Shoalwater–Cove Point and the North Beach Peninsula barrier-accretion plain, occurs a 9-km tidal shoal and channel area. A narrow tidal channel, over 20 m deep, with strong tidal currents, has eroded northward over 3 km in this century. Accompanying this erosion, the flood-tide Graveyard-Empire spit is prograding into Willapa Bay, overlapping two older spits at Tokeland and Kindred Island. The deep tidal channel between Willapa Bay and the Pacific Ocean has migrated from south to north at least three times since the initiation of the Grayland beach-accretion plain, correlating the three flood-tidal spits with the three major beach-accretion ridges of the Grayland plain. A secondary, southerly deep tidal channel is forming and may again erode northward, driven by tidal and littoral processes, initiating another beach-accretion ridge on the Grayland plain and another southeasterly trending flood-tidal spit in the near future. The geologic events causing this large late Holocene Epoch coastal plain format, unique to the Pacific coast, remain obscure.

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Hydrocarbon Exploration on Ancient Shelf-Slope Breaks

A general set of traps, reservoirs, and seals occurring on the shelf-slope break can be hypothesized based on the structural regime, provenance, and width and slope of the shelf. To evaluate this break is to look at the entire region—shelf and slope.

With a wide or moderately wide shelf, gentle slope, and peneplaned provenance, carbonate sediments would dominate in marine environments. Logically, a reefal environment (reservoir) would be expected at the shelf slope. Conversely, with a narrow shelf and a positive continental borderland in close proximity, terrigenous clastics would be expected. Deltaic-like reservoirs could be expected on the shelf; turbidites would logically occur downslope. A broad shelf with a positive provenance could inspire various lithologic deposition (depending on the environment)—reefal at the shelf-slope area, deltaic or lagoonal behind, and turbidites in front.

Examples of such former reservoirs are Empire-Abo reef trend of Texas-New Mexico; Cretaceous Stuart City shelf margin of Texas; Golden Lane-Pozo Rica trends of Mexico; Miocene pinnacles of the Salawati basin, Irian Jaya; and Kirkuk field on the Arabian Platform.

Penultimate reservoirs are the linear sands of the San Joaquin and Ventura basins; Oligocene sands of south Louisiana; Triassic sands of the North Sea basin; Cretaceous Seaway sands in the Powder River basin; and the ancient Mississippi delta and cone. Latter reservoirs are found in the eastern shelf, Midland basin, and Bombay offshore basin, India.

It is understood that for some of these reservoirs to become traps, the founding structural regime is modified, e.g., faulting, diapirism. Seals are classed as carbonate muds, evaporites, and faults. Source matter may be incorporated in marine shale and limestone deposited in anoxic environments.

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Radiolarian Distribution and Enhanced Preservation in Modern Sediments: Indicators of Oceanographic Environments

Analysis of the geographic distribution of radiolarians shows that they are preserved in restricted zones and/or enhanced under particular oceanographic environments. Surface, warm-water-dwelling radiolarians are preserved in the equatorial region. However, intermediate and deep, cold upwelling radiolarians exhibit cosmopolitan distributions in the sediments with enhancement under oceanographic convergences and divergences. Specifically artostrobids and plectopyramids appear to be enhanced in the sediments under oceanographic convergence and divergences; the *Dictyocoryne profunda-truncatum* group is enhanced under high productivity regions; and actinommids in general and collosphaerids in particular are enhanced under the oligotrophic gyre regions. The enhancement under convergences and divergences may be due to (1) mass mortality of deep and/or cold forms brought into warm surface waters via upwelling at a divergence or laterally at a convergence, (2) an increase in standing crop of deep forms under high productivity regions or higher productivity at the convergence's nutricline, or (3) a stripping of the metallic protective coating of shallow forms by bacteria at the nutricline. Collosphaerids may be enhanced in oligotrophic gyres owing to the acquisition of detrital aluminum on their surfaces which might deplete the deeper waters and inhibit deeper water radiolarian preservation. Collosphaerids are also enhanced along the Mid-Atlantic Ridge which may be due to metal abundance in the sediments, low sedimentation rates, and/or high silica concentration of interstitial and bottom waters.

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Subsurface Facies Analysis of Saltos Shale Member (Miocene), Monterey Shale, Cuyama Valley, California

Distributional analysis of the lithology, sedimentary structures, and microfauna in core samples from oil wells in Cuyama Valley allows recognition of distinctive lithofacies and biofacies in the Saltos Shale Member of the Monterey Shale. Depositional environments are determined from the interpretation of these lithofacies and biofacies. The distribution and character of the depositional environments record the basin-history for this part of the Cuyama basin during the late Saucesian through Luisian (late early to middle Miocene).

Middle bathyal, fine-grained, base-of-slope clastics predominate during the Saucesian. Intercalated, thin-bedded, turbidite sandstones are prominent in some well sections and sand/shale ratios help indicate a source to the north or northeast. Relizian depositional environments are more varied, ranging from middle bathyal shales and siltstones in the area just to the east of South Cuyama oil field, to nonmarine sandstone, conglomerate, and mudstone in eastern Cuyama Valley. The distribution of these depositional environments was controlled partly by contemporaneous tectonic activity as evidenced by depositional thinning over structural highs, abrupt thickening across at least one fault, and progradation of the shelf from the east. By Luisian time the eastern Cuyama Valley area was characterized by shelf-to-nonmarine deposition. This is in marked contrast to upper bathyal diatomaceous mudstones and diatomites which accumulated in a low-oxygen environment immediately to the west, in the vicinity of Whiterock Bluff.

The Monterey Shale is overlain by the shallow-water Santa Margarita Formation (late Miocene), which marks the final phase of marine sedimentation in the Cuyama basin.

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Evaluation of Atlantic Coastal Plain Geothermal Reservoirs Using Seismic Reflection Data

Ongoing studies of the moderate-temperature hydrogeothermal resource potential of the Atlantic coastal plain use seismic reflection data to evaluate potential reservoirs. Resource evaluation is dependent upon the determination of temperature and reservoir characteristics. The temperature of a potential reservoir can be estimated accurately if heat flow and thermal conductivity of the overlying sediments are known. Heat flow was determined in 51 shallow (300 m) exploratory holes. Equilibrium geothermal gradients in these holes indicate that thermal conductivity is a function of bulk composition, and can be characterized by the relative proportions of quartz sand, clay minerals, and water.

Seismic reflection data are being correlated with thermal conductivity of cores and cuttings from drill holes by making use of the relations between seismic velocity and bulk composition, and thermal conductivity and bulk composition. Seismic lines tied into drill holes allow interpretation of thermal conductivities between holes by correlating velocities to sedimentary units with known compositions and thermal conductivities. The seismic data are also being used to estimate the distribution and size of potential hydrothermal reservoirs by interpreting compositional differences between acquifers and aquitards.

Thus, the location, size, and temperature of potential hydrothermal reservoirs are estimated from seismic data. Preliminary results suggest that water at temperatures exceeding 60°C may occur in many areas in the eastern United States. Results of a deep test at Crisfield, Maryland, are encouraging. Brackish water at a temperature of 57°C was produced from an acquifer at a depth of 1.2 km. Further testing of the transmissibility of the deep aquifers beneath the Atlantic coastal plain is necessary.

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Origin and Evolution of Saline Formation Waters, Lower Cretaceous Carbonates, South-Central Texas

Systematic chemical variations exist in formation waters collected from a dip section through Lower Cretaceous rocks of south-central Texas. These chemical variations can be explained by an interactive water-rock diagenetic model.

Cyclic Lower Cretaceous shelf carbonates of the Edwards Group that dip into the Gulf Coast geosyncline act as an aquifer contained by basement beneath, and relatively impermeable Upper Cretaceous clays and chalks above. The hydrodynamic character of this carbonate system is strongly controlled by major fault systems which serve as pathways for the vertical movement of brines into the Lower Cretaceous section. Formation-water movement in this system has strong updip and upfault components.

The parent Na-Ca-Cl brine originates deep in the gulf basin, at temperatures between 200 and 250°C, by the reaction: halite + detrital plagiocalse + quartz + water → albite + brine. Other dissolved components originate by reaction of the fluid with the sedimentary phases, K-feldspar, calcite, dolomite, anhydrite, celestite, barite, and fluorite. Significant quantities of lead, zinc, and iron have been mobilized as well.

As the brine moves updip out of the overpressured deep gulf basin, encountering limestones of the Stuart City reef trend (the buried platform margin), small amounts of galena precipitate in late fractures. Updip and up-fault, the brine becomes progressively diluted with downward-moving meteoric water. On encountering significant quantities of dolomite in the backreef facies, the Ca-rich brine causes dedolomitization. Although thermochemical considerations suggest that small amounts of several authigenic phases should precipitate, they have yet to be found, except for minor amounts of calcite spar. As the brine evolves by dilution cooling, no systematic changes in any cation/Cl ratio occur, except for regular updip gain in magnesium as a result of progressive dedolomitization. The high-diluted formation water eventually discharges along faults as hot mineral water.

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Downward Vertical Fluid Flow in Subsurface: Implications at Kitty Field, Powder River Basin, Wyoming

Drill-stem test pressure data and subsurface geologic studies permit interpretation of fluid-potential relations in the Kitty field area of the Powder River basin. These relations provide substantiation of significant downward fluid flow from Mowry Shale source rocks to Muddy reservoirs in areas where maximum thicknesses of permeable sandstone are developed. Potentiometric contours indicate vertical flow becomes lateral and radiates outward from areas of high potential once confined to the Muddy aquifer system. Pressure distribution within individual reservoir beds is consistent with this interpretation. Vertical flow is presumably sustained by a combination of the following: (1) expulsion of bonded water during thermal alteration of mixed-layer clays in the Mowry Shale; (2) water generation associated with catagenesis and oil generation in the Mowry Shale; and (3) aquathermal pressuring at temperatures in excess of 200°F (94°C).

Local downward vertical flow of water at Kitty field may provide the means for hydrocarbon migration from Mowry source beds to Muddy reservoirs. Additionally, pressure gradients associated with this flow may be responsible for trapping approximately 75% of the total oil column in the field. Capillary pressures can account for a maximum of about 200 ft (61 m) of the total observed 835 ft (255 m) oil column. Calculations suggest that an additional 460 ft (140 m) of oil represents the minimum hydrodynamic column and that fluid-potential gradients necessary to trap the additional 175 ft (53 m) probably exist in the field.

The Muddy potentiometric surface implies a dynamic aquifer system of downdip inter-formational and vertical, cross-formational fluid flow. Early fluid migration is obscured by this present flow, but can be pressured to be updip toward the basin flanks in response to initial compaction processes. Post-Laramide (Eocene?) exposure of the Muddy aquifer resulted in recharge by meteoric waters. The interaction between meteoric downdip regional flow and local vertically downward flow at Kitty field suggests late accumulation of hydrocarbons.

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Imaging Beneath Complex Structure: Case History

Migration is recognized as the essential step in converting seismic data into a representation of the earth's subsurface structure. Ironically, conventional migration commonly fails where migration is needed most—when the data are recorded over complex structures. Processing field data shot in Central America and synthetic data derived for that section.