thickness as a result of the post-Hunton unconformity, and Woodford rests unconformably on rocks varying from Arbuckle in the Hollis basin in southwest Oklahoma to Upper Hunton in south-central Oklahoma. A unique carbonate sequence with maximum thickness of 125 feet in the subsurface occurs at the base of the Woodford shale, and rests unconformably on beds as old as Viola along the Mansville-Aylesworth trend in Marshall County, Oklahoma. This carbonate is an oil reservoir on the north flank of the Aylesworth anticline, and has been informally called "Misener" and "Hunton detritum" in the Ardmore area. This carbonate occurrence, its lithologic description, and its possible relationship with the outcrop are briefly discussed.

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Stratigraphic Traps along Northern Shelf of Anadarko Basin

Extensive stratigraphic accumulations of oil and gas along the northern shelf of the Anadarko basin have been the visions of petroleum geologists for more than two decades; however, only recently have these visions become a reality. Prolific discoveries at Laverne, Southwest Stockholm, Woodward, and pools of the "Cherokee trend" have focused the attention of all exploration men to the stratigraphic trap possibilities of the northern shelf area.

Early exploration along the shelf area was derived from surface indications and geophysical study. Test wells were drilled without the aid of gas detectors and modern methods of surveying the bore hole. Consequently, many prolific gas reservoirs were penetrated with the drill without evaluation.

The remedy for this situation has come from the many advancements made in the field of research which has developed new evaluation tools for the geologist.

Numerous deep tests along the shelf area and in the basin proper have enabled the geologist to familiarize himself with the vast possibilities of stratigraphic traps in sediments throughout the Middle and Upper Paleozoics, from the Silurian-Devonian into early Permian.

Convergence due to truncation and onlap, and interruption in deposition of sands and "reef" type limestones provide most of the stratigraphic traps of the northern shelf area. Multiple traps of this nature in any area are not uncommon. Two wells in Laverne have as many as four prolific gas horizons, all stratigraphic, which will gross the operator approximately $4,000,000 per well. More than 50 per cent of the completions in this pool are dual.

The area has a great future, and the returns will be gratifying to those adept in delineating stratigraphic traps.

CHARLES H. GLIDDEN AND W. MARTIN BORG, Union Oil Company of California, Tulsa, Oklahoma

Morrow Formation of Northwestern Oklahoma

Morrow sediments occupy the northwestern Anadarko basin-Hugoton embayment area southwest of a northwest-southeast diagonal line extending from north-central Harper County to the southeastern corner of Dewey County. More than 1,400 feet of Morrow has been encountered in a deep well in southern Ellis County. The formation thins to zero, due to transgressive overlap northeast.

Very few of the wells that drilled the entire Morrow section have failed to encounter shows. Production now extends along a 60-mile trend. Both oil and gas have been found. At present it is felt that the gas reserves are by far the more important.

Maps and cross sections illustrate the structure, distribution and thickness of the Morrow formation.

VICTOR J. VERODA, Republic Natural Gas Company, Hugoton, Kansas

Morrow Rocks of Western Kansas and Panhandle Counties of Oklahoma

The Morrow rocks of Western Kansas and the Oklahoma Panhandle have a maximum thickness of 700 feet and pinch out northeast on the flank of the Anadarko basin.

Sands within the Morrow series occur in two basic intervals designated as upper and lower. Upper sands are very lenticular but usually produce where present. They account for production in the Camrick pool, Texas County, Oklahoma; Light pool, Beaver County, Oklahoma; Interstate pool, Morton County, Kansas; and the Leslie pool, Meade County, Kansas. Lower sands produce in the Mocane pool, Beaver County, Oklahoma; Keyes pool, Cimarron County, Oklahoma; and the Sparks pool, Stanton County, Kansas.

Morrow sands produce more than half of the area's crude oil and a large percentage of the pre-Permian gas. Production from the 60 pools in the area is from simple anticlinal to complex stratigraphic traps. Common completion practice is through casing with fracture treatment following a light-mud acid wash. Some excellent quality sands are completed natural.

Wells sufficient to test the Morrow range in depth from 4,600 to 8,500 feet. Well costs average $10 per foot dry and $15 per foot completed. Reservoirs range from 3 to 90 feet in thickness, resulting in non-commercial to excellent wells with fast payout (less than 1 year). Average porosity is 14%; average connate water saturation is 25% with instances of 40% in commercial wells. Reserves in place

range from 300–750 MCF per acre foot and 400–750 barrels per acre foot. Reservoir engineering studies of the character and behavior of some Morrow sands indicate that they should be capable of permitting efficient "sweep out" under secondary recovery.

Subsurface geology and imaginative thinking are essential to the exploration approach of the Morrow. Gravity and seismic methods are being used with success. This area is in the early stages of development, and many reserves remain to be found.

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RICHARD L. PARKER, Petroleum Exploration, Inc., Amarillo, Texas

Morrowan Series of North Texas Panhandle

Morrowan sediments are recognized in the subsurface over most of the northern Texas panhandle. Morrowan terminology is based primarily on lithology and stratigraphic sequence with some faunal identification. The rocks are predominantly shales with less amounts of limestones and sandstones. The sandstones are of prime economic importance in the production of oil and gas distillate, and account for a greater part of the recent discoveries in the panhandle.

ABSTRACTS

PACIFIC SECTION MEETING, LOS ANGELES, NOVEMBER 7 8, 1957

R. J. BEAN AND R. C. SPIVEY, Shell Oil Company, Los Angeles, California

Geological and Geophysical Studies at Railroad Valley, Nevada

In Paleozoic time 20,000 feet of sediments accumulated in the Railroad Valley area. Limestone and dolomite make up about 85 per cent of these sediments, with 5–10 per cent sandstone and the rest shale. Fossils and lithologic characteristics indicate most or all of these sediments were deposited in shallow water, but subsidence of the area was nearly continuous, and all of the Paleozoic systems are represented in the sequence of beds.

In late Paleozoic or early Mesozoic time the area was uplifted and no seas are known to have covered it since that time. Erosion produced a surface with slight to moderate relief, and beds ranging in age from Devonian to Permian were exposed. On these upper Paleozoic strata Tertiary lake and stream sediments and volcanic materials were deposited in thicknesses ranging up to 15,000 feet. These Tertiary beds can be subdivided into four groups which can be recognized in wells in Railroad Valley and in several nearby mountain ranges. Some diastrophism occurred in early and middle Tertiary time, resulting in several widespread unconformities, but the diastrophism which produced the present basin-and-range topography occurred after deposition of all of these Tertiary beds.

Seismic and gravity surveys were used to delineate structural features in the sediments beneath the valley. Both methods show that Railroad Valley is an asymmetrical basin with the greatest depths on the east. The gravity survey shows a major border fault probably is present on the east flank of the basin, and a series of horsts and grabens parallel the mountain on the west side of the valley. Seismic reflections outlined several structural highs which were tested; one of these produced oil in the Eagle Springs field.

Seismic reflections are not of the best quality in the valley, but the most numerous, reliable, and continuous reflections originate from within Tertiary and Quaternary clastic deposits. Reflections from greater depths are fragmentary, but often are useful. In some instances, the unconformity at the top of the Tertiary volcanics could be mapped. Reflections could not be obtained on the fan deposits at the edge of the valleys, where major border faults probably occur. In these regions gravity data were used to trace the faults, obtain estimates of their dips, and to outline the structure of the Paleozoic surface. Estimates of depth to Paleozoic rock in several basins along the axis of the valley could also be made from gravity data; these depths range from 7,000 to 15,000 feet.

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C. R. ALLEN AND L. T. SILVER, California Institute of Technology, Pasadena

The west side of Baja California between 30° and 32° North exhibits a terrane of deformed pre-batholithic eugeosynclinal rocks, abundant batholithic and smaller intrusive bodies, and a coastal zone of relatively undeformed post-batholithic sediments.

The pre-batholithic section of great but unknown thickness consists of basic and intermediate volcanic pyroclastics and flows, graywackes, and rare carbonates. It has been intensely folded and faulted, and near contacts with plutonic intrusives is mildly to strongly metamorphosed. A persistent limestone zone has been a useful stratigraphic unit in regional study. Numerous fossils taken from this zone and from other horizons indicate Albian age.

Plutonic rocks of considerable variety intrude the eugeosynclinal terrane but occur most com-