unusual in these multi-reservoir fields.

The Hansford gas area of Hansford County is a large multi-reservoir field. Accumulation is controlled by lensing sandstones on the northwest flank of the Anadarko basin. Gas production occurs in rocks of various ages but the dominant number of reservoirs are Morrow in age. The Lips field in northern Roberts County has gas production from Morrow sands and is situated on a pronounced anticline. The accumulation of gas in this reservoir may be due in large part to its high structural position; however, there are other Morrow sand reservoirs in the adjacent area that are not astride this anticline.

Several large interstate gas pipelines traverse the Panhandle area and furnish a ready market for gas. Present prices paid for gas average 15–17 cents per MCF. This ready market, and numerous gas discoveries of the past year, have kept the drilling activity in the western Anadarko basin at a brisk pace through the first half of 1960. Large untested areas within this basin area, combined with favorable discovery rates and access to pipelines, give indications that the accelerated pace of exploratory drilling and development drilling will continue through the remainder of this year and into 1961.

ROBERT J. HESTER, Cosden Petroleum Corporation, Midland, Texas
RICHARD R. HOLLAND, Phillips Petroleum Company, Midland, Texas

Geology of Puckett Field

Geographically, the Puckett field is 27 miles southeast of Fort Stockton in central Pecos County, Texas. Structurally, it is a large faulted anticline on the north flank of Val Verde basin.

The geological evolution of this feature was controlled, primarily, by three periods of uplift and erosion —one in early Pennsylvanian time, a second in either late Pennsylvanian time or early Permian, and a third movement, sometime after the close of the Permian.

The discovery of gas here in 1952 opened one of the world's largest gas reserves and has contributed immensely to the unraveling of the geologic history of the Val Verde basin.

LOYD E. WALKER, Plymouth Oil Company, Midland, Texas

Geology of Benedum Field, Upton County, Texas

The Benedum field, in the east-central part of Upton County, Texas, is in the southwestern part of the Midland basin. It is an elongate anticlinal structure having a major fault along the east flank. Minor radial or peripheral faults are probably present; however, the throw of these faults appears to be less than the productive thickness of the Ellenburger section.

Surface elevations range from 2,618 to 2,710 feet in the Benedum field. A contour map of these elevations indicates a southeastward nosing in the central part of the field.

Gas condensate is produced from three reservoirs in the Benedum field. The Pennsylvanian produces from an average depth of 10,600 feet, the Fusselman from an average depth of 11,000 feet, and the Ellenburger from an average depth of 11,300 feet. These reservoirs range in size from 1,600 acres for the Pennsylvanian to 9,700 acres for the Ellenburger.

The presence of structure was detected by a seismograph survey, first in 1935 and later confirmed in 1946. The discovery well for the Benedum field was the Slick Urschel Alford No. 1 in the SE. $\frac{1}{4}$ of Lot 2, Sec. 50½, P. B. Scott Survey. This well was completed in the Ellenburger at total depth of 12,022 feet on December 6, 1947. The Fusselman reservoir first produced in October, 1948, from the Republic Natural Gas Company Barnet "A" No. 1 well located in the NW. $\frac{1}{4}$ of Sec. 40, Block Y, TCRR Survey. Pennsylvanian production was first established by the completion in April, 1948, of the Fred Turner Jr. (now Humble) Barnet No. 1 located in NW. $\frac{1}{4}$ of Sec. 4, Block Y, GC&SF Survey.

MARSH W. NOTTINGHAM, Continental Oil Company, Roswell, New Mexico

Recent Bell Canyon Exploration in North Delaware Basin

The upper Bell Canyon reservoir sands of the North Delaware basin are very fine-grained, arkosic sands cemented with small amounts of carbonate. Their blanket distribution and sedimentary textures suggest a depositional medium such as density currents.

The geologic history at one stage seems to have involved a pre-depositional sorting of the sand prior to its final transportation across the North Delaware basin. The reservoir sands exhibit a uniformity in texture, and mineralogy that might allow them to be termed "blanket," even though they do not exist with uniform thickness throughout the basin. This thickness ranges from a trace to approximately 70 feet, having a cross-sectional shape characterized by a concave base and a flat top.

The location of these sand bodies seems to be determined by local subsidence or compaction of the pre-Ford sediments. The fact that some of these sand bodies are not continuous over the local adjacent highs gives rise to the trap mechanism of the reservoir. A favorable hydrodynamic condition may also be increasing the efficiency of the trap. Evaluation of the reservoir section is greatly enhanced by core analyses and the Gamma-Ray Sonic type log.

The two most prominent fields in the North Delaware basin are the North Mason and El Mar fields, the former producing since 1952 and the latter since early in 1959. Their average reservoir characteristics are very similar: porosity 24%, permeability 25–34 md., oil saturation 13%, and water saturation 44%.

Wells can be drilled for as little as $20,000 depending on the depth required in the location in the basin. Accumulative production to date is approximately 7,500,000 barrels for the entire Mason and North Mason fields over 8 years, and 950,000 barrels for the entire El Mar field over a 1-year period.

Deeper possibilities exist throughout the 4,000 feet of the Delaware Mountain group, as well as in the pre-Permian sediments. Future discoveries are imminent, for well density is increasing each month. This allows better evaluation of each new test, thereby giving rise to more realistic acreage appraisals.

WILLIAM J. LE MAY, Hondo Oil and Gas Company, Roswell, New Mexico

Oil Accumulations along Abo Reefing, Southeastern New Mexico

During Abo (lower Leonard) time, clastic deposition in the Delaware basin was separated from the lagoonal deposits on the Northwest shelf by a transgressive barrier reef. A lithologic study of the Abo formation reveals facies changes from shelf to reef to basin. Shelf or back-reef deposits consist of interbedded green shale and light gray to tan, fine crystalline, anhydritic dolomite. The interfingering of shelf and reef dolomites form an effective permeability barrier to the migration of fluids

back-reef. The Abo reef is a clean white to light tan, anhydritic, fine to coarse crystalline dolomite exhibiting secondary porosity development due to fracturing and solution activity. Interconnecting vertical fractures and vugs give the reef excellent reservoir characteristics which would otherwise be absent in the tight reef matrix. Basin deposits (fore-reef) include black to dark brown argillaceous and cherty dolomites and limestones interbedded with fine-grained sandstones. Fore-reef deposits are called "Bone Spring formation" and are believed to be Abo equivalent.

Hydrocarbons are trapped where porosity has been well developed in relatively high structural areas along the reef. Four fields have been discovered along the Abo reef trend in New Mexico: (1) Lovington Abo, (2) Empire Abo, (3) Corbin Abo, and (4) Turner Abo. The latter three are currently being developed. The size and reserves of these fields are dependent on the following factors: (1) thickness of reef above water, (2) structural configuration of the reef, and (3) quality of the reef pay. In the Corbin and Turner Abo fields, oil is trapped along the crest of an elongated reef ridge, one or two locations wide. The productive limits are defined by their respective water tables. The reef in Empire and Lovington is characterized by the same steep dip toward the basin (10°–30°) but it has a gentle slope toward the shelf; thus, the productive limits are wider (3–6 locations wide) and production is limited shelfward by an effective permeability barrier.

A successful exploratory procedure has been to estimate a well's proximity to the reef crest by defining its relative stratigraphic position through correlation with areas of close control which traverse the reef. The intermediate drilling depth (4,000–8,500 feet) and high reserves (average 500,000 barrels per location) account for the acceleration of activity along the Abo reef trend.

FRANK J. SPIVA, JR., and A. K. DOSS, JR., consulting geologists, Abilene, Texas

Helium

Helium demands a price approximately 100 times greater than natural gas, with a possibility of the price doubling in the very near future. It is obvious that any company or individual engaged in exploratory work should give this gas consideration in their drilling program.

Due to the many unique properties of helium, it is of extreme importance to our national defense, research, and industry. The authors discuss these properties and their relation to the many and varying uses of helium.

Further discussion concerns the location of producing and non-producing helium reserves, the Government's proposed conservation program, past production, and possible future demand.

JAMES A. WEIG, Cities Service Oil Company, Midland, Texas

Page Field, Schleicher County, Texas

The Page field is in south-central Schleicher County, 9 miles southeast of Eldorado, the county seat. Geologically, the field is located near the southwestern margin of the Eastern platform. The discovery well, Page 1-A-40, was completed by Cooper Gas Company as a gas-condensate well in 1936. Oil production was opened in 1939 with the completion of Lone Star Gas Company's Humble-Page 1. Gas production occurs in several porosity lenses in a Strawn reef-limestone at approximately 5,300 feet. Mapping of the reef buildup indicates 250–300 feet of relief. Oil production occurs in three porosity lenses below the main Strawn reef buildup. Mapping of the first oil porosity shows primarily regional west dip with some low relief. The trapping results from an updip porosity pinch-out due to lithologic change.

Cities Service Oil Company recently purchased all producing properties in the field and plans for a pilot water-flood project in the oil zones and additional gas well completions have been proposed.

GEORGE R. PINKLEY, consultant, San Antonio, Texas

Edwards Gas Trend in South Texas

Drilling since 1954 across a wide area in South Texas has established a new and deeper trend of production which may be an important reserve of oil and gas. It extends from the Mexican border on the Rio Grande northeastward across Webb, LaSalle, McMullen, Atascosa, Karnes, DeWitt, and Lavaca counties, a distance of 200 miles, and has reached a width of 13 miles in McMullen County.

Several factors held back the early development of the play: it is deeper than most operators in the district usually drill; the gas encountered was sour; and the geology is more complex than anticipated. These factors are now fading into the background and additional development is expected. The large size of some of the reservoirs and their capability makes this a profitable operation.

The new development ranges in depth from 9,000 to below 14,000 feet, with the latter figure expected to be increased. Production is established in various structural features The Edwards limestone (Fredericksburg group of the middle Albian Cretaceous) is the main producing zone to date although additional drilling should prove other Cretaceous formations to be productive.

Structural patterns proved to date include piercement-type and deep-seated salt domes, folding along both down-to-the-coast and upthrown fault blocks, and possibly simple reef development in the limestone.

Across central Atascosa County is a series of up-to-the-coast fault blocks which have been tested and yielded several profitable oil and gas fields at depths of 7,000–8,000 feet in the Edwards limestone. This trend is now almost completely explored, and is not considered part of the new development area.

Seismic work has been largely responsible for most discoveries though some fields were mapped as surface structures as early as 1932. An unconformity at the top of the Cretaceous in some areas makes shallow subsurface misleading and the seismic interpretation difficult. Additional sample work is needed to determine newly found stratigraphic changes.

Well expenses have been reduced as contractors solve their local problems. A dry hole will range from $100,000 to $125,000, though some of the deeper tests have been extremely expensive. Completion costs are high due to the need of high-pressure connections and the sulphur content which makes corrosion-proof tubing and fittings necessary. The gas must be cleaned before sale and additional expensive plants will be required.

It is too early to estimate gross reserves for the district, but development to date indicates a major figure. The first opinions on the trends assumed that gas would be the only product, as the first ten fields yielded only minor condensate production. The discovery of the Persons field in Karnes County in 1959 changed that idea. One oil well was also completed on the north end of the Fashing field in Karnes County, with accumulation caused by a stratigraphic or permeability trap, within the gas reservoir.