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Reservoir Potential of Cretaceous Rocks, National Petroleum Reserve in Alaska

Petrographic, x-ray diffraction, and scanning electron microscope studies of core samples from Cretaceous units in nine wells from the National Petroleum Reserve in Alaska (NPRA), evaluated in the context of other available information, suggest that reappraisal of regional petroleum resource potential may be warranted. Evidence of secondary porosity development, together with the character of much of the Cretaceous section, indicates the potential for reservoir rocks to have been developed diagenetically. Heretofore, it has been held that significant reservoirs were unlikely in these units.

Consideration of other regional factors, including geothermal gradients, degree of maturation of organic materials, and structural and stratigraphic relationships, indicates potentially favorable conditions for development of secondary porosity elsewhere within the subsurface of NPRA, in rocks similar in nature to those studied. These same geologic factors are not inconsistent with regional potential for the generation and accumulation of hydrocarbons as well.

Continental, shoreline, and nearshore depositional environments are recognized as predominant throughout the Cretaceous in this region. Thus, associated organic material is likely to be predominantly terrigenous in character. This factor has led to consideration of the region as essentially "gas prone." However, recent reported work in NPRA and elsewhere indicates the possibility of generation of significant amounts of liquid hydrocarbons from at least some of these types of organic matter.

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Computerized Coal-Quality Prediction from Digital Geophysical Logs

A digital suite of geophysical logs, including gamma-ray, resistivity and gamma-gamma density, were used to develop and test a method for predicting coal quality parameters for the Wyodak coal in the Powder River basin of Wyoming. The method was developed by plotting the average of various log response increments (obtained from the contractor's 9-track digital tapes) versus the analytically determined ash, moisture, and Btu/lb for the same intervals of the coal seam. Standard curve-fitting techniques were then employed to determine which log response parameter most accurately predicted the various quality parameters. A computer program was written that reads 9-track, digital, log tapes and determines the coal quality parameters based on the relationships between log response and analytical values. The computer program was written in Fortran 77 for a VAX 11/780 minicomputer. The program was designed to run interactively with user-determined options depending on which geophysical logs were available. Preliminary results have been very encouraging to date with predicted versus analytically determined parameters being estimated to an accuracy of ± 300 Btu/lb (with the average being ± 150 Btu/lb), $\pm 2\%$ ash and $\pm 3\%$ moisture. This compares to ASTM lab-to-lab analytical standards of ± 100 Btu/lb, $\pm 0.7\%$ ash, and $\pm 0.5\%$ moisture. This prediction method is applicable to coals from other basins and offers promise as a cost saving tool for exploration and production uses.

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Oil and Gas Exploration and Development in Arizona

Recent oil and gas exploration activity has been widespread throughout Arizona. Development drilling has continued in the Dineh-bi-keyah and Teec-nos-Pos fields in the northeastern corner, and exploratory drilling continues to test potential Paleozoic reservoirs elsewhere on the plateau. Several shallow wells north of the Grand Canyon encountered shows and limited recoveries of oil from Permian and Triassic rocks.

The greatest activity has occurred along the "Overthrust trend" from northwestern to southeastern Arizona. Several million acres were leased and eight exploratory wells drilled along this trend. None were discoveries, but the presence of a Laramide thrust fault in the vicinity of Tombstone was established. The other tests have neither proved nor disproved the concept of the Overthrust belt in southern Arizona.

Recent discoveries in the nonmarine Tertiary and marine Paleozoic of southern Nevada have stimulated interest in the oil potential of similar rocks and structures in the Basin and Range province of Arizona, which are coincident with the Overthrust trend. Reported gas discoveries by Pemex in Miocene marine sediments of the Gulf of California have stimulated leasing in the Yuma area, where one uncompleted well is reported to be a potential producer.

The Pedregosa basin of extreme southeastern Arizona remains an area of great interest to explorationists because of the presence of a 25,000-ft (7,600-m) sequence of Paleozoic marine sediments similar to those of the Permian basin, and Cretaceous marine rocks, including coral-rudist reefs, similar to those that produce in Texas and Mexico.

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Evolution and Petroleum Potential of Mesozoic Marine Province of Northwestern Great Basin

The Mesozoic marine province of the northwestern Great Basin consists of late Early Triassic through Early Cretaceous volcanic, terrigenous clastic, and carbonate rocks. The rocks were deposited in a basin that was probably open to the north and bound on the west by the Sierran arc and on the east and south by continental uplands. Basin configuration was controlled by an enclave of noncontinental crust whose areal distribution and mechanical properties localized development of marine conditions in the region.

The deep axial region of the basin progressively shoaled during the Triassic and regionally extensive shallow marine carbonates and easterly derived clastics migrated westerly, overlapping deep marine clastics and subaerial to shallow marine volcanics interbedded with carbonates. In the Early Jurassic, depositional patterns changed. Basins, possibly related to regional extension, formed and accumulated locally derived coarse clastics and craton-derived quartz sandstones. Later, during continued synorogenic deposition, volcanogenic rocks were introduced in the west and migrated easterly.

Several hundred kilometers of stratal shortening associated with the Luning-Fencemaker thrust belt formed in response to northwest-southeast regional contraction, which began in the Middle or Late Jurassic and continued through the Early Cretaceous. Rocks deposited on the western flank of the basin did not experience northwest-southeast contraction and were separated from the thrust belt by a northwest-striking left-lateral transpressional fault, the Pine Nut fault. At about 100 Ma, thrusting ceased and transpressional motion reversed and became right-lateral.

Source-rock evaluation of thick, regionally extensive Upper Triassic carbonates has yielded TOC values ranging from 0.20 to 0.48 and conodont color indices (CAI 3.5-4.5) indicating paleotemperatures of about 180° to 250°C. Kerogen analysis indicates that the dominant organic matter is sapropelic to amorphous and in one area suggests the presence of the oil window. Hydrocarbon generation within the carbonate is a distinct possibility.

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Petroleum Occurrences Associated with Uinta Mountains, Utah and Colorado

The Uinta Mountains in northeastern Utah and northwestern Colorado are among the rare major structures in the western United States with east-west trends.

The east-west trend may have an ancestry in a Precambrian aulacogen and a lower Paleozoic arch. The area was quiescent until the Paleocene or Eocene when the mountain block began to rise and the basins on the north and south subsided. The mountain block cuts across north-south-trending arches formed during the Cretaceous, and it uplifted the belt of Sevier-Laramide overthrusts. The eastern part of the mountain block collapsed during the mid-Tertiary.

The range is an anticline with a core of Precambrian metasediments and steeply dipping Paleozoic and Mesozoic rocks on the flanks. Tertiary debris from the mountains overlaps onto older rocks.

Anticlines along the flanks of the mountains produce oil and gas from Paleozoic and Mesozoic rocks. Stratigraphic traps on the structures cut by the mountain block are enhanced by the intersection, and they produce from Cretaceous and Tertiary rocks. Uplift of the mountains was important in creating unconformity and stratigraphic traps in several oil and gas fields and in bituminous sand deposits.

Geophysical work and drilling have shown the flanks of the mountains to be thrust over or to overhang the adjacent basins.

The numerous structural intersections, overhanging flanks, and the facies changes caused by the Uinta Mountains provide good opportunities for continued exploration and success.

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Hydrocarbon Source Potential of Organic Facies of Lacustrine Elko Formation (Eocene-Oligocene), Northeastern Nevada

The Elko Formation, an Eocene-Oligocene lacustrine deposit cropping out in northeastern Nevada, is composed of two distinctly different organic-rich facies: a lignitic, gas-prone siltstone and an oil shale. A third organic-lean facies is represented by mudstones containing small amounts of fine-grained reworked kerogen. The deposit is thermally immature with respect to oil generation.

Geochemical indicators of the two major organic facies are distribution of steranes and diterpanes, presence or absence of a specific triterpenoid biomarker (gammacerane), kerogen form, and Rock-Eval pyrolysis parameters, S_2/S_3 and $(S_1 + S_2)/TOC$. The siltstones are characterized by: (1) vitrinitic kerogen, (2) pristane/phytane ratios slightly greater than 1.0, (3) relatively less negative $\delta^{13}C$ values for kerogen and C_{15}^+ hydrocarbons, (4) a predominance of C_{29} steranes and small amounts of rearranged steranes, (5) primarily C_{19} and C_{20} tricyclic diterpanes, and (6) a predominance of 17β(H)-22, 29, 30-trisnorhopane with respect to 17α(H) hopanes and 17β(H) moretanes. The oil shales are characterized by: (1) algal kerogen, (2) pristane/phytane ratios less than 0.5, (3) relatively more negative $\delta^{13}C$ values for kerogen and C_{15}^+ hydrocarbons, (4) a mixture of C_{27}, C_{28}, and C_{29} steranes and 4-methyl steranes, (5) a mixture of C_{19} to C_{26} diterpanes, and (6) a predominance of hopane and moretane and the presence of gammacerane. Hydrous pyrolysis of solvent-extracted oil shale produced a waxy oil-like bitumen whose more "mature" biomarkers and stable carbon isotopic composition resembled the unreacted oil shale.

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Bison Basin, Central Wyoming—Geologic Overview

The northeastern part of the Great Divide basin is a separate, unique, and until recently, little-explored subbasin sometimes called the Bison basin. It is bounded by the Wind River Mountains, Sweetwater-Granite Mountain foreland uplift, Lost Soldier-Wertz structure, and a little-studied very positive east-west structural arch approximately coincident with the Sweetwater-Fremont county line.

A comprehensive seismic, Landsat, and subsurface geologic examination or, better, dissection of the Bison basin was initiated in 1978. Numerous oil and gas prospects were delineated by this study. Since this small, 12 by 40 mi (19 by 64 km) basin is bordered by known reserves of 260 million bbl of oil and 90 million bcf of gas, these prospects proved to be a popular target of the drill bit. At least one of these prospects appears to be productive; others are currently being drilled.

The presence of major east-west wrench faults, a well-documented foreland uplift, until recently undrilled surface and subsurface structures, faults with throw measured in tens of thousands of feet, and an oil seep indicate possible additional hydrocarbon potential in the Bison basin that could exceed presently known reserves. Currently drilling wells and abundant already acquired reflection seismic data are the beginning step in an ongoing exploration program of an interesting, complex, and rewarding small basin with a lot of promise.

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Nacimiento Uplift and Its Similarity to Foreland Uplifts with Associated Production

The Nacimiento mountain front, east flank of the San Juan basin, is a well-documented foreland uplift. Based on detailed surface geology, its northern flank shows strong similarity to the Laramie Range and Owl Creek Mountain–Casper arch foreland uplifts of Wyoming. Petroleum has been discovered beneath these two uplifts by wells drilled through thrusted Precambrian rocks.

Recent exploration for petroleum trapped beneath Rocky Mountain foreland uplifts has provided a wealth of geologic and geophysical data not previously available. These recently published data, both from wells and reflection seismic profiles, show surface geology integrated with subsurface geology. Northern Nacimiento uplift surface geology is so similar to these other well-documented foreland uplifts that subsurface anticlines and/or faulted closures are very probably similar to productive subsurface structures under Wyoming's foreland uplifts. Such structures, if present under Nacimiento foreland uplift, could contain significant quantities of hydrocarbons considering the prolific production from stratigraphic traps in the immediately adjacent San Juan basin.

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Westernmost Structures of Idaho-Wyoming Thrust Belt: Structural Geology of Mt. Putnam and Vicinity, Northern Portneuf Range, Southeastern Idaho

Detailed mapping of Mt. Putnam in the Portneuf Range (Fort Hall Indian Reservation) has revealed the presence of previously unrecognized large-scale overturned folds and thrust faults characteristic of the Idaho-Wyoming overthrust belt. The structure of Mt. Putnam is controlled primarily by a northwest-trending overturned anticline-syncline system that is responsible for the inverted Precambrian Z–Cambrian stratigraphy of the area. Parts of the upper limb of the overturned anticline were sheared off and thrust over more gently dipping strata to the east. This "Bear Canyon thrust" places Precambrian Z–Cambrian Camelback Mountain Quartzite over the Cambrian-Ordovician carbonate sequence.

Mt. Putnam, as well as the rest of the Portneuf Range, is in the upper plate of the Putnam thrust that is exposed 7 km (4 mi) northeast of Mt. Putnam. The thrust is then displaced 5 km (3 mi) to the east by east-trending normal faults interpreted as reactivated tear faults. These faults have created windows through the upper plate Pennsylvanian-Permian Wells Formation, exposing the Ordovician Garden City Formation of the lower plate. South of this offset, the Putnam thrust resumes its southeasterly trend toward the Chesterfield Range and a possible juncture with the Paris thrust.

Ten kilometers (6 mi) west of Mt. Putnam in the Bannock Range are younger over older low-angle faults characteristic of the hinterland of the thrust belt. The area of transition between the two structural styles lies in the Pocatello Range north of Inkom, Idaho, and is presently being remapped in detail.

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Potential for New Stratigraphic Play in Mississippian Midale Anhydrite, Eastern Williston Basin

Midale (Mississippian) production was first indicated in 1953 in Saskatchewan, Canada. The productive unit was defined initially in the subsurface as the carbonate interval between the top of the Frobisher Anhydrite and the base of the Midale Anhydrite. This same nomenclature is used in this paper. In 1953, Midale production was found on the United States side of the Williston basin in Bottineau County, North Dakota. Later exploration extended Midale production westward into Burke County, North Dakota, in 1955. Cumulative production from the Midale is approximately 660 million bbl with 640 million from the Canadian side of the Williston basin.

Initially, hydrocarbon entrapment in the Midale was believed to be controlled by the Mississippian subcrop, with the Burke County production controlled by low-relief structural closure. Petrographic examination of cores and cuttings from the Midale in both Saskatchewan, Canada, and Burke and Bottineau Counties, North Dakota, indicates that production is controlled by facies changes within the unit. Use of a transgressive carbonate tidal-flats model best explains current production patterns and indicates substantial potential for additional production in eastern North Dakota and South Dakota.