The Oligocene-Miocene section along the deep western gulf apparently was deposited as part of an older deep-sea fan complex with a western source. The lower part of the fan sequence (Oligocene-middle Miocene) is characterized by strong, discontinuous reflectors and is interpreted as relatively coarse-grained material deposited in a channelized midfan environment. The upper Miocene part of the fan consists of fine-grained laminites and is characterized by prograding clinoforms, deposited as lobes seaward of a midfan zone of bypass.

The overall upper Tertiary fining-upward sequence in the western gulf and the gradual cessation of turbidites from a western source probably were due to the late Tertiary development of the Mexican Ridges foldbelt. This foldbelt apparently formed, or is still forming, owing to large-scale downslope gravity sliding of a more competent Tertiary section over incompetent, possibly geopressured, shales.

The northern margin of the deep Gulf is defined by the Sigsbee Scarp, which represents the southern extent of a zone of salt deformation along the entire Texas-Louisiana slope. The western scarp bulges southward and is characterized by salt wedges thrust 10 to 15 km seaward over Pleistocene rise sediments. East of the bulge area the scarp is formed by the seawardmost series of vertical salt ridges that have uplifted and deformed Pleistocene sediments. The salt deformation along the scarp probably is continuing today as a result of both downslope gravity forces and massive sediment loading in a large Pliocene-Pleistocene depocenter farther upslope.

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Hydrocarbon Accumulations in Overthrust Belt of Alberta

Estimated proved and probable ultimate reserves of marketable natural gas in Alberta are 80.5 Tcf of which approximately 10.5 Tcf are in Paleozoic carbonate reservoirs that have been involved in thrust faulting in the Foothills belt of Alberta. Interpretation of exploration data in this belt has contributed significantly to our understanding of the geology of the southern Canadian Rocky Mountains as a whole.

The Foothills belt is the easternmost of four major physiographic and structural divisions of the southern Canadian Rocky Mountains between the interior plains and the Rocky Mountain trench. The eastern boundary of the Foothills belt is marked by a zone of underthrusting, referred to as the triangle zone. The western boundary is defined by the surface trace of major thrusts which bring Paleozoic or older strata to the surface.

The Precambrian basement dips regionally to the west and is not involved in thrusting. The basement is overlain by a westward-thickening prism of Paleozoic sedimentary deposits which contain important reservoirs in Upper Devonian and Mississippian carbonate rocks. Approximately 8% of the reserves are in the Upper Devonian and 87% in the Mississippian. There is close correlation between reserves found and facies trends within the Mississippian Rundle Group. A widespread organic-rich source rock, the Exshaw Formation, provided the major charge for both Mississippian and Devonian reservoirs. Jurassic marine shales overlie the Mississippian in the southern part of the belt and form an effective seal and possible source rock. In the northern part of the belt, the Mississippian is overlain by Triassic sedimentary rocks in which reservoirs are present. The overlying Cretaceous and Tertiary section consists of clastic deposits, both marine and nonmarine in origin. Cretaceous sandstones generally lack reservoir qualities and less than 5% of the reserves found to date are in the Cretaceous.

The Foothills belt is divided longitudinally into two zones, an eastern or outer Foothills belt, and a western or inner Foothills belt. The outer Foothills are characterized by closely spaced listric thrust faults that repeat the Mesozoic section. Some of the thrusts cut deep enough to carry a single or multiple thrust slices of Mississippian carbonate rocks. Trap capacity is governed by horizontal displacement, vertical uplift, convergences of allochthonous and autochthonous structural strike, and probable seal quality of the thrust planes. Approximately 18 significant gas-bearing structures containing 5 Tcf marketable reserves have been discovered. Jumpingpound and Jumpingpound West are typical fields in this belt.

The surface geology of the inner Foothills is characterized by outcrops of Paleozoic carbonate rocks and relatively undeformed Mesozoic strata. The thrusts in this zone usually have large displacements, measured in tens of miles and commonly involve most of the Paleozoic section. Usually two or more thrust sheets are stacked in a general anticlinal form and provide multiple objectives. To date, 14 gas-bearing structures have been discovered in this zone containing approximately 5.5 Tcf of gas. The gas-bearing structures in the Waterton-Carbondale and Moose Mountain Panther River areas are typical. Previous interpretations which attempt to relate the gas-bearing structures of the Foothills belt to faulted stratigraphic traps or ancestral folds seem untenable. The gas-bearing post-lower Paleocene structures probably are related to the time of maturation of the major source rock and the west-to-east deformation of the southern Canadian Rocky Mountains. Despite the large areas of the Alberta Foothills belt in which exploration is restricted, it is estimated that 6 to 15 Tcf of gas may still be found.

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Application of Depositional Models in Coal Exploration and Mine Planning

Geologic studies have shown that many parameters of coal beds (thickness, continuity, roof and floor rock, sulfur and trace-element content, and ash) can be attributed to the depositional environment in which the peat beds formed and to the tectonic setting at the time of deposition. With an understanding of the depositional setting of the coal seam and contemporaneous tectonic influences, the characteristics and variability of many of these parameters can be predicted.

On a regional scale, depositional models can be used to predict the trends of coal bodies. At the lease-tract level, coal thickness variations are closely related to the preexisting depositional topography. In addition, the shape of the coal body is modified by coexisting and postdepositional environments such as channels.

Iron disulfides are present in coals either as marcasite or pyrite and are the major cause of sulfur variation within the seam. High sulfur contents in the form of disseminated framboidal pyrite are present in coals that were transgressed by marine to brackish-water environments. The only exception is where a sufficient thickness of sediment is introduced early enough to shield the peat from marine to brackish waters. Thus, the environments of deposition that overlie the coal are more important to the distribution of the type and amount of sulfur in the coal than the environments of deposition of the sediment on which the coal developed.

Roof quality in underground mines is dependent on the interrelations of rock types, syndepositional structures, early postdepositional compactional traits, and later tectonic features. Most of the features of roof conditions can be related to depositional or early-stage compactional processes of the environments overlying the coal. Later tectonic events may accentuate these early traits, but the basic characteristics seem to have been established during or shortly after the sediments were deposited.

Superposed on changes in seam character attributed to variations in environments of depositions are contemporaneous tectonic influences. Rapid subsidence during sedimentation generally results in rapid variation in coal seams but favors lower sulfur and trace-element content, whereas slower subsidence favors greater lateral continuity by higher content of chemically precipitated material.

Knowledge of depositional environments and of their tectonic setting is a valid and viable tool in the search for and development of coal resources.

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Oil Expulsion—A Consequence of Oil Generation

In source beds, much of the oil-generating organic matter is concentrated along bedding surfaces. During the principal phase of oil generation, when adequate thermal energy is available, 25 to 30 wt. % of the organic matter commonly is converted to liquids, mainly bitumen with some water. Part of the bitumen is then thermally cracked to crude oil. Hydrocarbon gases with some CO_2 and N_2 are generated also; much of the water and CO_2 is generated before oil is formed.

The release of fluids from organic matter causes a reduction in volume of the residual solid organic matter; however, this volume decrease is offset by the considerably greater volume of generated fluids. As a result, pressures increase greatly along sealed bedding surfaces. Internal (intrasource) migration of oil and gas occurs when local, transitory fluid pressures become sufficient to part the bedding laminae and to form or reopen near-vertical microfractures connecting the partings. Permeable migration pathways also may develop along laminae as a result of the reduced volume of the organic matter. Fluids are driven along permeable laminae and partings, into connecting, less pressurized laminae where two or more laminae converge, and along microfractures and faults within the source sequence. Eventually, high fluid pressures will develop in most parts of an actively generating source-rock section if the section is sealed and confined.

Two properties of argillaceous rocks that permit overpressuring are anisotropy and heterogeneity. Additionally, enough oil must be generated to increase fluid pressure sufficiently for local dilations to occur in oil-source rocks. This requires at least 0.5 wt. % of hydrogen-rich organic matter. In argillaceous source rocks, clay-sized quartz and clay provide brittle pressure and fluid seals, susceptible to microfracturing, on individual laminae. In carbonate-evaporite sequences, evaporites sealing laminae are less likely to fracture.

At a given generation site, dilation and fluid release are followed by a sharp reduction in pressure and closing of partings and fractures to further fluid movement. Pressure will again increase and dilation will recur at a given generation site until the fluid generation rate has diminished enough for the fluid pressure to remain below the dilation point, that is, the fluid pressure required to open or reopen any part of the system sufficiently for local internal fluid migration or expulsion.

A source-rock system functions much like a pressure cooker. It is self-opening and self-sealing. As liquids are expressed from a parting into a fracture, the pressure drops quickly and the fracture will close on the retained liquids, immobilizing them. Silica and/or calcite cement commonly are precipitated along such fractures, both before and after oil migration. Immobilized oil devolatilizes, leaving a solid or semisolid residue. These materials enable resealed parts of the system to repressurize and refracture through the peak gas-generation phase. Thus, the generation of fluids can provide the means by which oil and gas are expelled from source rocks.

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Resource Potential and Plate-Margin Geology of Frontier Basins of North Pacific and Bering Sea

Few of Alaska's offshore frontier basins have been explored by drilling. However, regional geologic data and tectonic considerations can be used to assess the likelihood that commercial volumes of oil and gas are present in the basins.

Basins of the northern margin of the Gulf of Alaska, and the contiguous Aleutian Ridge on the west, have formed along the Aleutian subduction zone, a tectonic terrane 3,600 km long that separates the Pacific and North American plates. The eastern gulf shelf is underlain by Cenozoic deposits that are as much as 10 km thick, but adequate reservoir beds are thought to be absent in Neogene and younger beds. However, the discovery that potential reservoir and source beds of early Tertiary age underlie the continental slope enhances the oil and gas prospects of the eastern gulf margin. Basins of the central gulf shelf (Kodiak Island area) contain upper Cenozoic beds that are as much as 5 to 6 km thick. These beds are broadly deformed and unconformably overlie more deformed rocks of Paleogene and Cretaceous age. Grabens (unusual for the gulf margin) filled with 6 to 8 km of Neogene and younger beds are present beneath the western gulf shelf (Sanak Island). Publicly available data imply that reservoir and