the Burbank Sandstone whose maximum aggregate thickness is about 70 ft. The Burbank Sandstone was deposited on a tectonically stable shelf bordering the Arkoma basin on the south; evidence suggests that the sand was deposited in a shallow marine environment.

The productive limits of the Burbank field are controlled by an updip facies change from sandstone to shale toward the east and a tilted oil-water contact on the downdip margin toward the west. These conditions have combined to form a stratigraphic trap of about 50,000 acres, covering all or parts of 12 townships. At present, more than 1,600 wells are producing approximately 26,000 bbl of oil per day, of which 76 percent is by waterflood. Cumulative production from the Burbank field is in excess of 500,000,000 bbl of oil.

During the past 40 yr recurring cycles of field extensions and development followed by periods of relative inactivity have enlarged the Burbank field to what appears to be its complete areal extent. Intensive and imaginative geological investigation of more recently discovered stratigraphic-trap accumulations of oil and gas could reveal additional productive acreage that will put these fields in the "giant" category.

LATHAM, J. W., Sinclair Oil and Gas Co., Ardmore, Okla.

PETROLEUM GEOLOGY OF HEALDTON FIELD, CARTER COUNTY, OKLAHOMA

The Healdton field, in western Carter County, Oklahoma, is confined largely to the northeast half of T.4 S., R.3 W., but extends into adjacent townships. The townsite of Healdton is within the field's limits. Oil production is principally from the Hoxbar Group (Missourian) of Pennsylvanian age and the Arbuckle Group (Canadian) of Ordovician age.

Production was established first in 1913 with subsequent field development resulting in oil production from four shallow Pennsylvanian sandstones. These are the Healdton sandstones. All can be recognized across most of the field although local discontinuities exist. Approximately 2,600 wells had been drilled by 1955 covering a productive area of more than 7,100 acres.

Several of the earlier development wells were drilled into the pre-Pennsylvanian section where Ordovician oil was found in minor amounts.

In 1960, the discovery of a commercial reservoir within the Arbuckle brought renewed importance to this already prolific field. The new production is from three dolomite zones: Wade, Bray, and Brown. These zones are restricted to the upper 1,600 ft of a 5,000-ft carbonate section. The Brown zone is the lowermost unit and has proved to be the only zone of significance. It is a crystalline dolomite approximately 600 ft thick with good intercrystalline porosity and excellent permeability caused by a highly developed fracture system. The Arbuckle produces from 43 wells within an area of 1,800 acres.

Entrapment of hydrocarbons is attributed to a northwest-southeast structural trend which originated in Early Pennsylvanian time and was activated again during the Late Pennsylvanian. The Healdton area was subjected to intense uplift and faulting in Morrowan time by the Wichita orogeny. Associated high-angle faulting with a displacement of 10,000 ft placed Pennsylvanian shale and sandstone in juxtaposition with Ordovician carbonates. These younger sediments are believed to be the source and means of migration for the majority of if not all Arbuckle oil in the Healdton structure. Following an extensive period of erosion, Hoxbar sandstone and shale were laid down over truncated pre-Pennsylvanian rocks and later folded during the Arbuckle orogeny.

Because of the magnitude of stresses affecting pre-Pennsylvanian strata, the Arbuckle producing structure has closure in excess of 1,500 ft whereas the overlying Pennsylvanian closure is approximately 500 ft.

Hoxbar sandstones, from an average depth of 1,000 ft, have yielded approximately 250,000,000 bbl of oil and secondary recovery methods are now being employed. The Arbuckle produces from an average depth of 4,000 ft and has a cumulative production in excess of 2,000,000 bbl.

LING, HSIN-YI, Dept. of Oceanography, University of Washington, Seattle, Wash.

RADIOLARIA IN SURFACE SEDIMENTS OF NORTHEAST PACIFIC OCEAN

The taxonomy and the distributional pattern of Radiolaria in surface sediments of the northeast Pacific Ocean have been investigated from more than 50 sediment cores collected in the area from 40° N. lat. northward to the coast of Alaska and from the west coast of the North American continent westward to approximately 160° W. long. Previous knowledge of these microorganisms from the area has been limited.

The results of the present study strongly suggest that it is possible to delineate the biogeographic distributional pattern of Radiolaria of the area into subarctic and transitional faunas. It is found also that the southern limit of transitional fauna possibly would lie slightly south of the so-called subarctic boundary (approximately at 40° N.). Because of the pronounced variation of the oceanographic conditions in the region, both northern and southern boundaries of the transitional zone cannot be defined sharply at present. Nevertheless, on the basis of the relative abundance and the general biogeographic occurrence of the studied taxa, such a distributional pattern in the area could be ascertained reasonably. The observed biogeographic differentiation agrees in general with those of previous studies made by physical oceanographers and the results of the earlier researches on diatoms, planktonic Foraminifera, and zooplankton in the North Pacific.

Therefore it can be concluded from the present study that Radiolaria in the northeast Pacific could be used as a water-mass indicator and thus may be useful in the interpretation of paleoecology of deep-sea sediments as well as marine deposits on land.

LOUGHNAN, F. C., School of Geology and Geophysics, University of Oklahoma, Norman, Okla.

FLINT KAOLINS IN NON-COAL-BEARING TRIASSIC OF SYDNEY BASIN, AUSTRALIA

Claystones, similar in composition, texture, and structure to the flint kaolins of the Pennsylvanian of North America, the Westphalian of Europe, and the Permian coal measures of South Africa and Australia, form a persistent marker bed in the non-coal-bearing Triassic Narrabeen Group of the Sydney basin.

The claystones are indurated and characteristically possess oölitic textures, although vermicular crystals and brecciated fragments are present in most samples. Well-crystallized kaolinite is the only clay mineral present and is associated invariably with anatase and locally with abundant (> 50 percent) boehmite or siderite. Quartz, either as discrete grains or as chalcedony, is rare or absent.

The unit ranges in thickness from 1 to 6 ft and can be traced for more than 50 mi along the southeastern margin of the basin. However, extensive boring downdip has shown that it thins out abruptly in that direction.

The underlying sediments consist of red claystones, known locally as the "chocolate shales." Apart from well-crystallized kaolinite and anatase, these claystones contain appreciable quantitites of hematite (15–25 percent), but quartz and clay minerals, other than kaolinite, are sparse or absent. The overlying sediments, however, are composed of quartz, illite, and degraded illite as well as kaolinite.

The "chocolate shales" are believed to represent a transported laterite or lateritic bauxite and the flint kaolins are considered to be the reduced equivalent, formed by the advent of swampy conditions at the close of deposition of the sedimentary sequence.

MAGLOIRE, P. R., S.N. REPAL, Algiers, Algeria

TRIASSIC GAS FIELD OF HASSI ER R'MEL, ALGERIA

After the first important Saharan stratigraphic test (Berriane) had shown encouraging results, S.N. REPAL intensified its reconnaissance studies. Seismic refraction and reflection, carried out together with field geology, located the structure of Hassi er R'mel, about 60 mi southwest of Laghouat oasis. In 1956 the HR-1 well was spudded, and led to the discovery of the gas field of Hassi er R'mel.

Located on the Cretaceous high zone of the M'zab area, the structure of Hassi er R'mel is a part of a zone which has been stable tectonically since the Cambrian.

Above the granitic basement, are Cambrian and Ordovician formations, which are covered by Silurian where pre-Triassic erosion was less important.

The oldest Mesozoic deposits lying unconformably on the Paleozoic, consist of Triassic sandstones, which are, from base to top: (1) a lower series (with andesite flows) which fills the topography of the pre-Triassic erosion surface. The top of the lower series is the C reservoir, which exhibits important lateral variations; and (2) two separate sandstone reservoir zones: B (noncontinuous) and A (continuous). Above the reservoirs are the salt-bearing Triassic (1,300 ft thick), Jurassic (3,000–3,300 ft), and Cretaceous.

The structure at the top of the Triassic reservoir is anticlinal and has a north-northeast-south-southwest axis; its areal extent is about 1,000 sq mi.

An oil-water contact is at 5,016 ft (below sea level). Oil shows and minor production have been found in the Ordovician quartzites and Triassic sandstones. It is possible that there is a very narrow oil ring but so far this is unproved.

Though the structure is old, evidence has been found that the gas was trapped definitely during the Early Cretaceous.

Operated by SEHR (a subsidiary of S. N. REPAL and CFP[A]), the gas field of Hassi er R'mel has produced 380 Bcf of condensate gas since 1958. The reserves are now estimated at 70 trillion cu ft. Production could be increased considerably should the market requirements for gas be increased; because of the limited use for the gas at present, only five wells are now producing.

MALONEY, NEIL J., Instituto Oceanográfico, Universidad de Oriente, Cumaná, Venezuela

CONTINENTAL-SHELF SEDIMENTS OFF EASTERN VENEZUELA

The continental shelf between Carúpano and Barcelona, Venezuela (63° to 64° 45′ W. long.), exhibits large variations in size and topography. East of Margarita Island the shelf is 80–100 km wide. The southern, landward part is an east-sloping depression which extends from a depth of 20 fm east of Margarita to more than 63 fm west of Trinidad. The northern border of the depression is formed by the bank passing from Margarita to Los Testigos Islands. It is 12 to 20 fm deep except at Daring Shoal which shallows to 4 fm.

The depression is covered with olive-green silt containing 20–40 percent sand. Calcareous sand, rich in shell material, occurs on the bank. Algae and corals are abundant in the samples from Daring Shoal. Silty sand is present north of the bank to a depth of 100 fm. Silts with less than 5 percent sand occur below this depth.

An open shelf, 40 km wide, is north of Margarita. The sediments range from clayey silt to silty sand. Narrow, shallow straits characterized by strong currents are south of Margarita. Sand and gravel are the dominant sediment types in the straits.

West of Cumaná the shelf is less than 5 km wide. The shelf and upper slope to 110 fm are covered with calcareous sand; olive-green, clayey silt with less than 5 percent sand occurs below this depth. The highest concentrations of sand are on the central and outer parts of the shelf, suggesting that it is a relic sand.

Islands, bays, and gulfs are the main topographic features on the shelf between Mochima Bay and Barcelona. The outer parts of the bays contain calcareous sand, and the inner, more protected, parts are covered with sandy to clayey silts. The alluvial sand is being deposited on intrabay deltas. North of the islands the shelf is 4 to 8 km wide. Sands are present in the east but grade into silt and clayey silt on the west opposite Barcelona.

The sediment distribution is related to the bottom topography, ocean currents, and depth. Fine-grained sediments have accumulated in the depressions and protected areas. The topographic highs and open-shelf areas contain calcareous sand. No sand occurs in the surface sediment at depths greater than 110 fm.

MARTINEZ, ANIBAL R., Organization of Petroleum Exporting Countries, Vienna, Austria

GIANT FIELDS OF VENEZUELA

Only 44 out of the nearly 300 oil fields discovered in Venezuela to the end of 1965 could be classified as giants, *i.e.*, fields having resources of at least 100 million bbl of oil. Giant fields have been discovered in three of the sedimentary basins of the country. The average time lag for the recognition of an oil field as a giant is 8 years and 7 months. The estimated re-