is less common. Recrystallization of the $CaCO_3$ mud matrix also is a common source for secondary porosity development. The combined amounts of primary and secondary porosity and the resulting permeability values may be large. In Greater Aneth field, Four Corners area, porosity values range from 3.5 to 26.2 percent, with an average of 10 percent. Permeability values reach a maximum of 932 md, with an average of 25 md. Estimated primary and secondary petroleum reserves may amount to 500 million bbl.

Porosity destruction is caused primarily by secondary sparry calcite vug filling. Extensive leaching in the upper zones of an algal bank forms solutions which are oversaturated in $CaCO_3$. When these supersaturated solutions percolate downward into the lower zones of the mound, precipitation of sparry calcite commonly begins. A rarer type of porosity destruction is that which results from a total collapse of the algal fabric. A relatively rapid diagenetic hardening of the $CaCO_3$ mud matrix apparently is required to prevent collapse of the algal fabric under the weight of overlying sediment. In some places, anhydrite caused porosity occlusion. In one example, the porosity in a core had been destroyed completely by vug fillings composed of isolated small dolomite rhombohedra.

Synecological fossil assemblages associated with algal mounds or mound-associated facies have different compositions in mounds of different stratigraphic and regional settings. The following groups of fossils were recorded in algal banks: Foraminifera, including ophthalmid and encrusting Foraminifera, and fusulinids, ostracods, fenestellid and fistuliporoid Bryozoa, crinoids, echinoids, gastropods, tetracorals, brachiopods, sponges, *Chaetetes* (tabulate corals), *Komia* (questionable stromatoporoid), *Girvanella* (blue-green algae), and *Ungdarella* (red algae).

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LUMINESCENCE PETROGRAPHY OF SANDSTONES

(No abstract submitted)

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OBSERVATIONS ON SANDSTONE CEMENTATION

Comparative study of Permian and modern caliche, laterite, bauxite, and beach rock have shown that vadose cement, regardless of composition, can be distinguished from cementation below the water table or sediment-water interface.

Phreatic and connate cementation which occurs beneath the water table or sediment-water interface is more coarsely crystalline than vadose cement and is interstice-filling rather than grain-coating. Early carbonate cement precipitated from water-filled voids at shallow depths consists of sparry calcite and may push apart and replace quartz and feldspar to produce "floating" textures. Silica cement occurs as void-filling overgrowths on quartz grains. After deep burial uncemented sand grains become tightly packed, the depositional texture is modified, and late aqueous cement occupies smaller interstices.

The following characteristics and stages of intensity of vadose cementation can be distinguished.

1. *Initial stage.*—The original depositional texture is lost as precipitation of fine-grained evaporitic films of carbonate, iron oxide, or aluminum hydroxide forces the grains apart so that films separate grains at former contact points. Sedimentary structures such as beach laminae and current ripple cross-bedding still may be preserved in this stage.

2. *Intermediate stage.*—"Floating" textures are produced as grains become pushed apart by evaporite cement and by replacement of quartz and feldspar by carbonate. Coalescence of evaporite films around clusters of grains forms small pisolitic concretions. Sedimentary structures become obliterated or greatly obscured.

3. *Late stage.*—Extreme floating textures and large composite pisolites form by addition of more cement and replacement of quartz and feldspar. Brecciated caliche anticlines (also known as teepee structures) are formed by expansion resulting from the addition of large volumes of carbonate cement.

Extreme caution must be employed in interpreting the genetic significance of rocks classified as sandy micrite, wackestone, and boundstone or biolithite. Transformation of quartzose sand into sandy carbonate, consisting of up to 90% fine-grained carbonate (micrite) which commonly is pisolitic (strongly resembling algal boundstone), is well documented by numerous examples. Similarly, accumulations of oöliths, clasts, skeletal fragments, pellets, and calcarenaceous material may be transformed into rocks which could be identified as oömicrite, intramicrite, biomicrite, pelmicrite, wackestone, and boundstone or biolithite (pisolitic) by vadose processes (calichefication).

Many so-called oölitic iron ores represent vadose concentrations of iron oxide and hydroxide.

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CANADIAN (EARLY ORDOVICIAN) EL PASO GROUP, SOUTHERN FRANKLIN MOUNTAINS, EL PASO COUNTY, TEXAS

The El Paso Group and at least the upper part of the underlying Bliss Sandstone at their type sections in the southeastern Franklin Mountains probably is the most complete Canadian section exposed in northern Chihuahua, New Mexico, and west Texas.

The El Paso Group represents deposits of a general, but complex, west-to-east transgression of the Cambrian and Early Ordovician seas across Arizona, New Mexico, and west Texas. The group thins to a featheredge in central New Mexico as a result of post-Canadian erosion of the upper part of the sequence.

Flower (1964) has given 10 formational names for the El Paso Group that represent not only rock-stratigraphic units, but also distinct sequential biostratigraphic units.

Seven of these El Paso Group units are regional in extent and recognizable in the southern Franklin Mountains. They are (in order from oldest to youngest): the early Canadian Sierrite Formation; the middle Canadian Cooks, Victorio Hills, and Jose Formations; and the late Canadian McKelligon Canyon, Scenic Drive, and Florida Mountains Formations. The basal middle Canadian Big Hatchet Formation may be present and unrecognized because of facies changes in the southern Franklin Mountains area. The uppermost middle Canadian Mud Springs Mountain and Snake Hills Formations are believed to be absent because of nondeposition or erosion.

The El Paso Group overlies the Bliss Sandstone disconformably. The Late Ordovician Montoya Group overlies the El Paso Group with a regional angular unconformity in the west Texas-New Mexico area. The

Middle Ordovician Simpson equivalents are not present because of nondeposition or erosion.

The nearshore to supratidal El Paso Group section faunal zones have been correlated tentatively with the deeper water, miogeosynclinal, western standard section (Ibex and Garden City, Utah composite sections) of Hintze (1951, 1952) and Ross (1951).

Paleoecological studies of the sabkhas to nearshore sediments of the El Paso Group strata show excellent examples of digitate algae, stromatolithic algae, and cyclic reefoid mound structures. Recent sedimentation in the Khor al Bozam (Persian Gulf) and Shark's Bay (Australia) probably are modern analogues.

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BLOODWORTH NORTHEAST FIELD, COKE AND NOLAN COUNTIES, TEXAS

The Bloodworth Northeast field was discovered in February 1967. The discovery well was the Tucker Drilling Co., Inc., and Peter Henderson Oil Co. No. 1 Foster S. Price, 0.5 mi south of the Nolan County line in Coke County, Texas, and approximately 15 mi northwest of Robert Lee. The producing reservoir is a Canyon (Upper Pennsylvanian) sandstone having 44 ft of unbroken permeability and 18% porosity. A drill-stem test was run in the upper 14 ft of the sandstone section. Gas surfaced in 5 minutes and oil, flowing strongly, surfaced in 30 minutes. In December 1968 there were 28 producing wells and 6 dry holes; 9 of these are multiple completions.

This oil field was discovered as a result of drilling along a productive trend; isopach maps provided the principal lead to the discovery.

The writer had observed that all sandstones within a 350-ft-thick zone contain hydrocarbons regardless of structural position or any other geologic characteristic. Accordingly, cumulative sandstone isopach maps were prepared from spontaneous potential curves. The isopach map on which the discovery well was drilled indicated that 50 ft of sandstone would be present.

The writer believes that the sandstone was deposited originally by turbidity currents in compaction troughs adjacent to the Pennsylvanian reef mounds of the area.

The Texas Railroad Commission recognizes three separate sandstone zones in this field.

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BASEMENT ROCKS IN WEST TEXAS AND EASTERN NEW MEXICO

(No abstract submitted)

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PALEOMAGNETIC CORRELATION

There are two ways in which paleomagnetic results can be used to correlate rock formations with each other. The first is achieved by using an established paleomagnetic polar-wander curve and matching new results to this curve. The second is by determining a reversal sequence and using this to correlate sedimentary strata.

In the past, both methods have been successful, the first in correlating older rocks and the second in dealing with rocks of Pliocene and Pleistocene ages. The reversal method is discussed in respect to its recent successful application to marine sediments of Miocene or younger age. The possible extension of this technique to older rocks is investigated and a recent successful application of magnetic reversal stratigraphy in rocks of Triassic age is outlined. It is reasonable to predict that reversal sequences will be of most value in older rocks where independent faunal or mineralogical control is present. It should also be of value as a well-logging tool for correlations within individual sedimentary basins.

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TEXAS LINEAMENT: PLEISTOCENE-HOLOCENE MOVEMENT?

Post-Pliocene movement along the Texas lineament is indicated by analysis of regional joint-fracture-fault systems in northwestern Chihuahua, Mexico, and on the southern High Plains, Texas.

The southern High Plains, Texas, show evidence of a regional force couple created by stresses along the Texas lineament on the south and the Wichita lineament on the north. Pleistocene to Holocene stresses along the Texas lineament have been right-lateral, but the Llano Estacado of West Texas exhibits evidence of both right- and left-lateral stresses along the Wichita lineament.

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MOSSBAUER STUDIES ON A LARGE GRIPHITE CRYSTAL

The Mossbauer effect has been used to measure the ferric to ferrous iron ratio in two perpendicular profiles across a 5-ft griphite crystal. No ferric iron is observed in the center of the crystal. The amount of Fe^{+3} increases rather systematically toward the margins. This increase is interpreted to have been produced by a secondary alteration caused by hydrothermal solution or weathering. These observations are in agreement with strontium isotope studies reported earlier.

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DISHARMONIC FOLDING IN IRAN

Exploration for petroleum in the Iranian Zagros folded belt has revealed spectacular disharmony between surficial folds in the terrigenous clastic Fars-Bakhtiari sediments and deeper folds in and below the Asmari Limestone, the major producing formation. Anhydritic marl, and locally thick salt of the Lower Fars stage I mobile unit, separate the two disharmonic fold sets. Some geologists have interpreted the disharmonic folding to have developed essentially in place without significant differential movement between the two fold sets. An alternate interpretation more compatible with the structural details proposes differential movement of two uniquely folded litho-structural sequences. A time-lapse movie of a dynamic model illustrates how such disharmonic folds may develop.

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CHARACTERISTICS AND TECTONIC SETTING OF GROWTH FAULTS IN EASTERN VENEZUELAN BASIN

Subsurface faults were studied across an area of approximately 160 sq km of the Eastern Venezuelan