GEOLOGY FOR LAND-USE PLANNING OF WESTERN ROGERS COUNTY AND SOUTHERN WASHINGTON COUNTY, OKLAHOMA

By

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ABSTRACT

The purpose of this study is to contribute to efficient land-use by translation of geologic information into forms that would be directly usable by laymen. Five maps show the physical conditions that should have the greatest effect upon the development of the region: (1) an environmental geology map, (2) a land-resource capabilities map, (3) a current land-use map, (4) a relief map, and (5) a hydrology and mineral resources map.

The study area, located in western Rogers and southern Washington Counties, Oklahoma, includes about 450 square miles. Parts of the region undoubtedly will become part of metropolitan Tulsa. All parts of the study area are within 50 mi of the relatively new Port of Catoosa on the Verdigris River. Thus urbanization and industrialization within the study area are to be expected.

The bedrock that crops out in the study area includes the Desmoinesian and Missourian Series of the Pennsylvanian System. The strata are chiefly shale, siltstone, sandstone, and limestone. Stream terrace deposits and floodplain alluvium of the Quaternary System cover much of the bedrock. Formal stratigraphic units were not mapped. The environmental geology map shows the areas in which the above-mentioned rock types crop out. This method of mapping was chosen on the basis of the assumption that the environmental geology map would be more useful to the laymen.

Bedrock units, soil units, and man-made units are shown on the

land-resource capabilities map. These units are classified according to type of bedrock, its engineering and chemical characteristics, and the thickness and physical properties of the soil. The legend of the map shows the suitabilities of the units for specified uses of land.

The current land-use map and the relief map show the various uses of the land and the major aspects of the topography of the study area. The combined hydrology and mineral-resources map shows location and general quality of surface water, availability and quality of ground water, and location of known resources, including petroleum and natural gas, coal, limestone, sand, and gravel.

The five maps are designed to be useful in regional planning. The maps do not show the detailed information that is necessary to determine the final commitment of a specific tract of land.

INTRODUCTION

Objectives of the Study

This study is an experiment in documenting geology of a region in a manner that would increase the usefulness of geologic information in the planning process. The specific desire is to aid in the maximum efficiency of future land use within the study area by translation of geologic information into forms that would be useful to the layman.

Five maps show the existing physical conditions and factors that should have the greatest effect upon development of the region. These maps are (1) an environmental geology map, (2) a land-resource capability map, (3) a current land-use map, (4) a relief map, and (5) a combined hydrology map and resources map. The purpose, classification system, method of construction, and evaluation of each map is set out in the text.

Information that is shown by these maps is intended to be used for general planning. The scale of this study is such that the maps will be aids in determining specific areas for on-site investigation, but they may not show the detailed information that is necessary to determine the final commitment of a tract of land or to evaluate a construction site.

Location of the Study Area

The study area is located in northeastern Oklahoma, north and east of Tulsa (Fig. 1). The size of the area is approximately 450 sq mi, including all or parts of 20 townships in Rogers and Washington Counties. Claremore is the largest city within the study area; smaller cities are Catoosa, Oologah, Talala, Keetonville, Ramona, Vera, Ochelata, and Oglesby (Pl. 1). Parts of the region undoubtedly will be included in metropolitan Tulsa. All parts of the study area are within 50 mi of the relatively new Port of Catoosa (Pl. 1) on the Verdigris River. Thus urbanization and industrialization of parts of the study area are to be expected.

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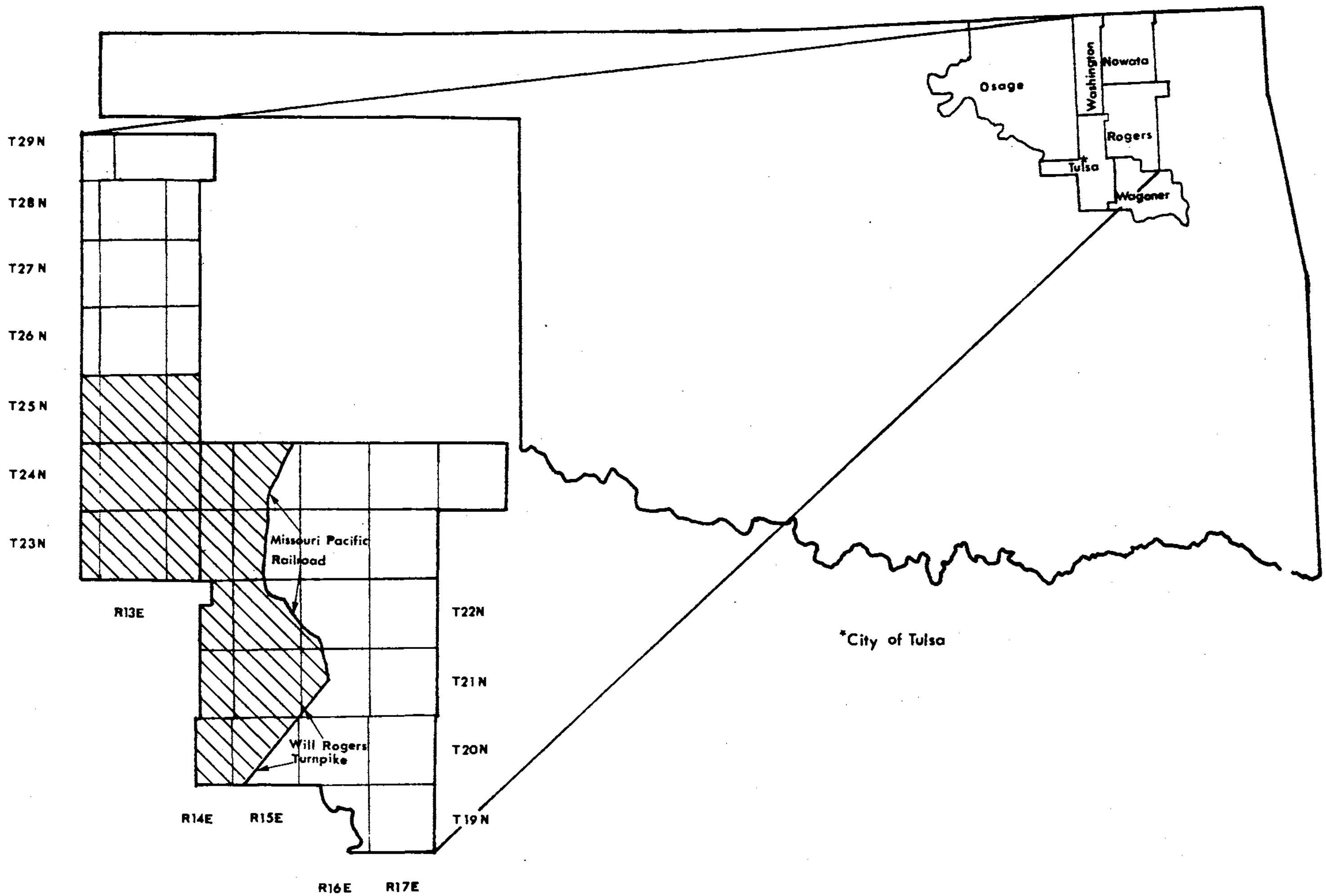

Figure 1.—Location map of study area.

Institute, Extension University; and Dr. Charles J. Mankin, Director, Oklahoma Geological Survey, The University of Oklahoma. Ms. Dorothy C. Colpitts, Assistant Librarian and Assistant Professor of Library Science, Oklahoma State University, assisted the author with procurement of manuscripts, maps, and aerial photographs.

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Previous Work

The geology of Washington County was first mapped in 1910 by Ohern (1930). The geology of western Rogers County was mapped by Ohern and Smith (1930). The most extensive and recent mapping of Washington County was done by Oakes (1940). Recent mapping in western Rogers County includes work by Oakes (1944) and Sparks (1956). Locations of previously mapped areas are shown in Figure 2. The geology of adjoining Tulsa County (Fig. 1) is described in detail by Bennison and others (1972).

Base Map

The scale of the base map is 1:62,500, approximately one inch to one mile. Topographic maps (scale 1:24,000) published by the U. S. Geological Survey were joined and reduced photographically to 1:62,500. Topography of two small areas within the study region is not mapped at the scale 1:24,000 (Fig. 3). Topographic maps of these areas were con-

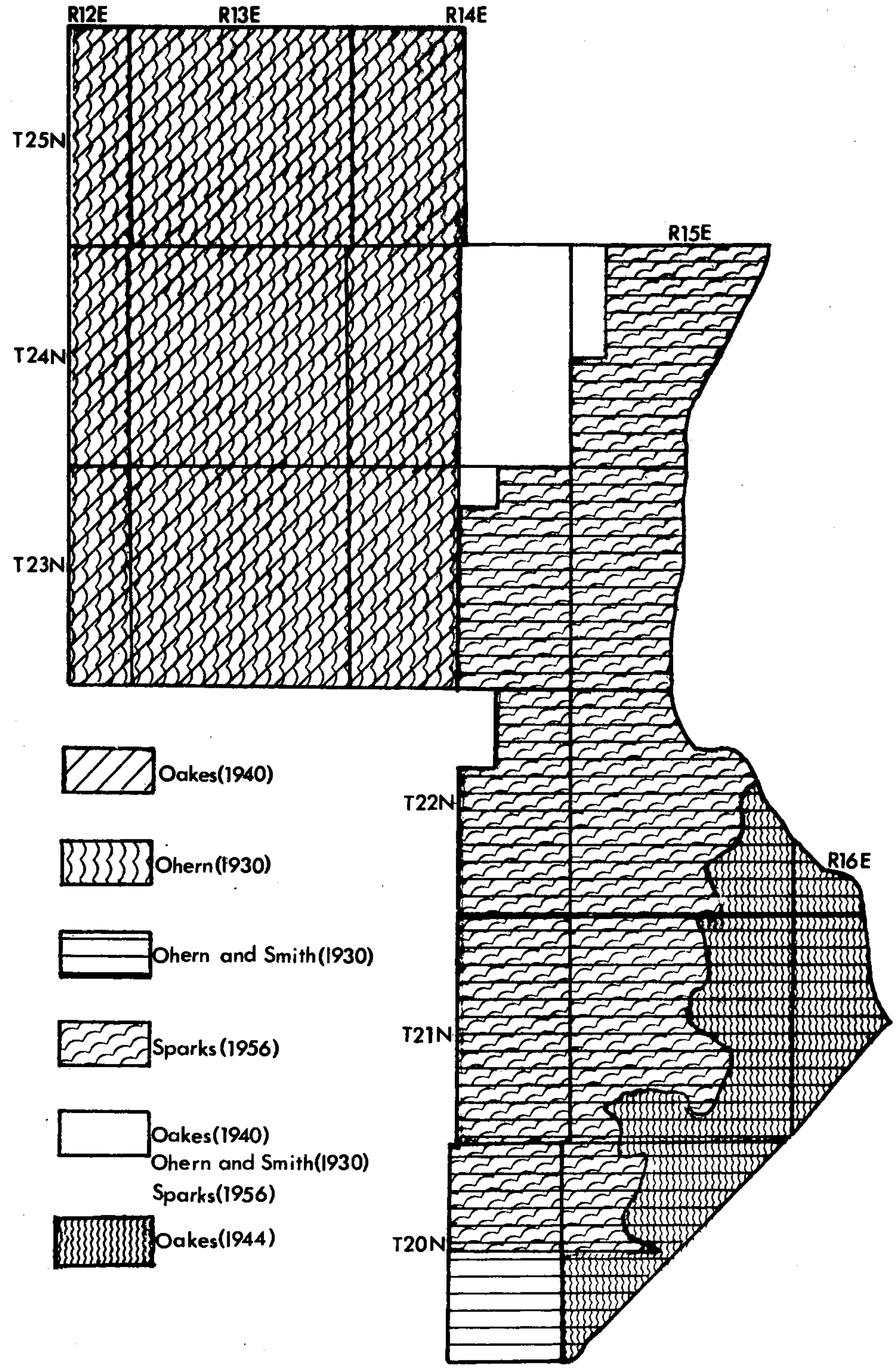
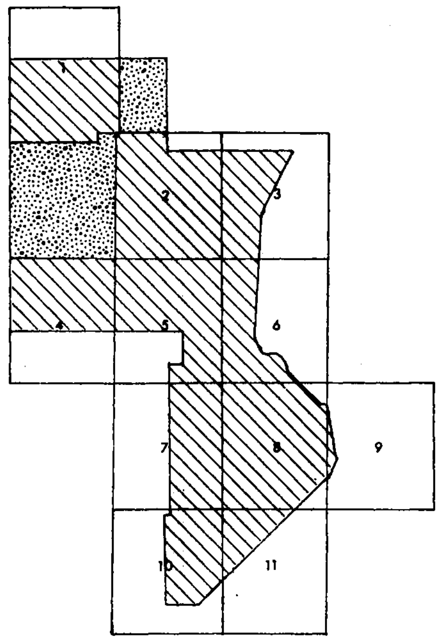
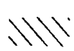


Figure 2.—Location map of previous geologic investigations.



1. Bartlesville South Quadrangle (preliminary topographic map)
2. Bartlesville Southeast Quadrangle
3. Talala Quadrangle
4. Vera Quadrangle
5. Collinsville Northeast Quadrangle
6. Oologah Quadrangle
7. Collinsville Quadrangle
8. Sageeyah Quadrangle
9. Claremore Quadrangle
10. Mingo Quadrangle
11. Catoosa Quadrangle

Portion of study area covered by topographic maps of scale 1:24,000



Portion of study area covered by maps at scales other than 1:24,000

Figure 3.—Locations of topographic maps used for construction of base map. (Modified from U. S. Geological Survey, 1970).

structed from maps of the Nowata Quadrangle (1914, scale 1:250,000), the Tulsa Quadrangle (1958, scale 1:250,000) and by reference to appropriate aerial photographs.

GENERAL GEOLOGY

The bedrock of the study area includes the Desmoinesian and Missourian Series of the Pennsylvanian System. Four groups comprised of 14 formations crop out within the study area (Fig. 4, 5). The Quaternary System in the study area includes stream terrace deposits of the Pleistocene Series and alluvium of the Holocene Series.

The environmental geologic map included in this study (Pl. 1) shows lithologic types of bedrock, but not the formal stratigraphic units that are commonly shown on areal geologic maps. The environmental geologic map is considered to be more useful to the layman than traditional geologic maps. However, the discussion below deals partly with formal stratigraphic nomenclature. The several references to other authors are included to direct the reader to areal geologic maps on which named stratigraphic units are shown.

Stratigraphy of the Pennsylvanian System

Desmoinesian Series

Cabaniss Group

Senora Formation.-The Senora Formation consists of sandstone, siltstone interbedded with shale that contains coal seams at some places, and a few strata of limestone. The Senora crops out in southeastern Rogers County (Oakes, 1944; Pl. 1). The Chelsea Sandstone Member (Fig. 4) is the thickest and most extensive sandstone unit. It forms

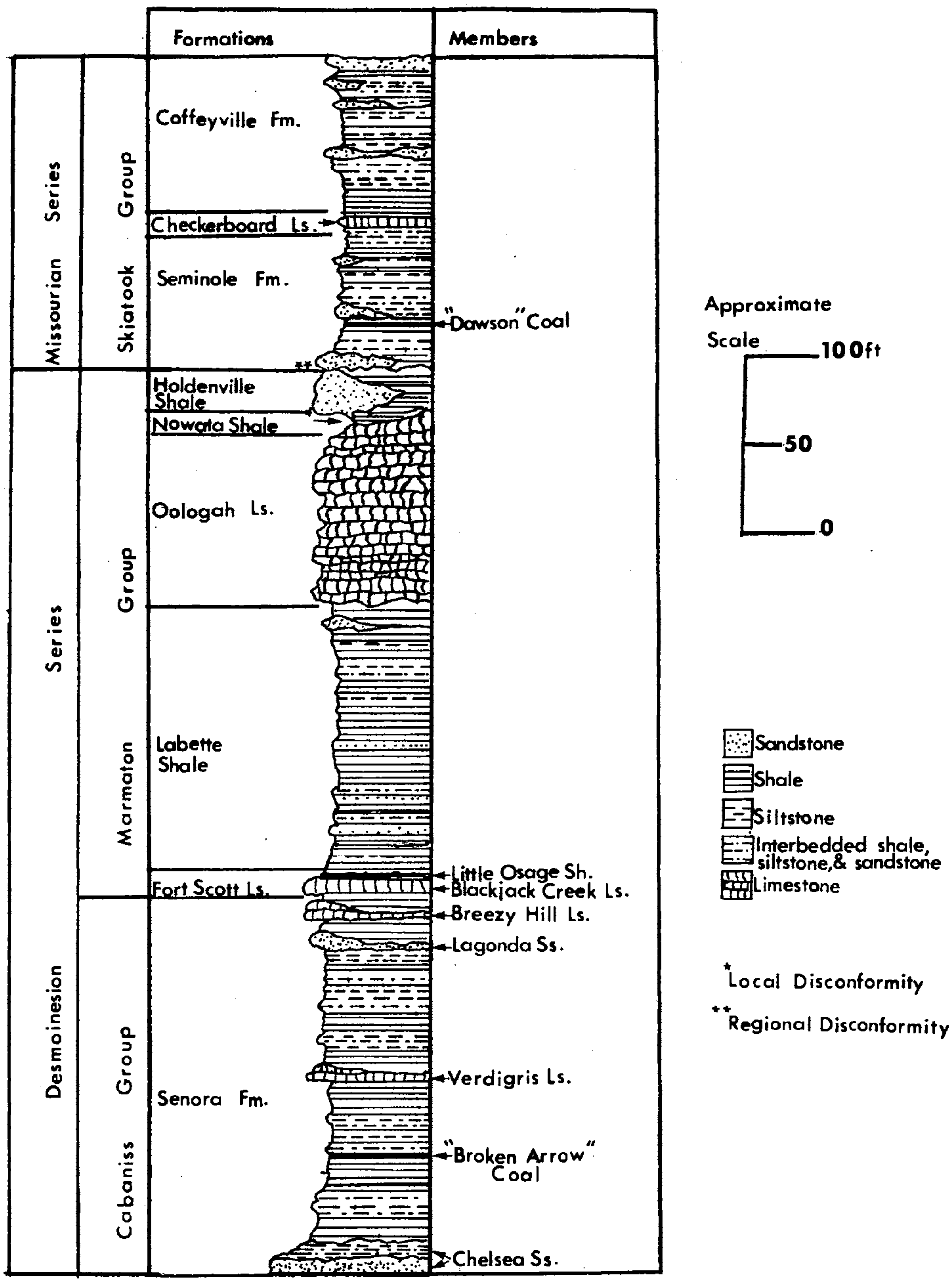


Figure 4.—Diagrammatic stratigraphic section of Pennsylvanian rocks of western Rogers County, showing named stratigraphic units referred to in text. (Information partially from Oakes, 1944; Sparks, 1956.)

hills and cuestas in the terrain near Claremore and southwestward. In secs. 20, 21, and 29, T20N, R15E (Pl. 1) the Lagonda Sandstone Member (Fig. 4) is thick and forms a resistant cap on the hills. However, northeastward toward Claremore (Pl. 1), the Lagonda is lenticular, much thinner, and less resistant to erosion. The Verdigris Limestone Member and the Breezy Hill Limestone Member (Fig. 4) each range from about 2 to about 10 ft thick. The dominant rock types in the Senora Formation are interbedded shales, siltstones, and lenticular fine-grained sandstones (Fig. 4).

Marmaton Group

Fort Scott Limestone.-In western Rogers County, the Fort Scott Limestone consists almost entirely of the Blackjack Creek Limestone Member (Fig. 4). This member is consistently about 10 ft thick where it crops out in the lower part of the hills that flank the west side of the Verdigris River, south of its confluence with the Caney River (Pl. 1; Oakes, 1944, Pl. 1; Sparks, 1956). Outliers of the Blackjack Creek cap many of the hills west of Claremore and east of the Verdigris (Pl. 1). The Little Osage Shale Member (Fig. 4) crops out west of the Verdigris River, but because the shale is thin and is rarely exposed, the Fort Scott is shown on the environmental geology map (Pl. 1) as limestone.

Labette Shale.-The Labette Shale consists almost entirely of shale and siltstone. The formation crops out in the bluffs along the west side of the Verdigris River in Rogers County (Pl. 1; Sparks, 1956, Pl. 1). Thin, lenticular sandstone beds and flaggy sandstones are included locally. The sandstone strata are not mapped on the environmental geology map (Pl. 1) because they are thin, lenticular, and nonresistant.

Oologah Limestone.-The Oologah Limestone caps the extensive cuesta west of the Verdigris River in western Rogers County (Pl. 1). The fossiliferous limestone may be more than 100 ft thick at some places. Throughout the study area, the Oologah is mapped as limestone although locally it contains beds of shale less than 1 ft thick. In western Rogers County, the Oologah Limestone is a reef-like complex similar to the well-described Oologah of Tulsa County (Bennison, 1972, p. 35).

Nowata Shale.-The Nowata Shale forms a belt of low relief topography throughout the area of study. It is comprised of claystone, shale, and thin, flaggy sandstone. Silty, flaggy limestones are in the lower portion of the formation at some places. Ironstone, limestone, or phosphatic concretions occur within the Nowata.

The Nowata Shale is shown on the environmental geology map (Pl. 1) extending from near Talala, to west of Oologah, and southwestward to sec. 22, T21N, R14E. The southern part of this outcrop belt is quite narrow, due to erosion of the Nowata that preceded deposition of the overlying sandstone units. The contact between the Nowata Shale and overlying rocks is a marked disconformity throughout the study area.

Holdenville Shale.-Within the study area the Holdenville Shale is mapped predominantly as a thick, massive sandstone. Some investigators believed this unit to be sandstone of the lower part of the Seminole Formation (for example, compare Sparks (1956, Pl. 1) and Bennison and others (1972, map 1).) According to Bennison (1972, p. 42), at places where thick sandstone lenses make up most of the Holdenville Shale, these units are often misinterpreted as being the lower sandstone unit of the Seminole Formation. The sandstone of the Holdenville crops out southwestward from Oologah along U.S. Highway 169 (Pl. 1), and south of the Caney River in extreme western Rogers County. It terminates at an apparent erosional contact approximately 1 mi west of Oologah (Pl. 1). The Holdenville lies disconformably on the Nowata Shale and is overlain disconformably by the Seminole Formation. The sandstone of the Holdenville is the youngest part of the Desmoinesian Series at some places in the study area. Elsewhere, however, the unconformity at the base of the Missourian Series extends downward into the Nowata Shale.

The lowermost part of the Seminole Formation is sandstone at many places, and the sandstones of the Holdenville and Seminole are not differentiated on the environmental geology map (Pl. 1).

Missourian Series

Skiatook Group

Seminole Formation.-The Seminole Formation consists predominantly of interbedded siltstone, shale, and sandstone (Fig. 4). A basal sandstone in the Seminole is believed to overlie sandstone of the Holdenville Formation mapped in the terrain north of U.S. Highway 169 in western Rogers County (Pl. 1). Black, fissile shale containing limestone concretions makes up the basal part of the Seminole Formation about 1.5 mi west of Talala in northern Rogers County (Pl. 1).

Much of the Seminole Formation is mapped as interbedded siltstone, shale, and sandstone in the area between the strip mines southwest of Talala and Rabb Creek in western Rogers County (Pl. 1). The sandstone units are lenticular and thin northward. Coal is contained in at least two seams. In southeastern Washington County, southeast of Vera and east of the Caney River in secs. 16, 17, 20, and 21, T23N, R14E (Pl. 1), the Seminole Formation is sandy shale.

Checkerboard Limestone.-The Checkerboard Limestone (Fig. 5) is thin-bedded and extensive, but is only about 30 in. thick, weathers readily, and thus has little topographic expression. The formation is mapped as a persistent limestone unit on the environmental geology map (Pl. 1), where it is shown extending from the center of the south line of sec. 36, T23N, R14E to the north line of sec. 6, T24N, R15E. The outcrop of this unit was primarily determined by reference to investigations by Oakes (1940) and Sparks (1956).

Coffeyville Formation.-The Coffeyville Formation is made up of shale, siltstone and sandstone (Fig. 5). It crops out in a large area of eastern Washington County and northwesternmost Rogers County (Oakes, 1940, Pl. 1). It is mapped chiefly as shale in the region around Vera and in the headwaters of Rabb Creek and Buck Creek in western Rogers County (Pl. 1). Elsewhere it is mapped almost entirely as interbedded shale and sandstone.

Hogshooter Limestone.-In ascending order, the Hogshooter Limestone is made up of the Canville Limestone Member, the Stark Shale Member, and the Winterset Limestone Member (Fig. 5). The formation is approximately 25 ft thick along Hogshooter Creek in T25N in the northernmost part of the study area. In southern Washington County, through T23 and 24N to sec. 32, T23N, R13E, the Canville and Stark are absent and the formation is almost uniformly 5 ft thick (Oakes, 1940).

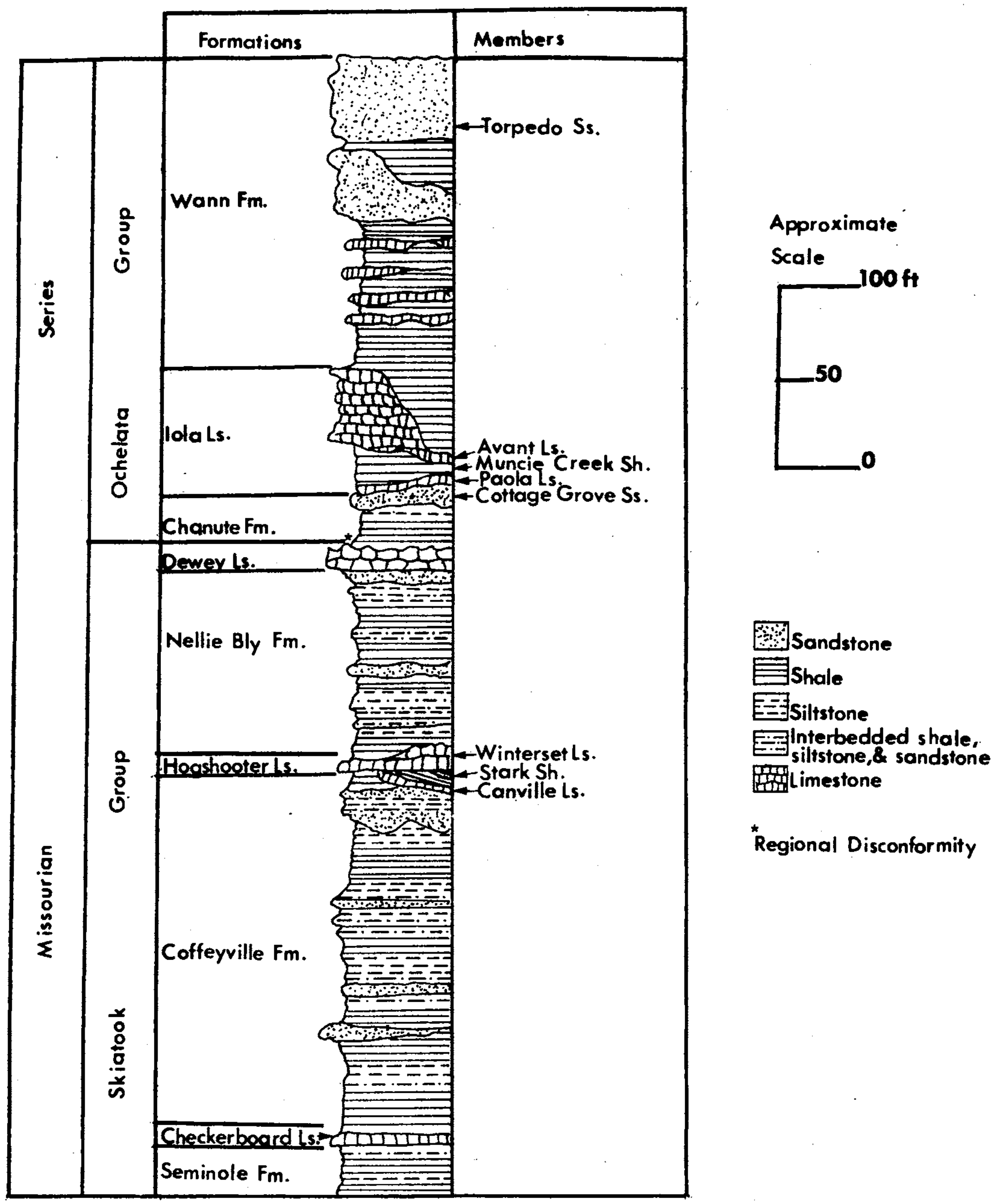


Figure 5.—Diagrammatic stratigraphic section of Pennsylvanian rocks of southern Washington County, showing named stratigraphic units referred to in text. (Some of the information from Oakes, 1940.)

Nellie Bly Formation.-The Nellie Bly Formation is similar lithologically to the previously described Coffeyville and Seminole formations (Fig. 5). It is composed of shale, overlain by siltstone interbedded with thin strata of sandstone. Gently undulating hills make up the topography of the outcrop. The formation is mapped as shale and interbedded shale, siltstone, and sandstone on the environmental geology map (Pl. 1) throughout the central portion of southern Washington County where it crops out above and west of the Hogshooter Limestone (see also Oakes, 1940, Pl. 1).

Dewey Limestone.-The Dewey Limestone is a resistant fossiliferous limestone throughout the area of its outcrop in southern Washington County. A thin, basal calcareous sandstone overlain by thin shale beds that grade upward into massive beds of limestone characterize the lithology of the Dewey.

The Dewey is overlain disconformably by the Chanute Formation; therefore the thickness of the Dewey varies considerably in southern Washington County. The Dewey is mapped as limestone on the environmental geology map (Pl. 1), where it is shown extending southward from secs. 5, 6, 7, and 8, T25N, R13E (see also Oakes, 1940, Pl. 1).

Ochelata Group

Chanute Formation.-As mentioned above, the Chanute Formation overlies the Dewey Limestone disconformably. This contact is the lower boundary of the Ochelata Group (Fig. 5). The Chanute consists of an unnamed basal shale unit, and the upper part of the formation is the Cottage Grove Sandstone Member (Fig. 5). The Cottage Grove thickens northward to approximately 20 ft. It is thin-bedded and fine-grained throughout southern Washington County.

The Chanute Formation is mapped as shale or interbedded shale, siltstone, and sandstone, or as sandstone in western Washington County (cf. Pl. 1, this study, and Oakes, 1940, Pl. 1).

Iola Limestone.-In ascending order, the Iola Limestone includes the Paola Limestone Member, Muncie Creek Shale Member, and the Avant Limestone Member (Fig. 5). In the western one-half of T23N, R13E, the Avant Limestone Member caps an extensive cuesta (Pl. 1). The Avant is approximately 40 ft thick in this area, but thins to about 3 ft in sec. 36, T24N, R13E.

The Muncie Creek Shale Member ranges in thickness from 1 ft in T25N to 40 ft in T23N. The Paola Limestone Member commonly is calcareous sandstone that ranges in thickness from 3 to 5 ft.

The Iola Formation is mapped on the environmental geology map (Pl. 1) as limestone and shale in the western part of T23N, but in western T24N and T25N it is mapped as interbedded limestone and shale because the units thin and the members show little topographic expression. The outcrop belt of the Iola is shown more explicity by Oakes (1940, Pl. 1).

Wann Formation.-The Wann Formation varies greatly in thickness and lithology within the study area. The Wann is made up of shale, interbedded shale and limestone, limestone, and sandstone (Pl. 1). Lenticular limestones that occur locally also are shown on Plate 1. The Torpedo Sandstone Member (Fig. 5) is an erosional remnant preserved in a syncline (Oakes, 1940) in the northwesternmost part of the study area, where it is a cliff-forming unit. The outcrop of the Wann shown on the environmental geology map (Pl. 1) was determined mostly by reference to Oakes (1940, Pl. 1).

Geology of the Quaternary System

Although the geology of the Pennsylvanian bedrock units of the study area has been investigated closely by several geologists, the geology of the Quaternary System has been studied very little and is poorly known. An extensive study of the Quaternary geology is beyond the scope of this study, but a few observational facts are worthy of mention.

Stream terrace deposits occur locally (Pl. 1) throughout most of western Rogers County and locally are abundant in Washington County. These materials are far more widespread (Pl. 1) than they have been shown on any published geologic map. These deposits range from clay to gravel. Chert as gravel or coarse sand is common in almost all terrace deposits within Rogers County. A thin veneer of terrace deposits or colluvial material derived from terrace deposits, probably covers most of northern Rogers County. This inference is based upon the common occurrence of rounded chert pebbles in soils of most of northern Rogers County. However, terrace deposits probably never covered the cuesta in the northwestern corner of the county. Stream terrace deposits also are extensive in the area east of the Verdigris River, where chert gravel and fine- to coarse-grained quartzose sand are abundant.

The stream terrace deposits of Washington County are composed mostly of clay, silt, and fine-grained sand. They occur in proximity to the present streams and thus are not as widespread as the terrace materials of western Rogers County. Locally in western Washington County, stream terrace deposits have been redistributed by colluvial processes. Due to difficulty in discrimination between this colluvium and stream terrace alluvium, all such deposits are shown on the environmental geology map (Pl. 1) as stream terrace alluvium.

The alluvium of the creeks and rivers is predominantly silt and fine-grained sand, with minor proportions of clay, and medium- and coarse-grained sand. Gravel deposits have been recorded in drilling records of water wells within the floodplain of the Verdigris River (Marcher and Bingham, 1971), but little gravel is observable in the upper parts of the alluvium.

The Quaternary geology of western Rogers County is complex. The high stream terrace deposits may be of relatively early Pleistocene age. Lower terrace deposits and floodplain alluvium probably are of later Pleistocene and Holocene age, but the basic Quaternary history of the area cannot be worked out until the stratigraphy of the Quaternary deposits has been established, and until these units have been correlated with the Pleistocene deposits of Kansas.

Structural Geology

The strata of southern Washington and western Rogers Counties strike regionally northeastward and dip about 20 to about 50 ft per mi northwestward from the Ozark Dome (Oakes, 1940; Woodruff and Cooper, 1930). The regional dip is interrupted by local domes, anticlines, and synclines. In some places normal faulting is associated with these flexures (Oakes, 1940, p. 100-103). Oil fields and gas fields are associated with some anticlines and domes.

Most of the local folds apparently have less than 100 ft of closure on shallow strata (see Carpenter, 1930, p. 143). The largest flexures within the study area include the Caney River Syncline, the Ochelata Anticline, and the Ramona Syncline. The course of the Caney River in T25N, R13E (Pl. 1) is about the position of the axis of the Caney River Syncline (Oakes, 1940, p. 99). The axis of the Ochelata Anticline trends about parallel to the Caney River Syncline, extending from about sec. 19, T25N, R13E to about sec. 35, T25N, R13E, and then southward into the northeastern part of T24N, R13E (Pl. 1). The Ramona Syncline trends northwestward from about sec. 4, T23N, R13E, to the Washington County line about in sec. 26, T24N, R13E (all locations regarding the Ochelata Anticline and the Ramona Syncline are inferred from Oakes, 1940, p. 99).

Evidence of smaller folds is shown well by outcrop patterns of various lithic units included on the environmental geologic map (Pl. 1). For example, a dome is located in sec. 13, T25N, R12E exposing the interbedded shale, siltstone, and sandstone of the Nellie Bly Formation (Pl. 1, Fig. 5). The younger Dewey Limestone (Fig. 5) surrounds the Nellie Bly in this area. In sec. 21, T25N, R13E (Pl. 1) there are 2 intersecting normal faults; the Hogshooter Limestone is exposed on the upthrown blocks, whereas the Nellie Bly Formation is exposed on the downthrown blocks. In T21 and 22N, R14 and 15E a large anticlinal fold is suggested by the outcrop pattern of the Oologah Limestone and the Labette Shale (Pl. 1).

Geomorphology and Soils

The topography of the study area is due to differential erosion by running water of strata of unequal resistance. Broad valleys interspersed with gentle hills make up the topography, except along the Verdigris River in Rogers County and in western Washington County, where high eastward-facing cuestas held up by thick sandstones or limestones stand above the plains.

The primary drainage pattern of the study area is dendritic, except in areas of local folding or fracturing where the dendritic patterns are somewhat disrupted. In general the streams of the study area flow from west to east. Major streams cut through cuestas of resistant strata in many instances. This discordant relationship between trends of streams and trends of strata can be explained best by the theory of regional superposition of drainage in the Midcontinent (Melton, 1959; see also Stone and others, 1972). Superposition of drainage denotes a history involving active deepening or down-cutting by a stream, so that the stream eventually flows across rock of different tectonic aspect from that on which it developed (Melton, 1959).

Evidence for the assumption of superposition of streams in the study area is entrenched meanders in resistant rock strata, and the widespread terrace deposits. An example of an entrenched meander can be seen by reference to the present course of the Caney River in Rogers County (Pl. 1). The Caney flows through a large meander cut in the Oologah Limestone, near its confluence with the Verdigris River. Terrace deposits consisting largely of chert gravel occur in many areas throughout Rogers County. As mentioned previously, in the northern portion of the county chert is abundant in the soils. In the southern portion of Rogers County extensive terrace deposits exist, most of which contain an abundance of chert.

In sec. 19, T21N, R15E a presumed former stream valley exists. Within this area and for 1 mi northwestward rounded chert gravel is common in the soil. The bluffs that border the stream that flows through sec. 19, T21N, R15E, can be inferred to be steep, former valley walls where a larger stream cut through the Oologah cuesta. The writer believes that this presumed ancient valley may have been a previous course of the Verdigris River. The abandonment of the valley probably was due to piracy within the Caney and Verdigris drainage systems.

The hills and cuestas of the study area are made up of limestone or sandstone. Shale strata generally underlie the valleys. In some instances topography is misfit to lithology of the bedrock. In the northern portion of Rogers County uncommonly gentle topography exists on terrain of interbedded shale, siltstone, and sandstone (Pl. 1). This is most likely due to previous courses of the Verdigris River or its tributaries having eroded this surface to low relief, having mantled the topography with a veneer of stream terrace materials, or both.

The soils of the study area are generally thin. Soil development is directly related to topographic position and parent material. Five primary soil associations are found within the study area (Polone, 1966, 1968).

(1) The Dennis-Okemah-Parsons association is developed on nearly level and gently sloping uplands.

(2) The Collinsville-Talihina-Bates-Choteau association occurs on gently sloping to hilly uplands.

(3) The Summit-Sogn-Claremore association occurs on gentle to moderately steep slopes.

(4) The Osage-Verdigris association is associated with nearly level bottom lands.

(5) The Darnell-Stephenville association is developed on gentle to steep slopes on uplands.

The relationships of soils, parent materials, and topographic positions are summarized in Table 1. A basically consistent relationship between soils, parent material, and topography exists. Examples are the Osage soils that develop within floodplains upon alluvium, and Sogn soils that develop from limestone and are found on hills. However, the Dennis, Bates, Collinsville, and Talihina soils develop from either sandstone or shale, or both and occur on hilltops, flanks of hills, or in valleys.

Table 1.-Soils of the study area, showing bedrock or parent material, description of the B zone of the soil according to the Unified Soil Classification, and the common topographic position of the soil. (All names shown are names of soil series. Information from Polone, 1966, 1968).

Soil	Bedrock or Parent Material	Unified Soil Classification	Topographic Position
Bates	Sandstone	ML	Hilltops, rock benches
Choteau	Terrace alluvium	CL	Upland prairies
Claremore	Limestone	ML	Hilltops (0 to 3% slopes, dip slopes)
Collinsville	Sandstone	ML	Hilltops, escarpment slopes of cuestas
Darnell	Sandstone	ML	Cuestas, escarpment slopes of cuestas
Dennis	Sandstone, shale	CL	Dip slopes (0 to 5%), hillsides and bottoms of slopes
Dwight	Shale, limestone	CH	Lowlands or valleys
Eram	Sandstone, siltstone shale	CL	Hilltops, escarpment slopes of cuestas, dip slopes of cuestas

Table 1 (Continued)

Soil	Bedrock or Parent Material	Unified Soil Classification	Topographic Position
Hector	Sandstone	ML	Hilltops, dip slopes of rock benches
Linker	Sandstone	ML	Hilltops, rock benches
Mason	Terrace alluvium	CL	Floodplains
Newtonia	Limestone	ML	Hilltops, dip slopes (0 to 3%)
Okemah	Shale	CH	Valley lowlands
Osage	Floodplain alluvium	CH	Floodplains
Parsons	Terrace alluvium	CH	Upland prairies
Riverton	Terrace alluvium	GC	Upland prairies
Stephenville	Sandstone	ML	Hilltops, rock benches
Sogn	Limestone	CL	Hilltops, cuestas
Summit	Limestone, shale	CH	Bases of slopes, steep slopes
Talihina	Shale, siltstone, sandstone	ML	Faces of cuestas, tops and flanks of hills

Table 1 (Continued)

Soil	Bedrock or Parent Material	Unified Soil Classification	Topographic Position
Taloka	Terrace alluvium	CH	Upland prairies
Verdigris	Floodplain alluvium	CL	Floodplains
Woodson	Shale, limestone	CH	Valley lowlands

ENVIRONMENTAL GEOLOGY

Environmental Geology Map

The environmental geology map of the study area (pl. 1) was constructed mainly from investigations reported in the geologic literature. These sources of information were supplemented by soil surveys (Polone, 1966, 1968), interpretation of aerial photographs and field reconnaissance mapping.

Boundaries of formal stratigraphic units are not shown on the environmental geology map (Pl. 1). Readers are referred to previous geologic investigations (Oakes, 1940, 1944; Sparks, 1956) or to the "Geologic Map of Oklahoma" (Miser, 1954) for locations of boundaries of formations that crop out with the area of study. Outcrop areas of 5 major kinds of bedrock are shown on the environmental geology map (Pl. 1): (1) limestone, (2) shale, (3) sandstone, (4) interbedded shale, siltstone, and sandstone, and (5) interbedded limestone and shale. The alluvium of creeks and rivers, and the terrace alluvium of ancient stream deposits also are shown on the environmental geologic map (Pl. 1). A brief discussion follows of the observed characteristics or the inferred characteristics of the 5 types of bedrock.

Limestone

In general, where limestone strata are thicker than 1 ft they may be difficult to excavate or to rip. Dense limestones transmit energy readily. As a general rule, housing additions should not be built on limestones that are being quarried nearby. Damage to foundations as well as to household belongings might occur as a result of blasting.

Springs and seeps are common in limestone terrain (Fig. 6). Solution of limestone tends to widen joints and to develop hidden cavities. Sinkholes result when these cavities collapse, sometimes causing damage to structures at the surface.

Joints commonly are abundant in limestones. The density of these natural discontinuities should be taken into account in some types of construction. Creep of limestone blocks is common at places where thick strata of limestone crop out. Whether limestone is in place and stable, or whether blocks are detached from the main body of rock and are in motion should be established before areas where limestones crop out are committed to use. In spite of these several qualities, limestone makes a stable foundation material where it is not weakened by solution or by open joints.

Sandstone

Within the study area, thick sandstones usually underlie areas of moderate to high relief. Sandstone limits building in hilly terrain, because the strata in some instances are highly jointed, permeable, and are difficult to excavate. Excessive ground water can cause significant problems in construction activities in sandstone terrain. Special attention should be directed toward searching for seeps, especially along the contacts where sandstone overlies shale, or where the soil mantle thins above sandstone bedrock. In general, sandstone is a stable foundation material, but steep slopes, thin soil, and rapid runoff of rain water can impose limitations on some uses of sandstone terrain, such as residential and urban development.

Shale

Shale terrain is extremely difficult to evaluate. Physical properties of shale are often highly variable, so comprehensive on-site investigations of shale terrain are necessary for some purposes. Shales are of markedly variable mineralogy, chemistry, and hardness. Many shales absorb and dispel water seasonably, resulting in changes of volume. This factor may cause damage to foundations if proper engineering techniques are not used. Moreover, shale generally occurs in lowlands, so drainage is often poor. Where sites on shale terrain are to be used for construction, adequate precautions must be taken to ensure good drainage, stable excavations, and stable foundation design. Some thick strata of shale make good host materials for sanitary landfills, but an adequate evaluation of local drainage is called for to minimize the transport of pollutants in water.

Interbedded Siltstone, Shale, and Sandstone

The physical properties of interbedded siltstone, shale, and sandstone vary with the relative thicknesses and lithologies of the strata. Sandstone commonly forms benches and caps hills in terrain where bedrock is interstratified siltstone, shale, and sandstone. Seeps are common at contacts where sandstone overlies shale or siltstone. Plans for excavation of interbedded materials should include consideration of the fact that steep slopes may be unstable. When heavy structures are to be built on this type of material, settlement of the material by compaction, or slippage along the numerous lithologic contacts could occur. Interbedded siltstone and shale can be borrow material of good quality if the sandstone strata are not thick enough to limit excavation.

Interbedded Limestone and Shale

The properties of units made up of interbedded limestone and shale are also uncommonly variable. Limestone generally forms rock ledges or caps hills, whereas shale forms slopes. Creep of limestone blocks bounded by joints is common in this type of terrain. Seeps may be present locally at contacts where limestone overlies shale. Interbedded limestone and shale may be difficult to excavate at places where the limestone beds are more than about 1 ft thick. Solution-widened and clay-filled joints may be numerous within the limestone strata.

Land-Resource Capabilities Map

The term "land-resource capabilities" is defined in this study as the physical properties of land, and the relations of these properties to specific uses of land. Three basic categories of materials established from this definition are (1) bedrock, (2) soils (considering terrace alluvium and floodplain alluvium to be soils), and (3) man-made land. The land-resource capabilities map (Pl. 2) is designed to be an aid in large-scale site evaluation for urban, industrial, and agricultural development. The map is not intended to be used as information from which to make final decisions in the evaluation of prospective building sites or for final commitments of tracts of land.

The resource capabilities map was constructed from information shown on the environmental geology map and from information in soil reports of the Soil Conservation Service (Polone, 1966, 1968). The classifications of soil thicknesses, engineering characteristics, and chemical characteristics were derived from the soils maps and texts prepared by Polone. The classification system of land-resource capabilities is based mainly on the environmental geology of the region. A "bedrock unit" is shown on the resource capabilities map (Pl. 2) at places where soil above the "C" horizon is thinner than 30 in. A "soil unit" is shown where soil above the "C" horizon is thicker than 30 in. "Soil units" are classified according to soil thickness, lithology of bedrock, and engineering or chemical characteristics of both soil and bedrock. "Man-made units", former coal strip mines for example, also are shown (Pl. 2). The legend of the map is constructed to describe the dominant characteristics of the bedrock units, soil units, and man-made units. Faults, or areas of suspected faulting, are included on the map, and a short description of the typical characteristics of faulted bedrock is included in the legend. A matrix based upon several kinds of land use units is shown as part of the legend; bedrock units, soil units, and man-made units are shown as good, fair, or poor, classified according to their suitabilities for use in the prescribed actions.

Three examples of descriptions of land-resource capability units are set out below: (1) limestone with soil cover less than 30 in. thick; (2) interbedded siltstone, shale, and sandstone overlain by soil of low plasticity and 30 to 45 in. thick; and (3) floodplain alluvium of high plasticity and thicker than 45 in.

(1) Limestone cropping out or overlain by silty or clayey soil less than 30 in. thick. The uppermost few inches or few feet generally are highly weathered. The surface of the limestone may be weathered to be quite irregular. Relief on

the weathered surface may be as much as 5 ft. Limestone thicker than 1 ft may be difficult to excavate or to rip. Strata are generally highly jointed, and the joints are commonly widened by solution. Sinkholes may be developed locally. Blocks of limestone creeping down slope are common along the outcrop. Seeps and springs are common along contacts between limestones and strata beneath, along joints, and between bedding planes within limestone. An example of a spring due to such conditions can be seen in sec. 9, T21N, R15E (see also Fig. 6).

(2) Soil ranging from 30 to 45 in. thick over interbedded shale, siltstone, and sandstone. The soil generally is colluvial and occurs on the lower parts of moderate to steep slopes. It is of low to moderate plasticity, is highly permeable, and is strongly acidic. Seeps are common where soil thins markedly and in areas of exceptionally thick colluvium. Bedrock is rippable except in areas where sandstone strata are uncommonly thick. Slopes constructed by excavation in this type of may be unstable. This type of "soil unit" is mapped in sec. 6, T23N, R15E on the resource capabilities map (Pl. 2).

(3) Floodplain alluvium thicker than 45 in. consists mostly of silt and clay. The soil is of high plasticity, low permeability, and a seasonably high water table is common. The soil tends to change volume markedly during wet and dry seasons. This soil has never been consolidated; it has not released all the interstitial water present from the time of its deposition. This property makes the soil somewhat unstable when large structures or other heavy loads are placed upon it. The soil is subject to seasonal flooding. This kind of "soil unit" is mapped in sec. 7, T23N, R14E, on the resource capabilities map (Pl. 2).

Current Land-Use Map

The current land-use map (Pl. 3) shows seven primary classes of land use: (1) general urban areas, (2) industrial areas, (3) recreational areas, (4) timbered lands, (5) oil fields, (6) man-made lands, and (7) agricultural lands. Four secondary classes are: (1) major pipelines, (2) major power-transmission lines, (3) railroads, and (4) major transportation routes. A tract of land may serve several purposes simultaneously; therefore, it may fall within two or more of the classes mentioned above. An example of multiple classifi-

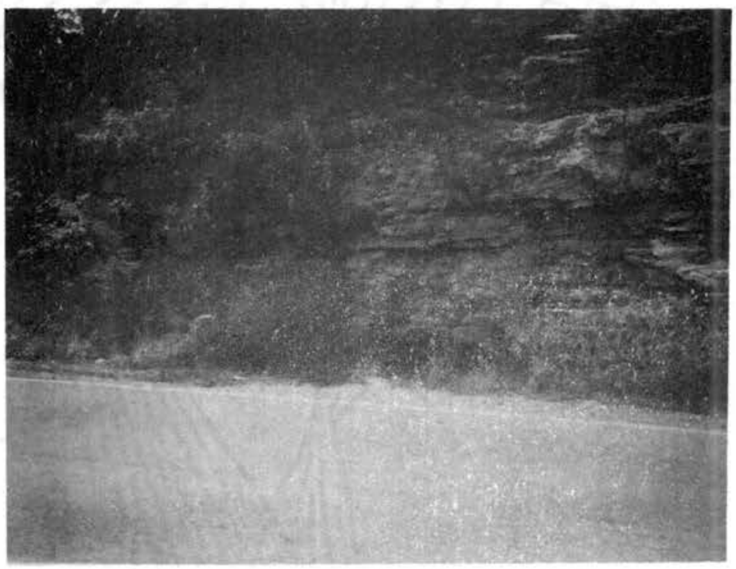


Figure 6.—Water flowing from springs at contact of Oologah Limestone and Labette Shale, sec. 9, T21N, R15E.

cation can be seen by reference to sec. 32, T22N, R15E (Pl. 3). This area is classified as timbered land but it also is the location of an oil field. The legend of the current land-use map describes land-use classes and characteristics of these classes.

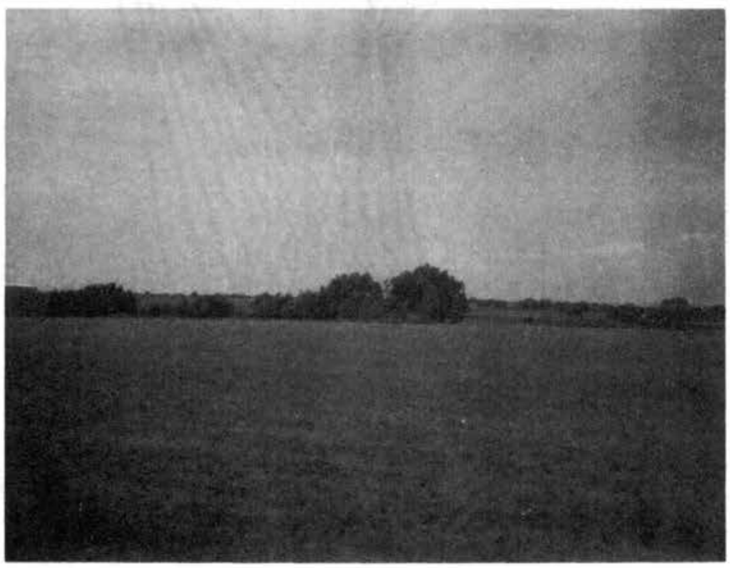
The map was prepared mainly from aerial-photograph index sheets. Also, much information is shown on the topographic base map. Locations of pipelines, power-transmission lines, and oil fields were obtained from Oklahoma Water Resources Board (1971, p. 136) and Oklahoma Geological Survey (1966).

Much of the study area is classified as agricultural land. This classification includes cultivated lands, pasture lands, and land where there is evidence to infer former agricultural use. Due to the frequent and cyclic changes in the farm industry, and to the consequent changes in the uses of agricultural lands, cultivated lands and pasture lands are not differentiated.

Prior to settlement, the study area was chiefly a vast prairie, and climax prairie grasses were dominant. Oak-hickory forest occupied sandstone ridges, and cedars grew on limestone bluffs. Pecan, walnut, elm, maple, hackberry, oak, ash, sycamore, and willow invaded the river and creek bottoms; they occur mostly in groves (Polone, 1966).

Approximately 10 percent of the study area is made up of woodlands (Pl. 3). Examples of land classed as timbered and not timbered are illustrated in Figure 7. Most of the woodlands are used primarily for grazing, but a few privately owned sawmills are operated. Lowland timber is the main source of lumber. Black walnut, white and red oak, burr oak, pin oak, post oak, sycamore, pecan, and hackberry are the principal species cut. Red elm, white elm, black cherry, hickory,

A



B

Figure 7.—(A) Example of density of timber on land classed as "timbered land".
(B) Example of density of timber on land not classed as "timbered land".

ash, and black oak also are used (Polone, 1966). Pecan and walnut are plentiful within the lowlands of the study area. By removing all other trees and shrubs in areas of dense pecan and walnut, abundant harvests of nuts may be secured. Woodlands furnish food and cover for wildlife and are aesthetically valuable. They should be considered as resources for these reasons, as well as for supply of lumber.

Industrial areas shown on the map indicate that the tracts are actively used for industry. Man-made lands are sites of previous industrial facilities, such as inactive gravel or limestone quarries, or inactive coal strip mines.

The class of land denoted as "urban areas" chiefly includes residential developments. The criterion for mapping urban areas was the density of dwellings. An example of the density of dwellings that defines an "urban area" can be seen by reference to sec. 27, T20N, R14E, (Pl. 3), where approximately 15 dwellings are located within an area of about one-eighth square mile.

In the areas classified as oil fields, many collector pipelines exist. They mostly are buried a few feet or less, and before any excavation is undertaken within the oil fields, the locations and depths of the lines should be established. Only major pipelines and major power-transmission lines are indicated on the map.

The information shown on the current land-use map is not entirely accurate, for the uses of the land change considerably with short spans of time. The information on this map (Pl. 3) was obtained primarily from aerial-photograph index sheets made by the Agricultural Stabilization and Conservation Service, U. S. Department of Agriculture, in 1966 (Washington County) and 1971 (Rogers County). In spite of the rapid changes in uses of land, the current land-use as depicted on the map should be of significant value to planners and land developers.

Inasmuch as close relationships among types of bedrock and types of soil exist, as has been described above, it follows that some correlation exists between agriculture and bedrock geology and topography. By far the most common agricultural use of land in the study area is pasture for cattle. Virtually every type of terrain within the study area is employed for this purpose. By and large, the residual soils of the region are shallow, but they support moderately productive native grasses. Alfalfa is grown on floodplain alluvium of the bottomlands, on stream terrace alluvium of the upland prairies, and in some places on thin soils on upland limestone terrain, where the alfalfa almost certainly derives most of its water from the bedrock. Maize is grown predominantly on alluvium in the bottomlands, stream terrace alluvium in the upland prairies, and on calcareous shales in the lowlands. Pecan groves, as explained elsewhere in the text, are abundant. They are developed mostly on alluvial plains, but some productive groves occur naturally or can be developed on stream terrace materials; in a few instances groves have been observed in presumably residual soils above clayey shale.

Relief Map

The purpose of the relief map (Pl. 4) is to show the major changes of elevation of the landscape, so that the reader can determine the general topographic conditions by simple and rapid inspection of the map.

The elevations represented by contour lines on the map are accurate except in two areas. Township 24 North, R12E and R13E, and T25N, R13E and R14E (as mentioned in the discussion of the construction of the base map) have not been mapped at the scale of 1:24,000. Elevations within this area are somewhat inaccurate because parts of the areas were contoured at 100-ft intervals, and parts at 50-ft intervals on the only available maps. Fifty-foot contour lines were added by reference to topographic maps of the Nowata Quadrangle (1914), the Tulsa Quadrangle (1958), and by inspection of aerial photographs.

In construction of the relief map, topographic maps were reduced from the scale 1:24,000 to 1:62,500. Consequently, in areas of high relief and steep slopes, contour lines converge to form uncommonly wide, dark bands. The reader can evaluate the elevations shown in these parts of the map by reference to the color changes that demarcate the lower and upper boundaries. For example, in the central portion of sec. 16, T21N, R15E, individual contour lines are not distinguishable. As shown by color, however, the lower elevation of the escarpment is 650 ft and the upper elevation is 750 ft. The 700 ft contour line was deleted due to the discrepancy mentioned.

Hydrology and Mineral Resources Map

Hydrology

Quality and Quantity of Surface Water

With few exceptions, industry, municipalities, and farms of the study area are dependent upon surface water. The primary rivers, creeks, and lakes within the study area have been investigated as potential sources of water (Marcher and Bingham, 1971; Oklahoma Water

Resources Board, 1971).

The Verdigris River is the largest stream; it enters the study area approximately 2 mi south of Oologah. The Caney River is the second largest stream in the area; it flows through southern Washington County to its confluence with the Verdigris River in western Rogers County (Pl. 5). At a gaging station at Inola (Fig. 8) near the study area, the annual average flow for a 25-yr period of record is 2,915,000 acre-feet for the Verdigris River (Oklahoma Water Resources Board, 1971, p. 65). This flow is regulated to some extent by Lake Oologah, north and east of the study area (Fig. 8). The average annual flow of the Caney River near Ramona (Pl. 5) was 623,000 acre-feet for a 27-year period of record (Oklahoma Water Resources Board, 1971, p. 65).

Major creeks and rivers within the study area are classified in this study according to water quality. Three basic classes based upon amounts of total dissolved solids are: (1) good water (0-500 mg/l); (2) fair water (500-1,000 mg/l); and (3) poor water (more than 1,000 mg/l) (Oklahoma Water Resources Board, 1971, p. 106). Standards of the U. S. Public Health Service suggest that streams with less than 1,000 mg/l total dissolved solids could be considered as sources of water for municipal usage, as long as concentration of specific individual ions do not exceed recommended limitations (Oklahoma Water Resources Board, 1971).

The Verdigris River is the greatest potential source of surface water because of its continual large volume of flow and its fair-to-good water quality. Discharge from Lake Oologah should keep flow of the Verdigris River reasonably constant. The Caney River also should

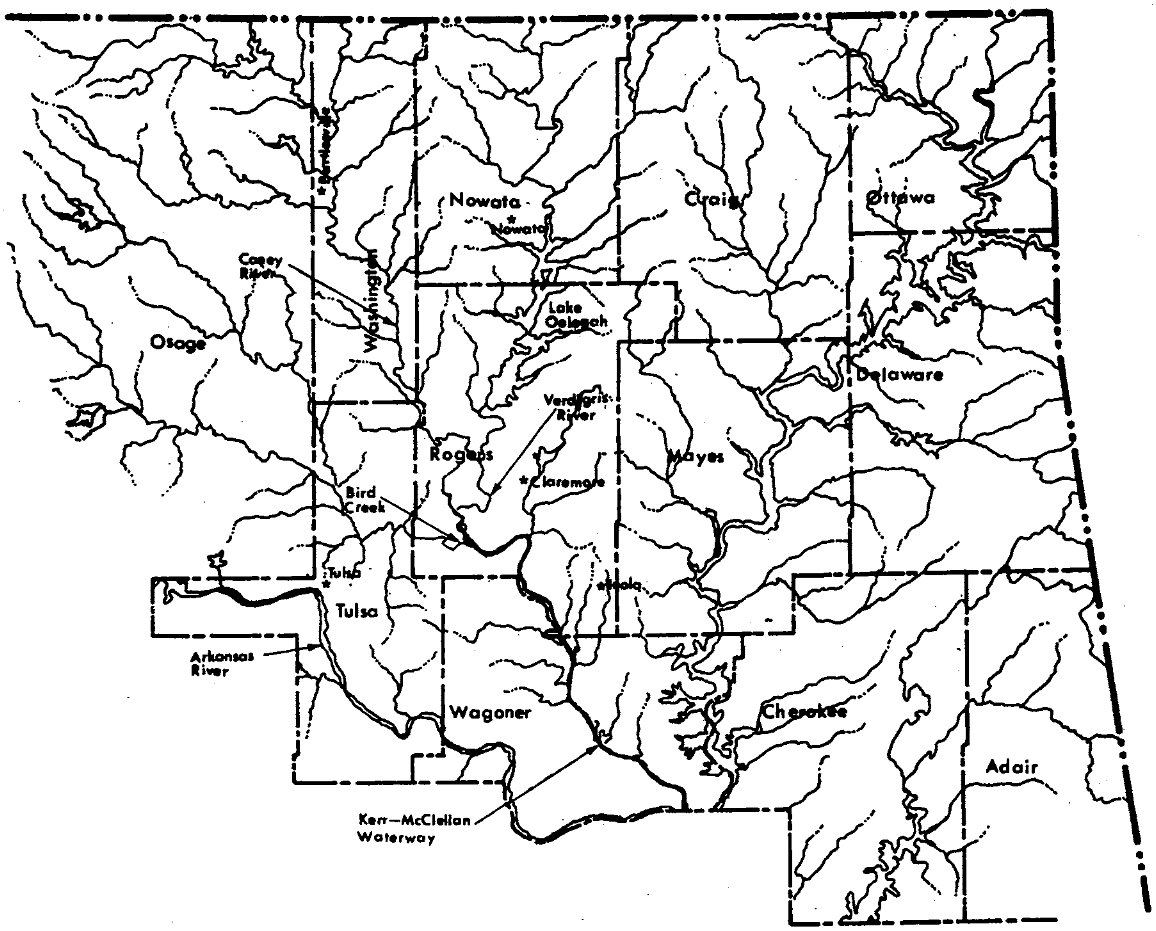


Figure 8.—Locations of rivers and creeks within northeastern Oklahoma. (From Oklahoma Water Resources Board, 1971, p. 10.)

be considered as a source of water; adequate quantities are available for small industries and municipalities. Bird Creek (Pl. 5) might also seem to be a potential source of water, but the quality of water is poor due to high concentrations of dissolved solids, and during dry seasons the flow would frequently be insufficient to meet the needs of some kinds of industries (Oklahoma Water Resources Board, 1971, p. 65).

Lakes of 10 acres or more are shown on the hydrology and resources map (Pl. 5). Quality of lake water ranges from fair to good, except in areas where local pollution may occur. Lakes within strip-mined areas are rated as having fair quality, for analyses show that the water is safe for use in irrigation and recreation (Polone, 1966). The drainage basins of many creeks in the study area contain numerous highly favorable sites for lakes.

Availability and Quality of Ground Water

The bedrock and stream terrace deposits of the study area are not good prospective sources of ground water. The average yield of wells in bedrock is estimated to be only about 0.5 gpm, and the quality of water ranges generally from poor to only fair (Marcher and Bingham, 1971). The alluvium of the Verdigris and Caney rivers and of Bird Creek is the best source of ground water. The alluvium of the above-mentioned streams is shown in yellow on the hydrology and resources map (Pl. 5), signifying that conditions for recovery of ground water exist. The alluvium is less than 40 ft on the average; it consists of clay, silt, and fine- to coarse-grained sand. Yields as great as 25 gpm may be obtained from it locally (Marcher and Bingham, 1971). Quality is fair, but high content of calcium and magnesium may cause the water to be hard (Oklahoma Water Resources Board, 1971, p. 97).

Mineral Resources

Limestone

Limestone crops out or is covered by less than 3 ft of soil in about 40 sq mi within the area of study. Five limestone units are thick enough to be of potential commercial value for building stone, rock aggregate, or manufacture of cement. Two thinner units could be used locally for aggregate and for building materials.

A limestone unit of potential major importance crops out within the valley of the Verdigris River in western Rogers County. This unit is designated "I" on the hydrology and mineral resources map (Pl. 5). West of the Verdigris River, the mapped unit consists of two limestones separated by a shale. The formal stratigraphic names are the Blackjack Creek Limestone Member of the Fort Scott Limestone and the Breezy Hill Limestone Member of the Senora Formation (Fig. 4). Average thicknesses of the Blackjack Creek and Breezy Hill are about 6 to 10 ft. The shale separating these two units is about 7 ft thick.

East of the Verdigris River, three limestones are potential sources of commercial stone, including the Blackjack Creek, the Breezy Hill, and the Verdigris Limestone Member of the Senora Formation (Fig. 4). The Verdigris is 2 to 5 ft thick (Oakes, 1944). The Blackjack Creek caps many of the hills west of Claremore (Pl. 5), and the thickness of the unit varies markedly due to erosion.

The limestone unit that may be of greatest potential economic value crops out in a cuesta that extends along the west side of the Verdigris River in western Rogers County. This unit is designated "II" on the hydrology and resources map (Pl. 5). The formal stratigraphic name for the unit is the Oologah Limestone (Fig. 4). It is quarried extensively in western Rogers and eastern Tulsa Counties for building stone and for rock aggregate. It may be as thick as 100 ft at some localities; the minimal thickness is about 25 ft. Rocky Mountain-Dewey Cement Company operates a large cement-manufacturing plant in sec. 22, T20N, R14E, using the Oologah Limestone and the underlying shale as raw materials.

In the northern part of the study area, limestone crops out west of the Caney River in Wasington County. This unit is designated "III" on the hydrology and resources map (Pl. 5); its formal stratigraphic name is the Hogshooter Limestone (Fig. 5). The Hogshooter is almost uniformly 5 ft thick in T23N and T24N. In T25N, it grades into two limestone units separated by a shale. The entire interval is about 25 ft thick. The upper limestone unit is about 20 ft thick, but the lower limestone unit is only about 1 ft thick (Oakes, 1940).

In western Washington County, the unit designated "IV" on the hydrology and mineral resources map (Pl. 5) is formally named the Dewey Limestone (Fig. 5). The Dewey has been quarried in northern Washington County by the Dewey Portland Cement Company. The average thickness of the Dewey in the study area is about 10 ft.

In southwestern Washington County, Unit V (Pl. 5), the Avant Limestone Member of the Iola Formation (Fig. 5), crops out in an extensive cuesta. It is about 40 ft thick in T23N, but thins markedly northward (Oakes, 1940). Only the outcrop area in T23N is shown as being of potential commercial value. This unit has been quarried in Osage County.

Unit VI, formally known as the Checkerboard Limestone (Fig. 5), crops out in western Rogers County and southern Washington County (Pl. 5). It is a minor limestone unit which may be used locally for rock aggregate. The Checkerboard is consistently about 2.5 ft thick. At a few places it is concretionary.

Unit VII is comprised of several thin limestone strata and lenticular limestones. They are interbedded with shale, and little information about their thickness is available. For some purposes they may be of sufficient value to quarry locally. The formal stratigraphic names for Unit VII are the limestones of the Iola and Wann formations that crop out in T24N and T25N (Pl. 5; Fig. 5).

Sand and Gravel

Nearby sources of sand and gravel are important in the construction industry. Potential sources of sand and gravel also are shown on the hydrology and mineral resources map (Pl. 5).

Chert gravel has been quarried at several places in western Rogers County. Chert generally makes a rather poor aggregate for portland cement, but it is ideal for road metal, aggregate in asphaltic concrete, decorative landscaping, and packing of septic-tank lines and water wells. Areas of large potential resources of gravel are shown on the hydrologic and resources map (Pl. 5). Areas noted on the map as potential sources of sand may contain significant amounts of gravel also.

Several potential sources of sand are located within deposits of terrace alluvium. Sand may also be recovered from floodplain alluvium of creeks and rivers of the study area (Pl. 2).

Dredging operations, such as those used on the Arkansas River in Tulsa County, could be an economical approach to obtaining sand. Replenishment of sand in the Verdigris River is now limited because of the Oologah Dam, but the confluence of the Caney and Verdigris rivers might be a potentially profitable dredging site.

Clay and Shale

In general, clay and shale are used in the manufacture of cement, brick, tile, lightweight aggregate, pottery, and refractory products (Oklahoma Water Resources Board, 1971, p. 130). Shale is being quarried by the Rocky Mountain-Dewey Cement Company in sec. 22, T20N, R14E in Rogers County. The shale lies below thick limestone, is quarried in conjunction with this limestone, and both rock types are used for manufacture of cement. The formal stratigraphic names of these units are the Oologah Limestone and Labette Shale (Fig. 4).

Expanding clay is used in the production of light aggregate by the Chandler Materials Company in sec. 24, T20N, R14E in Rogers County. The formal stratigraphic name of the clay unit is the Labette Shale (Fig. 4). Deposits of expanding clay have been recorded also in T22N, R14E in Rogers County (Oklahoma Water Resources Board, 1971, p. 130). Studies of the shales within the project area could lead to discovery of extensive reserves of materials for the cement, brick, and tile industries.

Coal

Numerous coal seams are contained within the strata of the study area. Most of them are too thin to be of economic importance, but two coal beds are noteworthy. They are informally referred to as the Dawson coal and the Broken Arrow coal (Fig. 4; Pl. 5).

The Broken Arrow coal, also referred to as the Croweburg coal, has been strip-mined extensively in western Rogers County. The Broken Arrow coal ranges in thickness from 12 to 22 in. throughout western Rogers County (Oakes, 1944). A complete analysis of the quality of the Broken Arrow coal as it occurs throughout the study area is not available. Results of an average analysis of the Broken Arrow coal taken from strip pits near Catoosa follows (Oakes, 1944). The fixed carbon is 57.1 percent, and the volatile matter is 32.5 percent. Ash content is about 4.8 percent; the ash has a softening point above 2,000°F. The sulfur content is erratic, but the average is 0.9 percent. The average Btu (British Thermal Unit) value of the Broken Arrow coal is 13,350 per pound.

The Dawson coal of the Seminole Formation has also been strip-mined extensively in western Rogers County. Average thickness of the Dawson coal in T22N and T23N is 20 in. The Dawson coal thins to about 1 ft in T24N (Trumball, 1957). A complete analysis of the Dawson coal within the study area is not available. An analysis that shows the average quality of a sample of the Dawson coal collected in a strip mine near Collinsville in Tulsa County follows (Oakes, 1952). Fixed carbon is 46.6 percent; volatile matter is 37.5 percent; ash content is 4.7 percent; the sulfur content is 4.7 percent; and Btu value is 12,590 per pound.

Strip-mining of coal is more of an economic problem than it is a geologic problem. The economy of coal is heavily dependent upon market value, cost of mining, and cost of transportation. The extent of strip-mining of coal and the depths from which coal is obtained are more dependent upon the variables mentioned above than upon geologic limitations in areas where coal reserves exist (Frank Podpechan, oral communication, 1973).

The Broken Arrow and Dawson coals are not presently being mined commercially in the study area. The approximate locations of the Broken Arrow and Dawson coal beds are shown on the hydrology and mineral resources map (Pl. 5).

Petroleum

The petroleum industry has played a dominant role in the economic development of the region. The production history of the area began in the late 1800's with the discovery of the Bartlesville Field in Washington County (Table 2; Pl. 3, 5). The study area has been explored extensively for petroleum throughout the century. Several moderately large oil fields have been discovered (Table 2; Pl. 3, 5), most of which are almost depleted. A few new wells are drilled each year. The area has produced oil worth many millions of dollars, but total production could not be determined from available records. Current production of the region including Rogers, Washington, Craig, and Nowata counties is about 7,000 barrels per day (Vance Rowe Reports, 1969).

TABLE 2

LOCATIONS OF MAJOR OIL FIELDS
WITHIN THE STUDY AREA

Washington County	General Location
Bartlesville	Secs. 3, 4, 5, T25N, R13E
Hogshooter	Secs. 1, 2, 11, 12, 13, T25N, R14E; Sec. 24, T25N, R13E
Ochelata	Secs. 22, 25, 26, 27, 34, 36, T25N, R13E; Sec. 2, T23N, R13E
Vera	Secs. 29, 31, 32, T23N, R14E; Sec. 6, T22N, R14E
North Ochelata	Secs. 1, 2, 11, 12, 14, 23, T25N, R12E
Candy Creek	Sec. 2, T24N, R12E
<u>Rogers County</u>	
Catoosa	Secs. 7, 8, 17, 18, 28, 29, 32, 33, T20N, R15E
Claremore	Widely spaced wells in T21N, R15 and 16E
Oologah	Secs. 3, 4, 5, 8, T22N, R15E
Sageeyah	Secs. 24, 25, 35, T22N, R15E

(From Oakes, 1940; Woodruff and Cooper, 1930)

SUMMARY

This study was prepared as an experiment in evaluating the land and mineral resources of western Rogers and southern Washington Counties. Five maps have been prepared along with explanatory legends. A descriptive text explains map preparation, classification, and an evaluation of each map. The following basic maps have been prepared.

(1) Environmental geology map, a compilation of bedrock as well as sediments into basic classes for first-order environmental significance.

(2) Land-resource capabilities map provides a basis for decision-making by delineating units according to capabilities.

(3) Current land-use map consists of an inventory of land use in the study area, and shows timbered areas.

(4) Relief map shows land-surface configuration so that one can evaluate topographic conditions by simple inspection.

(5) Hydrology and mineral resources map shows known locations of current resources such as petroleum, limestone, sand and gravel, expanding clay and shale, coal, ground and surface water.

Land-resource capabilities units are delineated according to bedrock lithology, soil thickness and texture, and physical and chemical properties of soil and bedrock. Their distributions should aid greatly in regional planning and in the preliminary evaluation of specific sites.

The study area contains a moderate amount of mineral resources. Petroleum has played a dominant economic role in the past, but in the future, production of oil and gas in the study area probably will continue to decline. Abundant supplies of limestone and gravel

exist within the study area.

Two coal seams within the study area may become highly valuable energy resources, dependent upon the economics of the coal industry.

The expanding Tulsa metropolitan area is predicted to encompass a great deal of the study area in the future. Planners and developers must be cognizant of the physical environment that surrounds them. It is believed that this study supplies basic information to the layman and professional alike that will aid in the present and future efficient use of the land.

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VITA

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PLATE I

ENVIRONMENTAL GEOLOGY MAP OF WESTERN ROGERS AND SOUTHERN WASHINGTON COUNTIES, OKLAHOMA

By

JARRETTE L. IRELAND

1973

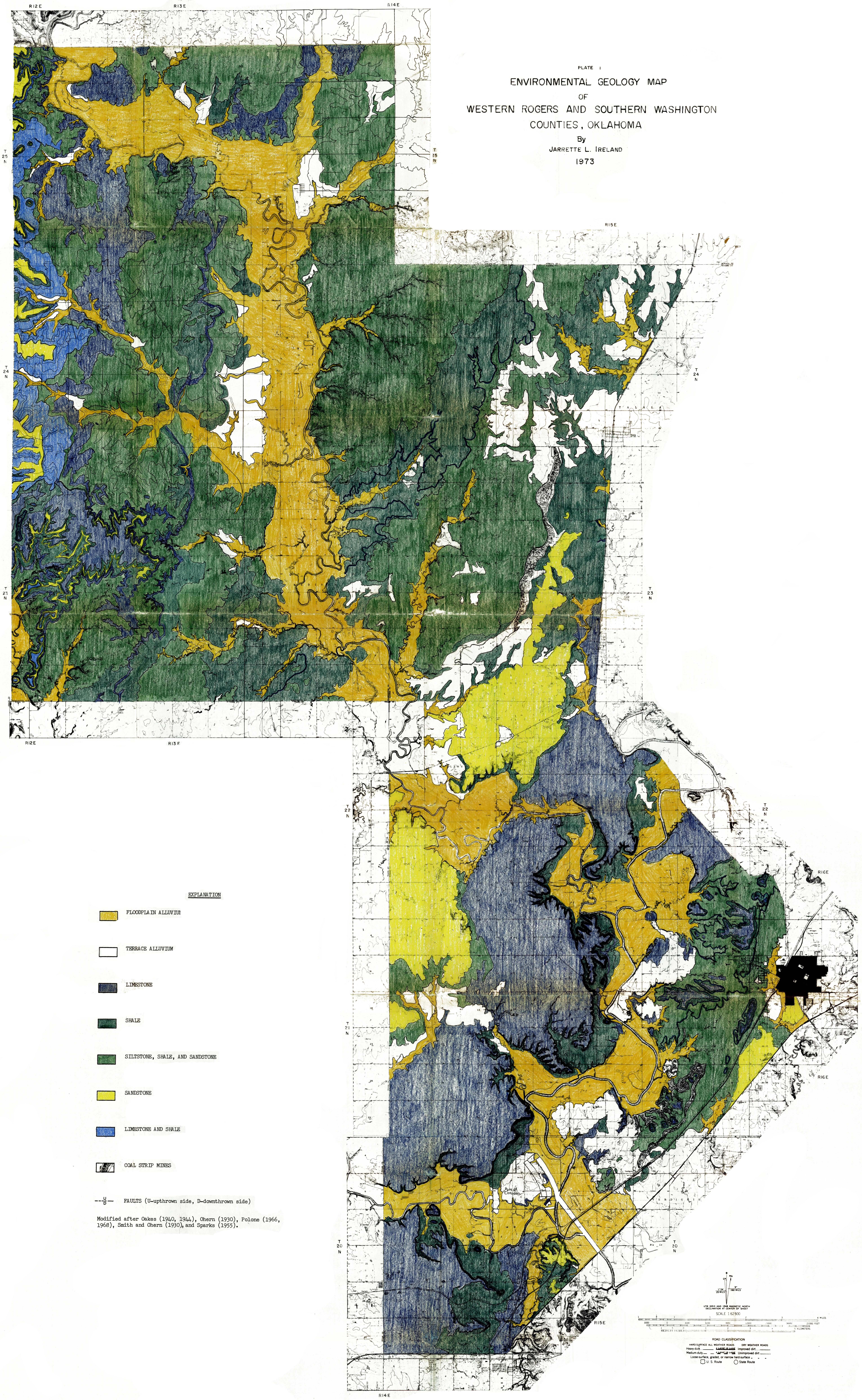
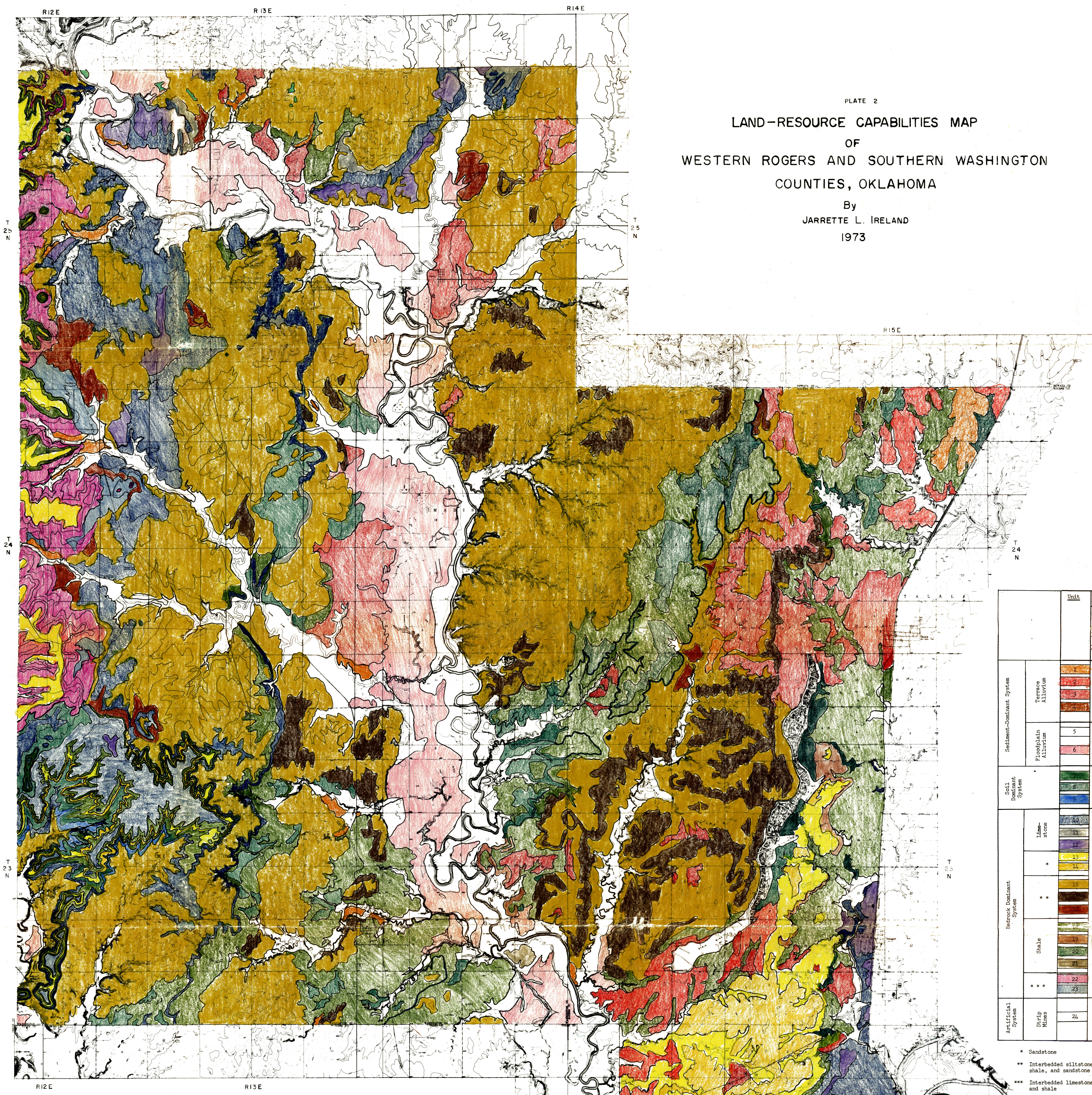


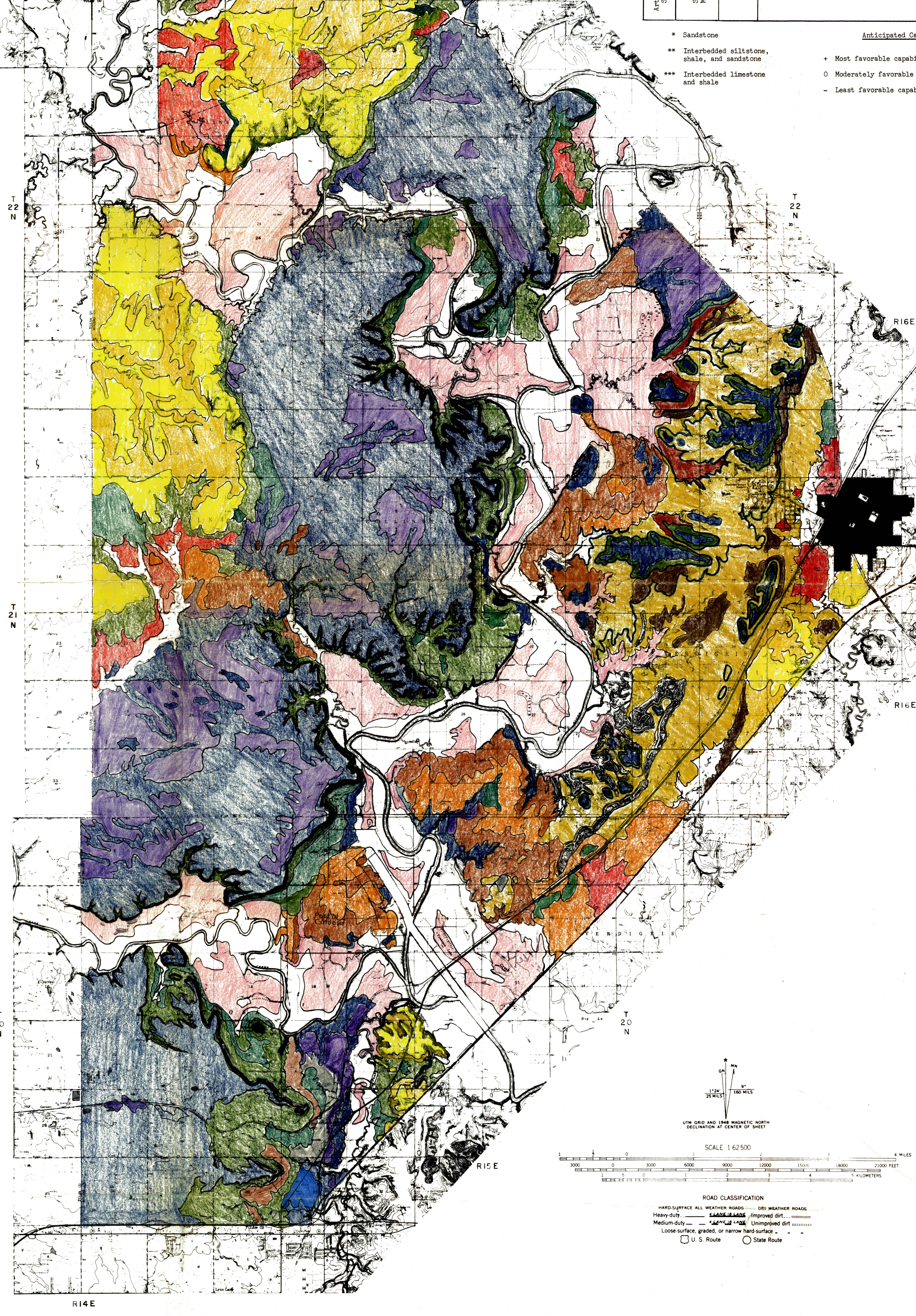
PLATE 2

LAND-RESOURCE CAPABILITIES MAP OF WESTERN ROGERS AND SOUTHERN WASHINGTON COUNTIES, OKLAHOMA

By
JARRETTE L. IRELAND

1973





EXPLANATION

System	Group	Unit	Liquid Waste Disposal	Solid Waste Disposal	Light Construction	Heavy Construction	Highway Location (Subgrade)	Select or Sub-base Material	Base Material	Aggregate	Fill Material	Excavation	Underground Installations	Buried Cables and Pipes	Reservoir Location	Shrink-Swell Potential	Permeability	Erodibility	Water Table Position	Seepage	Acidity	Alkalinity	Ripping Potential	Slope Stability	Flood Potential
Sediment-Dominant System	Terrace Alluvium	1	-	-	+	0	+	0	-	-	+	0	-	-	+	M	M	H	M	H	H	L	H	L	L
		2	-	-	0	-	-	-	-	-	-	-	-	0	+	H	L	H	H	L	M	L	H	L	L
		3	-	-	0	-	-	-	-	-	-	-	-	0	+	H	L	H	H	L	H	L	H	L	L
		4	-	-	+	+	+	+	+	+	+	0	-	0	0	L	H	H	M	H	M	L	H	M	L
	Floodplain Alluvium	5	-	-	-	-	-	0	+	-	+	-	-	0	+	L	M	H	H	M	M	L	H	L	H
		6	-	-	-	-	-	-	-	-	-	-	-	0	+	H	L	H	H	L	L	L	H	L	H
Soil Dominant System		7	+	+	+	+	+	0	0	-	+	0	0	+	+	M	L	M	H	L	M	L	M	M	L
		8	+	+	0	-	0	0	0	-	0	-	0	0	+	H	L	M	H	L	L	L	H	L	L
		9	+	+	0	-	0	0	0	-	0	0	-	0	+	H	L	M	H	M	L	L	M	L	L
Bedrock Dominant System	Lime-stone	10	-	-	+	+	0	+	+	+	+	+	+	0	-	L	M	L	H	H	L	M	L	H	L
		11	-	-	0	0	0	-	-	0	-	0	0	0	+	H	L	M	H	M	L	L	M	L	L
		12	-	-	0	0	+	+	+	0	+	+	+	+	+	M	M	M	M	H	L	L	M	H	L
	*	13	-	-	+	+	+	0	0	0	-	-	-	-	-	L	M	L	L	H	H	L	L	H	L
		14	-	-	+	+	+	+	-	-	0	0	0	0	0	M	M	M	L	H	H	L	M	H	L
	**	15	-	-	+	0	+	+	+	+	+	-	-	0	+	L	M	M	L	H	M	L	M	L	L
		16	-	-	+	0	+	+	+	+	+	-	-	0	+	L	M	M	L	H	M	L	M	L	L
		17	-	-	0	0	0	-	-	-	-	-	-	0	+	H	L	M	M	M	M	L	H	L	L
	Shale	18	[illegible]	+	0	0	+	0	0	0	0	+	+	+	+	M	L	M	L	L	M	M	H	M	M
		19	+	+	0	0	+	0	0	0	0	+	+	+	+	M	L	M	L	L	H	L	H	M	M
		20	+	+	-	-	-	-	-	-	-	-	-	0	+	H	L	M	H	L	L	M	H	L	M
		21	-	-	-	-	-	-	-	-	-	-	-	0	+	H	L	M	H	L	M	M	H	L	H
	***	22	0	0	0	0	0	0	0	0	0	-	-	0	+	H	L	M	H	H	L	M	M	L	L
		23	0	0	-	-	-	-	-	-	-	-	-	0	+	H	L	M	H	H	L	M	M	L	L
Artificial System	Strip Mines	24	-	0	-	-	-	-	-	-	+	0	-	0	+	M	M	H	H	H	H	L	H	L	L

* Sandstone

** Interbedded siltstone, shale, and sandstone

*** Interbedded limestone and shale

Anticipated Capability

+ Most favorable capability; minimal problems
0 Moderately favorable capability; moderate problems
- Least favorable capability; maximal problems

Key

H High
M Moderate
L Low

EXPLANATION

1 Terrace alluvium thicker than 45 in., consisting predominantly of unconsolidated fine sand and silt. Material slightly plastic, moderately permeable, strongly acidic. Seeps common where material thins downslope. Natural bulk density may be less than optimum for heavy buildings. Highly susceptible to water erosion. Slopes in road cuts and other excavations tend to be unstable.

2 Terrace alluvium thicker than 45 in., consisting mostly of unconsolidated silt and clay. Material highly plastic, slightly permeable, moderately acidic. Water table seasonally high. Slopes in road cuts and other excavations tend to be unstable.

3 Terrace alluvium thicker than 45 in., consisting mostly of unconsolidated silt and clay. Material highly plastic, slightly permeable, strongly acidic. Water table seasonally high. Slopes in road cuts and other excavations tend to be unstable.

4 Terrace alluvium thicker than 45 in., consisting of well graded silt, sand, and gravel. Material highly permeable, slightly acidic. Seeps common where material thins downslope. Material highly susceptible to water erosion.

5 Floodplain alluvium thicker than 45 in., consisting of unconsolidated silt and fine-grained sand. Material slightly plastic, highly permeable, slightly acidic. Water table seasonally high. Natural bulk density may be less than optimum for heavy structures. Susceptible to seasonal flooding.

6 Floodplain alluvium thicker than 45 in., consisting of silt and clay. Material highly plastic, slightly permeable, slightly acidic. Water table seasonally high. Material changes volume markedly during wet and dry seasons. Material has never been consolidated; it has not released all the interstitial water present from the time of its deposition. This probably makes the soil somewhat unstable when large structures or heavy loads are placed upon it. Susceptible to seasonal flooding.

7 Shale overlain by silty, clayey soil thicker than 45 in. Soil moderately plastic, slightly permeable, moderately acidic. Shale bedrock is slightly aklaline. Water table seasonally high.

8 Shale overlain by very clayey soil thicker than 45 in. Soil highly plastic, slightly permeable, slightly acidic. Shale bedrock slightly alkaline. Water table seasonally high.

9 Limestone overlain by clayey soil thicker than 45 in. Soil highly plastic, slightly permeable. Water table seasonally high. Limestone probably nonrippable where thickness is more than 1 ft.

10 Limestone at surface or overlain by silty or clayey soil less than 30 in. thick. Weathered upper surface markedly irregular at some places. Strata probably nonrippable where thickness is more than 1 ft. Rock generally highly jointed. Many joints are widened by solution and locally sinkholes may be present. Creep of blocks occurs at outcrops. Seeps and springs locally common from between bedding planes, joints and along contacts with underlying strata.

11 Limestone overlain by clayey soil 30-45 in. thick. Soil highly plastic, slightly permeable. Water table seasonally high. Limestone probably nonrippable where thickness is more than 1 ft.

12 Limestone overlain by silty soil 30-45 in. thick. Soil slightly plastic, moderately permeable, and susceptible to water erosion. Limestone probably nonrippable where thickness is more than 1 ft.

13 Sandstone at the surface or overlain by sandy soil less than 30 in. thick. Soil highly permeable, strongly acidic. Sandstone caps hills or is exposed as rock benches. Seeps common where soil thins downslope, and along contacts with underlying strata. Rock generally highly jointed. Creep of blocks occurs at outcrops. Bedrock generally nonrippable except where highly jointed.

14 Sandstone overlain by silty or sandy soil 30-45 in. thick. Soil moderately permeable, strongly acidic. Seeps common where soil thins downslope, and along contacts with underlying strata. Bedrock generally nonrippable except where highly jointed.

15 Interbedded siltstone, shale, and sandstone at the surface or overlain by silty or sandy soil less than 30 in. thick. Sandstone strata cap hills or form rock benches; siltstone and shale form slopes. Seepage common along bedding planes and where soil thins downslope. Creep of sandstone blocks occurs at outcrop. Slopes in road cuts and other excavations may be unstable. Strata rippable except in areas where sandstone is thick.

16 Interbedded siltstone, shale, and sandstone overlain by clayey, silty, sandy soil 30-45 in. thick. Soil slightly plastic, highly permeable, strongly acidic. Slopes in road cuts and other excavations may be unstable. Seeps common where soil thins downslope. Strata rippable except in areas where sandstone is thick.

17 Interbedded siltstone, shale, and sandstone overlain by silty, clayey soil 30-45 in. thick. Soil highly plastic, slightly permeable, moderately acidic. Soil is colluvial; found at lower parts of moderate to steep slopes. Slopes in road cuts and other excavations may be unstable.

18 Shale at the surface or overlain by silty, clayey soil less than 30 in. thick. Soil is strongly acidic. Shale strata slightly alkaline. Strata are generally rippable and locally may be highly jointed.

19 Shale overlain by silty, clayey soil 30-45 in. thick. Soil moderately plastic, slightly permeable, strongly acidic. Shale strata slightly alkaline. Strata are generally rippable.

20 Shale overlain by very clayey soil 30-45 in. thick. Soil highly plastic, slightly permeable, slightly acidic. Seasonally high water table. Shale strata slightly alkaline. Slopes in road cuts and other excavations may be unstable. Strata are generally rippable.

21 Shale overlain by very clayey soil 30-45 in. thick. Soil highly plastic, slightly permeable, slightly acidic. Seasonally high water table. Shale strata slightly alkaline. Slopes in road cuts and other excavations may be unstable. Susceptible to seasonal flooding. Strata are generally rippable.

22 Interbedded limestone and shale at the surface or overlain by silty, clayey soil less than 30 in. thick. Limestone forms rock ledges or caps hills; shale forms slopes. Creep of limestone blocks occurs at outcrop. Seeps locally common from contacts where limestone overlies shale. Solution-widened and clay-filled joints may be present in limestone strata. Material nonrippable where limestone thickness is more than 1 ft.

23 Interbedded limestone and shale overlain by clayey soil 30-45 in. thick. Soil highly plastic, slightly permeable, slightly acidic. Bedrock nonrippable where limestone is thicker than 1 ft.

24 Abandoned Coal Strip Mines: Sandstone, siltstone, or shale boulders and original soil mantle mixed. Material forms ridges 20 to 40 ft high between narrow troughs commonly containing water. Steep, irregular slopes are susceptible to erosion. Rapid runoff of rain water is common. Seeps are common at bases of slopes.

Oil-Waste Lands: Areas where liquid wastes, principally oil and salt water, have accumulated. Includes slush pits and adjacent uplands and lowlands. Generally high NaCl level in soil, general lack of vegetation. Highly susceptible to water erosion.

--U/D-- Faults or Suspected Areas of Faults: Fractures in bedrock where relative horizontal and vertical movement has occurred. High density of joints in bedrock common near faults. Bedrock may be pulverized along fault planes. Seeps are common along faults and bedding planes bounding faults. All faults in the study area are believed to be inactive.

Information drawn partly from Polone (1966, 1968).

PLATE 3
CURRENT LAND USE MAP
OF
WESTERN ROGERS AND SOUTHERN WASHINGTON
COUNTIES, OKLAHOMA
By
JARRETTE L. IRELAND
1973
R12E
R13E
R14E
R15E
R16E
T 25 N
T 24 N
T 23 N
T 22 N
T 21 N
T 20 N
EXPLANATION
Agricultural lands: Includes cultivated lands, orchards, range lands, and pasture lands. Locally crops of corn, small grain, sorghum, and soybeans are cultivated on floodplain soils. Pecan orchards are common in the Caney and Verdigris river floodplains. Range lands and pasture lands are commonly developed on shallow soils above sandstone and shale. Native pastures consist of bluestem grass, indian grass, and switchgrass mixtures. Improved tame grass-legume pastures are commonly seeded to improve yields. Sumac, hackberry, oak, and persimmon tend to invade pastures on shallow soils.
Lowland Timber: Grows in floodplains and abandoned channels of streams. Terrain of seasonally high water table, poor drainage, some local swampy conditions, and subject to occasional flooding. Hardwoods predominate, including red and black oaks, pecan, walnut, maple, ash, cottonwood, elm, hackberry, and sycamore. Growth rate is good on most sites but locally poor where cattle graze.
Upland Timber: Grows on moderate to steeply sloping upland soils on shale, sandstone, and limestone. Pin oak, red oak, post oak, black oak, and hickory trees occupy sandstone ridges; a few cedar occur on limestone bluffs and ridges.
Residential-Urban Areas: Include cities, residential developments, trailer parks, and commercial developments in urban areas.
Industrial Areas: Include factories, active quarries and pits, and port facilities.
Golf course.
Oil and gas fields, present limits.*
Pipelines: Approximate locations of major lines.
Power-transmission Lines: Approximate locations of major lines.
Airfield.
Man-made Land
Strip Mines: Bedrock forms ridges 20 to 40 ft high between narrow troughs that commonly are lakes; willow and cottonwood trees occur in troughs. Ridges predominantly are shale thinly covered with broomsedge and other coarse grasses and brush. Lakes furnish good stock water. Land is suited to both tame and native pasture; pines, cedars, and post oaks also grow well. Problems result from irregular slopes, large boulders, rapid runoff, and erosion of ridges.
Inactive Sand or Gravel Pits, or Limestone Quarries: Local areas where soil or bedrock has been excavated. Deep quarries may contain water suitable for agricultural or recreational use. Areas where soil has been partially removed are especially susceptible to erosion.
Abandoned Petroleum Tank Farms: Locally small, shallow depressions exist that may contain water. Suitability of areas for specific uses is dependent upon soil and bedrock conditions. Precaution must be taken during excavation in these areas because buried pipes may be encountered.
Man-made levees on navigational waterway.

PLATE 4

RELIEF MAP OF WESTERN ROGERS AND SOUTHERN WASHINGTON COUNTIES, OKLAHOMA

By

JARRETTE L. IRELAND

1973

PLATE 5

HYDROLOGY AND MINERAL RESOURCES MAP OF WESTERN ROGERS AND SOUTHERN WASHINGTON COUNTIES, OKLAHOMA

By

JARRETTE L. IRELAND

1973

EXPLANATION

WATER

Surface Water: Rating for Municipal, Industrial, or Agricultural Uses[1]

GOOD

Moderate to Hard Water: Total dissolved solids less than 500 mg/l, generally of the bicarbonate type. Quality in lakes and ponds is generally good, if not polluted locally.

FAIR

Hard Water: Total dissolved solids 500 to 1,000 mg/l, including moderate amounts of sodium. Troughs or pits from strip mining of coal contain good stock water, and analyses show that the water is safe for irrigation. Pits can be stocked with fish.

POOR

Very Hard to Brackish Water: Total dissolved solids occasionally exceed 3,000 mg/l. Water commonly is the sodium-chloride or calcium-sulfate type. High mineral content is due primarily to salt or gypsum dissolved from bedrock upstream. Local stream pollution may occur in proximity to oil-production sites, livestock facilities, or waste-disposal facilities.

Quality of stream water determined for low-flow conditions or for dry periods when concentrations of minerals are relatively great.

Ground Water: Rating for Availability and Quality[2]

Availability Favorable, Quality Fair to Good

Alluvium along the Caney and Verdigris Rivers and Bird Creek: Average thickness is less than 40 ft. Material consists mainly of clay, silt, and fine to coarse sand. Yields average 5 to 20 gpm, but locally wells that tap thicker and coarser beds of sand may yield as much as 50 gpm.

The water is moderately hard to hard; total dissolved solids range from 500 to 1,000 mg/l. Sulfate, chloride, and nitrate contents of water generally are low to moderate, except locally. Water commonly is of the sodium- or calcium-bicarbonate type. Quality represents 80 percent of sampled wells in alluvium of the Verdigris River; total-dissolved-solids contents of nearly 70 percent were less than 500 mg/l.

Note: In all other parts of the study area availability of ground water is not favorable, as bedrock and terrace deposits are the aquifers. Most wells yield only a fraction of a gallon to a few gallons each minute. The average yield is estimated at 0.5 gpm. However, yields as much as 20 gpm have been obtained locally from thick, coarse-grained terrace deposits.

The water is hard to very hard; total dissolved solids range from 500 to 3,000 mg/l. Sulfate, chloride, and nitrate contents of water generally are moderate to very high. Nitrate pollution occurs locally. Approximately 70 percent of wells sampled contain more than 500 mg/l total dissolved solids. Water from sandstone is the least mineralized; water from shale, particularly shale containing coal beds, is the most mineralized.

[1] Information chiefly from Oklahoma Water Resources Board (1971).

[2] Information chiefly from Marcher and Bingham (1971).

EXPLANATION

RESOURCES*

Limestone

I

In descending order, Blackjack Creek Limestone Member, Fort Scott Limestone, and Breezy Hill Limestone Member and Verdigris Limestone Member, Senora Formation. Blackjack Creek and Breezy Hill each about 6 to 10 ft thick, separated by shale about 7 ft thick. Verdigris Member about 2 to 5 ft thick, separated from Breezy Hill commonly by sandstone and shale locally as thick as 18 to 40 ft. West of the Verdigris River, Verdigris Member and overlying sandstone and shale present only in subsurface.

II

Oologah Limestone is as thick as 100 ft. Minimum thickness is approximately 25 ft.

III

Winterset Limestone Member of the Hogshooter Formation is approximately 5 ft thick in T23N and T24N. In T25N, along Hogshooter Creek, the Hogshooter Formation includes Winterset Member (approximately 20 ft) and Canville Limestone Member (approximately 1 ft). Stark Shale Member separates the above units and is about 4 ft thick.

IV

Dewey Limestone is approximately 10 ft thick. Grades into marlstone or calcareous sandstone at some localities

V

Avant Limestone Member of the Iola Formation is as thick as 40 ft. Minimum thickness is approximately 9 ft.

VI

Checkerboard Limestone is approximately 2.5 ft thick. Locally the Checkerboard may be concretionary.

VII

Lenticular limestones interbedded with shale. This unit is made up of the strata of the Iola and Wann formations.

Coal

Sand and Gravel

Predominantly chert gravel and quartzose sand.

Cl

Shale and Expanding Clay

Major Oil or Gas Fields

*Information principally drawn from Oakes (1940, 1944), Sparks (1955), Bennison (1972), Polone (1966, 1968), Jordon and others (1966), Oklahoma Water Resources Board (1971).