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.

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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.

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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.

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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.

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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 to the existence of three factors: large structures, favorably located pinchouts of most Frio sandstones, and a very large structurally uninterrupted drainage area extending basinward to the hydrocarbon source.

Entrapment is the result of anticlinal folding on a typical "rollover" feature common to the downthrown side of the Vicksburg flexure. Structural growth probably had its origin in large-scale gravity slumping of the clays of the early Oligocene Vicksburg Formation, either on the continental slope or near the continental shelf margin. A series of structure maps and cross sections show trap configuration at various horizons.

The excellent quality of the reservoir sandstones is discussed in relation to depositional environment. Reservoir and fluid characteristics are given by formation.

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GIANT OIL FIELDS OF NORTH AMERICA

A group of 45 oil fields in North America, each with reserves in excess of 500 million bbl, have been analyzed to determine their characteristics as an entity. The fields include 18 in the continental interior, 11 in California, 11 in the Gulf Coast area, 3 in Canada, and 2 in Mexico. They contain a total of 46 billion bbl of ultimate reserves, which is about 35 percent of the present total for the continent. The historical implications and future potential are discussed.

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PETROLOGY AND SEDIMENTATION OF JACKFORK SANDSTONES, ARKANSAS

A detailed field investigation along the intricately folded and faulted Frontal Ouachitas for the first time permits accurate sampling of sandstones encompassing the entire Jackfork section. The resulting petrographic information supplements paleocurrent studies and sedimentary structures in postulating a provenance and dispersal system. Rocks of the Frontal Ouachitas consist approximately 30 percent of sandstone deposited by mass flow or turbidity currents and 70 percent of shale, mostly contorted by downslope movement after deposition. Exposures along a southern belt consist of 75 percent of sandstone; only negligible amounts of gravity-deformed, argillaceous rocks are present in this southern belt.

Approximately 200 thin sections were analyzed from measured sections and isolated areas. Along the Frontal Ouachitas, the sandstone is predominantly fine-grained quartz arenite and wacke (range 0.07 to 0.31 mm; average 0.14 mm), high in polycrystalline quartz, and having less than 1 percent feldspar, 2.5 percent unstable rock fragments, a stable heavy-mineral suite, and varying amounts of matrix. These rocks are moderately sorted to moderately well sorted although pressure solution has masked and altered the original texture. Stylolites along bedding planes and sutured, interlocking grain contacts indicate considerable removal of silica by post-depositional means, a small amount remaining as quartz overgrowths. More argillaceous wacke shows highly corroded quartz grains due to local increases in pH but with little grain interpenetration. Dominantly friable sandstone along the southern belt has comparable grain sizes but a marked increase in matrix and decreased post-depositional changes. The matrix probably reduced the flow of silica-removing waters, also forming a cushion that would reduce number of point contacts. Feldspar content may approach 10 percent but remains lower than that of the Stanley sandstone.

Basinal filling was mainly from the end (east), aided by sediment bypassing through the Illinois basin. A volcanic archipelago (Llanoria) probably contributed the feldspar. Rocks throughout the Frontal Ouachitas apparently were deposited along a steep, south-dipping, unstable slope. West-flowing, bottom-hugging turbidity currents concentrated the sand in the deepest part of the east-west trending Ouachita trough which today is exposed as the rocks of the southern belt. Care must be taken when interpreting sandstone-shale ratios in flysch basins where the greatest sand content is along the basin axis.

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STRATIGRAPHIC DISTRIBUTION, PENNSYLVANIAN FUSULINIDS, MANZANO MOUNTAINS, NEW MEXICO

The Manzano Mountains, on the east edge of the Rio Grande Valley, are between Albuquerque and Abo Canyon, 40 mi south. Paleozoic rocks exposed in the range are chiefly of Pennsylvanian age. Rocks of Permian age crop out on the east flank of the mountains at the south end of the range.

Pennsylvanian and lower Permian rocks have been subdivided into three major lithic types—one constituting the Sandia Formation and two constituting the Madera Limestone. The Sandia Formation contains a basal sandstone and conglomerate, and upper beds of sandstone and dark-colored shale with a few thin beds of fusulinid-bearing limestone. The Madera Limestone overlies the Sandia Formation with apparent conformity. The lower part of the Madera is dominantly limestone (commonly cliff-forming) and a few thin beds of shale and minor amounts of sandstone. The upper part, which overlies the lower part with no more than minor disconformity, consists of rhythmically alternating sandstone and conglomerate, shale, and marine limestone. This upper part has been subdivided for convenience into units B, C, and D.

Fusulinids from the Sandia Formation indicate that these rocks were deposited during Atoka time. Fusulinids from the lower part of the Madera Limestone indicate deposition during Des Moines time. The upper part of the Madera is within the faunal zone of *Triticites*. The fusulinid fauna from unit B suggests deposition during Missouri time; that from unit C suggests deposition during early Virgil time; and that from unit D suggests deposition during late Virgil and early Wolfcamp times.

Studies of insoluble residues from 52 samples of fusulinid-bearing limestones from 5 measured sections suggest that there is correlation between the amount of terrigenous material in the limestone and the relative abundance of the fusulinids. If the amount of terrigenous material is taken to be an index of water turbidity, tentative conclusions may be drawn concerning clarity of the water in which the fusulinids lived.