nish a variety of structures and begin with an overburden of only 2,000 ft.

Most workers feel that, of all sediments, evaporites have received perhaps the least attention from American geologists and researchers. The writer finds that evaporitic conditions provide S.P.P.S.S.; that is to say they provide source conditions; they preserve organic material; they provide porosity; they provide excellent seals (aquicludes); and they are subject to plastic flow, thus providing a variety of structures.

It is hoped that all will learn their "evaporite" lesson and use it in their oil search. The support of all geologists for research is earnestly solicited.

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LATE PALEOZOIC SEDIMENTS DERIVED FROM PEDERNAL UPLIFT

The Pedernal uplift, elongated northward from southern Otero County, New Mexico, to the present-day position of Pedernal Hills, was a late Paleozoic feature 40–75 mi wide and about 225 mi long; at the time of maximum development, the uplift connected southward with the Diablo platform and northeastward with Sierra Grande arch and Amarillo-Wichita uplift. This is Hill's (1958) Pedernal-Sacramento-Otero uplift, Adams' (1962) Pedernal arch, and Meyer's (1966) Pedernal uplift, but differs from Galley's (1958) Pedernal massif which he extended northeastward to encompass the southern Sierra Grande arch.

The southern Pedernal area was beneath pre-Pennsylvanian seas, which derived their minor detritus from Peñasco dome of northern New Mexico and southern Colorado. The Pedernal uplift emerged during Early Pennsylvanian time. Sediments which became sandstone, dark shale, and silty limestone were deposited westward in Orogrande and Estancia basins and eastward in Delaware basin. During Desmoinesian time, there was wide expansion of shallow seas; the Pedernal barely was awash, and provided only silt and clay for the limestone-choked seas, except for some deltaic subgraywacke in the Orogrande basin. Uplift of the northern part of the Pedernal uplift during late Desmoinesian time supplied arkose northeastward to the Rowe-Mora basin and westward to the Joyita-Los Piños area and Estancia basin.

Beginning in late Missourian, the uplift took on the aspect of a tilted fault block, with the western edge higher (especially near Ruidoso) and providing more detritus westward into the Orogrande and Estancia basins, whereas only minor amounts of fine-grained materials swept eastward into the Delaware basin. These conditions continued into Virgilian time, culminating during the late Virgilian and early Wolfcampian with the westward dumping of a thick sequence of subgraywacke, arkose, and red to dark shale.

Early Wolfcampian sediments derived from the west side of the Pedernal uplift range from quartzite and granite-cobble conglomerate to red shale, but by middle Wolfcampian the major detritus source was the Uncompahgre highland of north-central New Mexico and southwestern Colorado. Reddish clastics from this highland flooded Wolfcampian seas southeastward where Abo redbeds intertongue with Hueco Limestone. By late Wolfcampian time, most of the Pedernal uplift was buried beneath redbeds; only locally, as at the present-day Pedernal Hills and Pajarita Mountain, did remnant Precambrian-rock monadnocks rise above the red clastic flood. Higher remnants supplied minor detritus to lagoonal seas during Leonardian time.

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TRANSGRESSIVE FACIES PATTERNS IN DELAWARE COASTAL AREA

Studies of Recent sediments in coastal Delaware show complex sediment-distribution patterns resulting from lateral and vertical movements of successive environments of deposition over a Pleistocene unconformity. Recent sediments are infilling a drowned topography with a local relief of 70 ft and possibly up to 125 ft eroded on highly variable Pleistocene sediments. Identification of the Pleistocene surface is a problem. However, it may be recognizable as a soil zone or intermixture of marsh clay with Pleistocene sands at the unconformity; it also may be recognized on the basis of radiocarbon dates.

Larger depositional features forming around eroding Pleistocene headlands and infilling the estuaries include characteristic depositional shoreline environments, such as spits, dunes, baymouth bars, an intermeshing network of tidal deltas, nearshore marine erosional-depositional sand and gravel, and the bays or estuaries and fringing *Spartina* and *Distichlis* marshes which form the westernmost edge of the transgressive units. The thickness and areal extent of the sedimentary bodies are controlled largely by the morphology of the Pleistocene unconformity. A large part of these Recent sedimentary units is being eroded by the transgressing Atlantic Ocean.

Cores of sediment taken under the shallow bays, such as Rehoboth, Indian River, and Assawoman Bays, and in the fringing marsh environment, show that the depositional units are thin, highly irregular in areal extent, extremely variable in thickness, and difficult to project. Sedimentary processes active in the shallow bays include shoreline marsh erosion and the formation of thin, possibly ephemeral, beach-dune complexes consisting of clean, well-sorted sand having typical beach and dune sedimentary structures. They are anomalous in that they are completely surrounded by *Spartina* marshes on the landward side and extremely muddy sand grading into dark gray lagoonal mud on the bay side. It appears that distinctive sedimentary structures, and sediment size-sorting relations such as those that characterize the larger more common sedimentary units of the coastal area may be formed in miniature at the very thin edge of transgression and may lead to considerable confusion in the interpretation of sediments of this type in the geologic record.

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BURBANK FIELD, OKLAHOMA—A GIANT GROWS

The Burbank field of Osage and Kay Counties, Oklahoma, a "giant" oil field by any standard, has dominated oil activity in northeastern Oklahoma since its discovery in the 1920s.

The major producing formation in the field is the Burbank Sandstone which is in the Desmoinesian Cherokee Shale of Middle Pennsylvanian age. Several lenticular and semiblanket sandstone bodies comprise 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.

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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.

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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.

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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.