the Edwards and equivalent units include burrowed and algal mudstone, skeletal siltite, skeletal calcarenite, rudist reef, and planktonic foraminiferal carbonate mudstone. Comparing the Cretaceous and Recent models, a change in reef frame from rudists to corals is the principal difference but minor faunal components in back-reef sediments are similar.

Rock samples are described quantitatively and compared vectorially. A reduction in the dimensions of the vector space is accomplished by factor analysis. Sample composition of the reef and associated facies is determined from the resulting rotated factor matrix. A factor score, computed by post-multiplying the transpose of the standardized data matrix by the square of the rotated factor matrix, emphasizes important rock components controlling the various facies. Thus, the number of critical components needed to outline the environments is reduced.

Parameters for the analysis include components modified by textural and structural adjectives (excluding burrowed carbonate mudstone). A second factor analysis was run using only important faunal components as outlined by the factor score. Environments outlined by the two analyses are very similar notwithstanding this reduction in the number of descriptive parameters. However, micro-sedimentary structures and textures are important in environmental interpretation of facies containing extinct faunas.

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UNIT REGIONAL VALUE AS BASIS FOR DECISION-MAKING IN SELECTING AN EXPLORATION STRATEGY

In a private-enterprise economy it is necessary that the search for, and development of, the non-renewable natural resources lead to a profit. The United States has produced such resources in the amount of \$458.101 billion in the period 1911–1964, or has returned \$151,569 per square mile. The value per square mile by states (1911–1964) ranges from $\$1 \times 10^6$ for Pennsylvania to $\$1.09 \times 10^4$ for Maine. The returns for Oregon (\$9,508)-Maine (\$10,906) and Minnesota (\$136,264)-Indiana (\$166,251) are similar despite very different geological environments between the similar pairs.

The objective of decision-making in selecting alternate exploration strategies is to select an optimal one; the potential value of a region is one attractive criterion. For example, a return for Alaska of \$3,483 per square mile is so far below the average expected value for the United States, and the geological environment of Alaska is sufficiently varied that a very large return from a systematic search procedure is almost guaranteed.

On this basis an examination of the value per unit area (or volume) of the earth's surface would pinpoint those areas which are over- and under-developed; coupled with broad geological comparisons among over- and under-developed areas this would indicate the areas of greatest future potential.

Systematic search procedure of a large region would supply an inventory of its natural resources and this may then be used for an orderly development of these resources; from the figures on past production per unit area of the United States, this search program also will almost certainly be a commercial success. Such a program would supply a wealth of geological information and rejuvenate local exploration for specific resources.

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STRATIGRAPHY AND PETROLOGY OF BECK SPRING DOLOMITE (PRECAMBRIAN), KINGSTON RANGE, SAN BERNARDINO COUNTY, CALIFORNIA

The Beck Spring Dolomite (Pahrump Group, upper Precambrian) has an average thickness of 1,300 feet in the type area, Kingston Range, San Bernardino County, California, where it is divided into three unnamed members. The lower member, 500–700 feet thick, is composed of alternating laminae of finely crystalline and medium-crystalline dolomite mosaic. Allochem ghosts are scarce but include intraclasts and pellets. The laminae are primary features modified by replacement and recrystallization. The middle member, a replaced oölite calcarenite, is 300–400 feet thick, composed of finely to medium-crystalline dolomite mosaic with abundant ghosts of oölites, pisolites, and pellet-lump intraclasts. Selective replacement by quartz is fairly common, as well as re-dolomitization in some places. The upper member, 400–500 feet thick, resembles the middle member, but is partly laminated, has been extensively replaced by chert, and is brecciated and recemented. Allochem ghosts are similar to those found in the middle member. Although contacts are gradational, the three members can be traced throughout the type area.

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HERITAGE OF PETROLEUM GEOLOGISTS

The heritage left us by the early petroleum geologists has been ignored and practically forgotten. Those geologists should be remembered not so much for their achievements, but for their methods of applying the geological science and their contribution to it. These methods and contributions should be "dusted off" and restudied, and once again used as guideposts for future thinking. Their intrepidity, firm persuasion, and complete dependence on sheer intellect created the basic concepts which were responsible for world-wide, successful petroleum exploration. It is stressed that, to meet exploration requirements of the future, the profession must develop more original ideas, and not be afraid to push those ideas forward into fruition. It is only then that modern geologists will emulate their predecessors, who, as pure scientists and free-thinkers, conquered their problems through their strong courage of conviction.

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GEOLOGIC SUCCESS AND ECONOMIC FAILURE (ARE WE HUNTING ROCKS OR DOLLARS?)

A geologic success that is an economic failure may range from a structurally high dry hole to a large and prolific gas discovery located in a sparsely settled area where there is neither a gas market nor prospects for getting one in the near future. If a project is not an economic success, it is, to some degree, an economic failure because there is no neutral ground. Economic success generally is measured by rate of return on invested capital and by total profit related to investment.

In addition to direct costs, the cost of money or capital and the cost of taxes are two very important factors affecting economic success, and must be considered in appraising a venture. The question, "How much oil or gas must be found for economic success?"

must be answered for any prospective area, and answers will range from a few thousand barrels to a billion barrels. Wells in "oil country" may be economically successful where each produces less than 10 BOPD. In contrast, wells located in some inaccessible places must produce more than 1,000 BOPD to avoid economic failure.

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DEPOSITIONAL ENVIRONMENT OF CHERRY CANYON SANDSTONE TONGUE, LAST CHANCE CANYON, NEW MEXICO

In the area of Last Chance Canyon the sandstone tongue of the Permian Cherry Canyon Formation, the subjacent lower San Andres, and the superjacent upper San Andres formations accumulated in a submarine canyon that extended from the Delaware basin margin northwestward into the Northwestern shelf. The Cherry Canyon tongue thickens basinward from the outcrop area which is 3–5 miles northwest of the Cherry Canyon basin margin. Early during the time of San Andres deposition, axial water depth in the canyon may have been as much as 600–1,000 feet. The presence of intertidal deposits in the lower Grayburg, including northwest-southeast flood and ebb-current directions, indicates that the canyon had shoaled sufficiently to become a tidal inlet.

Submarine-canyon deposits consist predominantly of narrow, deeply incised channels which are filled with massive, laminated, and current-rippled flow units, and numerous beds of conglomeratic carbonate-mudstone. The conglomeratic carbonate-mudstone beds commonly have hummocky upper surfaces and represent mud flow, slump, and avalanche deposits. In the lower San Andres and Cherry Canyon tongue, channel axes are inclined 4°–10°.

Orientation of channels, large and small current ripples, and aligned fusulines record a highly uniform southeasterly current flow pattern (*i.e.*, down the canyon axis).

The fauna of the canyon deposits is primarily a thanatocoenosis consisting of shallow-water marine invertebrates (fusulines, corals, bryozoans, brachiopods, mollusks, trilobites, crinoid columnals, and echinoid spines). Burrowing organisms have homogenized thick intervals. The sediments contain large amounts of plant material and other organic matter.

The canyon headed in a shelf lagoon on the broad Northwestern shelf of the Delaware basin. When the lagoon was constricted, clastics were prograded across it and intercepted by canyon heads. When the canyon was expanded little or no clastic sediment reached the canyon and carbonates accumulated on the shelf and in the canyon.

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RELATION OF PETROLEUM TO TECTONIC DEVELOPMENT OF ROCKY MOUNTAIN AND WESTERN PLAINS REGION OF NORTH AMERICA

Structural and depositional history of miogeosynclinal and cratonic areas of the Rocky Mountain-Western Plains region controls petroleum origin and entrapment. Extensive source beds associated with timely traps have characterized exceptional periods of petroleum entrapment—Devonian, late Paleozoic, and Cretaceous.

Late Precambrian marine sedimentary rocks were deposited in the Cordilleran geosyncline, and eastward extensions of the sea occupied parts of the region. In the western part of the geosyncline, deposition was continuous into Cambrian time, but on the east a period of erosion was followed by a Middle Cambrian-to-Early Ordovician marine invasion. Major tectonic elements that developed early in Paleozoic time include the Peace River, Alberta, and Transcontinental arches. Middle Ordovician-to-Silurian depositional patterns indicate early development of the Williston basin. The Upper Ordovician-Silurian section is the oldest oil-producing interval; significant production is restricted to the Williston basin.

Middle Devonian-Mississippian carbonates and evaporites record another major marine invasion. Upper Devonian reefs, with associated evaporites and marine shale, contain more than half the oil reserves of the northern part of the region (largely in Alberta). Oil and gas in Mississippian rocks are found in bioclastic carbonates (associated with anhydrite), at or near unconformities, and in large anticlines. Southwest of the Williston basin, Devonian and Mississippian oil production is limited, but the potential has not been adequately evaluated.

Late Paleozoic rocks have limited distribution in the northern part of the region. Pennsylvanian and Permian tectonic activity (Ancestral Rockies) was most pronounced in the southern part of the region. Pennsylvanian-Permian petroleum is trapped in a wide variety of clastic and carbonate structural and stratigraphic traps in the middle and southern Rockies, and offers many opportunities for future exploration.

Triassic miogeosynclinal deposits are restricted to the western edge of the region. Jurassic marine invasions from the Arctic extended as far south as the southern Rockies. Continental deposits dominate the Triassic and Jurassic sequence and account for the relatively small percentage of petroleum reserves in these rocks.

During Early Cretaceous time the sea again invaded from the north and in late Early Cretaceous joined a Gulf of Mexico sea. Coastal-plain, deltaic, and shallow-marine clastics that were deposited in this vast seaway form the source and reservoir rocks for some of the largest petroleum accumulations of the region. The present tectonic framework of uplifts, intermontane basins, and thrust faults on the west was formed during Late Cretaceous and early Tertiary time (Laramide orogeny). Many petroleum accumulations that had been stratigraphically trapped before the Laramide orogeny remigrated to their present structural positions. Reconstruction of migration paths should lead to significant additional petroleum discoveries in Cretaceous rocks.

Important petroleum accumulations have been found in Tertiary lake deposits of the middle and southern Rockies. Despite their relative shallowness, Tertiary rocks have been very incompletely explored.

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BIMINI LAGOON: MODEL CARBONATE EPEIRIC SEA

Bimini Lagoon contains a wide variety of marine environments, most of which have readily recognizable counterparts in the larger epeiric seas of the geologic past.

Located on the northwest margin of the Great Bahama Bank, Bimini Lagoon is a shallow area with