ated environments within an overall framework of deposition.

The Muddy Formation (Lower Cretaceous) in northeastern Wyoming is a clastic unit approximately 150 ft thick composed of sandstone, siltstone, shale, and carbonaceous deposits. Detailed core studies and selected isopach maps suggest that the unit was deposited in a manner very similar to the modern Mississippi deltaic complex. Oil productive distributary channels, crevasse splays, and marginal barrier bars are recognized by the vertical distribution of sedimentary structures observed in cores and by comparing the distribution in space of the interpreted elements to a Mississippi model.

In considering the Mississippi model, one must realize that different processes are taking place side by side at different elevations relative to sea level, hence the unidirectional current-flow processes of a distributary may occur 100 ft or more below sea level at the same time that the wave processes of a beach occur at and near sea level. The Muddy Formation must be understood as a total depositional system; detailed vertical subdivision will only obscure genetic relations.

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UTILIZATION OF WELL LOGS IN EXPLORING FOR STRATIGRAPHIC TRAPS

Well logs are used qualitatively to make stratigraphic correlations and environmental interpretations. Formational fluid properties, porosity, and compositional attributes are computed quantitatively from many well logs for use in preparation of exploration maps. Dipmeter data are treated statistically and incorporated with other log data for use in making stratigraphic interpretations and predictions in the subsurface. Computers may be used effectively to process digitized well logs and associated data; plotters are used to display exploration maps automatically.

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DELTAIC ORIGIN OF DIFUNTA GROUP (LATE CRETACEOUS TO PALEOCENE), PARRAS BASIN, COAHUILA AND NUEVO LEÓN, MEXICO

The Difunta Group is predominantly gray calcareous mudstone, siltstone, and sandstone with 3 wedge-shaped redbed units. The redbeds provide a basis for subdividing the group into 7 formations with a composite thickness of 12,000 ft. Simple structure, continuous exposures, and lithologic variability provide an excellent opportunity for paleoenvironmental interpretations.

The Difunta Group is largely the product of deltaic sedimentation in the Parras basin, a shallow embayment off the ancestral Gulf of Mexico. Major delta progradation was from southwest to northeast as shown by facies changes, thickness trends, and paleocurrent data. The redbed units are interpreted as delta-plain deposits that accumulated as lake and bay muds and silts and fluvial and distributary-channel sands.

Redbeds are bounded by resistant gray blanket sandstones 20–60 ft thick that have sharp bases, scour-and-fill bedding, *Ophiomorpha,* and local mudstone, wood, and oyster clasts. These sandstones are interpreted as delta-front and delta-destructional deposits formed during progradation and retrogradation of the deltaic complex.

Prodelta facies are gray sequences of either (1) burrowed mudstone or muddy sandstone, many beds of which have ball-and-pillow structure and a sparse molluscan fauna, or (2) interbedded graded sandstone and burrowed mudstone. The graded sandstone beds of the later facies were deposited by turbidity currents that were generated at the delta front probably by hyperpycnal flow.

Patchlike carbonate banks up to 1,000 ft thick developed in the north during episodes of low terrigenous influx in this area. Bank deposits are chiefly micritic bioclastic rocks; boundstone is rare.

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RESERVOIR ANALYSIS, PENNSYLVANIAN TENSLEEP FORMATION, LITTLE BUFFALO BASIN, WYOMING

The Little Buffalo Basin field, in northwestern Wyoming on the southwest side of the Big Horn basin, is a north-south asymmetric anticline 3½ mi long, 1½ mi wide, with about 1,000 ft of structural closure. Oil was discovered in 1943 in the Pennsylvanian Tensleep. Cumulative production has been over 30 million bbl of oil from the 1,500 acres. Reservoir energy is from an active water drive from the north-northwest. A core study of the Tensleep revealed that extensive crossbedding, permeability variation, and fracture orientation influence oil recovery from this reservoir.

The Tensleep sandstone and dolomite gradationally overlie the Amsden Formation carbonates and shales, and average 275 ft in thickness. There is a general increase in average grain size of the Tensleep sandstone progressing upward in the section and also an increasing amount of crossbedding and poor sorting. Deposition occurred in relatively high-energy transporting currents in a shallow water, nearshore, and/or deltaic marine environment. Nonmarine channeling and sand-dunes also occur in the upper part of the section. Pore-filling cements of carbonate, silica, anhydrite, and clay particles are generally due to 2 factors: (1) primary deposition of carbonate and clay with dissolution of these and other minerals during fluvial channeling and erosion in Late Pennsylvanian-Early Permian, and (2) redeposition of these minerals in open pore spaces and fractures by downward-percolating groundwater.

As a direct result of this reservoir study, well spacing has been reduced from 40 to 20 acres by drilling 30 new wells in certain areas of the field that would not otherwise have been efficiently depleted. These additional wells have accelerated production from 3,000 b/d to a new peak rate of 9,400 b/d and have increased ultimate oil recovery.

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OIL OCCURRENCES RELATED TO BREAKUP OF GONDWANALAND

The fragmentation of the Gondwana supercontinent during the Mesozoic Era produced tectonic features and depositional environments favorable for the genesis and entrapment of petroleum. Large-scale rifting is directly responsible for the pericratonic basins which may occur as taphrogenes or sphenochasms depending on rift phase and geometry. Deltaic environments developed subsequently from the altered river courses as the individual continents changed shape and new embayments and seaways were opened.

During the Jurassic and Cretaceous Periods, Gondwanaland progressively fragmented into the several larger southern continents plus the numerous smaller segments which were dispersed over almost half the globe. Each pulse of separation produced sedimentary basins.

The present oceans of the Southern Hemisphere were first opened as rift systems which received essentially nonmarine sediments deposited in a tectonically active trough. As the rifts widened during Cretaceous time, the sediments became more marine. Lithology, organic content, and petroleum potential were determined by the nature of the source material, water depth, and paleolatitude. Separation of the continents continued throughout the Cenozoic and current observations suggest that the rifting process and ocean widening are still active.

Oil reserves in excess of 25 billion bbl and gas reserves of several trillion cubic feet may be attributed to the fragmentation of Gondwanaland. Typical producing provinces include the Reconcavo, Gabon, and Gippsland Shelf basins as well as the Niger and Nile deltas. Most of the petroleum reserves have been developed during the past decade.

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ORIGIN AND DISTRIBUTION OF NATURAL GAS

Components of natural gases may come from a variety of sources, but the composition and extent of diagenesis of sedimentary organic matter probably control regional patterns of gas composition. Chemical analyses of suites of samples from different depths within single shale units indicate that the kerogen in ordinary shales may be the source of the order of 1 Tcf of methane gas and smaller amounts of carbon dioxide and nitrogen per cubic mile of shale. The process of generation is similar to coalification, as are the products.

Relative proportions of gases depend on differences in original constitution of starting materials and on the stage (*i.e.*, early or late) of maturation. The progression is from relatively more nitrogen in early stages, to more carbon dioxide, and finally to very large quantities of methane. Other sources must be called on to account for local anomalous gases, such as those very rich in H_2S and CO_2.

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GEOLOGIC OUTLINE AND OIL FIELDS OF SERGIPE BASIN, BRAZIL

In the Sergipe basin of northeastern Brazil a Lower Cretaceous unconformity marks a change in general depositional environment and tectonic style. Below this unconformity, Carboniferous to Lower Cretaceous beds are nonmarine, whereas the overlying Lower Cretaceous to Tertiary beds are dominantly marine. A period of intense normal faulting which preceded the unconformity resulted in an uplift which exposed Precambrian rocks in an area north of Aracaju, while in adjacent grabens thick wedges of syntectonic conglomerates were deposited locally over older sediments. Irregularities on this unconformable surface were filled by the Carmópolis Member of the Muribeca Formation, a conglomerate and coarse sandstone; the more extensive overlying Ibura Member evaporites of the same formation also covered the areas where basement was still exposed.

Late Cretaceous tectonism is characterized by small-scale faulting; the Riachuelo-Siririzinho and Vassouras-Carmópolis oil trends resulted from a combination of northwestward subsidence of basin-margin grabens and a regional southeastward tilting that started somewhat later.

Oil production in this basin from the Carmópolis, Siririzinho and Riachuelo fields comes mostly from the Carmópolis Member. Some oil is also produced from Lower Cretaceous reservoirs in contact with the unconformity. Depth range of all reservoirs is 400–800 m.

Favorable conditions for oil accumulation are the result of adequate structural evolution during Late Cretaceous time, presence of evaporites and probable oil source organic shales at the top of the reservoirs, and younger unconformities not reaching down to the trap. Locally, lateral permeability barriers or reservoir pinchouts complement the structural trap closure.

The oil is of mixed base ranging from 24 to 30.5° API. Cumulative production to December 31, 1969, with Siririzinho and Riachuelo fields still being developed, was 23.65×10^6 bbl of oil. This production comes from 205 completed wells drilled in a grid of 400 m.

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MAJOR DISCREPANCIES IN CURRENT SEA-FLOOR SPREADING MODELS

Studies of sea-floor spreading models from the viewpoints of paleontology, climatology, meteorology, and physical oceanography reveal serious discrepancies in these models. For example: (1) Late Paleozoic-Mesozoic tetrapod distribution reveals that the generic identity between Africa and South America is only 4%. There are no tetrapod genera common to southern Africa and Australia. (2) The dicynodont reptile, *Lystrosaurus,* has been found in Antarctica, South Africa, India, and western China, but not in Australia and South America. *Lystrosaurus* appears to be aquatic. (3) Eighteen freshwater ostracod species are common to western Africa and eastern South America, but there are few common marine species. Birds and large flying insects carry freshwater ostracod larvae today between continents; no doubt they did so in the past. (4) Species-diversity gradients are symmetrical with respect to the present pole at least as far back as Permian time. (5) Faunal realm studies of certain Mississippian and Triassic marine families show that migration between North America and Europe was via several Arctic routes. North American benthonic faunal identities with Europe at the specific level appear to be higher *today* (8%) than at any time in the geologic past (average, about 5%). (6) The presence of 95% of all evaporites, middle Proterozoic through the present, in areas underlain by today's dry wind belts shows that lower atmosphere circulation patterns have remained almost unchanged for 1 billion years—a physical impossibility unless the rotational axis, continents, and ocean basins have remained stable since middle Proterozoic time. (7) Because of a lack of moisture, coal could not have formed in the interiors of Laurasia or Gondwanaland. (8) Tillite distribution leads to the