FOR EDITOR (1971–1973)
Frank E. Kottlowski, Socorro, N.M.

Biographies of the candidates will be published in the December *Bulletin*. Ballots will be distributed to the active membership on or about January 15, 1971. The balloting will close on March 15; ballots postmarked thereafter will not be counted.

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## AAPG DISTINGUISHED LECTURE TOUR ABSTRACTS

CRAM, IRA H., 2 Sutton Place South, New York, N.Y.

Petroleum Potential of United States

Important oil and gas fields continue to be found in unusual and surprising geologic environments. Each discovery improves the petroleum geologist's understanding of the habitat of oil, and sharpens his oil-finding ability. An adequate supply of domestic petroleum in the future depends on unique discoveries to a greater extent than in the past.

The existence of many more unusual accumulations and others at customary or greater depths in both the less explored and more thoroughly explored areas is not doubted by the authors of the Association's Memoir 15, "Future Petroleum Provinces of the United States." They have approached the problems of the country's petroleum potential positively, not negatively, and have expressed their opinions qualitatively and generally quantitatively. An enormous amount of old and new geologic and other exploratory data has been assembled which should provoke alternate opinions lending to additional discoveries.

The extent to which the vast proved reserves of petroleum resources are reduced depends on the impact of ever-changing economic and political events on the rising tide of technologic competence and knowledge. The role of the petroleum geologist as earth scientist, explorer, and salesman is destined to grow in importance, particularly onshore in the conterminous United States where a significant percentage of the visualized undiscovered crude oil and natural gas is in stratigraphic traps, combination stratigraphic and structural traps, reefs, and complex structural situations.

Clearly, a great deal more exploratory drilling is needed, not only to explore such traps, but to provide much needed geologic and production data for the large undrilled areas. To the extent industry and government policies militate against expanded exploration, particularly drilling, a large part of the petroleum resources will lie uselessly in the ground.

ELLISON, SAMUEL P., JR., Consultant to Esso Production Research Co., Houston, Tex.

Geology of Middle East

A coincidence of sedimentologic, stratigraphic, and structural conditions is the reason for the occurrence of more than 10 supergiant petroleum fields in the Arab countries bordering the Gulf of Arabia. Of the known petroleum reserves of the world, 60% are in the large asymmetric Mesozoic-Cenozoic basin northeast of the Arabian shield. Marine shale; siltstone; sandstone; limestone; evaporites, including salt, dolomite, gypsum, and anhydrite; and nonmarine strata make up a complex stratigraphic section ranging from Cambrian to Holocene. The large petroleum reserves are in Mesozoic and Cenozoic sandstone and limestone where traps may be controlled both by sedimentary facies and structure. A wide variety of faulting and folding have accompanied the formation of the basin and of special note are the great overthrusts with large-scale plastic deformation. Salt intrusions are abundant in the southern part of the Gulf of Arabia and in the southern Zagros Mountains.

The Gulf of Arabia is along the border and parallel with the edge of the Arabian shield where it abuts the Tethys fold belt. Plate-tectonic concepts suggest a squeezing together (compression) of the Arabian shield and the main mass of Asia. Possibly this particular structural, stratigraphic, and sedimentologic geologic model should be a guide to geologists seeking other future petroleum provinces.

FISHER, WILLIAM L., Bur. Econ. Geol., Univ. of Texas, Austin, Tex.

Ancient Delta Systems of Gulf of Mexico Basin

Thick, offlapping, terrigenous clastic wedges make up the principal fill of the Gulf basin. Proximal parts of these wedges consist of paralic deposits formed either as large-scale high-constructive delta systems (with related strike systems) or as a series of smaller high-destructive delta systems. Distal parts accumulated as continental slope deposits associated with salt-diapir fields at the terminus of prograded paralic systems.

High-constructive delta systems (*e.g.*, lower Wilcox, Yegua, and Jackson) are comparable in scale and facies to Holocene Mississippi deltas. They were supplied by rivers with large-volume sediment discharge; fluvial facies are concentrated locally along the basin margin. These deltas consist dominantly of fluvial and fluvially influenced deposits, with extensive coal-bearing delta-plain facies, thick progradational delta-front sand facies, and very thick, organic-rich prodelta mud facies. Progradational sand facies show either lobate or elongate patterns in plan. Delta systems of this type supported extensive strike-fed systems comparable to strandplain and barrier-bar systems of the Holocene northwestern Gulf Coast.

High-destructive delta systems (*e.g.*, upper Wilcox and Frio) are analogous to the Rhône and other Holocene deltas with significant marine modification (chiefly wave action) of fluvially introduced sediments. These deltas were supplied by numerous, relatively small rivers with moderately high sand load; updip fluvial facies persist along the entire basin margin. High-destructive deltas are composed of a series of sand bodies with thickness axes roughly parallel with regional strike. Each delta consists of local progradational sand facies (channel and channel-mouth bars) flanked marginally by extensive sand units reworked from channel-mouth bars. Associated prodelta mud facies is moderately thick to thin. High-destructive deltas supported local rather than an extensive strike-fed system.

Principal oil and gas reservoirs in high-constructive deltas occur in the progradational delta front sands with trends controlled by geometry and distribution of these lobate or elongate sand bodies. Vertical stacking of sand bodies is common, resulting in multipay fields. Trends within these delta systems are discontinuous along strike as facies between main prograded lobes consist mostly of mud and "tight" sand. Attendant growth faulting, salt doming, and mud intrusion cause structural traps. In related barrier-bar and strandplain systems trends are regionally persistent and stratigraphic traps are common. Oil and gas trends in high-destructive deltas are defined by local cuspate-trending 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.

MORGRIDGE, DEAN L., Humble Oil & Refining Co., Los Angeles, Calif.

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.

GLENNIE, K. W., KSEPL, Rijswikj, The Netherlands

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 $\times$ $10^9$ $m^3$). Smaller Netherlands and northwestern Germany fields contain proved plus probable gas reserves of 8.4 Tcf (240 $\times$ $10^9$ $m^3$); North Sea gas fields have 22.5 Tcf (700 $\times$ $10^9$ $m^3$).

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 fluviatile 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 with 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.