anchor man on the exploration team, to be knowledgeable only in his own specialty. Conversely, he should recognize that he can not be all things to all people. It is his personal challenge, as well as that of the increasing number of specialists with whom he comes in contact, to make skillful use of team effort.

Modern oil exploration has become a process in which no two situations are alike. The diversity of plays demands the close cooperation of the geologist, geophysicist, and researcher with landmen, economists, and producing specialists in establishing optimum programs.

Overlaid on these responsibilities is the need for greater awareness of the political, educational, public, and community relations, considerations which have come to have an increasing importance in the conduct of exploration team activities. Such influences frequently affect strategy, tools, timing, and logistics, as well as land and legal procedures.

Still another area of responsibility for the team member lies in the development of improved communications. The obligation to share geological or geophysical data collected at all points within an organization's sphere of operations is an immediate necessity. Geological experience gained in one corner of the world may result in unsuspected benefit to operations in an entirely separate area.

Building and maintaining a team with the necessary skills and imagination capable of meeting and moving beyond contemporary requirements have thrust some new and specific responsibilities on the industry itself.

Intense competition and a soft price structure in foreign oil markets have sharpened the need for unprecedented efficiency in Free World oil circles. The oil explorer is no longer the glamor-boy of the industry, aloof from the economics of marketing and manufacturing. He must accept the role of a team member for his own survival in an era of vastly increased world-wide competition.

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Spore-Pollen Correlation of Cretaceous Rocks of Northern and Southern Hemispheres

This paper summarizes published and unpublished palynological data from Upper Jurassic and Cretaceous sediments of northwest Europe, Russia, North and Central America, the Middle East, North and West Africa, South America, Australia, and New Zealand. Many publications could be considered only in a very general way or had to be disregarded because of the inadequate illustrations and descriptions of species and nomenclatural confusion or because of the complete lack of stratigraphic data.

Numerous very distinctive forms of spores and pollen grains, some of which can be assigned with confidence to living families of plants, make their first appearance in the fossil record during Upper Jurassic and Cretaceous time. They are accompanied in the marine sediments by the incoming of equally distinctive forms of microplankton. Based mainly on the incoming of such forms of spores, pollen, and microplankton, many authors have erected varying numbers of palynological subdivisions for use purely in local correlation in their respective areas. Some, but unfortunately few, by comparison with spores, pollen, and microplankton from sections independently dated by other fossils such as ammonites or foraminifera, have attempted to correlate local palynological subdivisions with the standard biostratigraphic units of the Cretaceous.

A compilation of results from published works, together with unpublished results from Royal Dutch/Shell Group palynologists, suggests the following generalized sequence of spore and pollen floras and their approximate correlation with the standard biostratigraphic units.

Upper Cretaceous.—Floras with increasing numbers of species of dicotyledonous pollen grains. Tendency toward typical Northern and Southern Hemisphere floras is apparent in the Lower Senonian and is clearly marked by the Upper Senonian. In most areas considered, a broad 3-fold palynological subdivision is apparent, which is correlated generally with the Cenomanian-Turonian, Lower Senonian, and Upper Senonian.

Aptian-Albian.—First appearance of generally small and more or less sculptureless tricolpate dicotyledonous pollen grains in both Hemispheres. Last appearance in most areas of the Northern Hemisphere of such typical Jurassic-Lower Cretaceous forms as *Classopollis torosus, Caytonipollenites pallidus, Pilosisporites trichopapillosus.*

Hauterivian - Barremian. — Northern Hemisphere floras generally characterized by co-occurrence of Jurassic and older Cretaceous forms of spores and pollen together with *Ephedra*-like pollen and rare monosulcate pollen grains with clearly differentiated exine (*Clavatipollenites*).

Not sufficient data from Southern Hemisphere for comparison.

Valanginian.—In both Northern and Southern Hemispheres generally characterized by abundant specimens of *Cicatricosisporites dorogensis* and related forms together with abundant typical Jurassic gymnosperm and pteridosperm pollen. Clearly separated from Jurassic in Northern Hemisphere by first appearance of a number of forms including *Appendicisporites.*

The paleontological and stratigraphic evidence used in the correlation of local palynological subdivisions with the biostratigraphic units within the areas considered, is summarized in the form of range charts, and some of the more distinctive species of spores and pollen are illustrated by photomicrographs.

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Plant Microfossils and Geology

The role of palynology in the exploration for oil is essentially comparable with that of any other branch of paleontology. Advantages and limitations of sporomorphs, algae, miscellaneous protistans of uncertain affinity, and other similar-sized microfossils utilized in palynology as stratigraphic and paleoecologic indicators are briefly reviewed. The economic value of this relatively modern scientific field to the petroleum industry may be increased and hastened by avoiding some of the pitfalls which befell micropaleontology in its earlier years of application. Information should be developed simultaneously on the biology, ecology, and stratigraphy of these organisms.

Palynologists now being trained should be encouraged to develop their knowledge of both geologic and biologic fundamentals. Research should be sponsored in industry research laboratories and in private or university laboratories—research which includes studies of the distribution and preservation of sporomorphs in modern sediments; relative significance of living assemblages to other types of organisms; development of methods and programs for mechanical classification of these microfossils and analysis of data; improvement of techniques for separating spores and similar fossils from the rocks; and development of environmental information by the study of the character of preservation, presence of reworked fossils, relative percentages of other organisms, and characteristics of sediments themselves.

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RECENT ESTUARIAN AND MARINE SEDIMENTS, COOS BAY AREA, OREGON

Coos Bay, the estuary of Coos River, is located on the southern coast of Oregon. Although Coos River is one of the smaller rivers draining the Oregon Coast Range, its estuary is one of the largest along the Oregon Coast. The estuary occupies a structural depression and has been formed by drowning of the river mouth following rise of sea-level in late Pleistocene time. The outer part of the bay has been developed by the southward prolongation of North Spit by longshore drift. This estuary opens onto a narrow continental shelf, which, in this vicinity, ranges in width between 10 and 15 miles.

Texture and mineralogy of sediment samples taken along the 12-mile length of Coos Bay suggest derivation of the estuarian sediments from two sources: (1) sediment in the inner bay is chiefly fine sand and is similar to the detritus carried by Coos River; (2) sediment in the outer bay is mostly medium-grained sand, with an increase in grain size toward the bay mouth. This sand is most closely related mineralogically to sands along the coast north of Coos Bay. Thus, it appears that although sediment in the inner bay has been brought to it by Coos River, sediment in the outer bay has been derived chiefly from the influx of beach and dune sands carried over North Spit by the prevailing westerly winds and into the mouth of the estuary by tidal currents.

Sediment samples from the continental shelf adjacent to Coos Bay, between the mouths of the Umpqua and Coquille Rivers, range in median diameter from medium sand to silt, and from very well sorted to moderately sorted. They display a general decrease in grain size and degree of sorting in a seaward direction. However, a band of fine, well sorted, glauconitic sand lies along the outer margin of the continental shelf. The location and mineralogy of this sand suggest that it is relict sediment (Emery, 1952) related to a lower sea-level during Pleistocene time that has not yet been covered by modern sediment.

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MARINE SEDIMENTATION OF CLASTIC VOLCANIC STRATA

Many sequences of geosynclinal strata are composed of pyroclastic ejecta and detritus eroded from contemporaneous volcanic accumulations. Their lithologic successions are governed largely by secular variations in the type and intensity of the contributory volcanism and their facies patterns, by the spatial distribution of eruptive centers. The linkage between volcanism and sedimentation can be as direct as, for example, when showers of airborne ash rain into the final site of deposition, or the linkage can be as indirect as the subtle influences caused by changes in submarine topography with the construction of volcanic piles within a basin of deposition. To reconstruct the depositional histories of the clastic volcanic sequences, the role of volcanism in controlling environments of deposition, determining the dispersal agents of sediment, and creating transitory sources of sediment must be correctly evaluated.

The following genetic assemblages of clastic volcanic strata can be recognized in Paleozoic and Mesozoic marine sequences of western North America.

1. Volcanic center assemblages include (a) pillow lavas, pillow breccias, and palagonitic tuffs from submarine eruptions; and (b) lavas, flow-breccias, and pyroclastic breccias from subaerial eruptions.
2. Volcanic shelf assemblages were deposited on (a) narrow shelves flanking volcanic piles and (b) broad platforms of tectonic origin. The rocks of the assemblages are composed of vitroclastic ash and abraded grains in varying proportions, and are commonly fossiliferous.
3. Volcanic slope assemblages were deposited on subaerial or submarine slopes forming the sides of (a) elevated tracts built up by volcanic outpourings and (b) tectonic ridges capped by volcanos. The sedimentary structures of the assemblages include erosive scour, sole markings, cross-bedding, and graded bedding.
4. Volcanic basinal assemblages were deposited in (a) low tracts lying between volcanic piles and (b) tectonic depressions lying within the dispersal radius of volcanic sources. The rocks of the assemblages include vitroclastic tuffs deposited by showers of airborne ash and rocks formed by the settling of suspended sediment.

These assemblages have counterparts in other regions where similar rocks are exposed. Modern analogues are present in Recent sediments of the Caribbean and Indonesian regions.

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FUTURE OF OIL EXPLORATION ABROAD

In any consideration of the status of exploration of the oil industry today we are bound to look to history. The industry has always been pursued by the ghost of scarcity one day and the specter of overwhelming surplus the next. Part of this has been due to the sudden opening of new areas for exploration and part of it to the introduction of new methods of exploration, all of which has made available new supplies. Politics also affected the supply of crude.

Today we face surpluses in most areas of the world and the problem of these surpluses has afflicted us with a pessimism that has reached into our training schools for geologists and petroleum engineers. Such a mood makes it imperative that we glance at the future.

First we must remember that present world proved reserves of oil, producible at present costs, run in the neighborhood of 275 billion barrels, and that there is probably in sight 500 billion barrels. This is in contrast to Pratt's estimate of 77½ billion barrels made 10 years ago. Present world demand is close to 7 billion barrels per annum and is doubling every 11 years. This means that we have proved more than 20 years of supply. These figures would look very different, however, if it were not for the restriction of automotive use in the Communist countries. If all the world consumed oil at the same per capita rate as the United States, the demand would be 50 billion barrels a year and we would have about 5 years of supply in sight. We should, therefore, in our long-run interest, keep on looking. This raises the question of how well we have explored the world.

It is probably a maxim that every generation believes it knows the limit of world resources. This is largely self-delusion. The next barrel of oil (or ton of copper, if you prefer) is always the hardest to find. But ingenious minds develop new methods which are successful, or bold spirits invade new areas. We drill deeper holes, we refine our means of gathering data. We ven-