

contact. These data explain downdip shows and water production, poor oil production within the field, and gas production updip.

Integration of all information indicates that (1) Cut Bank field is a continuous reservoir which displays the classical updip progression of water to oil to gas, (2) local rock type variation accounts for the varying quality of production within the field; and (3) there is a common oil-water contact on the downdip edge of the field and its position is controlled by rock type differences.

Drilling subsequent to this study has confirmed the interpretation reported here.

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Seelyville Coal—Major Unexploited Seam in Illinois

New mapping has revealed that a major minable coal seam, the Seelyville Coal Member of the Spoon Formation, underlies a large area of eastern Illinois. Although the Seelyville coal has been actively mined in adjacent parts of Indiana for many years, and although its presence in Illinois has been known for some time, its extent in Illinois has not been determined. This study, which principally used geophysical logs from oil test holes, shows that the Seelyville Coal may be 4 to 8 ft (1.2 to 2.4 m) thick under an area of about 1,200 sq mi (3,120 sq km) of Clark, Crawford, Edgar, Lawrence, Cumberland, and Jasper Counties. In-place coal resources are estimated to be more than 7 billion tons. Much of this coalfield borders on the Wabash River, a potential locality for coal-conversion plants. The Seelyville coal has seldom been tested by coal exploration companies, and large blocks of the coalfield are believed to be unleased.

The Seelyville coal lies about 200 ft (61 m) below the Springfield (No. 5) Coal Member of the Carbondale Formation and ranges in depth from 300 to 1,500 ft (91 to 457 m) in the area studied. The Seelyville generally has one or more shale partings that range in thickness from a few inches to more than a foot. The number and thickness of partings are difficult to determine with available geophysical logs, thereby making coal resource estimates somewhat uncertain. The coal commonly has a siltstone or sandstone roof; in some areas cutouts in the coal are numerous. Core data are needed to confirm coal thickness and to evaluate the water content and stability of the sandstone and the quality of the coal. The Seelyville coal has significant resource potential and warrants the attention of coal exploration companies.

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Tabular Uranium Ore in Poison Canyon Area, Morrison Formation, San Juan Basin, and Application of Lacustrine-Humate Model

Surface ore trends in the Poison Canyon sandstone (of economic usage) coincide with a distinct facies in the underlying "K" shale. Uranium mineralization of the sandstone occurs only where the unit is underlain by an offshore-lacustrine, gray, pyritic mudstone facies of

the "K" shale. Where the "K" grades laterally into a nearshore-lacustrine red mudstone facies, the overlying Poison Canyon sandstone is unmineralized.

These relations suggest that the lacustrine-humate model may account for the origin of tabular ore in the Grants Mineral Belt. The basic premise of the model is that humate in tabular sandstone ore deposits originated as soluble humic substances in the pore fluids of nearby offshore-lacustrine gray mudstones.

Gray mudstones deposited in reducing, alkaline conditions are considered potentially favorable humate "source rocks" because reducing conditions favor preservation of humic matter in the pore water of lake-bottom sediments and because alkaline conditions favor solubilization of these humic substances so they can be expelled with the pore fluids during compaction. In the "K" shale in the Poison Canyon area early diagenetic reducing conditions are indicated by the presence of pyrite and the dark gray color. Alkaline conditions resulted from alteration of volcanic ash incorporated in the muds; the pore water pH rose sufficiently high to strip the muds of the humic matter and move it, during compaction, into the overlying Poison Canyon sandstone where it was fixed as a humate deposit. Subsequently, uranium delivered by groundwater was fixed by the humate to form the tabular ore deposit.

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Sedimentology of Westwater Canyon Member, Morrison Formation, Southern San Juan Basin

Outcrop measurements taken from trough cross-beds throughout the Westwater Canyon Member indicate that two separate fluvial complexes, each with its own distinct current direction, compose the member along the southern San Juan Basin. Lower Westwater streams flowed east-northeast at all points between Gallup and Laguna, whereas upper Westwater streams flowed consistently southeast over the same area. Measurements in the overlying Poison Canyon sandstone (of economic usage) suggest a return to northeast-flowing streams. Mine maps from the Ambrosia Lake area confirm these current directions in the subsurface.

These data preclude the existence of a single fan emanating from the southwest, as proposed by previous workers. The upper Westwater had a source to the northwest which not only changes the overall picture of Westwater deposition but also raises significant questions about uranium mineralization and basin geometry during Morrison time.

In many surface sections the lower and upper Westwater sandstones merge as a result of scouring by upper Westwater streams. In the subsurface these areas might appear as "sand thicks" on an isopach map. Elsewhere on the surface, the Westwater contains numerous "shale breaks." Regardless of the number of shale breaks or total sandstone thickness, the type of deposition (braided) and the current directions (northeast-lower, southeast-upper) remain the same. This suggests that use of isopachs in the subsurface to determine stream type and current direction is invalid. Areas of greatest sandstone thickness in the mineral belt most likely reflect thicken-

ing in synclines that were actively growing during deposition.

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Nature of Non-Recoverable Porosity Changes in Experimentally Deformed Indiana Limestone and Yule Marble

Cores of limestone and marble with porosities from 0.5% to 15% were experimentally deformed dry, at room temperature under confining pressures from 3.5 to 27.6 MPa. Deformations were documented by changes in porosity, permeability, and mercury-injection pressure measurements. Pore and fracture geometries and interrelations were preserved by epoxy impregnation. In Indiana limestone at axial loads to 95% of mean failure strength, no significant changes in porosity could be detected, although there was a significant increase in twinned grains around pores, and a slight increase in mercury-injection pressures. At loads to 90% of failure (1.2% axial strain of which 0.4% is non-recoverable), a slight change in recovery efficiency was produced. The significance of this change is uncertain. If real, it is probably the result of microcracking observed at grain boundaries. After failure, a direct relation seems to exist between bulk axial strain and porosity. The porosity increase seems to be entirely disseminated, as no major fracture was formed, though shear zones 1 to 2-mm wide characterized by twinning and grain rotation were noted. Failure was accompanied by widespread grain and pore-size reduction. Yule marble stressed at axial loads to 99% of mean failure strength showed no measurable change in porosity. Failure was accompanied by increase in porosity which showed a correlation to bulk axial strain. This increase in porosity is in the form of both major fractures and a general increase in intergranular pore widths from less than 1 μ (undeformed) to between 1 and 10 μ (deformed).

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Reevaluation of Depositional Environments of Salt Wash Member of Morrison Formation, Uravan Mineral Belt, Southwest Colorado

The Uravan mineral belt of southwestern Colorado has proved to be a significant source of uranium and vanadium. Since 1948, 63 million lb of U_3O_8 and 332 million lb of vanadium have been produced. About 90% of the ore has come from the upper sandstone ledge of the Salt Wash Sandstone Member of the Morrison Formation.

It has long been recognized that the Salt Wash was the product of fluvial sedimentation. More recently most authors have concluded that the Salt Wash was deposited as a braided stream system and some have proposed that the system was part of a large alluvial fan complex because of the arcuate pattern of the belt. However, results of a detailed sedimentologic analysis of this sequence in the Slick Rock district suggests that the entire Salt Wash including the uraniferous upper ledge was deposited in a fine-grained meander belt system.

Evidence for this interpretation is based on the high percentage (up to 54%) of fine-grained bioturbated and/or rooted flood-plain sediments; associated coarsening-upward crevasse splay or overbank splay deposits; and the abundance of fining-upward point bar sequences. The fine to medium-grained sandstones of the point bar deposits crop out as a series of discontinuous ledges numbering between 3 and 6 throughout the district. Each ledge consists of a number of abbreviated and complete point bar sequences ranging in thickness from a few feet to over 25 ft. These point bar deposits grade laterally and vertically into levee, abandoned channel, and crevasse splay assemblages and are interbedded with thick sequences of overbank mudstones, siltstones, and thin sandstones.

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Post-Middle Cretaceous Seismic Stratigraphy of Abyssal Southwestern Gulf of Mexico Basin

The post-middle Cretaceous sedimentary section in the abyssal Gulf of Mexico (7 to 8 km thick) is divided into seven major depositional sequences. The sequence boundaries represent widespread unconformities which are best observed along the base of the Campeche Bank. These depositional sequences provide a framework for reconstructing the geologic history of the area.

The oldest sequence (middle Cretaceous-early Tertiary) displays strong to weak, discontinuous reflections, interpreted to represent fine-grained pelagites and hemipelagites. The overlying three sequences (early Tertiary-Middle Miocene) are characterized by strong, high-amplitude, continuous to discontinuous reflections, and probably consist (predominantly) of sandy turbidites, as evidenced from cores recovered from the bottom of Deep Sea Drilling Project hole 90. Seismic facies analysis of these three sequences shows large convex-upward depositional buildups and numerous relict channels, suggesting deposition in large submarine fan complexes. The three youngest sequences consist of fine-grained turbidites and pelagites and display such features as prograding foreset beds deposited in the distal parts of submarine fans, and large-scale, dune-like features with wavelengths of 2 to 4 km. Westward thickening of most of the sequences indicates the source of the detrital sediments was to the west in eastern Mexico.

The southwestern Gulf of Mexico possesses excellent potential for hydrocarbon entrapment, especially in buried stratigraphic features such as the fan channel systems, and also in structural traps along the Mexican Ridges foldbelt.

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Multiple Barrier-Island and Deltaic Progradational Sequences in Upper Cretaceous Coal-Bearing Strata, Northern Kaiparowits Plateau, Utah

The Kaiparowits coalfield, Utah, contains reserves of 20 billion tons of coal which are confined to three major coal zones within the John Henry Member of the Straight Cliffs Formation (Upper Cretaceous). Mapping and subsurface work in the northern part of the coal-