(550– >760 m thick); (4) pre-Gilmer salt diapirs (Oakwood and, possibly, Grand Saline); and (5) post-Gilmer salt diapirs in the basin center. This inward increase in shape maturity results from increasing salt thickness and distribution of post-Louann sedimentary facies.

The Louann Salt (Middle Jurassic) was deposited in a broad continental basin on a post-rift unconformity surface. Domain 1 suggests that a critical salt thickness (~500 m) was necessary to initiate flow. In the Late Jurassic, an aggrading carbonate wedge uniformly loaded the underlying salt and formed the salt pillows of domain 2. Salt flow in the basin center had not begun by Gilmer time, probably due to a thinner overburden of basinal carbonate facies there. The Upper Jurassic–Lower Cretaceous Schuler-Hosston regressive terrigenous clastics prograded rapidly across the carbonate platform as coalescing fan deltas, filling the central basin. Salt anticlines of domain 3 grew by serial amplification of pre-Gilmer pillows to form ridges normal to dip direction fronting depocenters. Salt diapirs subsequently evolved from the distal anticlines.

Salt anticlines have trapped 80% of petroleum produced from the west-center of the basin. Marine pre-Gilmer source rocks, early initiation of folding, and the large size of the anticlines have all contributed to petroleum accumulation.

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Sedimentologic Aspects, Mannville Group, Southwestern Alberta

Due to the relative paucity of data, the Mannville sediments located at the western margin of the plains (T10-20, R27W4 to W5) have not been subjected to detailed study. However, recent exploration activity in this area has resulted in the acquisition of much core and drilling data. Using these data, together with those obtained from outcrop studies in the Foothills and from all the available core toward Range 20, a regional appreciation of the stratigraphy, sedimentology, and diagenesis of southern Alberta is now possible. Three major phases of sedimentation are recognized.

The first phase of Mannville sedimentation commenced with the deposition of coarse conglomerates in the Foothills (Cadomin) and chert-rich, often pebbly, sandstones in the plains (Basal Quartz, Cutbank, and Sunburst equivalents). These sediments were deposited as shallow braided or meandering stream deposits, often restricted to broad valleys on the Pre-Cretaceous unconformity. Fine-grained flood-plain deposits with well-developed pedogenic horizons are recognized within this interval.

The second, a transgressive phase of sedimentation, followed, with the deposition of bentonitic shales and fossiliferous limestones (Ostracod Member) and quartzose (Glauconitic) sandstones. The areally extensive sediments, which were primarily deposited in a complex of shallow restricted marine(?) environments, have a distinctive mineralogy compared to the underlying and overlying units. Changes in sediment provenance can account for this mineralogic diversity.

Thirdly, continental conditions returned to much of the area during post-Glauconitic time. This interval is represented by silts and shales intercalated with feldspathic and volcanic channel and crevasse sandstones. The textural and mineralogic immaturity of these sandstones is typical of the upper Mannville sediments of Alberta.

Complexities arise to the east of Range 22 where deep-channels originating during Ostracod, ?Glauconitic, and Upper Mannville times have cut through the underlying sediments. Recognition of the initiation point of these channels is important because reservoir quality is largely controlled by sediment composition. The most prospective reservoirs are quartz-rich sandstones which were not subjected to extensive silica cementation, a consequence of deep burial.

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Development and Hydrocarbon Potential, Carbonate Platforms Offshore Northeastern America

The Jurassic-Lower Cretaceous carbonate platforms and banks form a discontinuous belt extending from the Grand Banks to the Bahamas (over 6,000 km). The thickness of the carbonate buildups progressively increases southward along the margin, attaining a thickness of more than 5 km on the Bahamas. The platforms also become younger southward, which has been interpreted as an indication of a northward motion of the North American plate. Six types of carbonate buildups recognized document variability of depositional, paleo-oceanographic, and tectonic processes along the margin. The composition of the buildups closely resembles the recent deposits of the western Great Bahama Bank, since oolitic shoals were present near the shelf edge and skeletal, peloid wackestones and biomicrites were deposited in the inner part of the platform. Coral-hydrozoan, sponge and algal stromatolite bioherms and reefs are important constituents of the Late Jurassic-Early Cretaceous shelf edge. The hydrocarbon prospectivity of the carbonate front differs for the individual carbonate platform types which prevents construction of a single model for evaluation of their hydrocarbon potential. Porosity has locally developed as a result of secondary dolomitization in a mixing zone. Hydrocarbons were at least locally generated and migrated through the porous carbonate rocks. The major critical factor is presence of a rich source rock. The latest deep sea drilling on the northwestern African and eastern North American margins, together with the interpretation of the Mesozoic paleogeography of the shelf, allows the elucidation of this important factor in a time and space framework of margin development.

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Sedimentation Associated with Cirque Barite-Zinc-Lead Deposit

The barite-zinc-lead Cirque Deposit and other major showings in the Gataga district are part of an Upper Devonian to Mississippian sequence of basinal shales and submarine fan deposits of chert pebble conglomerate which were derived from the northwest. This sequence is preserved in the Akie, Pesika, and Gataga troughs, and unconformably overlies Ordovician to Silurian slope and basinal facies of the Kechika trough. The Akie trough is host to all known potentially economic barite-zinc-lead deposits in the district.

Both regional and detailed linear elements of the Cirque Deposit trend northwesterly and are asymmetric normal to the strike line. The background depositional unit is a soft gray aluminous shale which grades into black and carbonaceous shale to the southwest. An envelope consisting of diagenetically silicified fine carbonaceous clastic units was formed about the deposit. The outermost part of the diagenetic envelope consists of ribbon-bedded porcellanite with blebby and laminated massive barite on the northeast. Silicified platy poker chip shales with calcareous siltstone laminae are between the ribbon porcellanites and ore. The core of the cycle consists of up to 70 m of barite and sulfides on the axis of the deposit. Laterally, the ore section interfingers to the northeast with an equal thickness of flaggy to blocky bedded silicified black shale containing abundant finely laminated pyrite. Pb:Zn ratios increase northeasterly, and ore isopachs are asymmetric toward the northeast with the thickest zone being on the southwest edge of the deposit.

Genetically the barite-sulfide accumulations are considered to result from exhalative activity restricted to regionally developed basement faults. Accumulation occurred within a minor trough with resultant facies asymmetries being related to different topographic and paleochemical conditions during sedimentation and diagenesis.

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Oil Shale Development in Ohio: An Overview

The energy resource contained in the oil shale of Ohio represents a significant reserve for future development. These black shales were deposited during the Devonian and Mississippian Periods beneath a deep equatorial inland Kaskaskia sea that accumulated detrital organic sediments at the bottom. The oil-rich shales of Ohio are the lower and upper Huron members, the Cleveland Member of the Ohio Shale, and the Sunbury Shale. Thermal maturation of the vitrinite in the Ohio shale averages 0.54 Ro in Ohio. The present distribution of the oil shale in Ohio is in the north-south central and northeastern parts of the state. The shale oil industry to develop these energy resources began with the pioneers, and in 1886 with the St. Louis Shale Oil Co. Financial and technological interest continues today.

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Geothermal and Hydrocarbon Regimes, Northern Gulf of Mexico Basin

Geotemperature transients and the phenomena of heat flow define the fluid hydrocarbon regime in petroliferous sedimentary basins. The redistribution of heat and the thermo-physical properties of the rocks are mainly determined by the hydrogeology. As the temperature thresholds of smectite dehydration and kerogen diagenesis are passed, endothermic chemical changes convert solid rock mineral matter to fluids, reducing the net volume of mineral solids in each unit volume of rock and thereby increasing its porosity. As this occurs, the pore-fluid pressure rises markedly in response to the loss of load-bearing strength in the altered rock. Simultaneously, the aqueous solubility of fluid hydrocarbons is enhanced and the hydraulic permeability of the altered rock is greatly increased. Pore water carrying dissolved hydrocarbons moves through the altered rock and into adjacent aquifers, driven by steep hydraulic gradients. Subsequently, mass movement of water from the geopressure zone to the hydropressure zone migrates the dissolved hydrocarbons to traps, near which a sharp pressure drop causes exsolution.

The threshold temperature of smectite dehydration generally occurs a short distance below the top of the geopressure zone. The 100°C (212°F) isothermal surface closely approximates the top of the geopressure zone, except where water loss from the geopressure zone is in progress. At depths where temperature exceeds 150°C (302°F), petroleum occurrences are rare indeed. The abundance of natural gas, however, in both vapor phase and in aqueous solution, increases with pressure and temperature, and thus with depth, probably as a result of progressive natural cracking of petroleum residues in the rocks with deepening burial.

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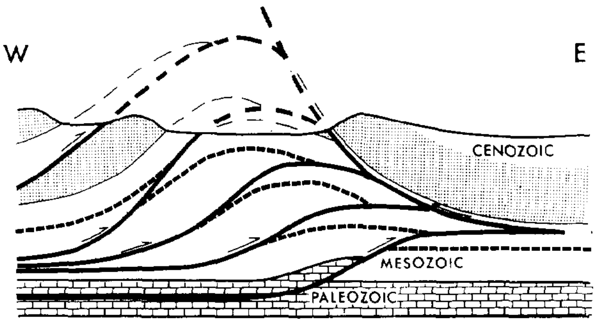
Oil and Gas Beneath East-Dipping Underthrust Faults, Alberta Foothills

Throughout most of its length, the Cordilleran front in Alberta is characterized by east-dipping Mesozoic and Cenozoic sediments overlying an east-dipping detachment surface that consists of one or more low-angle underthrust faults. More than 5,000 sq mi (13,000 sq km) of deformed sediments containing several major oil and gas fields are concealed beneath the detachment. East-dipping underthrusts of the detachment outcrop along east flanks of quasi-anticlinal structures sometimes called "triangle zones" because of their overall appearance in cross section. Oil and gas fields in triangle zones occur in Paleozoic carbonate and Mesozoic clastic reservoir rocks. Because of their complexity, triangle zones have also been the sites of some very expensive dry holes. Surface and subsurface data can be used to determine the geometry of a triangle zone and create an idealized model. The model can be adapted to structural problems both within and beyond the limits of the triangle zone, suggesting a new perspective on the tectonic development of the entire Foothills belt.



The Ideal Triangle Zone

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Organic Facies Distribution: Contributor to Both Wins and Losses

The dearth of oil-prone marine source rocks (organic facies B) in the Tertiary-Mesozoic deposits underlying the Holocene shelves is a primary reason for the low success ratio when exploring for oil in these deposits. The predominant organic facies are C, which is gas-condensate prone and is usually dominated by terrestrial organic matter (OM) deposited at an oxic sediment-water interface, and D, which has a negligible generating capacity and is either dominated by highly oxidized OM from any source or by reworked OM deprived of its liquid generative capacity in a previous thermal event. The east and southeast coasts of the United States illustrate this problem in both a clastic and carbonate realm.

Oil-prone source rocks are rare under the shelves, but do exist. They are apt to be rather restricted in areal extent and reflect rather local conditions that permitted the development of anoxia at the water-sediment interface. These conditions are preferentially achieved during the structural developments that occur in the rifting stages. The lacustrine source beds that are the source of much oil in offshore Brazil, Gabon, and Cabinda are prime examples. Might such organic facies exist elsewhere under thick sedimentary piles? As shown by the Kimmeridgian in the North Sea, marine transgressions during the rifting stage are clearly an opportunity for the deposition of oil-prone marine source rocks (organic facies B). Although drifting usually ultimately leads to oxic deposition in an open ocean, anoxic conditions can be preserved at least episodically for a long time as indicated by the Cretaceous of the Atlantic. The correct projection of the organic facies and maturation of the Cretaceous "black shales" under the continental shelves will clearly be rewarded.