tural 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.

GIES, ROBERT M., Canadian Hunter Exploration Ltd., Calgary, Alberta, Canada

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

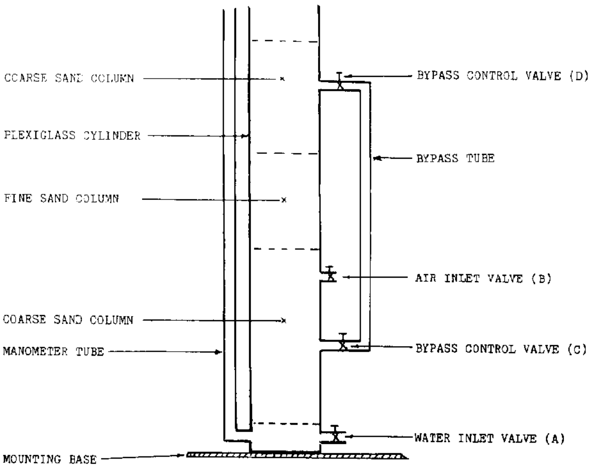
Gas entrapment in the Elmworth deep basin occurs under a variety of conditions. Typical trap types include (1) stratigraphic, (2) structural-stratigraphic, and (3) deep basin. The deep basin type of gas trap is the most important in terms of its large size and unconventional trapping conditions. The 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.

GIES, ROBERT M., Canadian Hunter Exploration Ltd., Calgary, Alberta, Canada

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.

GLASS, DOUGLAS E., Canada-Cities Service Ltd., Calgary, Alberta, Canada

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