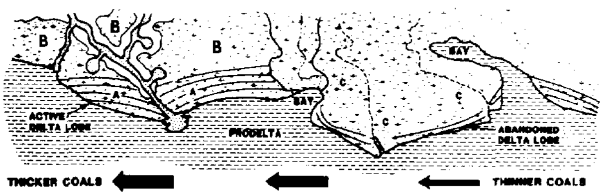
Springs Formation, a depositional model was developed to account for areas of variable thickness in coal accumulation. Coals within the formation developed along lower delta plain, upper delta plain–fluvial or on abandoned deltaic lobes and are referred to as Type A, Type B or Type C coals, respectively.

GENERALIZED RELATIONSHIP OF COAL THICKNESS TO DEPOSITIONAL SETTING



Depositional regression represented by extensive sheet sandstones are inferred to be delta-front deposits which reflect the cuspate to arcuate geometry of wave-dominated delta deposits. Widespread coal deposits up to 22 ft (6.7 m) thick that occur on top of the deltaic sandstones extend for up to 15 mi (25 km) along depositional dip and 36 mi (58 km) along depositional strike. They accumulated in lower delta plain environments as Type A coal seams. Thick coal seams that were deposited in upper delta plain-fluvial environments are less than 20 mi (32 km) in length and are more variable in thickness (1 to 17 ft, 0.3 to 5.2 m). They are referred to as Type B coal seams. Persistent but thin coals, less than 25 mi (40 km) in length and 1 to 8 ft (0.3 to 2.4 m) thick, that occur on top of delta plain–fluvial deposits and that are overlain by sheet sandstones are inferred to represent peat accumulation during delta lobe abandonment and are referred to as Type C coal seams. Coal seam discontinuities, represented by areas of reduced coal thickness or by wedges of sediment producing multiple benches or rider coals, are caused by sediment influx from distributary channels, fluvial channels, and splays. Analysis of the geometries and spatial distributions of coal seams is used to develop a detailed geologic model that can serve as a predictive tool for future coal exploration in this region and in other basins with similar depositional settings.

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Computer-Assisted Exploration in a Deltaic Environment

Oil and gas exploration in a deltaic environment is complicated by apparent erratic sand distribution. The structure and isopachous maps, normally so useful to the explorationist, are often of little use by themselves in locating prospective drill sites. The relationships of source beds, reservoirs, and sealing beds are of far greater importance in identifying prospective areas.

The shallow Wilcox Group in central Louisiana was used in this study. The section is relatively unfaulted and thickens gradually basinward. Several good correlation horizons enabled the study team to subdivide the section into relatively thin intervals and to examine the development of sand distribution through time. These data together with the present-day occurrence of hydrocarbons in these intervals were the primary criteria used in establishing potentially prospective areas.

Due to the large number of wells and the numerous producing zones in the study area, it was impossible to manually generate the statistics, maps, and cross sections needed within a reasonable time. As a result, most graphic and statistical output was generated by the computer.

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Anatomy of the Dolomitized Carbonate Reservoir, Mission Canyon Formation, Little Knife Field, North Dakota

The Mission Canyon is interpreted to be a regressive shoaling-upward, carbonate to anhydrite sequence deposited by a shallow epeiric sea. Upsection most of the formation is of subtidal origin, deposited as: (1) basinal "deeper water" carbonates, below wave base; (2) open shallow marine, which deposited major carbonate cycles of mudstone grading into skeletal packstone/grainstone; (3) transitional open to restricted marine, with minor carbonate cycles of mudstone grading into skeletal wackestone; (4) restricted marine of pelletal wackestone/packstone; and (5) narrow marginal, nearshore marine of skeletal wackestone interbedded with emergent intertidal deposits of skeletal, ooid-pisolitic packstone. Cratonward, the intertidal is interbedded with lagoonal limestones and both overlain by tidal flat to supratidal anhydrite beds.

The reservoir is structurally trapped within a northward-plunging anticlinal nose with less than 100 ft (30 m) of closure. Facies changes create stratigraphic entrapment southward. The seal is the overlying anhydrite beds.

Porous hydrocarbon-bearing beds are isolated within transitional open to restricted marine, restricted marine, and marginal nearshore marine facies. These lime-mud-rich beds underwent replacement by anhydrite to skeletal fragments, which was later leached, and the muddy matrix was dolomitzed to a porous calcareous dolostone.

Thin-section petrography and scanning electron microscopy studies of core samples and relief pore casts reveal four pore types. Pore types include moldic pores and dolomite intercrystal pores; namely, polyhedral, tetrahedral and interboundary-sheet pores, each pore progressively smaller in size. Pore throats are of two major sizes, the largest five times the width of the smallest.

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A Late Cretaceous Submarine Canyon in Brazil: Seismic Stratigraphy

A continuous sequence of gently dipping clastics covers a deep submarine canyon which was cut into Upper Cretaceous sediments and subsequently filled with Tertiary clastics. Conventional seismic work provides some indication of the complex sequence which filled the channel, but the full detail of the depositional history is revealed in detail by inverting the seismic data to produce synthetic sonic logs. The results reveal classic patterns of sedimentation, illustrate several changes which occurred in the source and distribution of sediments which filled the canyon, and map the individual members in close detail.

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Missourian and Virgilian Brachiopod Biostratigraphy, Bird Spring Group at Arrow Canyon, Clark County, Nevada

The Arrow Canyon section of the Bird Spring Group has been proposed as a stratotype section for the base of the Pennsylvanian and of the Permian because of its apparently uninterrupted deposition across those boundaries, extensive invertebrate fauna, nearly total exposure, and readiness of access. Both fusulinid zonation and detailed petrographic studies have already been completed. The Missourian and Virgilian sequence includes about 132 m of carbonate rocks divided into 46 units for collection and description. Eighteen of these units yielded a silicified brachiopod assemblage totaling 21 strophomenids and 17 taxa of other orders. Fossil abundance is greatest in the lower part of the Missourian and from the topmost Missourian through the middle Virgilian. Correlation with the middle Virgilian of North Texas and, perhaps, the lower Missourian of the southwest is especially strong. Notable range extensions include: (1) *Paeckelmanella*? n. sp., an otherwise Arctic Permian taxon, in the Virgilian; (2) *Mesolobus euampygus* in the Early Missourian, an extension of generic range from the Desmoinesian; (3) *Paucispinifer* n. sp., a Permian genus occurring in the Missourian; and (4) *Neospirifer latus lateralis*, a Missourian species occurring in the Virgilian. In addition, *Calliprotonia* n. sp. is reported the second occurrence of this genus in the North American Virgilian.

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Kinematic Model for Evolution of Cordilleran Fold/Thrust Belt, Canada to Mexico

Cretaceous to early Tertiary shortening of the foreland region occurred along listric thrust faults bounded by conjugate wrench faults that cut through and ductilely deformed the underlying Precambrian basement. Oblique convergence on east-dipping B-type subduction along the western edge of the North American plate coupled with west-dipping A-type subduction along a zone east of the plate margin and marked by muscovite-bearing two-mica granites produced conjugate WNW-trending left-slip and NE-trending right-slip faults and the foreshortening evinced by the decollement faults of the Western Overthrust. Many left-slip faults split into right-turning splays that join other left-lateral faults, creating thrust systems with a regional Z-shaped bend (e.g., thrusts of the Sawtooth Range, Montana). Conversely, right-slip faults split into left-turning splays that join other right-slip faults creating S-shaped thrust systems. Conjugate pairs of strike-slip faults bound concave-westward zones of decollement thrust faults (e.g., thrusts of the Belt graben, Montana). Complex flower structures mark the loci of many wrench faults (e.g., Arizona and southwestern New Mexico). Late Tertiary to Holocene extensional deformation of western North America produced the north-trending listric normal faults of the Great Basin and reversed the sense of movement on many preexisting strike-slip and thrust faults. These regional relationships are clearly visible on digitally processed Landsat imagery.

This model also accounts for the synchronous intrusion of both two-mica (muscovite) and one-mica (copper porphyry type) granitic rocks in the region. This geologic paradigm will assist the exploration for hydrocarbons and minerals.

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Lithology and Depositional Environment of Ashern Formation (Middle Devonian), North Dakota

The Ashern Formation (Middle Devonian) is the basal unit of the Kaskaskia Sequence in North Dakota. It is unconformably underlain by the Silurian Interlake Formation, and overlain, generally conformably, by the Winnipegosis Formation of Middle Devonian age. The Ashern is present in the northwestern one-third to one-half of North Dakota. Beyond the limits of the overlying Winnipegosis Formation, the Ashern is indistinguishable on electric logs from the basal argillaceous members of the Dawson Bay and Souris River formations and, together with these, must be considered undifferentiated basal Devonian.

The Ashern Formation is composed of two members. The lower red member is predominantly an argillaceous microcrystalline dolostone, containing nodular anhydrite and thin shale partings. The upper dark gray member is predominantly a featureless microcrystalline limestone. Together, these two members range in thickness from about 10 m near the limit of the Ashern Formation to about 50 m near the center of the Williston basin.

The red member owes its color to a reworking of a lateritic soil on top of the Late Silurian/Early Devonian erosional surface. The fine-grained dolostone and its nodular anhydrite imply supratidal deposition in a sabkha environment. The featureless gray member was deposited in a low intertidal to subtidal environment. There is an occasional suggestion of bioturbation, though no fossils have been found. No porosity is evident in the formation, except for some partly anhydrite-filled fractures near the top in one core.

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Depositional Environment and Rock Fabric, Birdbear ("Nisku") Formation (Upper Devonian), Williston Basin, North Dakota

The Birdbear Formation was deposited as the upper part of a widespread marine carbonate and evaporite system prevalent in the Williston basin during the Middle and Late Devonian. Rock facies representing shallow-water and associated carbonate subenvironments are present in the Birdbear. Stillstands of subenvironments and frequency of transitions between subenvironments are similar to those in the underlying Duperow Formation. Evaporites are dominant in the uppermost part of the Birdbear.

Original depositional environments are recognized with subsequent diagenetic events evaluated. The development of interparticle and moldic porosity is outlined, in particular, with reference to dolomite.

Dolomites are prevalent in the upper section of the Birdbear Formation. Evidence suggests shallow intertidal and supratidal conditions with porosity development associated with the dolomites. Overlying limestones and anhydrites act as caprock.

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Origin of Dolomite, Red River Formation, Richland County, Montana

Distribution of limestone, dolomite, and anhydrite as determined from compensated neutron-density logs and core studies of the Ordovician Red River Formation in Richland County indicates that: (1) virtually all deposition, including the B and C zone anhydrites, occurred subtidally (contrary to previous interpretations invoking localized tidal flats on paleo-highs); (2) various rock units such as the anhydrites and B and C "laminated" zones have remarkable uniformity and lateral continuity over many tens of miles; and (3) dolomitization occurred in subtidal stromatolites, by primary precipitation, or by gravitational seepage of Mg-rich brines into normal marine subtidal carbonates. The lateral persistence of the A and B zone dolomites indicates they formed mainly by primary precipitation and/or dolomitization of subtidal stromatolites whereas the localized replacement dolomites of the C and D zones formed by gravitational seepage of dense brines.