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 $\times 10^3$ 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 $\times 10^3$ to $6.76 $\times 10^3$; 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.

Examples are known where several of these various types of porosity are present in a single deposit and influence log analysis in either a negative or positive manner. A nonpermeable chalk or calcisphere porosity carrying high water saturation may produce oil if the fracture fabric or associated intergranular permeability is oil-bearing. Likewise the reverse may be true if nonproducible oil is trapped in the high porosity-low permeability deposits and the more permeable fracture and (or) intergranular porosity is water-bearing.

The presence of these varied porosity fabrics can be recognized in samples and a method of logging and estimating the importance of the different types is suggested. Utilization of well sample data coordinated with realistic log analysis can lead to successful completion in zones which might be overlooked in a cursory log analysis. Examples of these sedimentary types from the Mid-Continent area are discussed and illustrated.

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ORDOVICIAN OIL IN SEDGWICK EMBAYMENT

The Sedgwick embayment occupies approximately 8,000 sq mi in south-central Kansas. The area is bounded on the west and northwest by the Pratt anticline and the Central Kansas uplift. The Nemaha ridge limits the embayment on the east. Late Mississippian and Early Pennsylvanian movements were primarily responsible for the development of the embayment.

The most important reservoir for the Ordovician oil is the Simpson sandstone. Other reservoirs contributing significant recoveries are the Viola and Arbuckle.

Simpson sandstone of the area was laid down by transgressive seas, with locally regressive phases, which invaded from a subsiding basin on the south. Source of the sand was on the north and northeast.

The Sedgwick embayment has undergone two phases of exploratory activity. In the late 1920s and early 1930s the large features were found through core-drilling operations. Subsequent to World War II many new fields were found by subsurface studies and seismic activities.

Fields in the Sedgwick embayment have produced approximately 303,000,000 bbls of oil. Of this total, 108,000,000 bbls, or approximately 30%, has come from Ordovician rocks.

Most of the oil fields of the area which produce from the Ordovician exhibit similar geologic characteristics. Among the more important factors governing Ordovician accumulation are thinning of the Mississippian, existence of adequate reservoir rocks, and Permian structure.

Proper geological application of the known factors which control Ordovician oil accumulation will result in many future Sedgwick embayment discoveries.

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USE OF CLAY MINERALOGY IN DETERMINING SOURCE OF BASIN SANDS

(No abstract submitted.)

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DEPOSITION OF CHESTER SANDSTONES OF MISSISSIPPIAN AGE IN SOUTHWESTERN KANSAS

The Chester Series of the Mississippian System covers all or part of 12 of the counties that comprise extreme southwestern Kansas. The erosional surface on which sediments of Chester age were deposited was an extremely rough one, representing a major unconformity. Significant commercial oil fields have been found in sandstones of Chester age in this area. Commercial oil accumulated in highly lenticular sandstones. This oil accumulation is mainly stratigraphic. Chester sediments change thickness abruptly in the area that was studied. The Chester seas generally were transgressive with several periods of quiescence. Several facies are recognized, including the sandstone facies.

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AN APPLICATION OF DIRECTIONAL FEATURES AND SCALAR PROPERTIES OF SEDIMENTS TO HYDROCARBON EXPLORATION

Ripple marks, cross-bedding, and groove casts are examples of directional features of sediments. Variations in grain size or mineral composition are examples of scalar properties. Although directional features normally are considered to be the domain of the surface geologist, by means of the oriented core and more recently the dipmeter, these features also can be used by the subsurface geologist. Recent literature abounds with reports of new types of scalar properties.

Directional features and scalar properties of sediments are used to determine paleocurrent direction. The integration of paleocurrent data with environmental information yields a paleogeographic map. Prediction of favorable areas for wildcat exploration and the exploitation of wildcat discoveries can then be made from the paleogeographic map.

The Desmoinesian-age Hartshorne Formation of eastern Oklahoma is a shallow but major gas producer within the Arkoma basin. A study in the nature of directional features → paleocurrent direction + depositional environment = paleogeographic map is presented. This study indicates that the probable nature of the productive Hartshorne sandstone in the discovery well of the South Pine Hollow field, Pittsburg County, Oklahoma, is a deltaic channel sandstone with a northeast-southwest alignment. This information could have been used to exploit the discovery well.

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CHEROKEE SAND POSSIBILITIES, CENTRAL KANSAS

Cherokee sandstone reservoirs west of, parallel with, and flanking the Central Kansas uplift produce oil primarily from structural traps. Of probable late Cherokee age, these sandstones are the products of the erosion of the nearby positive arch area. Several depositional environments probably are represented, although shallow-water marine conditions from the transgressing Cherokee seas are an obvious influence.

A basinward facies change to dominantly limestone and shale confines the maximum sandstone development within a northwest-southeast trend. This trend generally coincides with the truncated updip limit of the Mississippian, although the sandstones onlap rocks as old as Cambro-Ordovician (Arbuckle) on the pre-Pennsylvanian unconformity surface on which they are deposited.

Sandstones at nearly all levels in the interval produce. Correlation of individual sandstones can be accomplished only on a limited scale, indicating the lenticular nature of the section. Intraformational limestones are not widely persistent.

Pennsylvanian and Permian movements were most important in forming the producing structures. How-