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REGIONAL OIL POSSIBILITIES OF ABILENE-NEMAHA ANTICLINE AREA, NORTHEAST KANSAS

The Abilene-Nemaha anticline area of northeast Kansas has potential commercial oil possibilities in rocks of Ordovician to Permian ages.

The area is structurally and stratigraphically complex and, in these respects, is one of the most unusual in the state of Kansas. Represented are horsts, grabens, faults, unconformities, and abrupt lithofacies changes.

Within these complex geological phenomena are oil and gas fields in reservoirs of the Simpson, Viola, Hunton, Mississippian, Cherokee, and Permian; oil shows have been recorded in units of other ages. Structural and stratigraphic traps abound, because all units from the Reagan to the Kansas City are truncated or pinch out around the high-relief granite knobs of the Nemaha trend.

Basement tectonics probably has controlled most of the structural movements, including present-day movements along the still-active Nemaha fault. Most isopachous "thicks" correspond in geographic position to the thick Rice Formation of Precambrian age. Conditions during deposition of the Rice set the stage for the creation of subsequent basins and tectonic highs.

Future oil will be found in buried structural highs masked by the unconformities, in cuestas formed by the truncation of successive stratigraphic units around the highs, and in stratigraphic traps caused by the abrupt changes in lithology within individual units.

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STRATIGRAPHIC APPLICATIONS OF DIPMETER DATA IN MID-CONTINENT

Dipmeter techniques recently developed to solve Mid-Continent stratigraphic problems use short-correlation-interval dip computations and a statistical approach to interpretation. These techniques extend dipmeter interpretation methods first introduced in Tertiary formations along the Gulf Coast.

Paleozoic sandstones, as in the Pennsylvanian section of the Anadarko basin, commonly were deposited on surfaces of low dip and low topographic relief. Lithologic unit boundaries usually are nearly parallel, providing little information with which to predict the direction of improved sandstone development. In these nearly parallel beds, cross-stratification anomalies produce most of the dips computed.

To detect cross-bedding and describe its orientation within thin sedimentary units, correlation intervals must be short, yielding computed dips for every few feet of hole. Correlations are influenced by many factors, including the attitude of the underlying surface at the time of deposition and subsequent tilting. Many of the dips computed were caused by current-bedding, and indicate the direction of sediment transport.

Random variations in sedimentation tend to cause confusion if the data are studied only superficially. To emphasize trends and minimize random events, statistical methods are used. Azimuth-Frequency diagrams and Modified Schmidt plots reveal the direction of sediment transport, the direction of interval thickening, and present structural dip. These methods produce greater accuracy and confidence in orienting and extrapolating sandstone isopachous contours.

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EARLY PALEOZOIC OVERLAP, SOUTHERN MID-CONTINENT

Cambrian volcanics and Precambrian basement rocks produced an irregular topography in the Mid-Continent during intermittent Late Cambrian-Early Ordovician inundations. Large islands remained until Roubidouxian time; highest peaks persisted until Mississippian. The early Paleozoic sequence is thickest in inter-island channels of northeastern Oklahoma and in the more rapidly and uniformly subsiding basinal area of southern Oklahoma.

Dresbachian transgression, spreading west, north, and possibly south, failed to reach most of Kansas and northern Oklahoma. During Franconian time, only southern Oklahoma and Missouri received sediments; Trempealeauan inundation covered all but central Kansas and the islands of northeastern Oklahoma. Sandstone and carbonate comprise the Cambrian.

Following post-Cambrian regression, Ordovician seas spread a blanket of carbonate over most of Oklahoma and Kansas. Sandstone is most abundant at the base of the Gasconade in eastern Oklahoma. It is also common in Roubidouxian rocks.

Paleogeographic maps and a worm's eye map illustrate the intermittent nature of the transgressions and emphasize the inherent problems of time correlation.

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PRE-PERMIAN PALEOZOIC STRATA OF LAS ANIMAS ARCH—NEW OIL PROVINCE

Drilling on the Las Animas arch during the past 3 years has provided the control for a more complex structural theory of development than has been considered previously. Pre-Pennsylvanian folding has a predominantly northwest-southeast trend, whereas Pennsylvanian and later movements are oriented primarily northeast-southwest. In addition, instead of being a broad simple arch, there is a record of obvious Early Pennsylvanian movement considerably east of the well-known Las Animas arch axis.

Many prejudices to the effect that the Las Animas arch is not an oil province have been disproved as a result of the reserves found in the Brandon field. In this field the Pennsylvanian is producing, or is capable of producing, from five separate zones, and the Mississippian is producing in the St. Louis, Spergen, Warsaw, and Osage zones, with the deepest pay being 325 ft below the Pennsylvanian subcrop.

The most significant development has been the completion of several wells that would have been plugged in the past because of the discouraging results of the drill-stem tests. This has caused scrutiny of many assumed dry holes in the arch area.

Success during the past 2 years and recent activity indicate that the virtually unexplored Las Animas arch is becoming "A New Oil Province."

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PETROLEUM HYDROGEOLOGY

Observations of the pressure and composition of interstitial fluids permit more intelligent interpretation of the geological data on the solid rocks in a prospective area. In plains areas, oil-field waters usually are static, although regional tilting has shifted the location of some oil fields. In mountainous areas artesian flow occurs, which commonly flushes certain parts of prospective oil-bearing strata. The flushed areas usually can be recognized by a characteristic water composition.

In zones of recent rapid sedimentation such as the Gulf Coast, shale is less compacted than normal and associated lenticular sandstone contains fluids under abnormally high pressure. Similar abnormal pressure is found in front of overthrust mountains because of the rapid addition of stratigraphic sections by tectonic processes. This suggests that during compaction of shale the pore water follows bedding planes and usually does not migrate across the strata or along faults. High pore pressure in shale facilitates large-scale gravity slumping and sliding which are more common than have been supposed.

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DALHART BASIN CHALLENGES THE EXPLORATION GEOLOGIST

The Dalhart basin is a small stratigraphic and structural basin underlying the greater part of Cimarron County in the Oklahoma Panhandle, and Dallam and Hartley Counties in the extreme western Texas Panhandle.

Genetically, the Dalhart basin is closely related to both the Palo Duro and Anadarko basins, because connecting seaways from these basins were open into the Dalhart basin through most of Pennsylvanian and Early Permian times.

The Dalhart basin is a region of fairly abrupt facies changes, with interfingering of nearshore sandstone and granite "wash," shelf sediments, and basinal sandstone and shale. Under these conditions, reservoirs can be expected to be controlled as much by stratigraphic factors as by structural position.

Excellent reservoir beds occur throughout the basin at relatively shallow depths, with average pay zones ranging in depth from 4,500 to approximately 6,500 ft. The primary objectives in Cimarron and Dallam Counties appear to be sandstone, "wash," and conglomerate of Morrowan and Desmoinesian ages, whereas in Hartley County, the main exploratory effort should be centered on the Missourian and Virgilian sandstone and "wash." It is also very possible that Wolfcampian and (or) Virgilian reef or reef-like carbonate deposits may be found in Hartley County.

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MISSISSIPPIAN ROCKS OF WESTERN KANSAS

In western Kansas, Mississippian rocks, all marine and all in the subsurface, are correlated with rocks of the Kinderhookian, Osagian, Meramecian, and Chesteran Stages. Unconformities separate dominantly carbonate Mississippian rocks from Pennsylvanian rocks above and Cambrian to Devonian rocks below.

Karst, diagenetic alterations, and facies changes complicate the problem of establishing lateral stratigraphic equivalents. Dolomitization, silicification of fossils, and chertification are widespread.

Conodont faunas recovered as acetic acid insoluble residues from cores are correlated with conodont biostratigraphic zones of the type area of Mississippian rocks. Part of the study area once contained Devonian rocks; evidence of this is the presence of reworked Devonian and Kinderhookian conodonts preserved in Kinderhookian rocks.

The primary sediment source of Osagian and Meramecian rocks was organic. Sediments probably were deposited in warm, shallow seas. Thin intraformational conglomerate beds, quasi-brecciated limestone beds, and local beds of anhydrite are known in upper Meramecian rocks. An increased content of clastic (quartz) rocks in upper Meramecian strata marks a change in sediment source. Siliceous sediments were provided from areas of provenance from the Central Kansas uplift and the Las Animas arch. In Chesteran rocks, sandstone, siltstone, and thin limestone beds predominate.

A normal sequence of Osagian and Meramecian rocks was deposited in south-central Kansas. The term "Cowley Formation" should be dropped; the cherty "Cowley" facies is developed only locally.

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UNIT REGIONAL VALUE CONCEPT AND ITS APPLICATION TO KANSAS

From 1911–1964 the United States produced nonrenewable natural resources whose value was $458.101 billion, yielding a return of $151,569 per sq mi; with this as the expected value, one finds that the individual states have returned from 9.6×10^3 to 1×10^6 per sq mi. Thus the return is not uniform. Return does not appear to depend solely on geology, and in particular is independent of surface geology. In fact, the distribution of return in dollar value per square mile is log-normal and, in these terms, dollar return per unit area is a random variable. This implies that any area large enough may be equally well blessed in resources to return at least the expected value of the United States.

In this period the return for Kansas is 196.402×10^3 per sq. mi; with basement at 5,000 feet, this is equivalent to the return per cubic mile. For the year 1960 the distribution of unit regional value per square mile per county ranges from 36×10^3 to 6.76×10^3; the effect of the Central Kansas uplift is, of course, obvious but what is not by any means clear is whether those areas with very much lower than average value have been given an equal opportunity to achieve their true level of return.

On the basis of unit regional value it appears possible to classify areas into those which are largely depleted, those worthy of additional search, and those which have received little attention. Because the existence of resources in an area is not the sole determinant of its value, the unit regional value concept may be used as a useful planning tool.

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SOME INTERESTING ASPECTS OF CARBONATE OIL ACCUMULATION IN MID-CONTINENT AREA

Detailed sample studies are necessary to evaluate properly the porosity and permeability characteristics of carbonate reservoirs. The depositional porosity fabric and resultant permeability are varied in carbonates. These may range from highly porous impermeable chalk into somewhat less porous, but highly permeable, intergranular porosity present in carbonate banks, which may be composed of pellets, oölites, or admixtures of fragmental debris. The presence of fossil cavities, calcispheres, and a few reefoid deposits may modify the overall fabric. In addition to these depositional characteristics, tectonism can alter the basic porosity-permeability relations by means of fracturing, recrystallization, and (or) tectonic dolomitization.