commercial oil well in the world in 1859 near Titusville, Pennsylvania; the late Pattillo Higgins, whose faith and inspiration led to the discovery of Spindletop and the beginning of the liquid fuel age; and Columbus "Dad" Joiner, the aged and impoverished Oklahoma wildcatter, who proceeded on his goal in the face of "learned" advice to cease drilling and the scornful criticism of earth science leaders, to bring in the greatest oil field in North America—the vast East Texas field where more than six billion barrels of oil eventually will be produced.

There were other great contributors to the abundance of petroleum, such as William Knox D'Arcy, an Englishman, who suffered years of heartaches and hardships, while working in a locale which was so forbidding that other civilized men dared not venture into it, before his discovery led to the opening of the vast Persian Gulf oil reserves; the pioneer geologist, Charles Eckes, whose painstaking and minute geological investigations led to exploration for, and eventual discovery of, the great deposits of oil under Lake Maracaibo in Venezuela; and, Robert DeMares, whose persistence, based on his observations of oil seeps that spouted high into the tall tropical trees, enabled him to attract the wildcatting firm of Benedum and Trees to the rich production in the heart of the Colombian jungles.

These were only a few of the men who sought and found opportunity through faith, determination, and optimism and, by so doing, developed the energy and fuel for a better way of life for all mankind; this suggests that the petro-professionals in the industry should pause and re-evaluate their own contributions toward a better society and a more profitable industry. A look at the past is timely in view of the prevalent pessimism and lack of determined leadership on the part of most industry personnel, especially in the field of exploration. Successful leaders of tomorrow will be individuals in today's petroleum industry who are as dedicated, determined, and purposeful as those illustrated in this paper.

4. HENRY L. OTT, Chevron Oil Company, Western Division, Casper, Wyoming

PALYNOLOGY AND ITS USE IN PETROLEUM EXPLORATION

Palynology is basically the study of pollen and spores, both fossil and recent. Many students of modern pollen are allergists, whereas the fossil pollen student is generally referred to as a palynologist.

Most hayfever suffers become acutely aware of the presence of modern pollen and spores during the summer months. These pesky little bodies have long played key rolls in the annual plague of itchy eyes and runny noses. However, their fossil cousins have received relatively little attention until the last few decades. During this time their presence has been noted in rocks of all geologic ages dating to the Silurian.

Pollen and spores are the male and female reproductive bodies of the flowering and non-flowering plants, respectively. They are produced by the countless trillions by plants everywhere and are distributed to the four corners of the globe by winds and water. Everyone has observed the yellow film on a high mountain lake, or the yellow "smudge" on a garment after contacting the goldenrod blossom. This yellow "smudge" is pollen dust. The individual pollen grain is of microscopic size, about 3,000 of them fitting side by side on the head of a pin. In spite of their extremely small size they are hardy little individuals, being relatively indestructible both physically and chemically. For this reason they have become important to the geologist. They are widely distributed by winds and water to all environments of deposition and then may be buried and preserved to furnish a fossilized record of geologic events of the area.

Palynologists have been able to utilize the pollen record for (1) age determinations, (2) correlations, (3) climatic interpretations, (4) depositional environmental interpretations (associated micro-microfossils), and (5) oil migration and accumulation studies. The application of the science of palynology is relatively new to the petroleum industry and new and better techniques as well as continued experience may yet add other uses to the ever-growing science.

5. LOUIS F. KEATING, Imperial Oil Enterprises Limited, Calgary, Alberta

EXPLORATION IN CANADIAN ROCKIES AND FOOTHILLS

The Canadian Rockies form the most easterly ranges of the Cordilleran system for a distance of more than 1,050 miles, from the Yukon border south into central Montana. They are bounded on the east by the Interior Plains and on the west by the Rocky Mountain trench. The main deformation occurred during the Eocene, resulting in a system of stacked thrust plates which are restricted to the sedimentary section and do not involve the crystalline basement rocks. More than 100 miles of shortening in the sediments occurred as a result of this deformation.

Exploration in this structural belt has resulted in an important oil- and gas-producing province, the major reserves being located in the southern Foothills. The vast amount of information that has been accumulated in the course of this exploration through surface mapping, drilling, and geophysical work has provided excellent structural detail over a large part of the area.

Prospective structures are difficult to locate and require careful integration of all available geological and geophysical control. Reflection and refraction seismic methods have had considerable success in locating many of the presently producing fields and have provided information that is fundamental to our understanding of this complex structural belt.

6. RUDOLPH MARTIN, Rudolph Martin and Associates Limited, Calgary, Alberta

APPLICATION OF PALEOGEOMORPHOLOGY TO EXPLORATION FOR OIL AND GAS

Hydrocarbon traps are customarily subdivided into two main classes: *structural* and *stratigraphic*. A third important class, hitherto not considered separately, includes hydrocarbons trapped in buried hills, ancient sandstone-filled valleys, fossil reefs, and other primarily geomorphological phenomena. These are termed as *paleogeomorphic* traps. The analysis of and prospecting for this type of trap must proceed along purely geomorphological lines of reasoning. These include both *form* and *process:* the form creates the trap, but the process shapes the form. Trapping may be below or above the paleogeomorphological surface, and be either direct or indirect.

Paleogeomorphology includes all geomorphic phenomena recognized in subsurface geology, *i.e.*, all buried-relief features, whether formed on land or under water. Geomorphic processes may be divided into "constructive" and "destructive." Constructive forms of interest to petroleum geologists are dunes, barrier beaches, organic reefs, *etc.* Destructive processes create hills and valleys, underground drainage in carbonates, submarine canyons, *etc.*, and create or destroy porosity by weathering.

Fossil organic reefs have a multitude of morphological characteristics which may be explained in terms of hydraulics, rate of subsidence, influence of deep-seated faulting, and other factors not of a strictly stratigraphical nature.

The interpretation of buried landscapes presents many problems still unresolved among geomorphologists and also high lights several lesser-known geomorphological phenomena. Subsurface data reveal that many landscapes exposed for millions of years, although technically "peneplains," still have sufficient relief for the accumulation of sizable hydrocarbon reserves. The solution of paleogeomorphological problems is aided greatly by applying quantitative geomorphological principles. The geological aspects of paleogeomorphology concern primarily the identification of erosion-resistant and less resistant horizons and the influence of structure (folding and faulting) on ancient drainage systems.

Sandstone bodies filling buried valleys commonly are dissected by river meanders and thus exhibit shapes that are different from the shape of the valley. The analysis of a drainage system from headwaters to delta can help to relate sandstone reservoirs to source areas.

7. ROBERT P. KUNKEL, Consulting geologist, Salt Lake City, Utah

EXPLORATION AND DEVELOPMENT IN UTAH AND NEVADA, 1964–1965

Utah's Uinta basin continues to be the best part of that State in which to prospect for oil and gas. Wildcatters discovered gas at two localities and oil at six localities out of 24 wells drilled in the Uinta basin between September 1, 1964, and June 1, 1965. Excluding the Four Corners area, half of the wells drilled in Utah were in the Uinta basin. Other wildcat wells were drilled at scattered localities through the northern Paradox basin, the northern plunge of the Uncompahgre uplift, the northern San Rafael swell, and the Kaiparowits region. These wells resulted in one oil and one gas discovery.

All but two of the new oil discoveries were completed in Tertiary Green River sandstones near Red Wash field and in the belt of productive Green River sandstone extending west from Red Wash. Of the others, one was a new "pay" discovery (Jurassic Entrada Sandstone) in the old Ashley Valley field, and the other was an oil discovery in the Permian Kaibab on the Ferron anticline, between the San Rafael swell and the Wasatch plateau.

During the first half of 1965, approximately the same number of wells were completed in Utah as during the first half of 1964. However, fewer wells were completed in 1964 than during 1963. Daily oil-productive capacity is down to 75,000 barrels per day from 90,000 barrels in 1964. The number of acres of Federal land under lease declined by 150,000 acres during the first quarter of 1965 from the previous quarter.

Oil and gas industry expansion plans include a 6-inch gas transmission line to be built south from Price, Utah, to the Ferron gas field by Mountain Fuel Supply Company. Gulf Oil Corporation is considering the construction of a 3-million dollar viscosity breaker plant at the Wonsits Unit (near Red Wash) where its productive capacity of high-pour-point waxy crude oil exceeds the amount that can be accommodated by existing pipelines.

A successful $\frac{3}{4}$-mile step-out well east of the oil production in the Tertiary Sheep Pass Sandstones, Eagle Springs field, was completed early in 1965; this discovery gave added stimulation to leasing and drilling in Nevada. By mid-year, four development wells were being drilled around the step-out.

An additional $\frac{1}{2}$ million acres of Federal lands were leased during the first half of 1965, to bring the total to slightly more than 2 million acres of Federal lands under lease in Nevada. Northern Railroad Valley, White River Valley, and Jakes Valley are all leased. Large blocks of acreage also have been leased in Long Valley, Butte Valley, Steptoe Valley, and Newark Valley. Since the current play started in March, 1964, one dry hole has been drilled in Newark Valley, two in White River Valley, and one on the eastern flank of the Eagan Range.

8. WARREN S. LIPPITT, Consulting geologist, Denver, Colorado

EXPLORATION AND DEVELOPMENT HIGH-LIGHTS IN DENVER BASIN

A resurgence of industry interest in Denver basin oil and gas prospects has been reflected by a 30 per cent increase in the number of wells completed in western Nebraska during 1965. Eastern Colorado drilling activity has shown decline of less than 10 per cent compared with 1964. Any significant increase in the number of wells drilled ultimately will reverse the continuing decline of oil and gas production.

Exploratory drilling to the shallow. Cretaceous "D" and "J" Sandstone objectives was well dispersed throughout the basin and resulted in the discovery of many commercial, though no truly significant, fields. The 11-well Stage Hill field on the Scotts Bluff-Banner County line is representative, both geologically and economically, of the better structural-stratigraphic type oil accumulations discovered in western Nebraska. The Moccasin field of eastern Adams County is typical of the small, though profitable, structural-stratigraphic "J" Sandstone oil accumulations discovered in eastern Colorado.

Several exploratory tests to pre-Cretaceous objectives on the western flank of the Chadron arch and in extreme northwestern Nebraska were unsuccessful. Encouragement in searching for pre-Cretaceous oil and gas production on the fringes of the Denver basin in Colorado was afforded by a gas discovery in the Pennsylvanian Morrow Sandstone, Kit Carson County, and an oil discovery in the Mississippian Osage, northern Prowers County. The gas discovery is high on the eastern flank of the basin and appears to be a stratigraphic accumulation trapped in lenticular Morrow sandstones. A unique feature of this Morrow gas is its high helium content—more than 4 per cent.

The Comanche field discovery of oil in Mississippian Osage carbonates is the first indication of commercial oil production in the Mississippian in eastern Colorado. This discovery, even though it is located in the Hugoton embayment of the Anadarko basin, suggests that Mississippian carbonates may be prospective for oil and gas throughout much of the eastern flank of the Denver basin. The Comanche field appears to be primarily a structural accumulation on the western, or upthrown, side of a major northeast-trending fault zone.

Seismic activity and exploratory drilling to the Permian Lyons Sandstone and Big Blue carbonate objectives in the deeper part of the basin have increased during 1965. The increased interest in pre-Cretaceous objectives, combined with a continuing search for new Cretaceous "D" and "J" Sandstone fields, should maintain a relatively high level of exploratory activity during the coming year.