which the coal beds could be referred for specific correlations. Isopach maps of the major coal seams and a structure contour map of the unconformity at the base of the Corbin sandstone were prepared. A fence diagram incorporating the six core holes illustrates a detailed interpretation of the subsurface stratigraphic record, including depositional sequences, distribution, and thickness of the strata. A brief review of the general geologic history of the coal zones is presented.

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Mid-Tertiary Carbonates, Western Oregon

The distribution of marine limestones in the Oregon Tertiary is an important facet of the paleoenvironmental setting. Although the most extensive deposits of Tertiary limestones in the state are found in the middle Eocene Yamhill Formation in the coast range, several smaller exposures of late Eocene and Oligocene limestones occur in the Western Cascades east of Salem, Oregon.

All of these accumulations are of limited stratigraphic and areal extent. Much of the carbonate content is invertebrate shell material which accumulated in shallow-water environments during periods of limited terrigenous sedimentation. A significant amount of the limestones, however, reflects an offshore or open-ocean environment, such as a bank or seamount.

Porosity in the carbonates ranges from extremely low values, where sparry calcite has precipitated in pore spaces, to values of 5% where solution has extensively removed shell calcite.

A recently drilled well near Lebanon, Oregon, produced gas for a short time before being abandoned. That well was completed at 3,000 ft (914 m) near the top of the Spencer Formation at approximately the same stratigraphic level as Eugene carbonate-bank deposits in northern Marion and southern Clackamas Counties.

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Evolution of Formation Fluids in "J" Sandstone, Denver, Basin, Colorado

Hydrodynamic flow is a major factor in the entrapment of petroleum in the Cretaceous "J" sandstone of the Denver basin. Two distinct fluid potential minima trend northeast across the geographic center of the basin. The downdip flow of water toward these minima has enhanced holding capacities of oil traps on the eastern and southeastern flanks of the basin and made possible gas entrapment at the Wattenburg field in the basin deep.

The present regime of downdip hydrodynamic flow in the "J" sandstone resulted from subhydrostatic pressures created by regional Pliocene uplift and erosion of approximately 600 m of sediment proximal to the Front Range. Subhydrostatic pressure development is the result of cooling which contracted the fluids more than the pore volumes, and elastic expansion of the pores which exceeded that of the water.

Present hydrodynamic conditions do not adequately explain the unusually low formation water salinities throughout the "J" sandstone. Artesian flow conditions during the Eocene flushed the "J," replacing connate water with meteoric water, conditions similar to those occurring east of the Black Hills today. Growth of the Golden fault during the Oligocene terminated the artesian flow.

Hydrodynamic effects have not been commonly recognized, due partly to the fact that it requires analyzing data which are not usually obtained. The need to understand and evaluate hydrodynamic flow is essential to the explorationist searching for subtle traps, particularly in the Rocky Mountain region.

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Geology and Hydrocarbon Potential, United Kingdom Sector, Western Approaches Basin

The Western Approaches basin covers an area of approximately 20,000 mi^2 (52,000 km^2) and lies along the median line between the British and French sectors of the northwest European continental shelf. About 40% of the basin lies within United Kingdom designated waters. Seismic coverage of this area is extensive, but only four deep holes have been drilled.

The basin was initiated toward the end of the Carboniferous and then underwent rapid fault-controlled subsidence, accumulating a thick succession of Permo-Triassic red beds and evaporites. Marine conditions became widely established during the Rhaetic and Early Jurassic but block faulting and uplift then led to widespread erosion, with the result that Jurassic and Lower Cretaceous sediments are now largely confined to the deeper parts of the basin. These vertical crustal movements were the result of Atlantic rifting and appear to have been accompanied by strike-slip faulting and localized volcanism. A marine transgression tentatively dated as Barremian/Aptian marked the end of rifting activity and is visible on seismic records as a conspicuous angular unconformity. The basin then underwent gradual subsidence throughout the Late Cretaceous and early Tertiary until Alpine compressional movements led to further uplift and erosion.

Several different structural trapping mechanisms have been identified and potential reservoirs exist in the Permo-Triassic and Jurassic to Lower Cretaceous intervals. Rhaetic and Lower Jurassic claystones have source potential, and maturation studies, though not conclusive, suggest that locally they will be mature for hydrocarbon generation. The timing of migration and the effectiveness of seals remain speculative due to lack of stratigraphic information.

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Petroleum Exploration on Niger Delta

The Nigerian continental shelf, covering over 40,000 km^2 to a water depth of 200 m has been extensively explored since 1962. Most of the shelf is a submarine extension of the Niger delta where the first discovery was made in 1956. The section is a typical delta, where the prodelta shales of the Akata Formation prograde over Paleocene and Upper Cretaceous sediments and are overlain by interbedded sands and shale of the Agbada Formation of the deltaic facies proper. The deltaic facies are overlain by the massive freshwater alluvial-plain sands of the Benin Formation. These are lithostratigraphic units that, depending on the position on the delta, range in age from Eocene to Holocene. The delta is deposited over the boundary between continental and oceanic crusts and, in large part, overlies the oceanic crust of the Gulf of Guinea. The Akata Formation is thought to be, in part, the source of hydrocarbons. The reservoirs are found in the Agbada Formation and the Agbada shales act as seals. The dominant trapping is by down-to-the-basin growth faulting and the accumulation seems to be the result of migration updip along the major faults. As of January 1978, the Niger delta initial recoverable oil was estimated at 18.76 billion bbl. The major production occurs in a belt that runs approximately east-northeast to west-southwest, with the result that prolific production offshore has mostly been found in two places (east and west of the delta) where the belt crosses the shelf. These offshore prolific areas represent only 25% of the total shelf area. The reported offshore ultimate recoverable oil is 4.8 billion bbl or 25.4% of the Nigerian total. In general, the proportion of natural gas to oil in Nigeria is relatively high and increases basinward. Reserves in the order of 40 to 50 tcf have been reported. However, due to the lack of marketing opportunities, this gas has been found incidentally to oil exploration. It is, therefore, possible that in the least prolific offshore areas, considerable reserves of gas could be established if the proper economic incentives existed.

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Late Cretaceous Anastomosing Fluvial Systems, Northwestern Colorado

Basal Mesaverde deposits exposed near Rangely Dome in northwestern Colorado indicate a progradation of deltaic sandstones over the marine Mancos Shale. Overlying these deposits is a thick nonmarine sequence containing four major facies: (1) extensive organic-rich siltstones with laterally discontinuous coals, (2) elongate lenticular cross-bedded sandstones, (3) thin (0.3 to 2.5 m) ripple-stratified, sheetlike fine sandstones, and (4) thick (maximum 11 m) fine-grained sandstones with large-scale foresets and syndepositional slumping.

Two fluvial facies models were developed on the basis of study of over 80 measured sections. Variations in the models are seen in the types of cross-bedded sandstones. Type 1 forms belts 80 to 130 m wide and up to 21 m thick. Major erosion surfaces delineate nearly symmetrical units 3 to 8 m thick. In contrast, type 2 lenticular sandstones belts are broader (600 m) and thinner (3 to 7 m). The component lenses are fewer in number, have a greater width to depth ratio, and commonly show evidence of lateral accretion. Individual units in type 1 belts show little vertical variation in grain size or scale of structures. Type 2 units commonly fine upward in both respects. The fine-grained sandstones flank the major belts and have paleocurrent indicators at high angles to the transport direction of the coarser lenses.

The coarse-grained sandstones were major channels and the fine-grained sandstones were crevasse splays. The thin splays were deposited along levees or in shallow flood basins. The thick splays with foresets are associated only with type 1 belts. They were Gilbert deltas which prograded into interfluvial lakes. The type 1 belts, major interfluvial lakes, and Gilbert splays were associated with greater subsidence rates. This model is comparable to recently described anastomosing fluvial systems. Our other model is similar to a low-sinuosity fluvial system.

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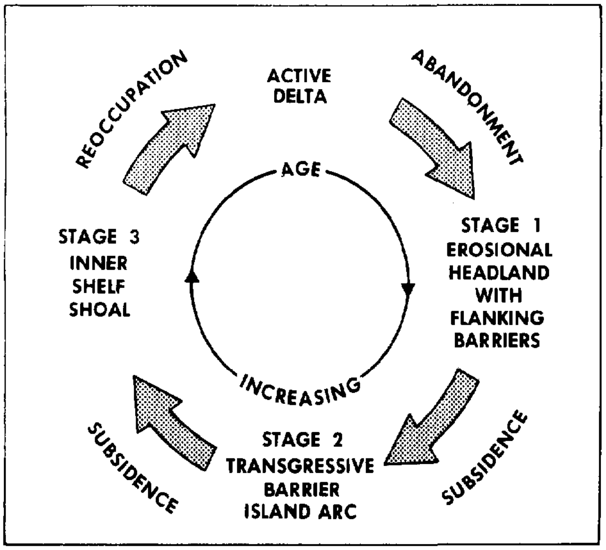
Evolution of Transgressive Deltaic Environments on Louisiana Coast

Mississippi River sedimentation is dominated by the process of delta switching. Upstream distributary diversion during the Holocene Epoch periodically shifted the depocenter of Mississippi River sedimentation, producing a sequence of four abandoned shallow-water delta complexes on the Louisiana coast. Abandonment and the cessation of active distributary sedimentation result in subsidence, creating a rapid coastal transgression in each abandoned delta complex.

In its destructional phase, the delta evolves through a sequence of three stages, each associated with distinct transgressive sedimentary environments. This evolutionary sequence begins with an *erosional deltaic headland and flanking barrier stage*, backed by restricted interdistributary bays. In the following *transgressive barrier island arc stage*, the barrier island encloses an open intra-deltaic lagoon. Long-term sea-level transgression eventually causes the destruction of the subaerial barrier and the development of an *inner-shelf sand sheet and shoal.*



Coarse-grained sediment dispersal following delta abandonment is characterized by reworking of distributary sand bodies into transgressive coastal barrier systems. Barrier orientation to the dominant wave approach controls the pattern of longshore sediment dispersal. Sediment transported offshore during frontal and tropical cyclone passage forms the inner-shelf sheet sand. Fine-grained sediments accumulate in a variety of subsiding back-barrier environments and on the continental shelf.

If the validity of the model proposed for Louisiana holds true for older shallow-water Mississippi-type deltas, an idealized stratigraphic record for this category of transgressive deltaic environments should contain the following vertical sequence: a thin bay facies overlain by tidal inlet and/or recurved barrier sands that grade updip into a thickening lagoonal facies overlain by extensive washover sands. The uppermost unit would consist of shallow marine sands with an overlying cap of continental-shelf muds.

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Environment of Deposition of Winnipegosis Formation (Middle Devonian), Williston Basin, North Dakota

The Winnipegosis Formation (Middle Devonian) is the major carbonate unit of the first transgressive-regressive pulse of the Kaskaskia sequence. The sea invaded the narrow, elongated Elk Point basin which extended from northern Alberta southeastward to North Dakota. The southeastern end of this basin corresponds to the present-day Williston basin.

In North Dakota, reworking of red beds and deposition of restricted argillaceous carbonates occurred (Ashern). Winnipegosis deposition began after a brief hiatus. Initially, there was a widespread establishment of a clear quiet shallow-marine environment. Subsequently, the basin differentiated into three distinct environments of deposition: (1) scattered pinnacle reefs, (2) a deeper interreef basin, and (3) an encompassing carbonate platform.

Carbonate production in the pinnacle-reef and platform en-