lithologic variation, an aid to local correlation of sequences, and a basis for environmental interpretation. Type (3) elements are of particular economic importance as the main reservoir rock of the hydrocarbon-bearing Viking Formation.

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WELL DATA FILES AND COMPUTER—EXPLORATION TOOLS FOR 1970s

Computer processable well data systems in the United States and Canada contain information of more than 700,000 wells. The use of computers to extract, analyze, and display this information is essential for economically efficient exploration where large amounts of data are available.

A systematic approach to exploration using the well data files and computer methods can improve exploration decision making. One case study demonstrates the use of well data files for the analysis of future gas potential in the northern Rocky Mountains. Another case history illustrates file applications that were used to evaluate the Muddy reservoir in the Powder River basin. Data in the Rocky Mountain well data file were used to delineate prospective Muddy trends on which subsequent drilling has discovered more than 250 million bbl of oil.

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COMBINATION FORMULA UNLOCKING LOWER TYLER "POINT BAR" EXTENSIONS IN CENTRAL MONTANA

The lower Tyler Formation of central Montana is oil productive from sinuous, point-bar sands deposited in a Pennsylvanian river channel. These hydrocarbon-bearing bars are hard to locate, and successfully offsetting a discovery is commonly difficult.

Combining the dipmeter with subsurface data and sample cutting studies is a method that will eliminate some dry holes.

Subsurface data indicate the location of the channel, the amount of erosion into underlying beds, and the type of channel fill. Sample cuttings show the type of bar facies found. The dipmeter illustrates the water-sediment transport direction and the deviations of dip within each facies change.

These 3 tools used together will produce a more accurate subsurface picture to determine which offsetting location will produce a field extension.

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LOWER CRETACEOUS COMBINATION TRAPS IN BIG MUDDY–SOUTH GLENROCK AREA, WYOMING

In the Big Muddy-South Glenrock field area, Natrona County, Wyoming, probably 100 million bbl of oil will be produced ultimately from 3 separate sandstone reservoirs within the Lower Cretaceous section; from oldest to youngest, the Dakota, the lower Muddy, and the upper Muddy. Entrapment of oil in each of these producing zones is the result of updip pinchout or facies change from porous and permeable sandstone to nonreservoir shale, siltstone, or sandstone, assisted by a favorable hydrodynamic environment.

Each of these sandstone reservoirs occupies a flank position around and across the east plunge of the Big Muddy anticline. Isoliths of permeable Dakota sandstone in the producing area and the regional pattern of sandstone distribution, together with the lithologic characteristics of the Dakota sandstones, suggest deposition within northeasterly flowing rivers that drained an incipient Big Muddy uplift and emptied into the sea near Glenrock. Sand delivered to the sea was distributed along a northwest-trending shoreline by relatively low-energy, destructive, marine processes accompanying the upper Dakota transgression. The Dakota pool at Big Muddy-South Glenrock has a continuous oil column more than 2,500 ft in length and an anomalous, inclined oil-water contact.

The lower Muddy sandstone pool also appears to be a single, continuous reservoir with a vertical oil column of at least 2,500 ft. This sinuous sandstone reservoir trends northeast along the southeast flank and around the east plunge of the Big Muddy anticline and has the classic meander morphology of a fluvial river deposit. The physical dimensions of this northeasterly flowing river are comparable with the upper reaches of the present Mississippi River. The influence of probable structural growth along the Big Muddy axis on the radius of meander curvature and depth of the scour channel in the lower Muddy river is particularly evident.

In the upper Muddy sandstone interval 2 nearly parallel sandstone pools trend essentially north-south across the east-plunging Big Muddy axis, and have the typical lithologic and morphologic characteristics of marine shoreline or barrier-bar deposits. Each pool has a vertical oil column of about 1,500 ft.

Regional mapping of the potentiometric surface of the 3 Lower Cretaceous producing intervals and the unusually long oil columns in each of the Lower Cretaceous sandstone pools at Big Muddy-South Glenrock indicate that a favorable downdip hydrodynamic flow must exist in the area of oil accumulation and must be enhancing the oil-holding capacity of the updip barrier zones.

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STRATIGRAPHY AND EXPLORATION OF LOWER CRETACEOUS MUDDY FORMATION, NORTHERN POWDER RIVER BASIN, WYOMING AND MONTANA

The Lower Cretaceous Muddy Formation in the Northern Powder River Basin of Wyoming and Montana was deposited during a marine transgression across a stream-dissected surface of the underlying Skull Creek Shale. The transgression occurred over most of the area, but was limited by a prograding delta on the northeast which supplied most of the sand for the area.

The Muddy Formation is divided into 2 units—lower and upper. The lower Muddy was restricted to a system of dendritic channels which were incised into the Skull Creek Shale during a period of emergence. The sands were supplied from the delta on the northeast and transported south by longshore currents. They were deposited principally in a transitional marine and estuarine environment, and are comprised of fine-grained moderately sorted, partly clay-filled quartzose sands.

By the time of deposition of the upper Muddy unit the incised depressions in the Skull Creek topography had been filled largely and the upper Muddy sands were deposited in a complex marine shoreline environment which resulted in offshore bars, barrier islands, beaches, and tidal deposits.

Several shoreline trends are recognizable in the upper Muddy. They are progressively younger eastward and reflect the overall west to east transgression. These trends were controlled by the remnant Skull Creek topography and changing conditions of sediment supply.

Production from the Muddy Formation is principally stratigraphic, however, in places structure is important in localization of accumulations.

Lower Muddy production is restricted to updip channel boundaries and is localized by structural noses and updip channel reentrants. Upper Muddy production is controlled chiefly by porosity development and lateral facies changes.

Exploration for Muddy sandstone reservoirs is accomplished best by the use of an isopach of the total Muddy Formation. This map shows the configuration of the Skull Creek channels and therefore the distribution of the lower Muddy sandstone bodies. It is also helpful in predicting the orientation of the upper Muddy shoreline trends where they were related to remnant Skull Creek highs and by showing an increased Muddy thickness due to sand buildups in nonchannel areas. As the sand geometry is complex, abrupt stratigraphic changes are common. Electric log maps combined with zonal sandstone isopachs provide a means of visualizing these abrupt changes in sand geometry and also aid in the interpretation of depositional environments.

Exploration must be focused on the location of primary stratigraphic traps which have not been altered strongly by later structural movements. The ubiquitous presence of clay-filled porosity has eliminated large areas as nonproductive. It is believed that the clay fill largely is diagenetic and occurred subsequent to primary oil accumulation. The lower percentage of clay fill in the oil-filled primary traps suggests that the presence of the oil inhibited clay diagenesis.

In the last 3 years nearly 3,000 wells have been drilled in the study and search for Muddy oil. Each year new fields of significant size have been discovered. Abrupt stratigraphic changes require detailed stratigraphic work and, most important of all, courage to use the drill as an exploration tool.

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Statistical Methods of Petroleum Exploration in Part of Denver Basin, Colorado

Pattern drilling, based on the hypothesis that any field with dimensions larger than the area between pattern wells certainly would be discovered, is tested in a sample area on the east flank of the Denver basin ("fairway" trend area) and compared with effectiveness of actual drilling. This test might be described as a combination of random and geologic-lead drilling. The pattern selected "discovers" 1.16×10^8 bbl of oil actually produced as of January 1, 1969. This quantity includes produced oil only and does not include estimates of reserves or total ultimate production. The pattern-drilling system yields 123,400 bbl/well of oil actually produced in the sample area (including dry holes). Actual drilling in the area has led to production of 1.53×10^8 bbl of oil or 66,500 bbl/well.

It is concluded that, in the sample area at least, pattern drilling could have been more economical than drilling according to geologic leads, promotional deals, and leasing arrangements, as has occurred in the area.

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Reevaluation of Use of Glauconite for Radiometric Stratigraphic Dating

(No abstract submitted)

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Stratigraphy of Black Shale Facies of Green River Formation (Eocene), Uinta Basin, Utah

In the Uinta basin, Utah, the black-shale facies of the Green River Formation (Eocene) is divided into 5 rock units: 4 lacustrine units designated by the letters A-D, and a fluvial unit, the Wasatch tongue of the black-shale facies. The Wasatch tongue occupies the same stratigraphic position as unit C. Unit A contains the oldest lacustrine rocks of the black-shale facies, and is transgressive on the underlying fluvial Wasatch Formation (Paleocene-Eocene). All of the lacustrine units contain black fine-grained clastic rocks. Units B and D contain more carbonate rocks than do other units. Units B and D are also the most extensive of the lacustrine units. Units A, B, and C range in thickness from 100 to 300 ft, whereas the Wasatch tongue is 100–400 ft thick. Unit D has the greatest thickness range, from about 100 to 500 ft.

Rocks contained in the 4 lacustrine units vary in composition depending upon where they were deposited in relation to the center of the basin. The central lake environment of deposition produced mostly dark-gray to black, fine-grained clastic rocks and finely crystalline, brown to dark-brown carbonate rocks. The total clastic content of the lacustrine rocks and their model grain size increase toward the peripheries of the depositional basin and sandstone and siltstone become more abundant. Near the edges of the basin carbonate rocks are more saccharoidal in texture and contain larger amounts of silt- and sand-sized grains, oolite, pisolite, and shell fragments.

The depositional axis trends east-west and the depositional center of the lacustrine units is south of Duchesne, Utah, except for unit D where the center is farther south. Well control is sparse in the western part of the Uinta basin.

Lake Uinta was initiated by the coalescing of several small freshwater lakes on a broad alluvial plain. Downwarping led to the formation of the first moderately deep Green River Lake and the deposition of the black fine clastics and other rocks in unit A. The lake was thermally or chemically stratified, which is suggested by the preserved organic material and the presence of pyrite and salt crystals. As the lake transgressed over the fluvial sediments and became larger, the sediments of unit B were deposited. Unit B contains abundant carbonate rocks that were deposited over the entire lake, but particularly in the shallower part where the temperature was highest. A change in climate and/or increasing downwarping caused the lake to diminish its total area and unit C was deposited. During the deposition of unit C, the fluvial sediments of the Wasatch tongue of the black-shale facies were deposited along the southern part of the basin. The lake then transgressed back across the fluvial sediments and deposited unit D. The dominant rock types of unit D are very similar to those of unit B, indicating a similar environment of deposition.

Much of the oil and gas production in the Green