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 depths exceeding 5 feet in very few places; the area is 8 square miles. It is divided into an inner and an outer lagoon. The outer lagoon opens to the Gulf Stream through a narrow, deep natural channel. The outer lagoon also opens onto the Great Bahama Bank proper across wide, shallow flats, exposed at low tide. Tidal range in the lagoon is 2–3 feet; large volumes of water enter and leave the lagoon with each tidal cycle. In the lagoon, bottom communities, sediments, and currents are closely interrelated. Distribution of the communities is controlled by current action, and by the degree of tidal exchange of water with the Gulf Stream; the nature of the sediment is determined by the organism community present.

Most of the tidal exchange into the lagoon takes place through the deep channel. Current velocities exceed 2 knots. Consequently the channel is floored by bare rock, sorted gravel, and coarse sand. The margin of the channel is marked by an abrupt rise and current velocities of about 1½ knots. The strong current over the channel margin promotes luxuriant growth of *Thalassia*, which acts as a sediment trap, and prevents erosion. The sediment is fine-grained and poorly sorted.

Away from the channel, the current velocity is less than 1 knot, *Thalassia* is sparse, and wave action affects the nature of the sediment. Many benthonic communities can be recognized.

The inner lagoon is an isolated hypersaline water mass. Current velocities are very low. Most of the bottom is covered by bare sand with a few species of algae, but the richest molluscan faunas occur here.

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A.A.P.G. PUBLIC INFORMATION COMMITTEE—WHAT IT CAN DO FOR GEOLOGY

The A.A.P.G. constitutes an enormous reservoir of knowledge, experience, material—and money—which can and should be used to aid in the dissemination of geological information to an interested public.

It is not now effective in that area, largely because the emphasis always has been on geologist talking to geologist—not on geologist talking to public. The budget, the interest, the organization, and the function of the A.A.P.G. emphasize this point.

Furthermore, in a world which is made by scientific knowledge and which, if it is to be destroyed, will be destroyed by misapplication of scientific knowledge, a scientifically alert populace is essential to human survival. Public information on scientific matters is, therefore, not an opportunity but an obligation—the greatest obligation.

What geologists have failed to acknowledge is that the future of the A.A.P.G.—of petroleum geology—of geology in general—rests largely with non-geologists. To the degree that geologists interest and educate the public—the ultimate decision-makers—the profession will be rewarded by public understanding and support.

Public information—public education—is an enormous task, but fortunately there is one route open to all the public—the public schools. Other routes lead to various groups of adults and children. These routes need only to be used.

The A.A.P.G. as an organization with a vast and competent membership, a wide geographic distribution, and the money to do whatever must be done has the obligation to take the lead in the area of public information in geology.

The opportunity is there—the capability is there—only the awareness is limited.

Geologists can remove that remaining limitation, for it is of their own making.

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EDUCATION FOR A SCIENTIFIC AGE

Science will play an increasingly significant role in the lives of educated people in the years ahead. For this reason, young people going through school now, and those who are yet to be educated, should be getting a basic understanding of the language of science as part of their general education. Most students now in schools, including colleges and universities, are not getting the kind of education in science which will prepare them for life in a scientific age. Science is being presented to them as a body of facts and techniques. Consequently students have little, if any, opportunity to develop an understanding of the basic principles and concepts common to science.

Facts and techniques have a short half-life—a way of becoming obsolete in a hurry. Individuals whose science training has been largely fact- and technology-oriented also become obsolete in a hurry. It is grossly unfair to the young people who are now being educated and those who will be educated in the future to burden them with obsolete training in science. New materials and new courses, which emphasize the "structure or broad unifying principles" of each science discipline, need to be developed and teachers trained to present science as inquiry. Sound training in science should begin in the early school years to provide children with a conceptual framework which they can use as a base for assimilating and understanding later experiences in science.

The new elementary and secondary-school science curriculum materials provide a base on which a sound curriculum can be built, but much remains to be done if tomorrow's citizens are to be scientifically literate.

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BASIC FRAMEWORK, DEFORMATION, AND PETROLEUM IN MIDDLE EAST

The most prolific oil-producing area of the Middle East lies on the southern flank or extension of the ancient Asiatic Tethyan geosyncline and was at least partly subjected to the same tectonic forces which produced the Alpine-Taurus-Himalayan Mountains.

The importance of these tectonics is second only to depositional conditions in the Arabian-Persian Gulf geosyncline during which occurred the proper distribution of salt and anhydrites in time and place. To emphasize the importance of the evaporites, most if not all of the large gentle structures of Arabia and the southern gulf are salt-generated and the remaining structures in Iran and Iraq were created or modified by plastic deformation of salt and anhydrite. The Hith Anhydrite caps Jurassic oil in Arabia; the Fars Anhydrite caps Cretaceous Miocene oil in Iran and Iraq.

Late Tertiary deformation and fracturing of the Cretaceous Bangestan and Miocene Asmari Limestones created the long lines of story-book folds of the Zagros Mountains and oil reservoirs in Iran and Iraq. Fractured Bangestan oil reservoirs leaked much of their contents upward into fractured Asmari reservoirs where oil finally was trapped by the plastic Fars Formation.