detrital peat. Expansion of the bay by wave erosion of the many marsh islands removes most of the organic-rich upper unit. A thin unit of bioturbated muds is currently being emplaced on the bay floor.

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Seismic Stratigraphic Interpretation of Mississippi Fan, Gulf of Mexico

Examination of extensive multichannel and single-channel seismic data across the Mississippi Fan, Gulf of Mexico, reveals that at least 7 seismic sequences comprise the upper Pliocene-Pleistocene section of this giant fan. These sequences are divided into 2 groups based on continuity and amplitude of reflectors. The lower 3 sequences are generally characterized by high-amplitude, parallel to subparallel, continuous reflectors overlain in places by a hummocky clinoform reflection configuration. The reflection patterns suggest distal turbidites deposited in a relatively low-energy environment. In contrast, the upper 4 sequences are generally thicker and characterized by regionally extensive chaotic units interbedded with thin, high-amplitude, parallel to subparallel reflection packages. The chaotic zones grade laterally into more continuous, parallel to gently diverging reflection patterns, probably a lower energy, more distal turbidite facies. Isopach and structure maps of each sequence indicate a seaward and eastward migration in the Pliocene-Pleistocene depocenter during fan development.

Channel, levee, slump, turbidite, and hemipelagic deposits are interpreted within each sequence. Channel/levee deposits are extensive, showing great variability in their morphology and distribution. On the upper fan, the channels are large with well-developed levee sequences. On the middle and lower fan, the channel sequences are smaller, confined mainly to the apex of lobes, and show little evidence of migration and abandonment during lobe development. Slumping off the slope apparently contributed a significant percentage of the material deposited on the upper fan. In addition, the truncation of prominent reflectors and the mounded, chaotic and diffracted patterns on the middle and lower fan suggest that slumping was continually active during fan development.

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Appraisal of Coal Resources from Uranium Drill-Hole Logs, Southern San Juan Basin, New Mexico

Geophysical logs from uranium drill holes in the Grants region are a valuable source of information on coal resources. Coal occurs in the southern San Juan basin of New Mexico in the Upper Cretaceous Gallup Sandstone, Crevasse Canyon Formation, and Menefee Formation. Uranium has been mined from the Upper Jurassic Morrison Formation that underlies the coal-bearing Cretaceous formations and is separated from them by approximately 1,000 ft (300 m) of section.

Permission was obtained from Santa Fe Mining, Inc., Pathfinder

Mines Corp., and Ranchers Exploration and Development Corp. to examine their uranium drill logs for information on coal. Over 1,400 logs spudded above the base of the Gallup formation were examined, and depth to coal, coal thickness, and coal stratigraphic horizon were determined for coal beds at least 3 ft (1 m) thick. Coal isopachs have been drawn, and depth from the surface to the first coal have been contoured for the Crevasse Canyon and Menefee Formations. Data from an earlier study, which used geophysical logs from petroleum test borings, has been incorporated. The relationship between the coal resources determined from uranium drill holes and known coal deposits and mines in the southern San Juan basin is discussed.

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Log-Derived Evaluation of Shaly Sandstone Reservoirs

Significant natural gas resources are known to exist in the United States in tight, low-permeability sandstones that cover a prospective area of 1,000,000 mi^2 (2,590,000 km^2). Characterization and reliable estimation of their production potential based on well logs are important although difficult task.

Proper evaluation of low permeability sands based on conventional log-interpretation techniques is frequently inadequate. Furthermore, while empirical rules of thumb assist in the evaluation of localized conditions, they only provide guidelines.

Recent developments in quantitative log-analysis techniques incorporate natural-gamma-ray spectral data and application of the Waxman-Smits model for detailed reservoir description. Quantitative correlations of cation exchange capacity (CEC), water salinity, porosity, and conductivity of water- and hydrocarbon-bearing shaly sand reservoirs are based on resistivity, density, neutron and natural-gamma-ray spectral data. These correlations provide important information about clay volume, reservoir porosities (total, effective) and fluid-saturation distribution (total, effective), type of clay minerals (smectite, illite, chlorite/kaolinite), their distribution in the reservoir (dispersed, laminated, structural), and log-derived indicators of potential formation damage.

Field experiences are reviewed for logging and evaluating tight formations in south Texas; the Jurassic Cotton Valley trend in east Texas, Louisiana, and Arkansas; and the Tertiary Fort Union and Cretaceous Mesaverde Formations of the Piceance basin in Colorado.

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Depositional Systems and Productive Characteristics of Major Low-Permeability Gas Sandstones in Texas

Major tight gas sandstones in Texas range from lenticular to blanket geometry, from hydropressured to geopressured, and from Pennsylvanian to Eocene in age. The Cotton Valley sandstone (East Texas basin) includes barrier- and marine-bar sandstones (blanket) derived from prograding fan deltas with associated braided stream, delta-front, and prodelta deposits. The overlying Travis Peak Formation contains a lower deltaic facies, a middle, dominantly braided fluvial facies (broadly lenticular), and an upper transgressive clastic-to-carbonate transition. Estimated gas in place varies from 53 tcf (Cotton Valley) to 25 tcf (Travis Peak); most wells initially produce from 500 to 1,500 mcf and few wells produce 2,500 mcf. Tight gas sandstones in the Wilcox and Vicksburg Groups (Gulf Coast basin) are mostly geopressured delta-front, shelf, and slope deposits. These lenticular sandstones isolated in shale have pressure gradients up to 0.81 psi/ft (18.3 kPa/m). Initial well yields are mostly 300 to 2,400 mcfd; resource estimates for tight Wilcox and Vicksburg trends are not available.

Canyon Group sandstones of the Sonora basin (parts of the Ozona arch, Concho platform, and Val Verde basin) contain 24 tcf of estimated gas in place and initial flow rates are commonly 100 to 1,000 mcf. These sandstones are broadly lenticular and are interpreted to be submarine fan and possibly shelf-margin deposits. The Olmos Formation (Maverick basin) contains gas within broadly lenticular delta-front deposits of high-constructive delta systems; liquid hydrocarbons in the Olmos are trapped in more proximal facies. Gas in place in the Olmos is estimated to be 5 tcf and initial well yields are 300 to 3,000 mcf. In 1980, 893 wells were completed in formations designated as partially or completely tight by the Railroad Commission of Texas. These completions represent 2.5% of new gas wells in the state, but 28.0% of those completed in the 5,000 to 15,000-ft depth range in that year.

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Zuloaga Formation (Upper Jurassic) Shoal Complex, Sierra de Enfrente, Coahuila, Northeast Mexico

The Zuloaga Formation at Sierra de Enfrente may be divided into 7 interbedded carbonate facies. In order of abundance, they are: pell-ooid grainstone-packstone, lime mudstone, pelletal packstone-grainstone, ooid grainstone, pelletal wackestone, skeletal wackestone, and algal boundstone.

Three measured sections located on an east-west trending, overturned anticline (Sierra de Enfrente) were described and sampled. The sections are oriented along depositional strike and are roughly 395 m (1,300 ft) thick. Approximately 20 shoaling-upward "cycles" that display an upsection trend from mudstone-wackestone lithofacies to packstone-grainstone-boundstone lithofacies are readily distinguished in each section. The cycles vary in thickness with thick cycles correlating well from section to section along depositional strike. Within any cycle, interpreted subenvironments may include, from base to top: subtidal, outer shoal, inner shoal, and inter-tidal-supratidal.

The Zuloaga Formation sediments were deposited on a broad carbonate ramp dipping southward off the emergent Coahuila peninsula. The study area is located between Zuloaga-equivalent, near-shore, siliciclastic deposits to the north and outer-ramp Zuloaga lime mudstone facies to the south. This intermediate position was ideally situated for the development of high-energy shoals. Time-equivalent shoal facies that rim the Gulf of Mexico are prolific hydrocarbon producers (Smackover Formation, USA; San Andres Formation, Mexico).

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Paleoenvironments of Middle Member of Quitman Formation, Hudspeth County, Texas

The middle Quitman Formation is composed of 95-195 m (310-640 ft) of interbedded shale, sandstone, and limestone in the southern Quitman Mountains and Hueco Bolson, Hudspeth County, Texas. The lower and upper members consist of interbedded sandstone/limestone and thin to thick-bedded carbonate strata, respectively. The Quitman Formation was deposited along the eastern slope of the Chihuahua trough during the late Aptian and early Albian. The formation is interpreted as the oldest transgressive phase of 4 transgressive-regressive cycles that occur throughout the Lower Cretaceous within the Chihuahua trough.

Eight major facies representing nearshore to offshore environments of the middle Quitman Formation are listed below. They are: (1) nodular, sandy, peloidal to skeletal wackestone (lagoonal, basinal); (2) nodular, sandy, peloidal to skeletal packstone (lagoonal, basinal); (3) laminated to cross-bedded sandy ooid to skeletal packstone and grainstone (upper shoreface, storm); (4) laminated to cross-bedded sandstone/siltstone (upper shoreface, storm); (5) massive sandstone/siltstone (lower shoreface, lagoonal); (6) *Exogyra* biostromes (offshore-lower shoreface transition); (7) sandy, bioclastic, marly silt-shale (offshore-lower shoreface transition); (8) mudstone (offshore, lagoonal).

Vertical and lateral relations of strata within the middle member have shown several transgressive and regressive cycles. The more applicable terms of progradation and aggradation describe the lateral and vertical buildup of terrigenous and carbonate clastic rocks within the upper half of the middle member in the southern Quitman Mountains. These sequences are not present at the section west of the southern Quitmans.