

National Petroleum Reserve in Alaska by the Naval Petroleum Reserves Act of 1976 and jurisdiction was transferred to the Secretary of the Interior. Beginning June 1, 1977, the U.S. Geological Survey was charged with the responsibility to (1) continue the petroleum exploration program, (2) expand production of natural gas at Barrow for local consumption, and (3) environmentally rehabilitate those parts of the reserve disturbed by previous exploration and construction activities.

All of these activities are accomplished through a contract with Husky Oil NPR Operations, Inc.; the activities were previously supervised by the U.S. Navy in 1975 and were assumed in 1977 by the Department of the Interior. The U.S. Geological Survey provides technical and contract supervision and makes the final determination of the exploration strategy. Sixteen plays have been defined on the basis of geological and geophysical parameters to assess the petroleum potential and aid in management and land-use decisions.

From 1974 to June 1, 1977, the Navy drilled seven test wells and completed 7,680 line mi (12,360 line km) of a planned 26-well and 10,000 line-mi (16,093 line km) seismic program. All test wells were drilled in northern NPRA along trend with Prudhoe Bay. At the W. T. Foran test well on the Arctic Coast, the Sadlerochit Formation (the principal reservoir at Prudhoe) had good porosity and permeability with residual oil. The other wells had minor shows of oil and/or gas.

Twelve test wells were included in the program for fiscal years 1978 and 1979. Eight have been completed with shows of oil and gas; the J. W. Dalton well on the Arctic Coast produced a few barrels of heavy oil, but there were no commercial discoveries. A five-well exploration program is projected for fiscal year, 1980.

One exploratory and two development gas wells were drilled at Barrow in 1978. The two producible wells in a new section of the Barrow gas district were tied into the pipeline system that delivers gas to the Barrow communities.

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Mississippian Shelf Margin and Carbonate Platform from Montana to Nevada

The Kinderhookian to middle Meramecian history of a carbonate platform and shelf margin, extending from Nevada to Montana, is documented through four time-rock correlation charts and five successive maps that are synchronized by foraminiferan, conodont, and coral zonations. The platform was bordered on the west by a starved basin, a flysch trough, and orogenic highlands. The history of platform development is an integral part of the sedimentary cycle of the deep-water Deseret starved basin. Antler orogenic activity produced epeirogenic movements on the craton, which affected sea level and caused episodic progradation and retreat of the carbonate shelf margin. The sequential history is: (1) in earliest Mississippian time a narrow, northeast-trending seaway bordered by low coastal plains received mostly fine clastic sediments; (2) during late Kinderhookian time, a carbonate platform and shelf margin formed as

a result of eastward expansion of the seaway; (3) during early Osagean time, the shelf margin retreated and a broad, gentle (less than 0°5') clinoform ramp developed; (4) during middle Osagean time, lowering of the basin and craton and rise of sea level changed the pattern and sedimentary regime of the carbonate platform. Progradation of the shelf margin over the former ramp resulted in maximum expansion of the platform concurrent with maximum deepening of the starved basin. The foreslope attained a maximum steepness of 5°; (5) in middle Meramecian time, uplift of the craton and lowering of sea level caused shoaling of the carbonate platform and development of a sabkha landward. With increased uplift a karst plain developed over most of the former carbonate platform, and some cratonic sands were transported westward by streams into the basin. Meanwhile, filling of the flysch trough allowed eastward spillover of distal-flysch sediments to almost completely fill the basin.

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Petroleum Possibilities in Altar Desert, Sonora, Mexico

A late Miocene-early Pliocene marine basin has been identified in the northwestern corner of the State of Sonora, Mexico. The existence of the Altar basin has been established by geophysical means. Its stratigraphy and hydrocarbon generation potential are known from the geologic history of the adjoining areas.

The geology of the Altar basin is compared to basins of the same age in California which have been proven to contain more than 27 billion bbl of oil. The San Andreas fault system is a very important factor in the oil possibilities of the region.

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Foreign Frontiers—An Overview

Undiscovered potential in foreign frontiers is believed to be substantial. This potential is located in moderate and harsh physical environments. Very little exploration has been conducted in these basins and the majority are classified as essentially unexplored. These areas are not geologic mysteries and it is highly possible that they can contribute large increments of discovery. The attractive possibilities which exist in these foreign frontiers must not be overlooked, therefore, all must be adequately explored. Major exploration activities should begin in these areas as soon as possible if they are to have any impact on new reserves and production before the end of this century. Governments controlling harsh frontier areas are beginning to recognize the high costs and risks incurred in exploring and operating therein and are beginning to offer greater incentives to those willing to undertake the environmental challenges.

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Application of Ecologic Studies of Living, Algal Symbiont-Bearing Foraminifera to Paleocologic Interpretation

Recent studies of the biology and ecology of large, living, algal symbiont-bearing foraminifera have vastly improved the potential for use of these organisms for paleoecologic interpretation and as sediment tracers. Using assemblage composition, size, shape, and lamellar thicknesses, the depth and habitat of the biocoenosis can be predicted from the thanatocoenosis. Robust, commonly spinose, forms are characteristic of the turbulent intertidal and shallow subtidal zone of modern carbonate environments. Robust forms are succeeded by intermediate forms on reef and lagoon slopes. Flatter, larger forms characterize depths approaching the limits of the euphotic benthos. Presence or absence of algal symbiont-bearing species also indicates the relative primary productivity of the paleoenvironment.

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Deltaic Systems and Associated Growth Faulting of Vicksburg Formation (Oligocene), South Texas

The Vicksburg Formation (Oligocene) in south Texas contains several geopressed giant gas fields. These fields occur in sandstone facies to a depth of 17,000 ft (5,182 m) and are associated with stacked deltaic systems complicated by growth faults.

Analysis of cores and electric logs from the McAllen Ranch field (Hidalgo County, Texas) indicate that the sandstones were deposited in shallow water. Cores from the field contain root traces and plant debris, trace fossils (e.g., *Ophiomorpha*), and other evidence of shallow-water deltaic environments. Maps of net sandstone thickness show outlines of high-constructive lobate deltas. Depocenters are developed along growth faults.

The structural style of growth faulting in the Vicksburg Formation is due to a combination of rapid sedimentation and diapirism of shales from the underlying Jackson Group. The displacement and number of growth faults increase with depth. Alternation of down- and up-to basin faults is characteristic, with tilting of beds related to thickness variations of depositional units.

A series of coarsening-upward sequences are recognizable on electric logs. These sequences have a maximum thickness of 1,500 ft (457 m) and good lateral continuity in the middle part of the formation, but are interrupted by numerous growth faults in the lower Vicksburg. Growth faults over structural highs associated with shale tectonism create gas traps for many gas fields.

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Depositional and Tectonic Evolution of a Basement-Bounded, Intracratonic Basin, Palo Duro Basin, Texas

Continental collision along the southern margin of the North American continent during Pennsylvanian time created northwesterly directed compressional stress that was transmitted to the continental interior along boundary faults of the southern Oklahoma and

Delaware aulacogens. As a result, numerous basins and uplifts were formed in the aulacogens and edges of the craton, including the Anadarko, Delaware, Midland, and Palo Duro basins, the Amarillo-Wichita uplift, Matador-Red River arch, and Central Basin platform.

The Palo Duro basin is a basement-bounded, or yoked, shallow intracratonic basin filled largely with Pennsylvanian and Permian strata. Its tectonic-depositional history may be divided into four stages: (1) formation of the basin between basement blocks (Matador arch, Amarillo uplift) that were uplifted along boundary faults of the southern Oklahoma aulacogen during Early Pennsylvanian time, and subsequent deposition of basement-derived, fan delta "granite wash" around uplifts flanking the basin; (2) planation and burial of uplifts through Early Permian time, and infilling of the deep basin with shelf-margin carbonate and basinal facies; (3) encroachment of continental red-bed facies from sources in New Mexico and Oklahoma and deposition of thick Middle to Upper Permian marine evaporites in sabkha environments; (4) marine retreat during Late Permian time and development of a Triassic lacustrine basin brought about as a result of continental rifting and drainage reversal.

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Utah-Arizona Hinge Line-Thrust Belt—Potential New Hydrocarbon Province

The Overthrust-hinge line belt of central Utah is part of the Rocky Mountain orogenic complex. When viewed in its entirety, the hinge line extends many miles to the north and south, representing the western margin of the North American continent during Paleozoic time. Except for occasional eastward transgressions of the seas onto the continental shelf, the position of this transition zone remained closely confined through Triassic time.

An ancient continental margin with superimposed overthrusting and the ability to successfully explore such a setting have excited the petroleum industry.

The Overthrust-hinge line play has now been extended from southwest Utah-northwest Arizona to southeast Arizona and into Mexico. Recent geologic and geophysical work in Arizona indicates the presence of deep troughs and large anticlines that are locally covered by multiple thrust plates.

Much of southwest Arizona has previously been defined as part of the Basin and Range province. Many Tertiary-filled basins are bounded by mountain ranges (horsts) made up of allochthonous Mesozoic, Paleozoic, and Precambrian strata.

Some of the most favorable areas to explore for oil and gas have been defined within and below the allochthonous sequences. Deep regional grabens and rifts were probably filled with mostly marine sediments and some salt deposits. We believe that some of these salt sequences will be documented within the Jurassic system.

The marine sediments in the Sonora trough, just south of Arizona in Mexico, are more than 45,000 ft