

coastal barrier sands and downdip progradational channel mouth bars; principal traps are stratigraphic.

Continental-slope systems that make up the distal parts of Gulf basin terrigenous wedges have been penetrated only in younger units of the basin or in very deep wells. Systems are comparable in scale, composition, and structural association to modern continental-slope deposits of the northwestern Gulf. Thick and rapidly deposited delta systems of the Gulf basin mobilized underlying deep-seated salt. Principal flowage was toward the distal front of the prograding systems resulting in distinct diapir fields coextensive with continental-slope systems; minor flowage was toward thinner interdeltaic areas. Salt mobilization was a significant control in determination of facies fabric and growth faulting. Younger offlapping units inherited and perpetuated the tectonic grain established by underlying systems.

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GEOLOGY AND DISCOVERY OF PRUDHOE BAY FIELD, EASTERN ARCTIC SLOPE, ALASKA

The Prudhoe Bay field is one of the largest oil fields in North America with estimated reserves of 5-10 billion bbl. Reconstruction of the geologic history suggests that the combination of geologic controls on the field probably will not be found elsewhere.

Hydrocarbons are present in Jurassic and Permo-Triassic sandstone and Pennsylvanian-Mississippian carbonate reservoirs. These strata, locally folded into a west-plunging, faulted anticlinal nose, are truncated by a pre-Cretaceous unconformity resulting in the subcrop of progressively older reservoirs on the northeast. Most of the hydrocarbons are trapped below the unconformity in the Permo-Triassic Sadlerochit Formation. This reservoir is present in the field area as a uniform wedge of alluvial-deltaic sandstone and conglomerate.

The pre-Cretaceous clastic reservoirs were derived from the ancient Beaufort arch, north of the present coastline. In contrast, the unconformably overlying Cretaceous and Tertiary sandstone and marine shale were derived from uplifts on the steep south flank of the basin, near the present Brooks Range.

In 1944, the U.S. Navy initiated the first extensive Arctic exploration program. This program was carried on for 10 years at a cost of over \$55 million. Drilling was conducted principally in 2 areas, the Barrow high and the Arctic Foothills belt. The Umiat field, on a foothills anticline, was the largest oil discovery with estimated reserves of 20-100 million bbl in Cretaceous sandstones. The high finding costs experienced by the Navy tended to discourage industry exploration.

In 1963, several wells were drilled jointly by BP Exploration Company (Alaska) Inc. and Sinclair Oil and Gas Company, in an attempt to extend the foothills Cretaceous play. BP-Sinclair and Union Oil Company of California each later drilled unsuccessful Paleozoic tests near the Arctic coast.

In 1964 Humble Oil and Refining Company joined Richfield Oil Corporation (now Atlantic Richfield) in evaluation of federal acreage south of Prudhoe Bay. Regional seismic data and federal leasing policy in existence at that time caused Humble to shift the exploration effort from the federal acreage to the eastern Arctic coastal area. The major part of the Prudhoe Bay structure was leased jointly by Humble and Richfield, and by BP at the State of Alaska sale in July 1965. The ARCO-Humble Prudhoe Bay No. 1 State was completed as the discovery well in June 1968.

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PERMIAN ROTLIEGENDES OF NORTHWEST EUROPE

The basal Permian Rotliegendes redbeds of the North Sea area, in the Northwest Europe Permo-Triassic basin, contain some of the world's largest gas reserves. Groningen field, The Netherlands, discovered in 1959, has proved plus probable gas reserves of 66.7 Tcf ( $1,904 \times 10^9 \text{ m}^3$ ). Smaller Netherlands and northwestern Germany fields contain proved plus probable gas reserves of 8.4 Tcf ( $240 \times 10^9 \text{ m}^3$ ); North Sea gas fields have 22.5 Tcf ( $700 \times 10^9 \text{ m}^3$ ).

The Northwest Europe Permo-Triassic basin is north of the Variscan mountain chain, which was folded during Pennsylvanian time and which extends from the southern British Isles to central Germany. North of the Variscan mountain chain is a block-faulted foreland on which the Mid-North Sea and Fyn-Grinsted highs formed.

The WNW-ESE-trending Northwest Europe Permo-Triassic basin is between these highs on the north and the Variscan chain on the south. A second Permo-Triassic basin, whose boundaries are not defined, may lie north of the Mid-North Sea and Fyn-Grinsted highs.

The sediments of the basal sedimentary unit of the Permo-Triassic basin, the Rotliegendes, were derived mainly from the Variscan mountain chain. As this mountain chain rose and was eroded, increasingly arid conditions predominated. As a result, the Rotliegendes is primarily a desert deposit, though marginal fluvial and local evaporitic sediments are present. When the arid climatic depositional conditions and desert origin of the subsurface Rotliegendes were recognized, it became imperative to develop criteria for the recognition of different desert-arid sedimentary facies, so that an exploratory program could be developed. Modern desert studies were made, and three major sedimentary facies were recognized: (1) wadi (intermittently flowing streams) gravel and sand which border highlands; (2) eolian sand, derived from deflation of wadi deposits and outcrops, forms barchan dunes (probably formed from intermediate-velocity winds) and linear (seif) dunes, parallel to the dominant wind direction (probably formed from high-velocity winds); and (3) sabkha deposits of both the inland (wadi or oasis types) and coastal varieties, including both layered and interstitial evaporitic deposits.

All three facies have been recognized in the Rotliegendes.

Generally, the wadi facies are basal or peripheral within the basin. Most are broad alluvial fans along the northern flank of the Variscan mountain chain. The eolian facies is widespread—some as thick as 660 ft (200 m). The lack of linear dunes suggests intermediate wind-velocity values. Directional data indicate a west-to-east wind flow, as in the modern horse-latitude deserts. Sabkha facies also are widespread, particularly in the upper and central parts of the basin. These include interior-desert sabkha deposits, where wadi waters reached the surface, as well as coastal sabkha deposits, the precursors of the later Permian Zechstein sea.

Although the environmental conditions which produced the Rotliegendes persisted locally, these environmental conditions eventually were replaced by the rapid transgression of the Zechstein sea when the basal Kupferschiefer (Copper shale) and associated marine evaporite deposition began.