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LOWER PALEOZOIC PALYNOMORPH PROVINCES AND PALEOCLIMATE

Lower Paleozoic palynomorphs show a large morphologic diversity and are, generally, extremely abundant in unmetamorphosed marine sediments, yet the stratigraphic ranges and regional distribution of most taxa still are poorly known. Only now are data becoming available to permit the determination of the distribution of palynomorphs in the Silurian System and, to a much smaller extent, in the Upper Ordovician and Lower Devonian as well. An embryonic palynostratigraphy is being constructed for the Silurian. Its zones are based on (1) the appearance of miospores and on their increasing morphologic complexity, and (2) the ranges of selected acritarch and chitinozoan taxa. Megafossil evidence, mainly from graptolites, fixes these ranges. The palynostratigraphic system, crude as it may be, appears to be valid for the areas bordering the Atlantic Ocean.

Several contrasting, "worldwide," acritarch biofacies existed in the regions bordering the Atlantic, in Arctic Canada, and in Siberia during the Silurian. From the megafossil evidence these biofacies are judged to be contemporaneous; they are regularly and predictably time-transgressive. On a regional scale the facies are not significantly correlative with such local differences in sedimentary realm as are expressed in changes in lithology, but because lineations based on compositional differences in acritarch spectra seem to be roughly parallel with lithotope boundaries, a causal relation between them is suspected.

On a Wegenerian palinspastic reconstruction of Atlantic Pangea, the parallelism of biofacies lineations, lithotopes, and perhaps even paleomagnetic latitudes is apparent. This parallelism is interpreted as reflecting regional differences of paleotemperature. For example, Silurian acritarch biofacies boundaries would be paleoisotherm-parallel, and therefore paleolatitude-parallel. Arguments are: (1) on Atlantic Pangea there was an epicontinental sea with a minimum width of at least 45°. In such a sea the latitudinal temperature gradient must have been quite pronounced; (2) biofacies regionally are continuous and have a simple and regular geometry; (3) lithotopes and biofacies are parallel and their boundaries follow small circles; (4) regional biofacies are independent from such short-living factors as islands, troughs, and local lithology changes; (5) biofacies form a cross-continental chronologic and regional homotactic arrangement; and (6) the biofacies show a time-transgression which follows the polar trajectory as extrapolated from Devonian and Ordovician pole positions.

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EXPLORATION AND DEVELOPMENT OF PETROLEUM RESOURCES, 1970–1975

The annual growth rate in domestic and free-world demand for petroleum from now until 1975 can be estimated at 5 and 7.5% respectively, resulting in 19 million and 57 million bbl/day total demand in 1975.

However, the areas which will supply this demand, especially those in the United States, can hardly be determined because of the bewildering variety of political, legal, and environmental factors—as contrasted to purely economic ones—which will be of critical influence. Therefore it is difficult to forecast definitely the areas and the amounts and costs of exploration and development, as well as prices and earnings.

One thing is certain, however, there will be a growing shortage of domestic crude and an increasing dependence on foreign supplies. Both the cost and dependability of the latter are questionable in view of political considerations and the actions of OPEC.

Any interruption of our foreign energy supplies would have a dramatic effect on our economy and security and would show the dangerous results of the lack of a coherent and positive domestic energy policy.

There are very few discovered but undeveloped oil reserves in the United States except on the North Slope, and those probably cannot be made available until 1976. Though the recent NPC-AAPG study indicates almost 200 billion bbl of expectable recoverable reserves, any large increase in exploratory effort to find them cannot have any great effect on our crude deficit before 1975 because of the necessary lead times. It is obvious, however, that steps should be taken immediately to encourage or to cause such an increase so that the period of danger to our economy and security will be as brief as possible.

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JAVA SEA PLATFORM AND MADURA BASIN, CENTRAL INDONESIA

The Pertamina-Cities Service, Ashland, Monsanto, Robina contract area covers Madura Strait, parts of the Java and Bali Seas, and the islands therein—about 57,700 sq mi. The Java Sea sector is part of a geologic platform, the remainder covers the Madura basin.

The Java Sea platform is the southeastern part of the "Sunda shelf" and occupies the stable region between Borneo and East Java. It consists of a basement complex of pre-Tertiary sedimentary, metamorphic, and igneous rocks overlain by varied thicknesses of Tertiary strata. Recurring Tertiary stresses created several prominent downwarps, shatter zones, and broad uplifts. Local folds tend to be associated with fault zones. Transgressive early Tertiary sediments filled the bottoms of the troughs, and were involved in strong tectonic activity. Subsequent sedimentation was more widespread and limestone deposits became important, especially in the southern and eastern parts of the platform. Extensive accumulations of younger Tertiary regressive strata suffered diminishing deformation. "Biohermlike" anomalies of several ages are abundant on the platform in the central part of the area and less common in the eastern half.

The Madura basin is the deeper, open-ended, offshore extension of the East Java basin which bounds the Java Sea platform along its southern margin. Several lines of compressional folds are present on the northern flank and localized areas of older folding adjoin the north coast of Java. Madura Island, an anticlinorium, and several islands on trend with it are upfaulted or upwarped parts of the northern flank of the Madura basin.

Geophysical surveys include 25,000 mi of seismic profile. Twelve exploratory wells were drilled on the platform part of this contract area and 8 wells were drilled in the contract area on the north. Numerous early-day tests were drilled on Madura Island; a recent well in the offshore part of the Madura basin failed to reach its primary objectives. Oil and gas shows have been common throughout the region and exploration continues although tests have resulted only in noncommercial flows.

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TRONA AND HALITE RESOURCES IN WILKINS PEAK MEMBER OF GREEN RIVER FORMATION, GREEN RIVER BASIN, WYOMING

The Wilkins Peak Member of the Eocene Green River Formation is estimated to contain about 100 billion tons of trona ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$) and halite ($NaCl$) in more than 40 beds at depths as great as 3,500 ft in a 1,300-sq-mi area in the Green River basin of Wyoming. Incomplete data on these beds indicate that trona comprises 80–85% of the total, and that individual beds range up to 40 ft in thickness and up to 900 sq mi in area. Trona, a major source of sodium carbonate, is mined at 4 localities. At least 30 billion tons of halite-free trona, possibly as much as 40 billion tons, are contained in beds that are at least 6 ft thick under an area of at least 25 sq mi. Halite is present either intermixed with trona, or interlayered with trona (in layers up to 20 ft thick), or rarely as halite beds with little or no trona. Halite is present only in the southwest part of the trona-halite area, only in 14 beds in the lower half of the Wilkins Peak Member, and only as part of, or continuation of, a trona bed.

The beds of trona and halite are evaporite deposits from a large alkaline lake that occupied the southern end of the Green River basin at the beginning of Wilkins Peak deposition, then gradually expanded northward. Beds of trona, or trona-halite, were deposited across successively larger areas until the middle of Wilkins Peak deposition, when trona deposition shifted northward and halite deposition ceased.

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ELECTRICAL ACCESSORY CURVES—NEW TOOL FOR SUBSURFACE CORRELATION

Electrical accessory curves facilitate recognition of subsurface formations from electrical logs and more accurate physical correlation of rock units. Two types of electrical accessory curves, which show the variation in percentage of thickness of sandstone (SP), and low resistivity mudstone as a function of depth, have been used to examine Laramide deformation in the Powder River basin of Wyoming during deposition of the thick (8,000 ft), nonmarine Late Cretaceous and Tertiary deposits which filled the basin.

The Laramide orogeny did not start in this part of Wyoming in late Maestrichtian, during deposition of the Lance Formation, and was only weakly active in early Paleocene time, during deposition of the Tullock Formation. Strong deformation started in middle Paleocene with subsidence along the axis of the basin and deposition of fine-grained Lebo mudstones. Other Laramide structures associated with basin deformation probably were started at this time. Strong subsidence continued into late Paleocene when coarse clastics of the Tongue River Formation first were deposited, indicating uplift and erosion of the adjacent mountains. Deformation continued through part of the Eocene, but ceased before Oligocene time.

Cross sections using electrical accessory curves illustrate their use in other thick nonmarine rock sequences and for detailed studies of subtle marine shale correlations. Electrical accessory curves are a new tool to help solve difficult subsurface rock correlation problems and they should be helpful in many other areas.

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UPPER PALEOZOIC EVAPORITES IN SVERDRUP BASIN, ARCTIC CANADA

Carboniferous and Permian evaporites and associated rocks in Arctic regions are of current interest in terms of global paleogeography and petroleum exploration. In the Canadian Arctic Archipelago, 3 upper Paleozoic evaporite formations are present in the Sverdrup basin, a regional depression overlying the Franklinian geosyncline and containing 40,000 ft (13,000 m) of lower Carboniferous to Eocene sediments. Two of these formations are: the Otto Fiord Formation (upper Carboniferous) in the axial region of the basin, and the Mt. Bayley Formation (Lower Permian), which is closer to the eastern basin margin. A third, unnamed evaporite unit of Moscovian or younger age is present along the north coast of Ellesmere Island.

The Otto Fiord Formation consists of over 1,300 ft (430 m) of interbedded anhydrite (75% by thickness) and limestone (25%) at the type section, with interbedded sandstones in other sections. The formation overlies sandstones and conglomerates of the Borup Fiord Formation (Namurian?), grades laterally into carbonates of the Nansen Formation, and is overlain by carbonates or siltstones of the Hare Fiord Formation (Moscovian at base). The Otto Fiord evaporites extend for at least 400 mi (650 km) in a broad, northeast-trending belt characterized in the south by numerous large piercement structures. Namurian and Bashkirian ammonoids discovered in these diapirs now have been found at several levels in the Otto Fiord type section.

Apart from a few cubic crystal casts, there are no positive indications of halite in surface exposures of the Otto Fiord Formation; breccia zones in anhydrite and limestone are not extensive. The Otto Fiord anhydrite beds vary in fabric from indistinctly bedded nodular mosaics, to fabrics apparently pseudomorphic after coarsely crystalline gypsum. Fabrics and bedding of the anhydrite, the biota of limestone interbeds, and the associated lithofacies indicate a marine subaqueous mechanism of deposition for these evaporites.

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POSTDEPOSITIONAL CHANGES IN DEEP-SEA SEDIMENTS

Deep penetration of marine sediments by the Deep Sea Drilling Project has permitted the study of the postdepositional physical and chemical changes which take place in deep sea sediments. Such studies have not been possible previously because of the inaccessibility of the deep-sea environment. The diagenetic changes can be viewed as functions of time, lithology, and rate of sedimentation. With the passage of time and increasing deposition of sediment, lithification proceeds gradually until the lithified analogs of facies normally found as soft surface sediments are formed. These lithified and partly lithified rocks can be compared with their unlithified equivalents and with lithified formations of possible deep-sea origin now found on the continents.