sources of all giant fields in Venezuela are 27.6 billion bbl. The average for the country is 628 million bbl per giant. Even if the resources of the Bolívar Coastal field were only 500 million bbl, the average resources would be 264 million bbl of oil per giant field. It is possible to combine the data on the giant Venezuelan fields with the study of the oil resources of the country. The ultimate number of giants is 78; ten giant fields had been discovered but had not been recognized by the end of 1965, leaving 24 giants undiscovered. It is estimated that 40 percent of the oil resources of Venezuela are in the giant fields alone.

MARTINI, I. P., Shell Canada, Ltd., Edmonton, Alberta

GRAIN-ORIENTATION AND PALEOCURRENT SYSTEMS IN MEDINA FORMATION

Several sedimentological parameters were examined to define the paleoenvironments of the Medina Formation (Lower Silurian; outcrops along the Niagara Escarpment in Ontario and New York State). The diverse sedimentological parameters change regionally as well as vertically in a quasi-regular manner. The trends of such changes are similar in all the properties examined. The consistency within the basin of the variations of the variables suggests a deltaic paleoenvironment for the Medina sediments.

Two of the sedimentological parameters, grain orientation and directional sedimentary structures, were studied in the Thorold and Grimsby Sandstone Members of the Medina Formation.

Determination of grain orientation yielded a complex pattern of directions hardly explainable except by a "mixed environment" model. It was found that the total sampled population of the grain orientations of the Thorold and Grimsby Sandstones was nonhomogeneous. Utilizing a trial and error methodology homogeneous subpopulations were distinguished:

1. Subpopulations related to the type of sedimentary structure present in the sampled bed: (a) cross-bedded (subpopulation); (b) laminated (subpopulation); and (c) massive (subpopulation).
2. Subpopulations related to the stratigraphic location of the samples: (a) Thorold plus upper third of the Grimsby; and (b) lower two thirds of the Grimsby.
3. Subpopulations related to the geographic location of the samples: (a) east of the Niagara River (New York region); and (b) west of the Niagara River (Ontario region).

The various subpopulations evidently are interrelated and they are partly duplicated in the behavior of the azimuths of the cross-beds and other directional sedimentary structures.

The directional data obtained from the Thorold and Grimsby Sandstones suggest the existence of two major paleocurrent systems:

1. A first system, trending northwest, was measured in the azimuths of cross-beds and in the cross-bedded grain orientation subpopulation of primarily the New York region.
2. A second system, trending northeast, was measured in the azimuths of cross-beds in the Ontario region and in the laminated grain orientation subpopulation.

The characteristics of the paleocurrent systems and the results obtained from other sedimentary properties which better define the subenvironments composing the "Medina delta," suggest that the first paleocurrent system is related to distributary channel complexes and the second to marine currents.

MAYUGA, M. N., Long Beach Harbor Dept., Long Beach, Calif.

GEOLOGY OF CALIFORNIA'S GIANT—WILMINGTON OIL FIELD

The Wilmington oil field is in the Los Angeles basin of southern California, one of the most prolific oil-producing basins of the world and considered to be an example of optimum conditions in the habitat of oil. The Wilmington structure, discovered in 1936, is a broad, asymmetrical anticline broken by a series of transverse normal faults which divide the producing beds into many separate pools. The seven major producing zones range in age from middle Miocene (Topanga) to early Pliocene (Repetto). Deposition of approximately 1,800 to 2,000 ft of nearly horizontal beds on top of the unconformity between the lower Pliocene Repetto beds and the upper Pliocene middle Pico Formation conceals the Wilmington anticline from the surface. The effectiveness of the faults as barriers to oil and gas accumulation in the field is shown by significant variations in edgewater conditions, subsurface pressure, gas-oil ratio, and oil gravity from one fault block to another. In general, the development program in the field has been based primarily on segregation of the pools by fault blocks and zones.

The problem of land subsidence in the Wilmington oil field has been attributed by many investigators to the reduction of pressures in the reservoirs due to the production of oil and gas. Total subsidence to date in the center of the bowl of subsidence is 29 ft. A massive water-injection program has reduced the subsidence in the area and increased oil recovery. The rate of subsidence at the center of the bowl has been reduced from an annual rate of 2.4 ft in 1951 to 0.1 ft in 1967. The area of subsidence has been reduced from 20 sq mi to less than 4 sq mi.

The Wilmington oil field has produced more than 1.1 billion bbl of oil, primarily from the old developed area. With waterflooding, it is estimated that another 700 million bbl of oil will be recovered from the old area of the field and an estimated 1.2 billion bbl of oil will be produced from the new area on the east (known as the Long Beach Unit or East Wilmington) within the next 35–40 yr under a pressure-maintenance program. Recent developments in the eastern area of the field revealed some lateral lithologic changes in the formations. To date, six of the seven known productive zones in the old area are also productive in the new area, but somewhat limited in extent.

MCCOY, SCOTT, JR., Phillips Petroleum Co., Bartlesville, Okla.

PALEONTOLOGY AND PALEOECOLOGY OF WANN FORMATION, NORTHEASTERN OKLAHOMA

The Wann Formation (Missourian) of northeastern Oklahoma is primarily a regressive marine sequence of calcareous shale, shale, and sandstone with a characteristic molluscan fauna traceable along much of the outcrop. The replacement of a crinoid-brachiopod fauna by the molluscan fauna in Washington County

reflects the change from deeper water to a nearshore marine environment. This environmental change was caused by the northward expansion of a deltaic area which generally was on the south. The deltaic sediments are well developed in the southern outcrops of the Wann.

The rich molluscan fauna, a "Drum-type assemblage," is similar to those found in other Middle and Upper Pennsylvanian formations in Oklahoma indicating a repetition of environments. *Trepospira, Worthena, Euphemites,* and *Glabrocingulum* are the predominant elements of the fauna although other gastropods and pelecypods are prominent locally. The relative abundance of a species at any location within the assemblage zone appears to be depth controlled.

MCGREGOR, A. A., Samuel Gary, Denver, Colo., AND CHARLES A. BIGGS, Sawtooth Oil Co., Denver, Colo.

BELL CREEK FIELD, AN EMBRYONIC GIANT, POWDER RIVER AND CARTER COUNTIES, MONTANA

The Bell Creek field is located in Ts. 8-9 S., Rs. 53-54 E., in southeastern Montana next to the Montana-Wyoming border. It is presently more than 15 mi long, up to 3 mi wide, and is still in an active stage of development. As of February 1, 1968, 7 months after discovery, there were 178 oil wells, 6 gas wells, and 25 dry holes within the area designated as the Bell Creek field by the Montana Oil and Gas Commission. This activity has taken place since June 1967 when Exeter Drilling and Sam Gary completed the discovery well, The Federal-McCarrel No. 33-1, C, NE¼, NE¼, Sec. 3, T.8 S., R.54 E., from perforations in the Lower Cretaceous Muddy sandstone between 4,532 and 4,537 ft. IP was 240 b/d of oil. Since that time more than 12,000 acres have been proved productive and the field is still expanding in all directions except toward the west and northwest. Even on the west and northwest, the downdip side of the field, the productive limits are not clearly defined.

The field is on the northeast flank of the Powder River basin. The structure is monoclinal with dip of approximately 100 ft/mi toward the northwest. The trap is a facies change from porous sandstone to shale updip toward the east and southeast. The trend of the producing is roughly parallel with the regional strike in this area.

The reservoir is a series of Lower Cretaceous sandstone lenses variously termed the Muddy, Newcastle, or Dynneson sandstones. The precise origin of these sandstone bodies is not clear, but they appear to be reworked from sands previously deposited in a deltaic complex at the margin of an encroaching Early Cretaceous sea. Total thickness of the porous sandstone ranges from 0 to 35 ft and exhibits excellent reservoir characteristics. Many wells have average porosity values of about 30 percent and average permeability values of several darcys. Productivity of the individual wells ranges from approximately 100 to 1,000 b/d of oil. Most wells are capable of producing more than 500 b/d of oil. Productive potential of the field presently is estimated at more than 50,000 b/d but is restricted to about 30,000 b/d by pipeline limitations. Proved ultimately recoverable reserves are in excess of 100,000,000 bbl. The oil is brown, intermediate-base, 32°–38° API gravity with gas-oil ratios ranging from 150:1 to 2,000:1. There appears to be a small gas cap in the updip edge of several of the individual sand lenses.

MCNULTY, C. L., JR., Dept. of Geology, University of Texas at Arlington, Arlington, Tex., AND BOB H. SLAUGHTER, Dept. of Geology, Southern Methodist University, Dallas, Tex.

TEETH OF CRETACEOUS BATOID GENUS, *Ptychotrygon*

Knowledge of extinct cartilaginous fishes depends primarily on their tooth remains. Familiarity with galeoid (shark) teeth is widespread, but it is restricted for batoid (ray) teeth, as illustrated by the Cretaceous batoid, *Ptychotrygon.*

Until now this taxon has appeared to be a monotypic genus restricted to the Upper Cretaceous of northwestern Czechoslovakia and adjacent Germany. The writers have found it to be widespread in the Upper Cretaceous of Texas and diversified into three species, including the original of Czechoslovakia.

These findings permit emendation of the genus, which is distinguished most readily from others, such as *Squatirhina,* by its uniserial interlocking arrangement of teeth; this arrangement is indicated by the presence of an anterior proboscis and a posterior receiving concavity on each crown.

From the writers' data it appears that ptychotrygonids may prove to be widespread in the Gulf coastal plain and of some chronostratigraphic value. Because of their size, typically 2 mm maximum dimension, they normally will be found in micropaleontological samples.

MEISTER, FREDERIC H., Sinclair Oil and Gas Co., Tulsa Research Center, Tulsa, Okla.

MIGRATION OF OIL AND DEVELOPMENT OF PERMIAN BASIN AS SHOWN BY CARBON ISOTOPIC COMPOSITION OF OIL

The carbon isotopic compositions of the +350°F boiling point fraction of oils collected from the Permian basin are presented. The sampled oils are from Lower Ordovician to upper Permian and from basinal and shelf environments. Evidence is presented indicating that: (1) the variation of δC^{13} from Middle Silurian to upper Permian is related to basinal development; (2) large-scale migration (tens of miles) has not occurred but small-scale (< 1 mi) migration has occurred; and (3) the variation in δC^{13} during one depositional period is primarily due to the relative amounts of terrestrial and marine-derived organic material and to contamination from other producing zones.

MILLS, H. G., Humble Oil and Refg. Co., New Orleans, Louisiana

GEOLOGY OF TOM O'CONNOR FIELD, REFUGIO COUNTY, TEXAS

The Tom O'Connor field, discovered in 1934, is in Refugio County, Texas, on the Gulf of Mexico coastal plain. Large accumulations of oil occur in the Oligocene Frio Formation; increasing proportions of associated gas appear in the progressively younger sandstones of this regressive sequence. In the basal, transgressive Oligocene Anahuac Formation, primarily gas reservoirs with small oil columns are present. In the regressive Miocene Fleming sandstones, dry gas occurs. The immense oil and gas accumulation is due