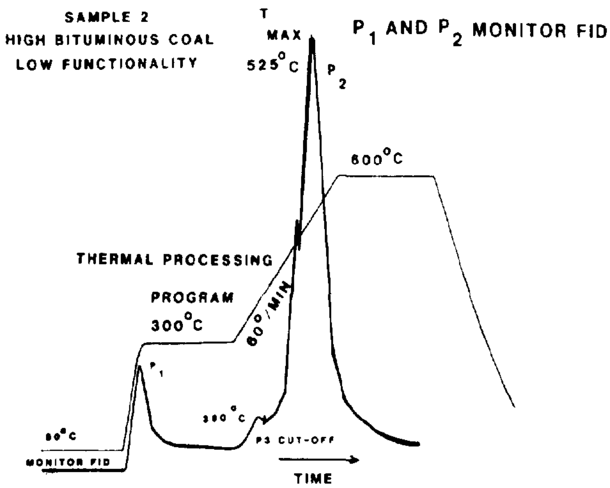

(P_1, P_2, P_3), and on-line high-resolution FID capillary gc analysis of the P_1 and P_2 composites. P_3 is determined by thermal treatment of the source rock to 390°C by internal trapping and subsequent desorption into a chromatographic column with thermal conductivity detection for carbon dioxide and other evolved gases. These data provide valuable insight into the sample composition, maturation, relation to process yields, and pollution/transport mechanisms.

Illustrations will be given of the organic analysis of kerogens, oil shales, coals, and sediments. The growing significance of analytical pyrolysis combined with concentrator technology will be demonstrated in applications of these advanced configurations dedicated to the geosciences.

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Temperature Anomalies and Gulf Coast Structures

Temperature anomalies associated with various structures in the Gulf Coast are interpreted to be the result of fluid migrations from depth. Pressure and salinity data are also part of an exploration model where hot, fresh, hydrocarbon-laden waters are believed to be migrating up faults. Traps in the vicinity of these migrations are of special interest to the explorationist because they are more likely to be charged with hydrocarbons.

The part of southeastern Louisiana studied has twelve areas of possible subsurface fluid migrations. Eight hydrocarbon fields are in the vicinity of these migrations. The areas of migration are most likely to occur at areas of structural expansion, i.e., grabens, crests of diapirs, and most importantly, intersections of faults.

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Margin Types: Their Characteristics and Potential

Offshore exploration has tested passive, convergent, and transform margin types. Passive margins are characterized by an initial rift structure, commonly involving nonmarine sediments, sometimes evaporites, and an overlying mostly marine sedimentary terrace of clastics and/or carbonates. Potential has proved variable. Significant hydrocarbons have been found in MacKenzie Delta, Gulf of Mexico, offshore Newfoundland, northwest Europe, Gulf of Suez, India, Indonesia, Australia/New Zealand, Brazil, and central west Africa from Ivory Coast to Angola. To date, little success has been obtained on the passive margins of the rest of Africa, South America south of Brazil, the east coast of the U.S., and most of Australia/New Zealand.

Convergent margins are characterized by an arc-trench system with intervening fore-arc basin and subduction complex. Sediments of fore-arc basins are predominantly marine volcanogenic clastics derived from the magmatic arc. The subduction complex is a tectonically imbricated package composed predominantly of volcanogenic clastics, but may incorporate significant amounts of deep-sea cherts, limestones, red clays, and slices of oceanic crust. Potential appears poor with the only significant hydrocarbons discovered in this setting being in southern Alaska and northern Peru.

Transform margins are relatively limited worldwide and are characterized by sharp fault-bounded basins with clastics derived from adjacent sides and carbonates developed in situ. Compressive structuring locally accompanies basin evolution. Potential is variable. Significant hydrocarbons have been found in this setting off southern California, Trinidad, northern Brazil, Ivory Coast, and Sakhalin Island, but none so far off western Canada, the northern Caribbean, or western Madagascar.

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Geological Development, Origin, and Energy and Mineral Resources of Williston Basin, North Dakota

The Williston basin of North Dakota, Montana, South Dakota, and south-central Canada (Manitoba and Saskatchewan) is a major producer of oil and gas, lignite, and potash. Located on the western periphery of the Phanerozoic North American craton, the Williston basin has undergone only relatively mild tectonic distortion during Phanerozoic time. This distortion is largely related to movement of Precambrian basement blocks.

Oil exploration and development in the United States portion of the Williston basin from 1972 to present have given impetus to restudy of basin evolution and geologic controls for energy resource locations. In consequence, oil production in North Dakota, for instance, has jumped from a nadir of 19 million bbl in 1974 (compared to a previous zenith of 27 million in 1966) to 32 million bbl in 1979 and 40 million bbl in 1980. Geologic knowledge of carbonate reservoirs has expanded accordingly.

Major structures in the basin, and the basin itself, may result from left-lateral shear along the Colorado-Wyoming and Fromberg zones during pre-Phanerozoic time. Deeper drilling in the basin has established several major new structures with indications of others. Most structures probably result from renewed movement or "tensing" of pre-Phanerozoic faults. Meteorite impact events have been suggested as the origin for one or two structures.

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Origin of Quebrada Arriba Oolitic Ironstone (Eocene), Venezuelan Andes

The Quebrada Arriba Formation consists of alternating beds of chamositic oolite, limestone, sandstone, and shale. The oolites consist of a framework of originally calcareous ooids, fossils, and intraclasts set in a calcareous cement, all virtually replaced by chamosite, siderite, hematite, pyrite, and silica. Textural analysis reveals the following paragenetic sequence: (1) calcareous fossils and ooids, (2) silica/pyrite, (3) chamosite, (4) siderite, and (5) hematite.

Petrographic evidence suggests a quiet water back-reef origin for the calcareous oolite. The first secondary minerals to form are pyrite and silica, the latter being mostly concentrated in foraminiferal tests. The mutually replacive relationship of silica and pyrite implies their cogenetic origin in a reducing barred environment. Abundant diagenetic chamosite formed next, replacing calcareous ooids and fossils in a still reducing but shallower environment. At this stage, dissolution of original carbonate sediments resulted in a high concentration of carbon dioxide in the basin facilitating precipitation of siderite. Hematite formed last in an oxidizing environment at the expense of earlier formed iron-bearing minerals. The abundance of pyrite/siderite and a corresponding scarcity of hematite in subsurface samples and the reverse relationship in outcrop samples imply oxidation of pyrite/siderite under surface conditions to produce hematite. The source of iron for the ferriferous minerals could be lateritization of emergent source rocks during a regressive phase. Fluvial supply either as hydrosols, colloidal suspension or adsorbed particles on clays would have concentrated the iron in a barred environment. Shelf-margin barriers in the form of shoals and reefs (for example, the El Guamo and Berlin limestones) prevented dilution and loss of the iron-bearing solution which on reaching sufficient concentration started precipitating different minerals under different Eh-pH conditions.

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Origin, Migration, and Entrapment of Natural Gas in Alberta Deep Basin: Part 2

Gas entrapment in the Elmworth deep basin occurs under a variety of conditions. Typical trap types include (1) stratigraphic, (2) structural-stratigraphic, and (3) deep basin. The deep basin type of gas trap is the most important in terms of its large size and unconventional trapping conditions. The three main physical conditions associated with the deep basin type of gas trap are (1) an updip water/gas contact, (2) a downdip gas/water contact is generally absent, and (3) the original reservoir gas pressures are equal to, or less than, water pressures at the same depth based on extrapolation of water pressure gradients from the updip water saturated region.

The physical principles underlying this kind of gas entrapment, together with the intimate association of mature source rocks, constitute a fundamental relationship which is applicable to gas exploration in other sedimentary basins of the world.

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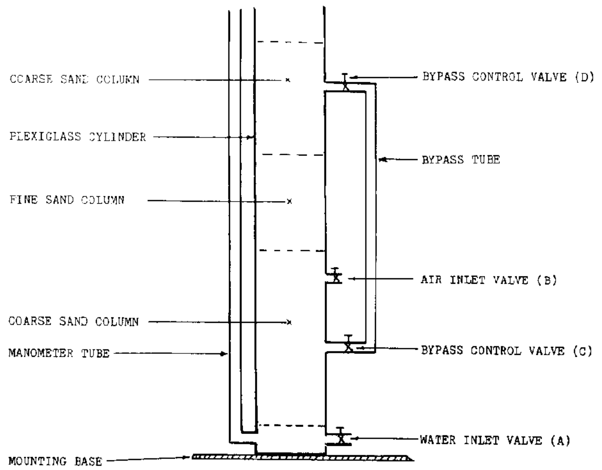
Basic Physical Principles of Conventional and Deep Basin Gas Entrapment

The model consists of a transparent plexiglass cylinder 2.5 in. (6.35 cm) in diameter and about 30 in. (76 cm) high mounted on a support stand. The cylinder contains a sand pack made of coarse, loose sand separated in the middle by 7 in. (17.8 cm) of loose fine sand. Permeability of the coarse sand is in excess of 1,000 darcys while that of the fine sand is several hundred darcys. The device was invented by me to study the behavior of gas and water flow through porous media and in particular to investigate the characteristics of conventional and deep basin types of gas traps.



The first demonstration represents the conventional trapping case. The second demonstration shows pressure/depth graphs for fluid phases to be identical with those found for the Elmworth deep basin gas traps, i.e., at the updip contact, the gas and water phase pressures are about equal as opposed to the conventional case where the gas pressure was much greater than the water pressure at the contact. Also, the downdip water column beneath the gas column is shown, in both cases, not to be in pressure continuity with the water column in the upper coarse sand column, even though there is a continuous water film wetting the sand grains through the gas-saturated coarse sand connecting the water-saturated fine sand with the water-saturated coarse sand below the gas column.

The fluid flow process through the depressured gas column from the upper water-saturated sands to the base of the gas accumulation will also be discussed.

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Reflection of Topography on Pre-Cretaceous Unconformity Through Overlying Section in Central Alberta

Topographic highs and lows on the Pre-Cretaceous unconformity of central Alberta are reflected as irregularities on the structure of overlying formations. These highs and lows are many times themselves reflections of changes in the deeper stratigraphy. In some places, the effects of large highs and lows can be seen directly on structure maps of Cretaceous formations. For example, the Leduc reef chain, which itself is up to 1,000 ft (305 m) below the unconformity, causes anomalies in the structure of all overlying formations and its effects can even be seen in the present-day topographic surface.

However, many irregularities on the unconformity are small and their effects are masked by the regional dip of the Alberta basin. Their effects also become more diffuse on the upper formations.

Trend surface analysis on the structure of the overlying formations removes the regional trend from the data, and these more subtle highs and lows can be recognized. They can be seen not only as differences between positive and negative residuals, but also as relative highs and lows within areas of positive and negative residuals.

Advantages of using residual maps of the structure of Cretaceous formations to locate highs and lows on the Pre-Cretaceous unconformity include: (1) showing that some structural and stratigraphic traps are a direct result of irregularities on the unconformity, and (2) despite limited well control to the unconformity, highs and lows can be mapped using the more