TREND AND GENESIS OF THE PENNSYLVANIAN ELGIN SANDSTONE IN THE WESTERN PART OF NORTHEASTERN OKLAHOMA

By

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PREFACE

This thesis is primarily a study of the depositional environment of the Elgin Sandstone which crops out in the western part of northeastern Oklahoma. It contains a description of the geometry and internal features along with the stratigraphic framework for the sandstone. Presented are thickness maps, correlation sections, measured sections, paleocurrent diagrams, permeability data, grain orientation analyses, grain size parameters, petrographic features, and water quality analyses.

The writer expresses his appreciation to individuals who provided assistance and information to him during the study. Dr. J. W. Shelton suggested the investigation and provided invaluable assistance, both in the field and during the writing of the paper. Advisory committee members, Dr. D. C. Kent, who helped in the permeability analysis, and Dr. T. B. Thompson, who helped in the petrographic analysis, offered useful suggestions during the study. Mr. Fred V. Cluck with T. N. Berry and Company and Mr. Mickey J. Overall with Cities Service Oil Company provided the electric well logs. Mr. R. H. Bingham, Mr. J. H. Irwin, and Mr. M. V. Marcher, of the U. S. Geological Survey, arranged for the chemical analysis of water samples. Appreciation is also extended to Oklahoma State University Arts and Sciences Research for funds used in preparation of illustrations. The writer also wishes to thank Mrs. Frank Roberts, who typed the manuscript, his fiance Cheryl Maynard, who helped in its preparation, his parents, Mr. and Mrs. L. H. Terrell, and fellow graduate students for their encouragement and suggestions.

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CHAPTER I

ABSTRACT

The Elgin Sandstone is a member of the Pennsylvanian Vamoosa Formation on outcrop in Oklahoma and a member of the Kanwaka Formation in southern Kansas. Surface exposures in the eastern part of the study area and electric well logs west of the outcrop belt permit a rather accurate description of the geometry and internal features of the sandstone.

Major sandstone development within the Elgin interval is represented by lenticular sandstones, which are multilateral and multistoried deltaic distributary and alluvial channel deposits. Thick sandstone belts are 1 to 3 mi wide and contain 100 to 150 ft of sand. Genetic units of lenticular sandstones which are characterized by sharp contacts, are 20 to 30 ft thick and as much as 600 ft wide. Characteristic sedimentary structures of this sandstone type include medium-scale cross-bedding, high-angle initial dip, cut-outs, and parting lineation. Local trends are quite variable; the average paleocurrent direction in the study area is N 35°W. The alluvial sandstones are more extensively developed laterally and are coarser grained than the narrow distributary units, which are very fine to fine-grained. Both contain intraformational particles, wood fragments, and secondary concretions.

Thin-bedded sandstones are coastal and/or marine delta-fringe units. They are generally quite thin, with gradational lower and

lateral contacts. The most common sedimentary structures are small-scale cross-bedding, ripple marks, low-angle initial dip, and interstratification. The primary paleocurrent direction is N 50°W; a secondary trend is N 40°E. The sandstones are very fine-grained and well sorted, and they contain carbonaceous matter, small wood fragments, and muscovite flakes. Paleocurrent data, regional distribution of sandstone, and southerly increase in chert content suggest the Ouachita and Arbuckle uplifts as principal source areas, with a possible contribution in the north from the Ozark province.

Maximum horizontal permeability corresponds to the direction of preferred grain orientation in the alluvial and distributary sandstones. However, a correlation does not appear to exist between grain orientation and permeability in delta-fringe sandstones. Water analyses show a rather wide variation in ion concentrations. Several of the samples have chloride and/or TDS concentrations in excess of the established limits for domestic use. The fresh-mineralized water boundary, which appears to be related to sandstone thickness and distribution, varies in depth from 150 to 600 ft. The Elgin Sandstone in the study area may contain as much as 3×10^{12} gal of fresh water.

CHAPTER II

INTRODUCTION

In Oklahoma, the Elgin Sandstone is a poorly defined member of the Pennsylvanian Vamoosa Formation, which is present on outcrop north of the Arbuckle uplift. The Vamoosa is a complex of sandstone and shale, with some conglomerate in the south, that changes northward into more typical units of Kansas megacyclothems.

The stratigraphic interval studied in this investigation is essentially that defined by Jordan (1959) as the Elgin Sandstone Member. The rectangular area of study (T14N to T25N, R9E to R6E), includes both a narrow, north-trending outcrop belt in Creek, Pawnee, and Osage Counties and an area of shallow subsurface control westward from the outcrop (Fig. 1).

Objectives

The objective of this study is to determine the trend and genesis of the Elgin Sandstone from a description of its geometry and internal features. Because of the complex sandstone pattern in the Vamoosa Formation, a corollory objective, which necessarily must precede any meaningful description, is the establishment of a correlation framework for the Elgin. Another purpose of the study is to provide from the description and interpretation a basis for detailed ground-water studies of the system of Elgin reservoirs.

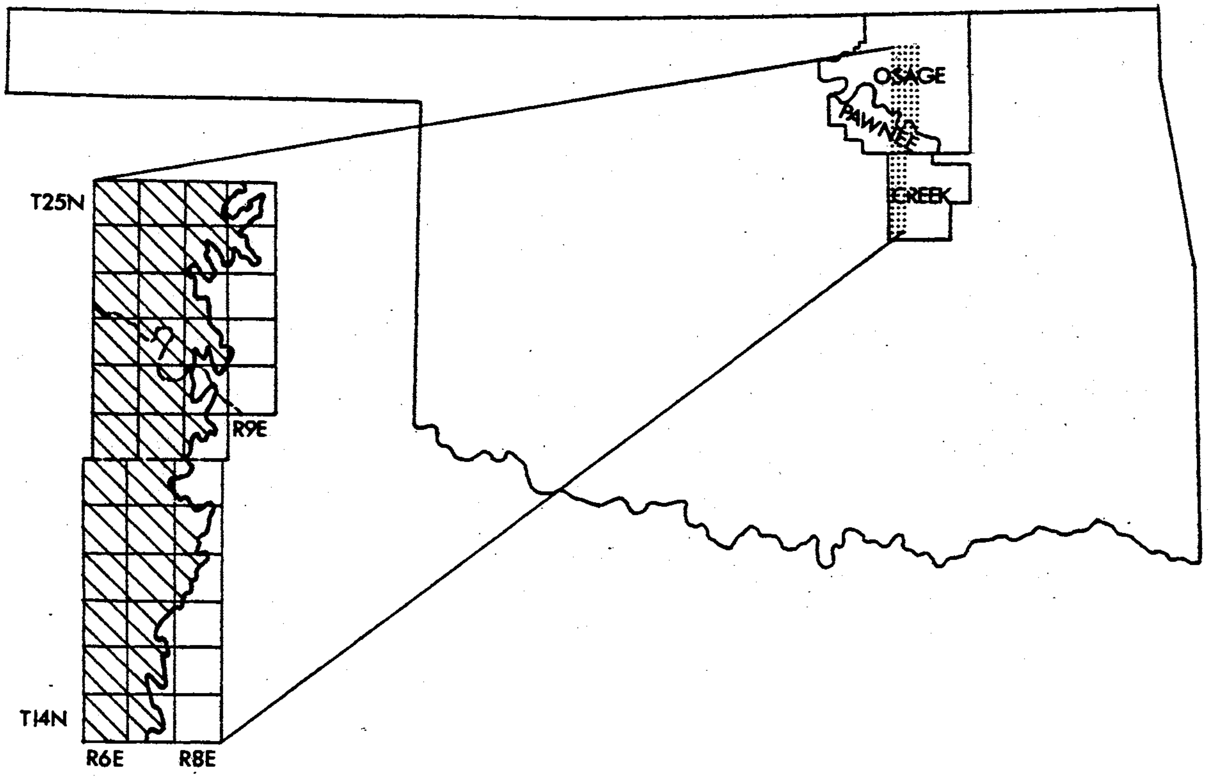

Fig.1.-Location map of area of study.

Methods

The geologic maps of Creek County (Oakes, 1959), Pawnee County (Greig, 1959), the Hominy area of Osage County (Russell, 1955), and the Pawhuska area of Osage County (Shannon, 1954), were used, with some modifications, as the basis for correlation in surface investigations. Electric logs were utilized in correlating between the various mapped areas and between the surface and subsurface in order to maintain a consistent stratigraphic interval for study.

Outcrop data from about 50 sections were described on measured section forms specifically prepared for sandstone and shale sequences by Shelton (1963). Paleocurrent indicators were plotted on azimith diagrams, from which trends of sediment transport were determined.

Surface data from 24 key measured sections together with subsurface data from approximately 300 electric logs were used in defining the stratigraphic interval containing the Elgin Sandstone (Figs. 2 and 3), thickness of net sandstone (Fig. 4), and thickness of the interval (Fig. 5).

CHAPTER III

STRATIGRAPHIC FRAMEWORK

The Elgin Sandstone, at the type locality in southeastern Kansas, is a member of the Kanwaka Formation of the Shawnee Group within the Pennsylvanian Virgilian Series. The Kanwaka is underlain by the Oread Formation and overlain by the Lecompton Formation (Fig. 6). In southern Kansas, it is divided into three members: the Jackson Park Shale, Clay Creek Limestone, and Stull Shale, in ascending order. The Elgin Sandstone is generally considered the equivalent of the Jackson Park Shale (Greig, 1959).

In central and southern Osage County, Oklahoma, the Kanwaka Shale, with the Elgin Sandstone, is recognized as part of the Vamoosa Formation (Shannon, 1954; Russell, 1955). Although the Oread Limestone does not extend southward beyond central Osage County, Greig (1959) distinguishes the Kanwaka Shale Member of the Vamoosa Formation in Pawnee County. Although sandstone units of the Vamoosa to the south in Creek County are designated informally by Oakes (1959), the Elgin has been identified there in the shallow subsurface and correlated to the surface (Jordan, 1959). Regional subsurface studies have delineated a complex of sandstone, regarded as the Elgin Sandstone, or Hoover Sandstone in some cases, in northern Oklahoma and southern Kansas (Lukert, 1949; Rascoe, 1962; Souter, 1966; Brown, 1967).

Elgin Sandstone is developed as far west as the easternmost part of

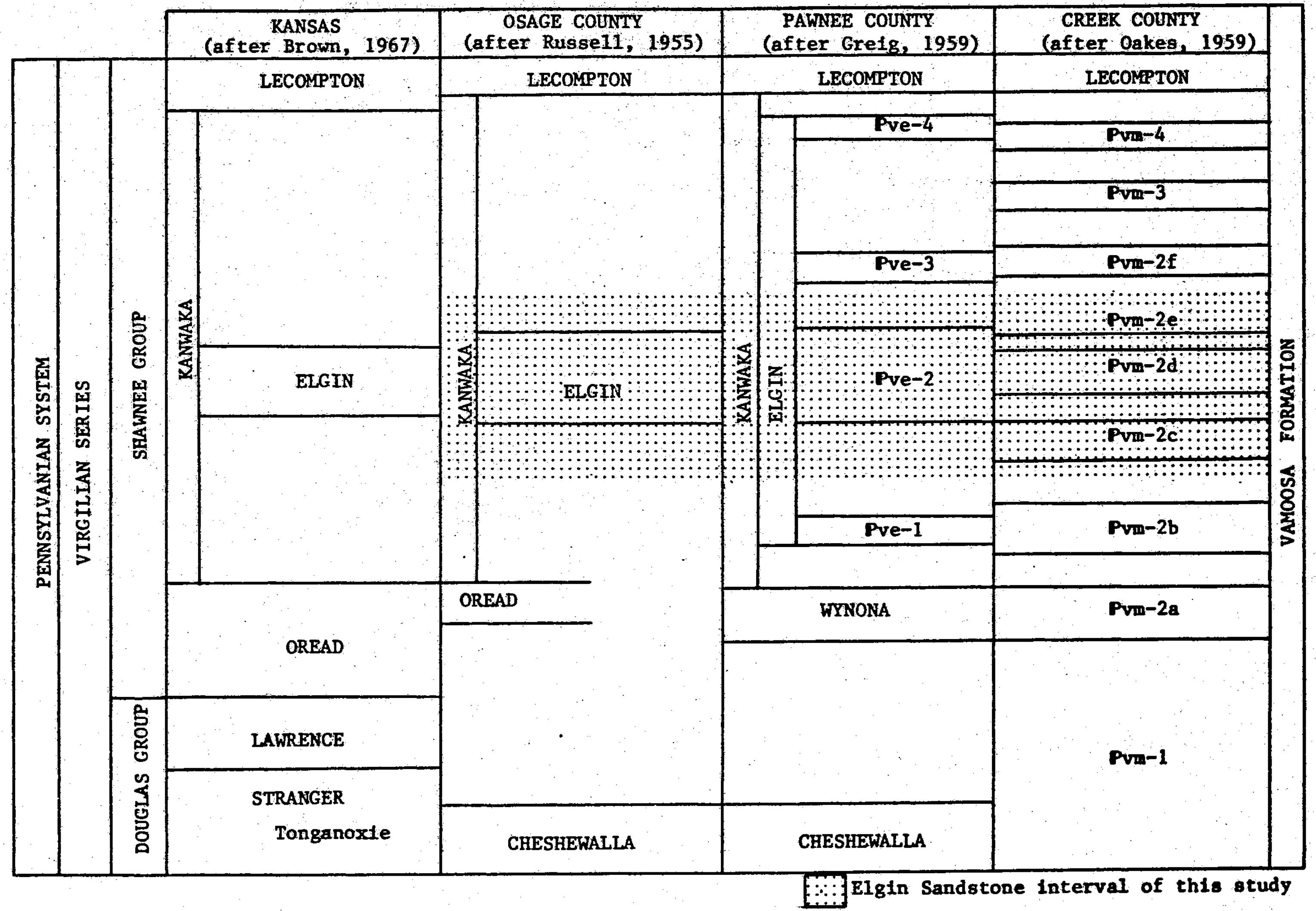

Fig. 6.-Stratigraphic correlation chart.

the Oklahoma Panhandle, approximately 200 miles west of its eroded edge (Rascoe, 1962). In southeastern Sumner and Crowley Counties, Kansas, the sandstone thins abruptly by wedge-out to the northwest and thins gradually by pinch-out to the northeast (Brown, 1967).

The stratigraphic interval of interest, herein regarded as a transgressive-regressive couplet in the Vamoosa Formation, is 100 to 150 ft thick and consists of lenticular sandstones with shale (Fig. 7). The upper transgressive marker lies approximately 130 ft below the base of the Lecompton Limestone (Fig. 7).

On outcrop, 80 to 100 ft of the interval are exposed. The top of the couplet is a well defined unit, characterized by a maroon, marine, fossil-bearing shale, 10 to 20 ft thick (Fig. 8). The base of this shale, which is uniform in character and widely distributed, is used as the upper marker for outcrop and subsurface correlations (Fig. 7). Good exposures of the shale are in roadcuts along Oklahoma Highway 99 and Oklahoma Highway 16, north and south of Drumright, respectively. The base of the couplet is represented by a series of interbedded sandstones and shales (Fig. 9). Although these beds commonly are poorly exposed, a few measurements of them were made in the field (Appendix A). In the subsurface, this marker is not so well defined as the upper marker, but it is thought to be generally reliable.

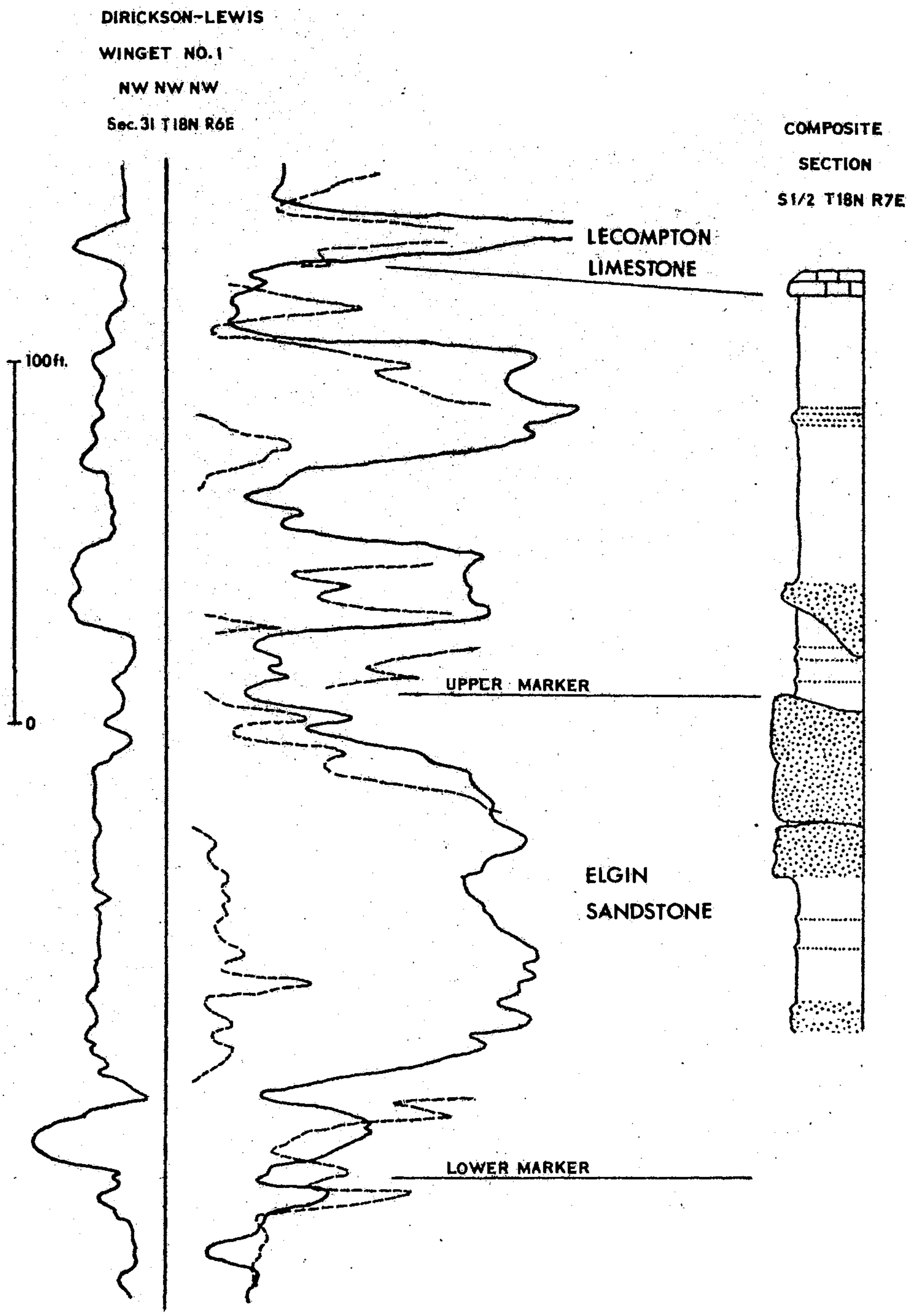

Fig. 7.-Stratigraphic interval of Elgin Sandstone, outcrop to subsurface, showing upper and lower contacts.

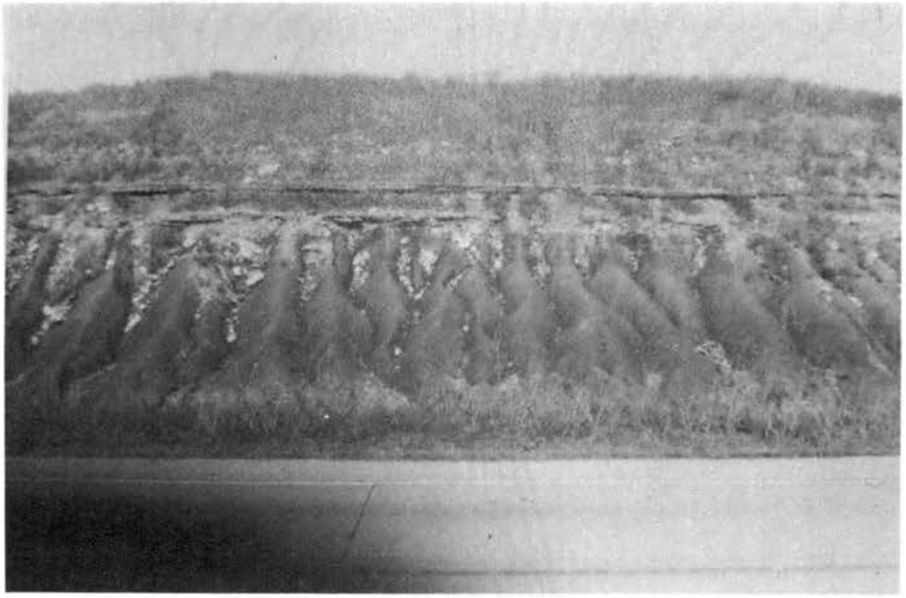

Fig. 8.-Upper marker on outcrop in Sec. 8, T18N, R7E. The marker is a maroon colored, marine shale, 10 to 20 ft thick. Top of the Elgin is exposed at edge of road.

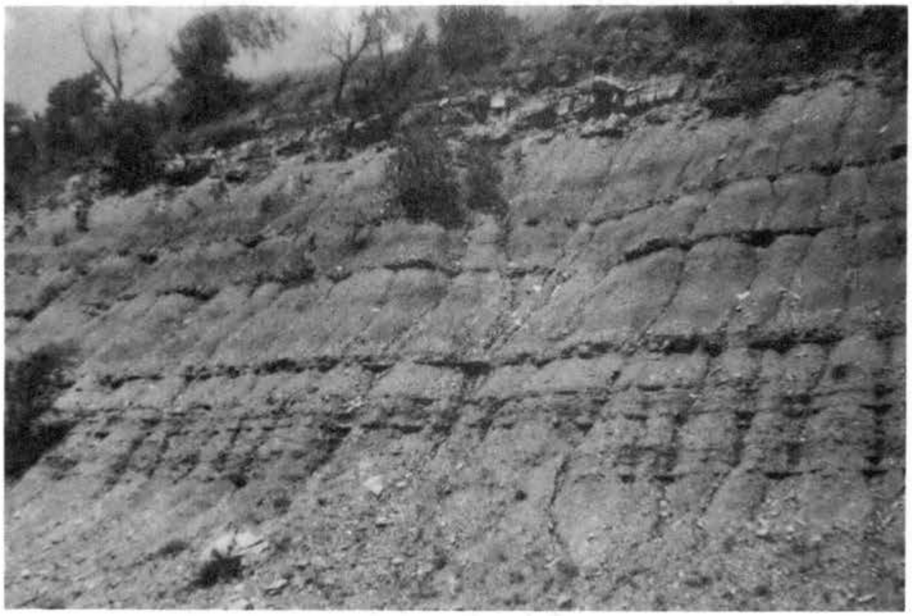

Fig. 9.-Lower marker on outcrop in Sec. 4, T21N, R8E. The marker is a series of interbedded sandstones and shales.

CHAPTER IV

GEOMETRY

Trend and Geographic Position

Sandstone on outcrop extends beyond the study area both to the north and the south. In the subsurface it extends 200 mi westward to the easternmost part of the Oklahoma Panhandle, and the overall trend is westerly (Rascoe, 1962). Although sandstone is present throughout the study area, it is best developed in Creek County (T15N to T19N) and in Osage County (T24N to T25N). The latter area shows an overall westerly trend, whereas trends in Creek County are diverse in orientation, with the most significant being northerly and northwesterly (Fig. 4). The Elgin interval is fairly uniform in distribution throughout the study area. Maximum thickness of approximately 140 to 170 ft in parts of T15N to T18N and T23N to T25N corresponds rather well to major sandstone development (Figs. 4 and 5).

Width and Thickness

On outcrop numerous sandstone bodies are as little as 10 ft wide and 5 ft thick. Genetic lenticular units are as much as 20 to 30 ft thick and are less than 600 ft wide. Some coarse-grained lenticular units, developed in the upper part of the interval, are thought from limited data to be 10 times the width of genetic units. Very thin units commonly extend beyond the limits of a single surface exposure.

Major sandstone belts contain 100 to 150 ft of sandstone and range in width from 1 to 3 mi. They are thought to represent multilateral and multistoried units. Sandstone is best developed in Creek County south of the Cimarron River and in the northernmost part of the study area. It is less than 20 ft thick in 2 areas in Osage County (Fig. 4).

Boundaries

The upper boundary of the couplet is generally sharp, both on outcrop and in subsurface, whereas the lower contact is not so abrupt or so well defined (Figs. 2 and 3). The couplet is characterized at many localities by poorly developed sandstone, with interbedded shale, in the lower part and well developed sandstone in the upper part. The boundaries of the latter are sharp, whereas the former type of sandstone shows a gradational base. Genetic units of lenticular sandstones are characterized by sharp upper and lower contacts and abrupt lateral contacts. Where they are present as multistoried and multilateral units, the sharpness of the boundaries is somewhat masked because the contacts separate units of the same lithology. The laterally persistent sandstones units are characterized by gradational lower and lateral boundaries. The upper contact is sharp where lenticular bodies directly overlie the thin units.

In subsurface the boundaries between major sandstone bodies are well defined (Fig. 3). The lenticular sands have sharp bases, and abrupt upper and lateral contacts. Thin-bedded sandstones exhibit gradational contacts.

CHAPTER V

INTERNAL FEATURES

Sedimentary Structures

Prominent sedimentary structures in lenticular sandstones, in order of decreasing abundance, are: medium-scale cross-bedding, high-angle initial dip, convolute bedding, massive bedding, parting lineation, cut-outs, small-scale cross-bedding, and ripple marks. Thin-bedded sandstones are characterized by small-scale cross-bedding, ripple marks, low-angle initial dip, parting lineation, and medium-scale cross-bedding. Other structures present are burrows, trails, and concretions.

Medium-scale cross-bedding, some of which is the festoon type (Fig. 10), is well developed in the upper half of the lenticular sandstone bodies, although development does occur throughout certain sandstone bodies. Features of soft sediment deformation in the lower part may have obliterated some of the cross-bedding.

Because cross-bedding and initial dip commonly have similar appearances, some difficulty was encountered in distinguishing these structures at certain exposures. Although some designations may be incorrect, the writer is of the opinion that the majority were classified correctly. Cross-bedding is distinguished by smaller size, higher angle of dip, and presence in the upper part of the sandstones. In the study area, high-angle initial dip is very common in the area south of the

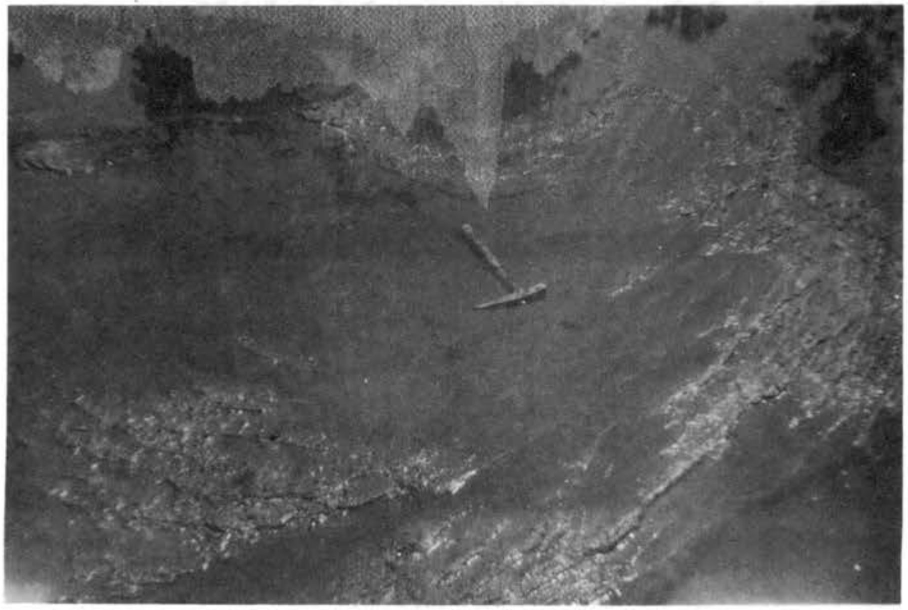

Fig. 10.-Festoon cross-bedding in Sec. 15, T23N, R8E. Hammer handle points in direction of dip. View is to the southwest.

Cimarron River in Creek County. The steepest dips, up to 35°, are present along the edges of the lenticular sandstone bodies and are thought to represent bank slope of channels. Initial dip in the thin-bedded sandstones is generally less than 10° and is present in both the sandstone and shale.

Small-scale cross-bedding characterizes the thin-bedded sandstones; however, it is also present near the top of the lenticular sandstones where the grain size is finest. Parting lineation is also commonly present near the top of the lenticular sandstones.

Ripple marks in the thin-bedded sandstone units are best developed where the sandstones are interbedded with shales (Fig. 11). Ripple marks are uncommon in the lenticular units, but they are present in some very fine-grained bodies (Appendix A).

Cut-outs and irregularities, associated with channel fill, are characteristic of the lenticular sandstone bodies (Fig. 12), and they generally represent minor channel remnants or poorly developed channels. Although deformed and convolute bedding is present in both types of sandstones, it is particularly well-developed at some localities in the lenticular sandstone bodies near the top of the Elgin Sandstone (Appendix A).

The thin-bedded units exhibit various organic structures, such as mottled or bioturbated bedding, burrows, and trails (Appendix A). In lenticular sandstones, on the other hand, these organic structures are much less common. Secondary concretions are present in both sandstone types and range in diameter from 4 to 400 mm (Fig. 13).

Fig. 11.-Ripple marks in thin-bedded sandstones in Sec. 18, T21N, R8E.

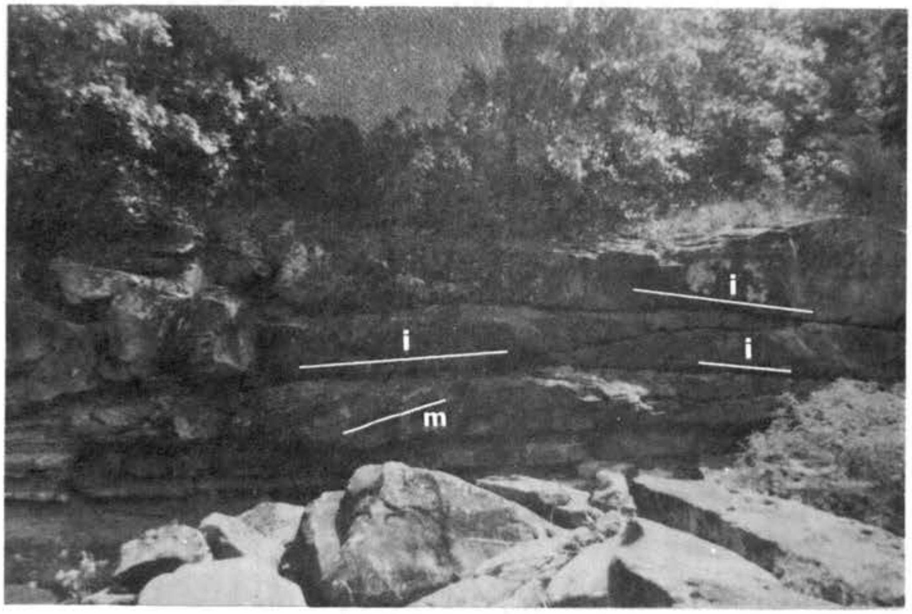

Fig. 12.-Sandstone lens in channel fill approximately 8 ft thick in Sec. 15, T23N, R8E. The sandstone displays initial dip (i) and medium-scale cross-bedding (m).

Fig. 13.-Secondary iron oxide concretions in Sec. 2, T17N, R7E.

Paleocurrents

Some 575 measurements of paleocurrent indicators were made of medium-scale cross-bedding, small-scale cross-bedding, initial dip, parting lineation, ripple marks, cut-outs, and grain orientation. At each locality, paleocurrents for lenticular sandstones were analyzed separately from the thin-bedded sandstones. For general analysis, data were grouped geographically and according to sandstone type. Because sandstone is not particularly well developed immediately north of the Cimarron River, it is used to divide the outcrop belt into two parts. Four paleocurrent diagrams show the range of the various directional features and give the average current directions north and south of the Cimarron River for each genetic unit (Figs. 14, 15, 16, and 17). An additional composite diagram for each sandstone type was prepared by plotting the weighted average paleocurrent direction for each locality (Figs. 18 and 19).

In the paleocurrent interpretation for the lenticular units, cut-outs, medium-scale cross-bedding, parting lineation, grain orientation, and small-scale cross-bedding were considered the most reliable indicators; small-scale cross-bedding, parting lineation, ripple marks, and grain orientation were the most reliable in the thin-bedded sandstones. The average current direction for the lenticular sandstones south of the Cimarron River is N 35°W (Fig. 14). The major paleocurrent direction for the thin-bedded type of sandstone south of the river is N 65°E; a secondary trend is N 20°E (Fig. 15). The average direction of the lenticular units north of the Cimarron River is N 60°W, compared to N 20°W and N 80°E for the thin-bedded units (Figs. 16 and 17). The

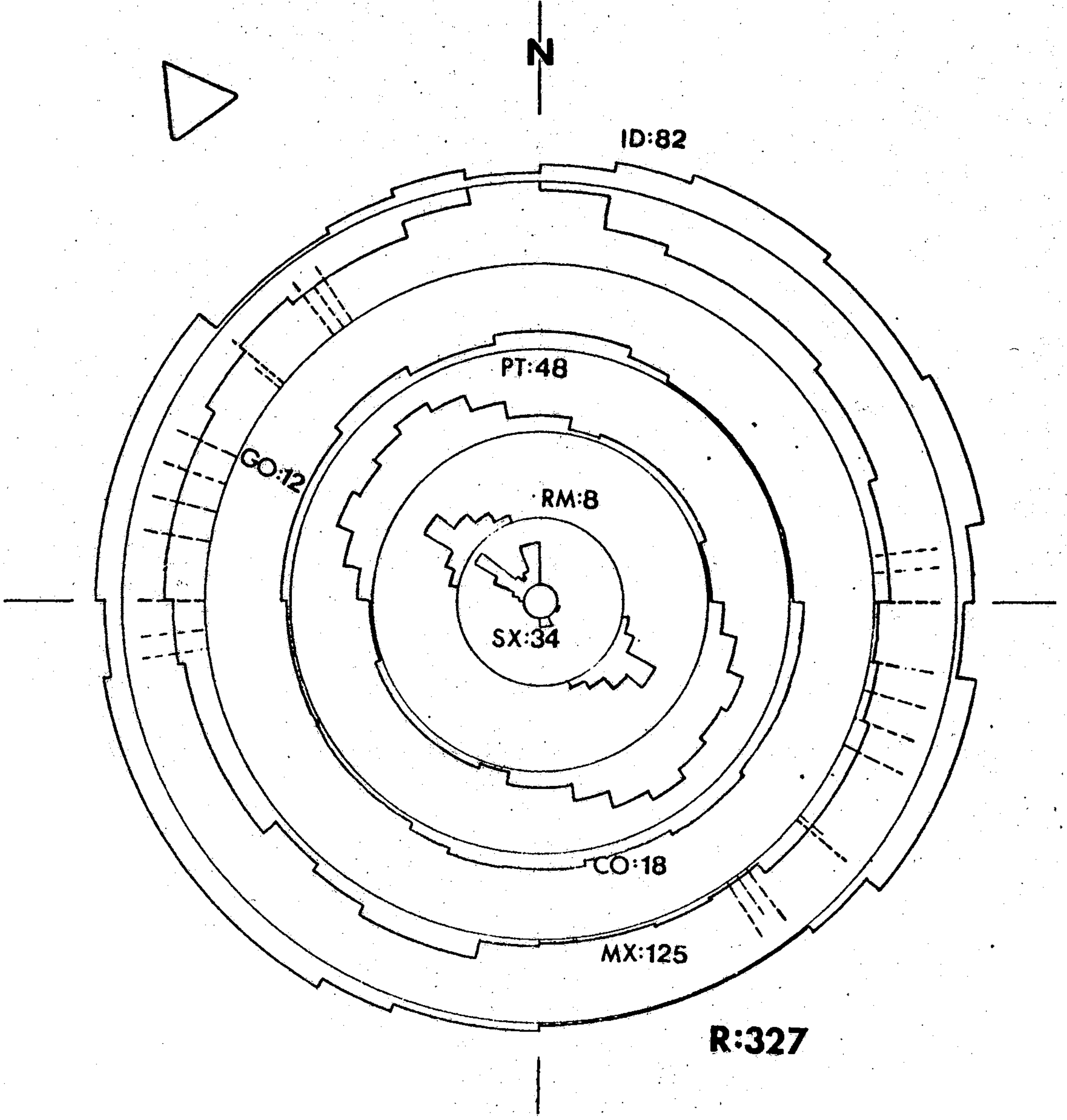

Fig. 14.-Paleocurrent diagram of lenticular sandstones south of the Cimarron River, indicating a trend of N 35°W. ID=initial dip, MX=medium-scale cross-bedding, SX=small-scale cross-bedding, PT=parting lineation, RM=ripple mark, CO=cut-out trend, GO=grain orientation (dashed lines), and R=total number of readings. A 30°-sliding average was used in preparation of diagram.

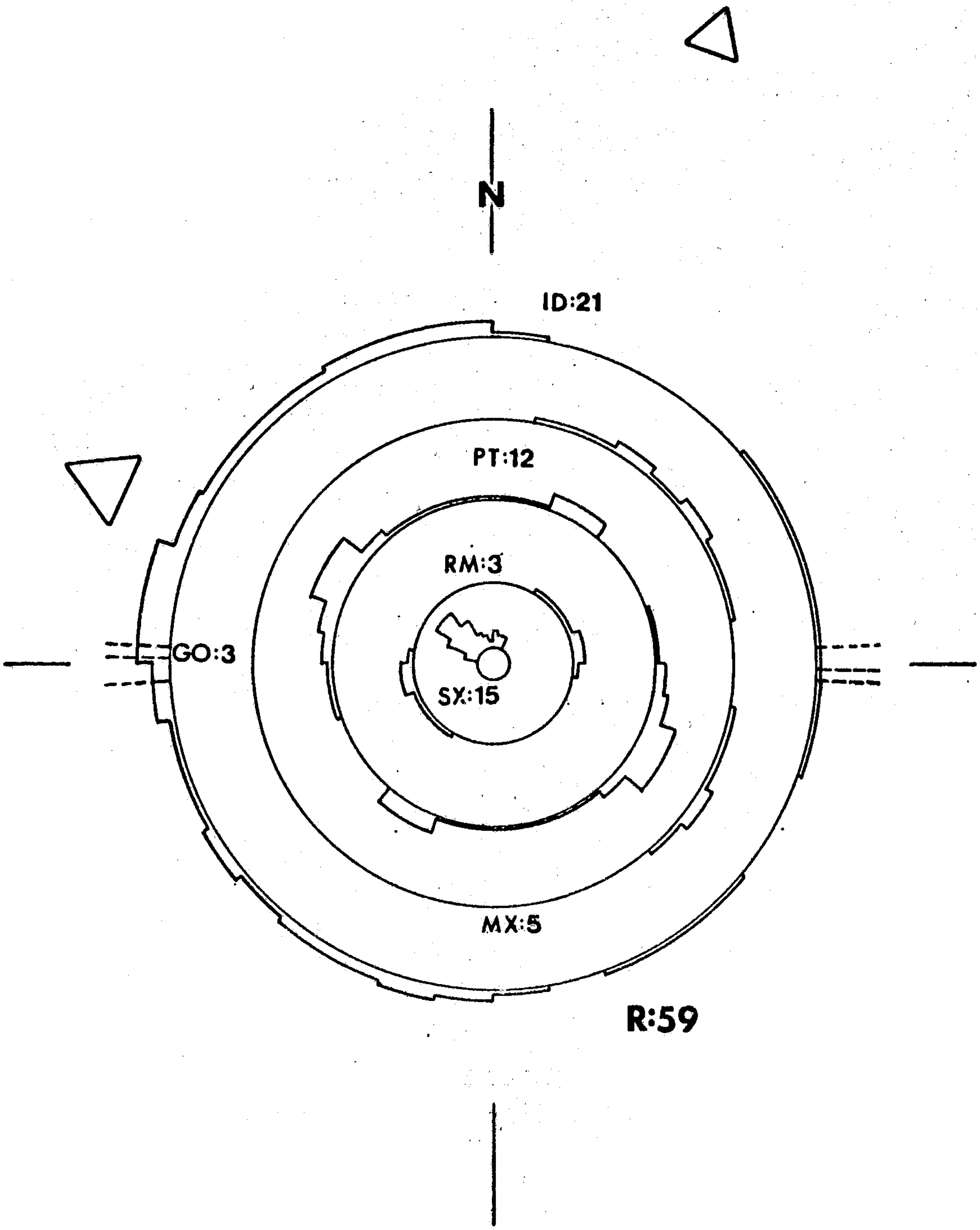

Fig. 15.-Paleocurrent diagram of thin-bedded sandstones south of the Cimarron River, showing a primary direction of N 65°W and a secondary direction of N 20°E. Key in Fig. 14.

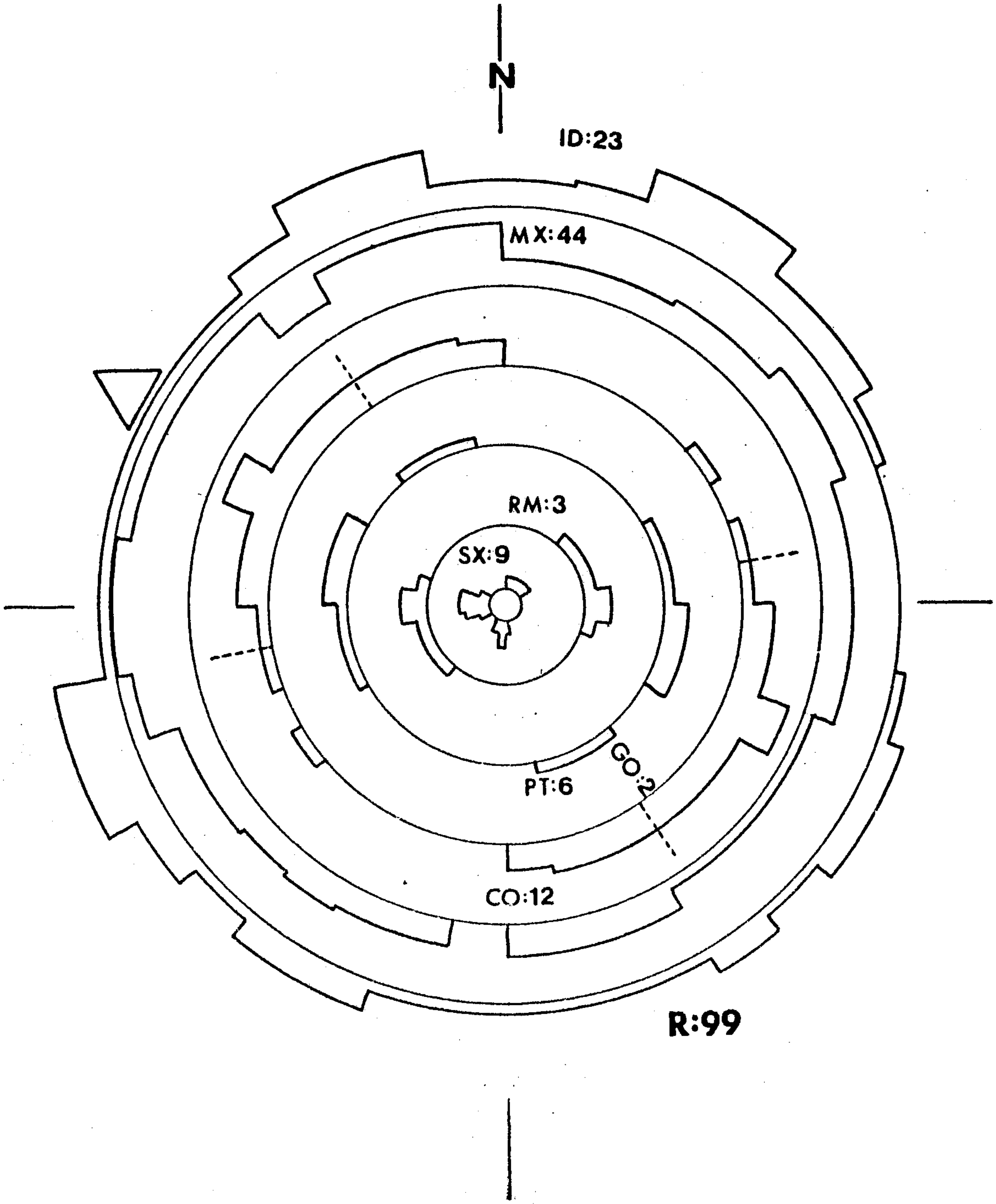

Fig. 16.-Paleocurrent diagram of lenticular sandstones north of the Cimarron River. Average direction is N 60°W. Key in Fig. 14.

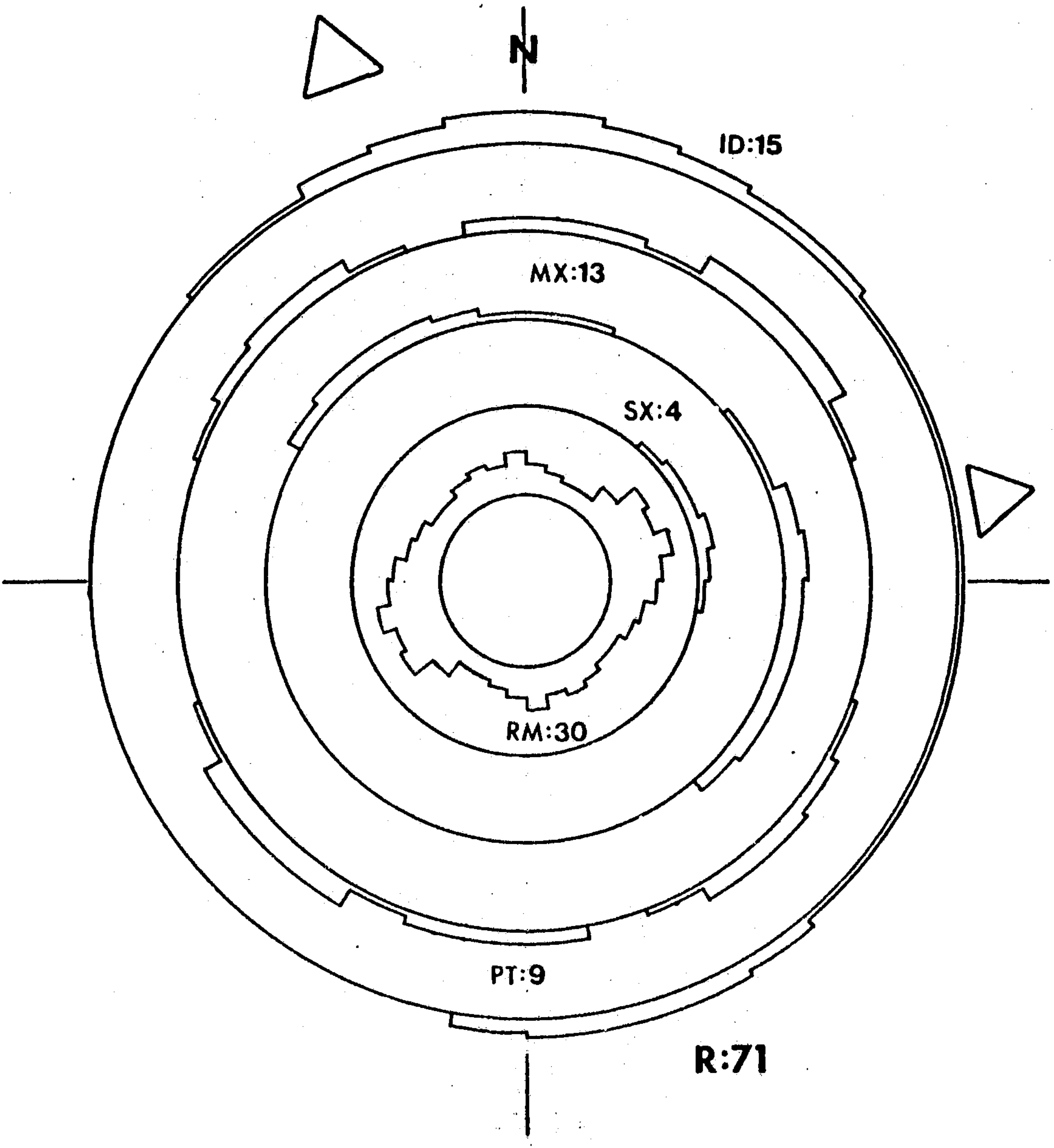

Fig. 17.-Paleocurrent diagram of thin-bedded sandstones north of the Cimarron River, with a primary average trend of N 20°W and a secondary trend of N 80°E. Key in Fig. 14.

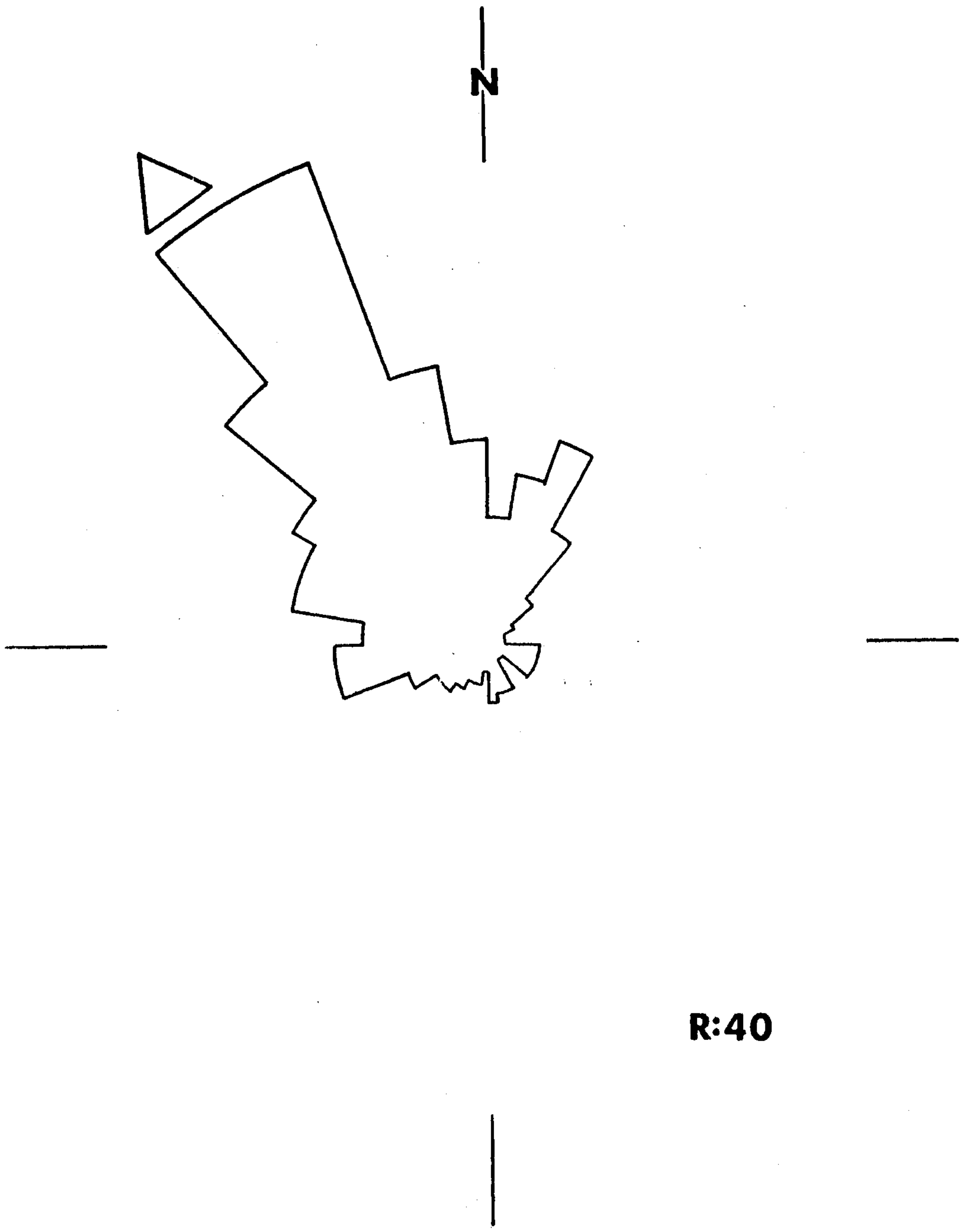

Fig. 18.-Composite paleocurrent diagram of lenticular sandstones from local average directions. Overall current direction is N 35°W. Key in Fig. 14.

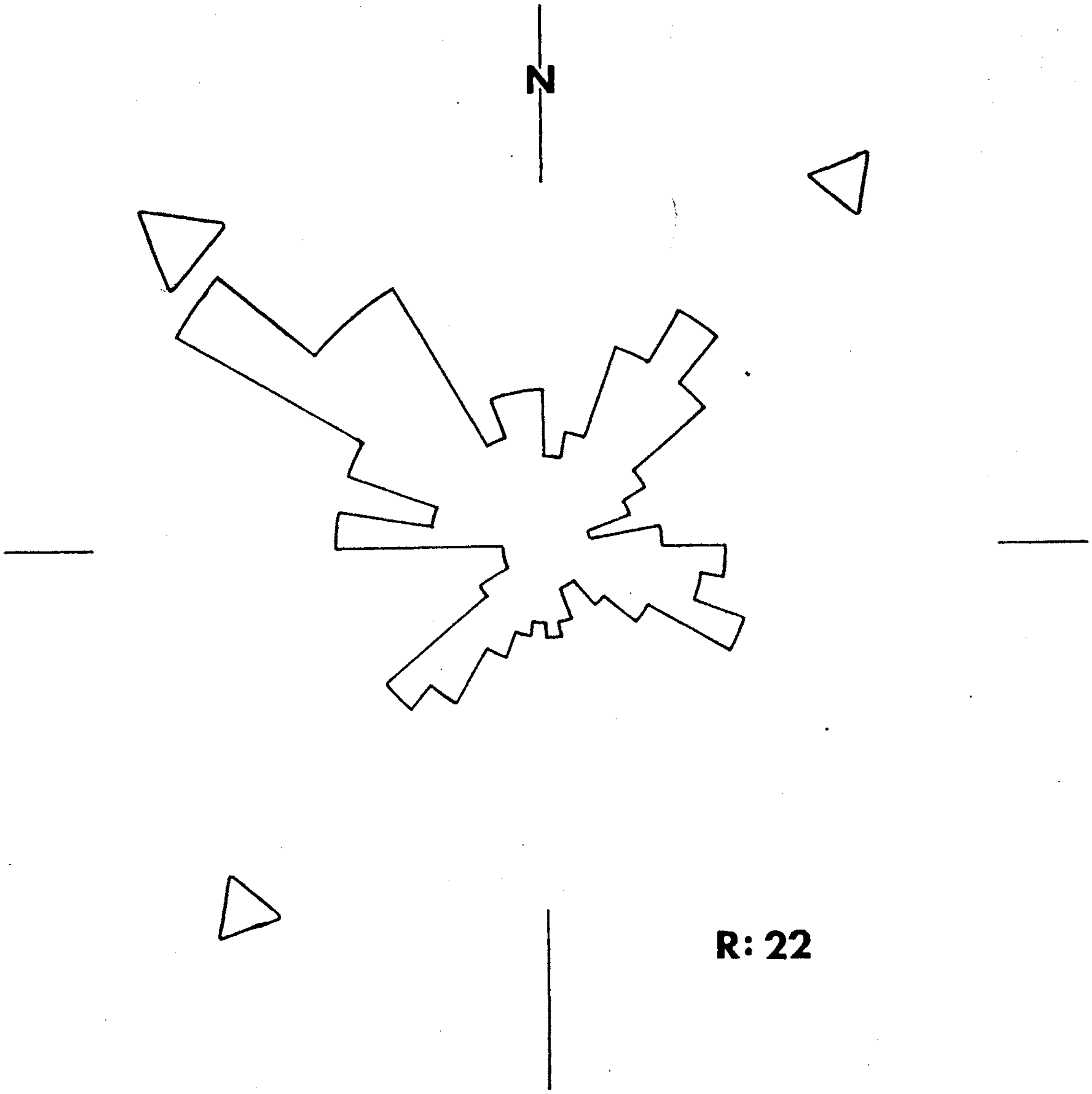

Fig. 19.-Composite paleocurrent diagram of thin-bedded sandstones from local average directions. Primary direction is N 50°W, and a secondary trend of N 40°E-S 40°W is present. Key in Fig. 14.

average trend for all lenticular sandstones is N 35°W (Fig. 18). The composite diagram of thin-bedded sandstones exhibits a primary average direction of N 50°W and a secondary trend of N 40°E (Fig. 19).

Texture

Lenticular sandstone bodies are commonly characterized by an overall upward decrease in grain size from fine- to medium-grained to very fine-grained. The maximum average grain size is present in the Drumright area, the area south-southwest of Depew, and the area northwest of Hominy, where the Elgin contains coarse-grained units. The thin-bedded sandstones are dominantly very fine- to fine-grained throughout the study area.

The visual accumulation tube (Subcommittee on Sedimentation, 1958) was utilized in the grain size analysis of 23 outcrop samples, which were easily disaggregated. Grain size distributions representing the coarsest, average, and finest grain size of the samples from the Elgin interval, show a change in the traction and saltation populations as the average grain size becomes finer and the total sample becomes better sorted (Fig. 20). The following parameters for each sample are presented in Table I: (1) maximum diameter (5 percentile) (Mx); (2) median diameter (Md); (3) mean diameter (M), (Inman, 1952); (4) phi standard deviation $\sigma\phi$ (Inman, 1952); and (5) Trask's sorting coefficient (So). The lenticular sandstones have maximum diameters ranging from .170 mm (2.56ϕ) to .405 mm (1.30ϕ), median diameters from .091 (3.46ϕ) to .240 mm (2.06ϕ), and mean diameters from .101 mm (3.30ϕ) to .225 mm (2.15ϕ). The phi standard deviation is .30 to .59, and the range in sorting coefficient is from 1.09 to 1.31. The average lenticular sandstone is

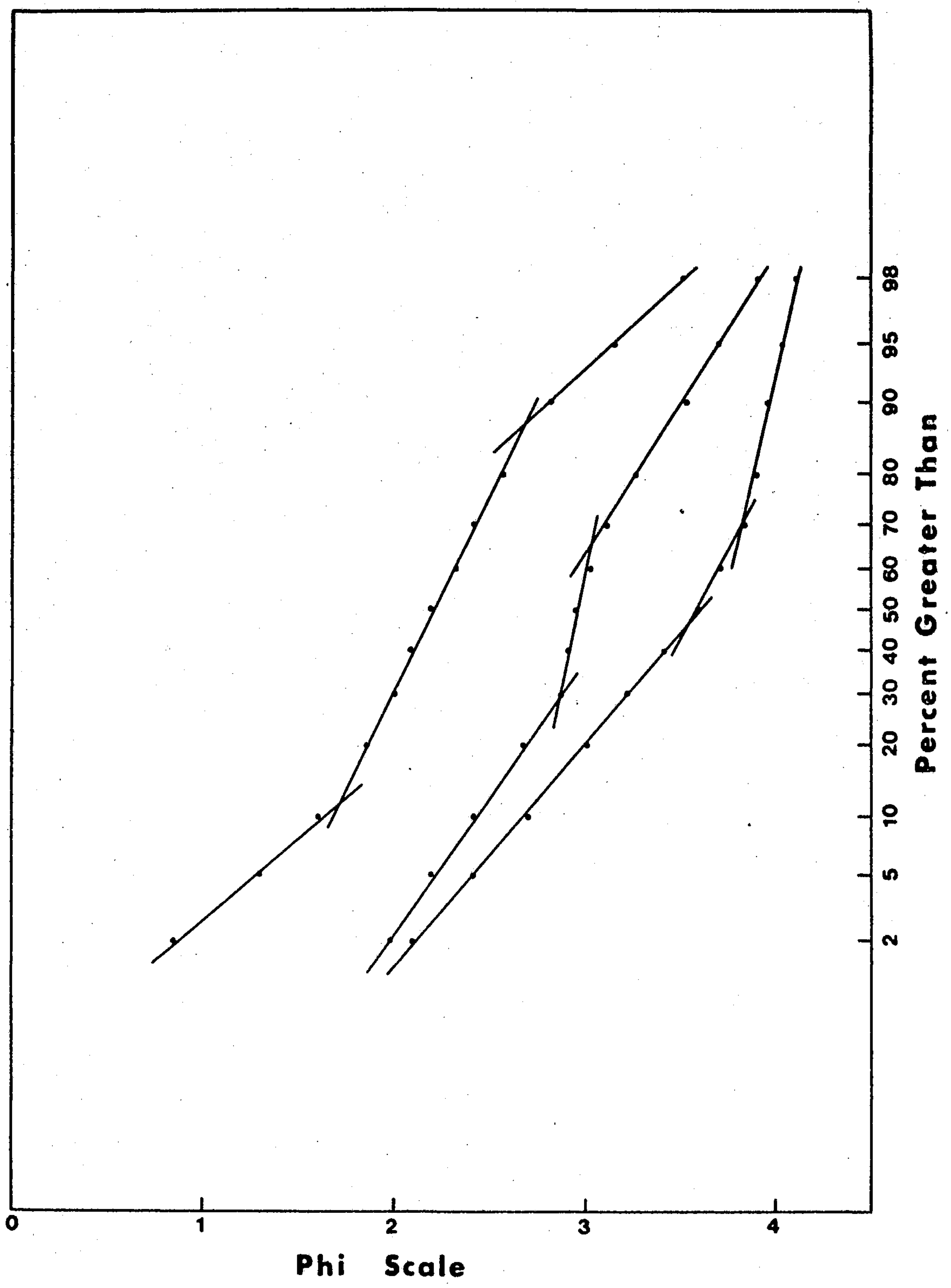

Fig. 20.-Grain size distributions representing the coarsest, average, and finest grain size.

TABLE I

GRAIN SIZE PARAMETERS

SAMPLE NO.	SANDSTONE TYPE[1]	Mx		Md		M		$\sigma\phi$	So
		mm	ϕ	mm	ϕ	mm	ϕ		
18	L	.405	1.30	.240	2.06	.225	2.15	.40	1.22
20-2	L	.195	2.36	.091	3.46	.101	3.30	.30	1.09
31	L	.215	2.22	.094	3.41	.108	3.20	.40	1.18
48-1	L	.265	1.92	.130	2.94	.137	2.87	.42	1.20
81	L	.280	1.84	.103	3.28	.119	3.07	.59	1.31
84	L	.170	2.56	.130	2.94	.123	3.02	.33	1.15
89	L	.225	2.15	.145	2.79	.141	2.82	.37	1.18
119	L	.255	1.97	.140	2.84	.135	2.89	.46	1.12
154	L	.220	2.18	.130	2.94	.128	2.97	.47	1.17
156	L	.240	2.01	.135	2.89	.122	3.03	.48	1.26
AVERAGE		.241	2.05	.128	2.96	.128	2.96	.42	1.19
10-1	B	.230	2.12	.084	3.57	.095	3.39	.45	1.30
20-1	B	.265	1.97	.147	2.77	.141	2.82	.60	1.31
73	B	.250	2.00	.170	2.56	.171	2.55	.76	1.43
74	B	.167	2.58	.107	3.22	.109	3.20	.27	1.13
82	B	.220	2.18	.107	3.22	.108	3.21	.46	1.24
83	B	.280	1.84	.160	2.64	.153	2.72	.67	1.48
83-1	B	.225	2.15	.100	3.32	.110	3.19	.47	1.22
83-2	B	.213	2.23	.115	3.12	.125	3.00	.35	1.18
105	B	.195	2.36	.091	3.46	.102	3.30	.35	1.20
113	B	.300	1.74	.100	3.32	.123	3.02	.23	1.24
114	B	.280	1.84	.118	3.08	.132	2.92	.52	1.27
203	B	.215	2.22	.088	3.51	.099	3.33	.48	1.23
AVERAGE		.234	2.10	.113	3.15	.121	3.05	.47	1.27
GRAND AVERAGE		.236	2.08	.120	3.06	.129	2.95	.45	1.23

[1] L = Lenticular, B = Thin-bedded

fine-grained (.128 mm, 2.96ϕ), and is very well sorted (1.19).

Thin-bedded sandstones show less variation in size. Maximum diameter is from .167 mm (2.58ϕ) to .300 mm (1.74ϕ), median diameter from .084 mm (3.57ϕ) to .170 mm (2.56ϕ), and the mean diameter is from .095 mm (3.39ϕ) to .171 mm (2.55ϕ). The range in phi standard deviation is from .23 to .76, and the sorting coefficient is 1.13 to 1.48. These sandstones are very fine-grained (.113 mm, 3.15ϕ), and are well sorted (1.27).

The thin-bedded sandstones are finer grained and are more poorly sorted than the lenticular sandstones. The sandstones together are very fine grained (.120 mm, 3.06ϕ) and well sorted (1.23).

Grain Orientation

Grain orientation measurements for 17 outcrop samples were made with Shell's dielectric and conductivity anisotropy instruments, which are very reliable measuring devices (Nanz, 1960; Orr, 1964; Shelton and Mack, 1970). Grain orientation measurements in lenticular sandstones are quite variable (Table II), and they are thought to reflect the range in local trend of the sandstone bodies. Measurements range in azimith from 260° to 326° (or N 80°E-S 80°W to N 34°W-S 34°E) whereas the average paleocurrent direction of the lenticular sandstones is approximately N 35°W (Fig. 18). In the 3 samples of thin-bedded sandstones, grain orientation varies from N 87°E to N 87°W. The primary paleocurrent direction for this type of sandstone in the study area is N 50°W; secondary trend is N 40°E (Fig. 19).

TABLE II

GRAIN ORIENTATION

Sample Number	Sandstone Type[1]	Number Plugs	Grain Orientation	Quality of Results[2]
10-1	B	4	N 87°W	E
13-1	B	4	N 89°W	E
13-2	B	4	N 87°E	E
10-2	L	4	N 75°W	E
18-1	L	4	N 34°W	E
20-1	L	4	N 82°E	G
20-2	L	4	N 85°E	E
54-1	L	4	N 51°W	F
54-2	L	4	N 80°W	E
67-1	L	4	N 65°W	E
70	L	6	N 38°W	E
70-1	L	4	N 36°W	G
81	L	4	N 34°W	E
82	L	4	N 70°W	E
84	L	4	N 90°W	E
89	L	4	N 80°E	E
115	L	4	N 50°W	E

[1] L = Lenticular, B = Thin-bedded

[2] E = Excellent, G = Good, F = Fair (Shelton and Mack, 1970)

Permeability

Permeability was measured in 8 outcrop samples in order to determine reservoir characteristics, permeability anisotropy, and directional permeability. Measurements were of vertical permeability and horizontal permeability in 3 directions; namely, parallel, perpendicular, and 45° to preferred grain orientation. Permeabilities were measured with a gas parmeameter at pressures between 1 and 2 atmospheres. The correction for the Klinkenberg effect was not made because extrapolation of the measurements from the small range in pressure is conjectural. Furthermore, it is thought reservoir anisotropy is reflected quite accurately by the relative, or uncorrected, values.

In 5 of 7 samples, the average horizontal permeability is greater than the vertical permeability (Table III). The ratio of vertical permeability to average horizontal permeability varies from 0.31 to 1.42 in lenticular sandstones and from .48 to 3.19 in the thin-bedded sandstones. Absolute variation in horizontal permeability is small, with a maximum of about 175 millidarcies and a minimum of 16 millidarcies. Maximum horizontal permeability parallels grain orientation in 5 of the 8 samples. All lenticular sandstones samples show maximum horizontal permeability parallel to the grain orientation; the ratio of minimum to maximum horizontal permeability ranges from .64 to .92. Maximum horizontal permeability parallels grain orientation in only one of the thin-bedded samples, and the ratio of minimum to maximum horizontal permeability varies from .44 to .81. The average horizontal permeability for all samples is 372 millidarcies; the average vertical permeability is 305 millidarcies. Permeability in the subsurface would, of course, be

TABLE III

PERMEABILITY DATA[1]

SAMPLE NO.	SANDSTONE TYPE[2]	VERTICAL PERMEABILITY (P_V)	AVE. ($P_{\bar{H}}$)	HORIZONTAL PERMEABILITY ($P_{\bar{H}}$)			$\frac{P_V}{P_{\bar{H}}}$	$\frac{P_H}{P_H}$ min/max
				PARALLEL TO G.O.	45° TO G.O.	90° TO G.O.		
81	L	555	390	507	344	324	1.42	.64
84	L	180	570	612	533	562	.31	.87
89	L	185	285	290	274	290	.65	.95
115	L	200	328	341	---	315	.61	.92
AVERAGE		280	399	438	383	372	.75	.84
10-1	B	270	85	111	62	80	3.19	.56
13-1	B	645	861	860	875	848	.74	.97
13-2	B	---	156	125	188	---	----	.66
82	B	105	215	140	315	190	.48	.44
AVERAGE		340	341	309	360	372	1.47	.66
GRAND AVERAGE		305	372	373	370	372	1.05	.75

[1] Permeability in millidarcies at 5 psi applied pressure

[2] L = Lenticular, B = Thin-bedded

lower than the surface values.

Results obtained in this study suggest that derived properties, such as permeability, are dependent on the dominant direction of grain orientation. Thin-bedded sandstones which fail to exhibit this relationship are thought to reflect the effects of grain size and the absence of a major unidirectional depositional agent. Mast and Potter (1963) in analysis of low-permeable sandstones also noted poor correlation between grain orientation and maximum horizontal permeability.

Constituents

Petrographic study of 4 outcrop samples indicates that the Elgin is quartz rich. Both samples of lenticular sandstones, one from the area between Depew and Drumright and one from the Cleveland area, are quartzarenites, with approximately 1 percent feldspar and 4 percent rock fragments (Figs. 21 and 22). The highest chert content of 7 percent is present in the sample from the southern location. The samples are fine-grained and well sorted; most individual grains are subangular; and contacts are generally line, although some are wedge (Fig. 22). Many grains contain a thin film of iron-bearing material, which may be an iron rich clay mineral or a hydrous iron oxide; in addition, some pores contain clay stained with iron oxide.

The two samples of thin-bedded sandstones are very fine-grained and well sorted. The sample from the Oilton area is a quartz-rich subarkose with 6 percent feldspar and 4 percent rock fragments. The sample from the Hominy area, classified as a quartz-rich sublitharenite, contains 4 percent feldspar and 5 percent rock fragments. Grain shape and contacts are similar to those of the lenticular sandstones. Interstitial

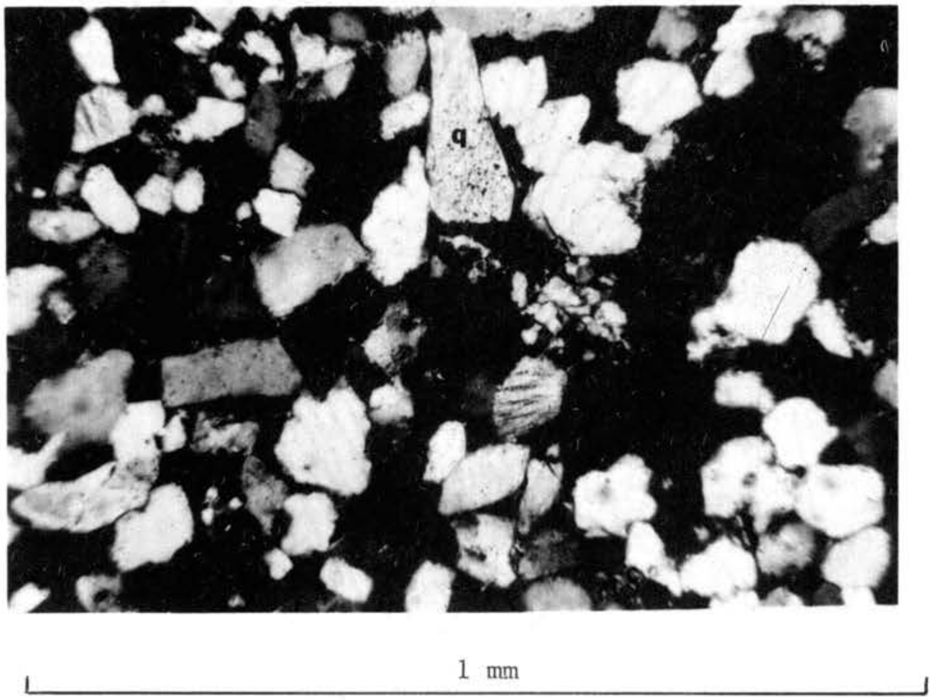

Fig. 21.-Photomicrograph of sandstone in Osage County (Sec. 4, T21N, R8E). The quartzarenite is composed primarily of subangular, well sorted, fine-grained quartz (q), with some chert (c), and feldspar (f). Crossed nicols.

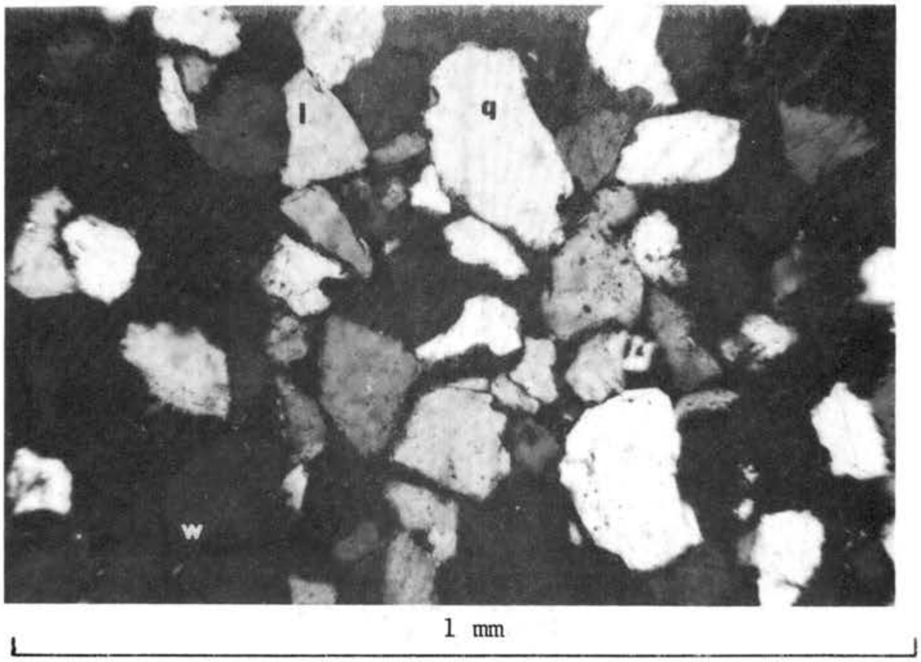

Fig. 22.-Photomicrograph of sandstone in Creek County (Sec. 18, T16N, R8E). The quartzarenite is composed primarily of subangular quartz (q), with line (l) and some wedge (w) contacts. Crossed nicols.

clay with iron oxide staining is also present in this type of sandstone. Overall the sandstones contain 90.5 percent quartz, quartzite, and chert, 3 percent feldspar, 4.5 percent rock fragments, and 2 percent accessories which include muscovite, tourmaline, and zircon.

Prominent constituents of the thin-bedded sandstones are finely divided plant material, or "coffee grounds," small wood fragments, and very fine-grained muscovite on upper bedding surfaces. Pelecypods, brachiopods, and crinoid stems are preserved as casts in the lower portions of a few lenticular sandstones; vertical burrows were observed on the top surface of one sandstone; and casts of small logs are present at several localities. A common constituent near the base of several lenticular channels is locally derived clay pebbles and shale and siltstone fragments (Fig. 23). In the Drumright area and the area south-southwest of Depew, where the Elgin is coarse-grained, chert is recognized on outcrop as a significant constituent. Small iron oxide concretions, which are minor in the upper part of a few narrow, lenticular sandstones in Creek County, are thought to have been sideritic at the time of formation. Large iron oxide concretions, secondary in origin are present at one locality near Drumright (Fig. 13).

Water Quality

Water samples from 9 wells that produce water from the Elgin Sandstone were analysed by the Water Resources Division of the U. S. Geological Survey (Appendix B). Standards established by the U. S. Department of Health, Education, and Welfare specify the following upper limits for ion concentrations in drinking water: chloride (Cl) - 250 ppm, sulfate (SO_4) - 250 ppm, and total dissolved solids (TDS) - 500 ppm.

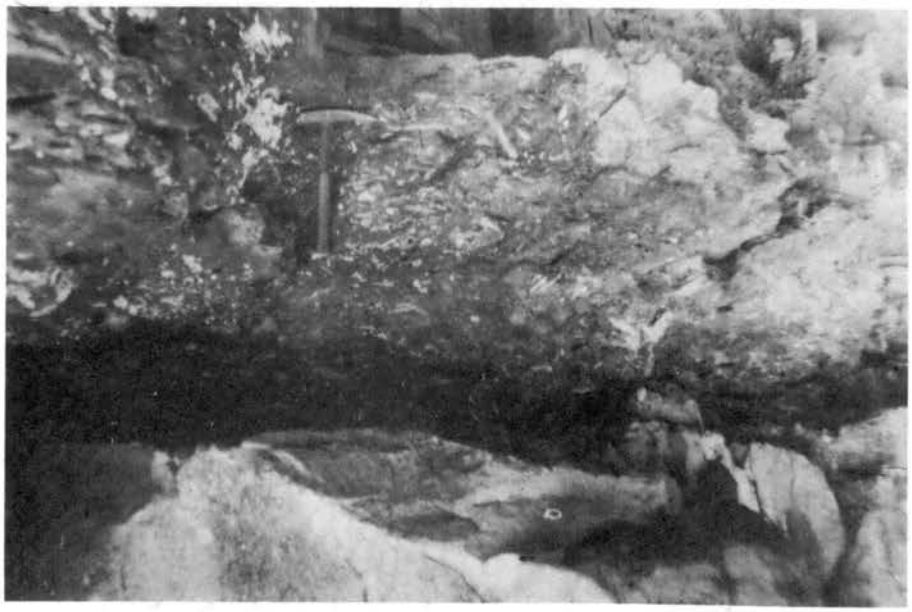

Fig. 23.-Channel fill with shale and siltstone fragments in Sec. 15, T23N, R8E.

The Elgin samples exhibit a rather wide variation in concentrations of ions (Table IV). In two samples the Cl concentration and TDS exceed the standards for drinking water. Two additional samples contain TDS in excess of the upper limit. The remaining samples exhibit no unusual high concentrations.

The fresh-mineralized water boundary in the Elgin Sandstone interval was determined from analysis of electric logs. The geographic contact between sandstones with fresh water and those with mineralized water is shown in Fig. 4. The boundary varies in depth from 150 ft to 600 ft. It is common at shallow depths (or relative updip positions) in the northern portion of the study area, where the sandstone units are poorly developed. The boundary is deepest (or at relative downdip positions) in the southern half of the study area, where the sandstone is thickest and latterly continuous.

The volume of fresh-water reservoir rock in the study area is approximately 30 million acre-ft. The total amount of fresh water in place for an average porosity of 30 percent is 9 million acre-ft (2.9 x 10^{12} gal), 7.5 million acre-ft (2.4 x 10^{12} gal) for 25 percent porosity, and 6 million acre-ft (1.9 x 10^{12} gal) for 20 percent porosity.

TABLE IV

WATER QUALITY IN ELGIN SANDSTONE

Na	HCO_3	SO_4	Cl	NO_3	TDS	Hardness	SAR	pH
4.9-250 ppm	24-388 ppm	7-120 ppm	7-620 ppm	.8-26 ppm	60-1400 ppm	20-410 ppm	.3-5.4 meq/ℓ	6.9-8.2

CHAPTER VI

DEPOSITIONAL ENVIRONMENT AND PALEOGEOGRAPHY

Major sandstone development within the Elgin interval is represented by the lenticular sandstones, which are multilateral and multistoried deltaic distributary and alluvial channel deposits. The maximum thickness for a genetic distributary unit is 20 ft and 30 ft for an alluvial sandstone. The stream width of Elgin distributaries was probably about 200 ft and 300 ft for Elgin rivers. The most diagnostic features of the distributary and alluvial sandstones are: (1) medium-scale cross-bedding, cut-outs, high-angle initial dip, parting lineation, parallelism of paleocurrent direction and local sandstone trend; (2) upward decrease in average grain size and very good sorting; (3) sharp, erosional lower and lateral contacts and sharp upper contacts for single genetic units; (4) rare occurrence of fossils. The distributary sandstones, commonly represented by narrow bodies, are generally very fine-grained, and they are characterized by small-scale cross-bedding, initial dip, cut-outs, and deformed bedding. The alluvial sandstones are coarser grained and more extensively developed laterally. They characteristically contain medium-scale cross-bedding, cut-outs, and initial dip.

The thin-bedded sandstones are coastal and/or marine delta-fringe units, deposited in front of or marginal to the distributaries. Delta-fringe units were eroded in part by the seaward-advancing streams.

Characteristic features of the delta-fringe beds are: (1) small-scale cross-bedding, ripple marks, low-angle initial dip, interstratification and variable local paleocurrent trends; (2) very fine-grained and good sorting; and (3) occurrence of some fossils.

Most of the sandstone thickness reflects deposition within or on the bank of channels. Sand deposition by deltaic marine or coastal processes was relatively minor. Holocene deltas with minor delta-fringe sand deposits and low sand percentages generally reflect high riverine input, whereas high sand percentages and major delta-fringe deposits reflect strong wave and tidal processes (Fisher, et al., 1969). Because sandstone percentages are greater than 50 percent in approximately 2/3 of the study area, the Elgin, to a large extent, represents a sand-rich deltaic sequence. Nevertheless, the riverine input is considered to have been dominant.

The Elgin Sandstone interval in the area of study represents a transgressive-regressive couplet within the regressive Vamoosa wedge. The Elgin Sandstone and equivalent units were deposited in the area north of the Ouachita, Arbuckle, and Amarillo-Wichita-Criner elements (Fig. 24). Sandstone forms a narrow fringe along the southern flank of the Anadarko basin but extends as a prominent westward bulge into northwest Oklahoma. The Elgin is recognized as far west as the easternmost part of the Oklahoma Panhandle, or some 200 miles west of the outcrop belt in the area of study (Rascoe, 1962; Souter, 1966; Brown, 1967). Deltaic sedimentation is thought to be represented by most of the Elgin interval to the west and north of the study area (Souter, 1966; Brown, 1967). In Kansas, the Elgin, which thins northward and northwestward primarily by pinch-out, is thought by Brown (1967) to be a large deltaic

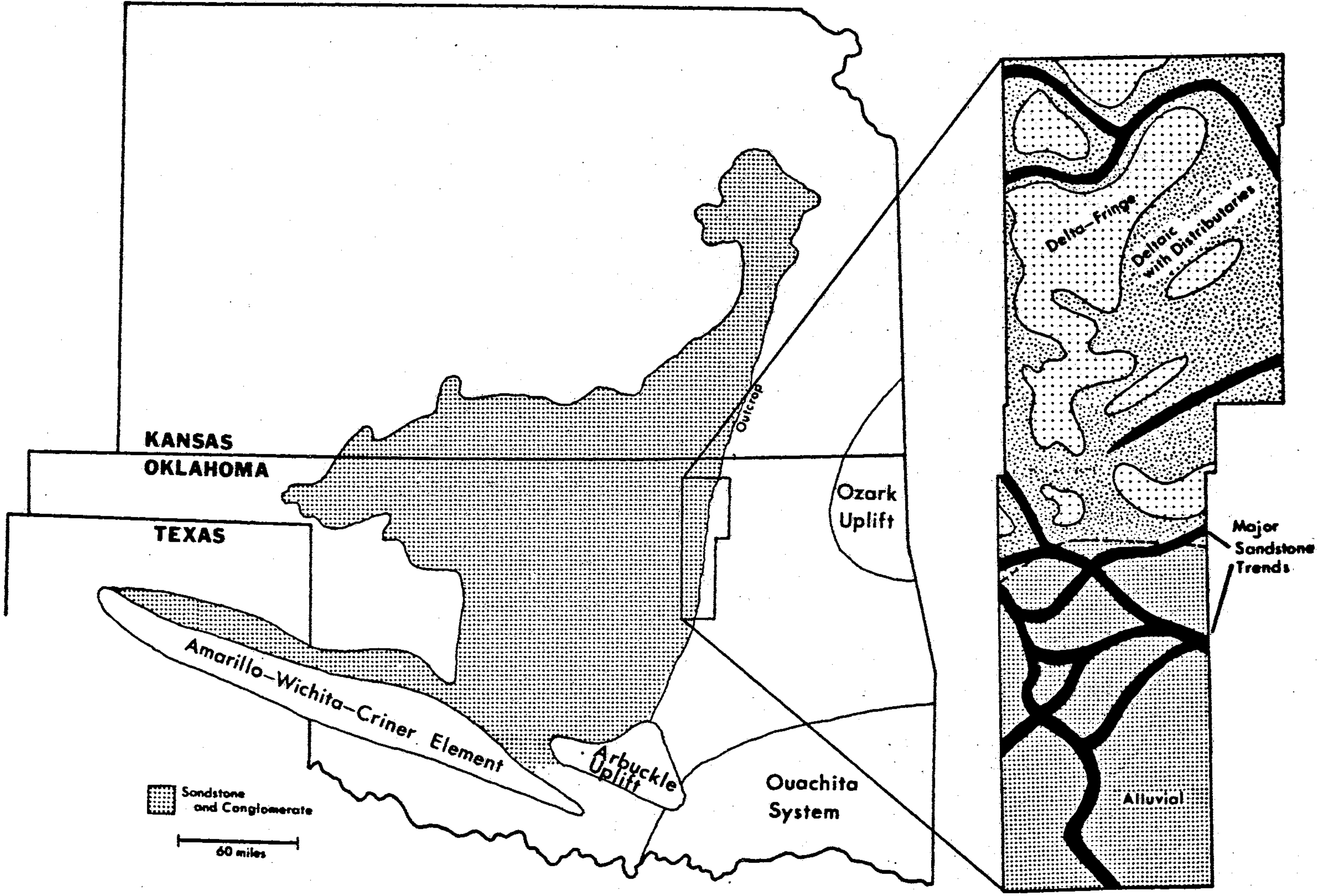

Fig. 24.-Paleogeographic map of Elgin Sandstone during maximum regression.

complex, deposited in a shallow-marine to marginal-marine environment.

As a result of a minor marine transgression which advanced southward and southeastward into the study area, shallow marine and delta-fringe units associated with the lower marker were deposited. Regressive conditions rapidly returned as the Elgin Sandstone was deposited. Delta building progressed northward and northwestward; distributaries advanced over delta-fringe deposits; and in the study area during maximum regression an alluvial plain, built on deltaic deposits, formed south of the deltaic environments (Fig. 24). The average paleocurrent direction suggests that the overall Elgin deltaic progradation was N 35°W. Local orientation of distributaries and rivers was diverse, and coastal-marine currents near the distributaries were likewise quite variable in direction.

Based on paleocurrents, regional distribution of sandstone, and significant chert content, the dominant source areas for the southern part of the area were probably the Ouachita and Arbuckle uplifts. The westward shift in paleocurrents in the area north of the Cimarron River suggests sediment contribution from the east, possibly the low-lying Ozark province (Hicks, 1962) or the eastern extension of the Ouachita uplift.

Deposition of the Elgin Sandstone was terminated by another minor transgression which only temporarily interrupted the Vamoosa regression. The transgression is represented by marine units associated with the upper marker.

CHAPTER VII

SUMMARY

The principal conclusions of this study are as follows:

1. Elgin Sandstone in the study area represents regressive deposits formed primarily by delta building. In the south, an alluvial plain was constructed on deltaic deposits. Paleocurrent data, regional distribution of sandstone, and southerly increase in chert content suggest the Ouachita and Arbuckle uplifts as principal source areas, with a possible contribution in the north from the Ozark province.

2. Individual lenticular sandstone bodies in the Elgin interval range upward from 10 ft in width and 5 ft in thickness to 600 ft in width and 20 to 30 ft thick. Major sandstone belts, which are generally 1 to 3 mi wide, contain 100 to 150 ft of sand. They are best developed south of the Cimarron River.

3. Lenticular sandstones are distributary and alluvial deposits, genetic units of which have sharp contacts. These sandstones are present as multistoried and multilateral units. The alluvial sandstones are laterally more extensive than the distributary sandstones.

4. Characteristic sedimentary structures of the channel sandstones include medium-scale cross-bedding, high-angle initial dip, and cutouts. Diverse local paleocurrent direction reflects variation in individual sandstone trends. The paleocurrent direction changes from northwest to a more westerly direction north of the Cimarron River.

5. The distributary sandstones are finer grained than the alluvial sandstones. Both show an upward decrease in grain size. The lenticular sandstones are quartzarenites; some have a significant chert content.

6. Thin-bedded sandstones are coastal and/or marine delta-fringe units. They are laterally more persistent than the lenticular bodies and contain gradational lower and lateral contacts.

7. The most common sedimentary structures of the thin-bedded sandstones are small-scale cross-bedding, ripple marks, low-angle initial dip, and interstratification. The average primary paleocurrent direction is N 50°W, with a secondary trend of N 40°E. The delta-fringe sandstones are very fine-grained and well sorted. Representative units range from quartz-rich subarkoses to quartz-rich sublitharenites.

8. Maximum horizontal permeability corresponds to the direction of preferred grain orientation in 5 of 8 samples. All lenticular sandstones exhibit this correlation, whereas delta-fringe samples show considerable variation.

9. Water analyses indicate a rather wide variation in ion concentrations. Several of the samples have chloride and/or TDS concentrations in excess of the established limits for domestic use. The fresh-mineralized water boundary appears to be related to thickness and lateral extent of sandstone. The boundary varies in depth from 150 ft in northern Osage County to 600 ft in western Creek County. Volume of fresh water in the Elgin within the study area may be as much as 9 million acre-ft.

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APPENDIX A

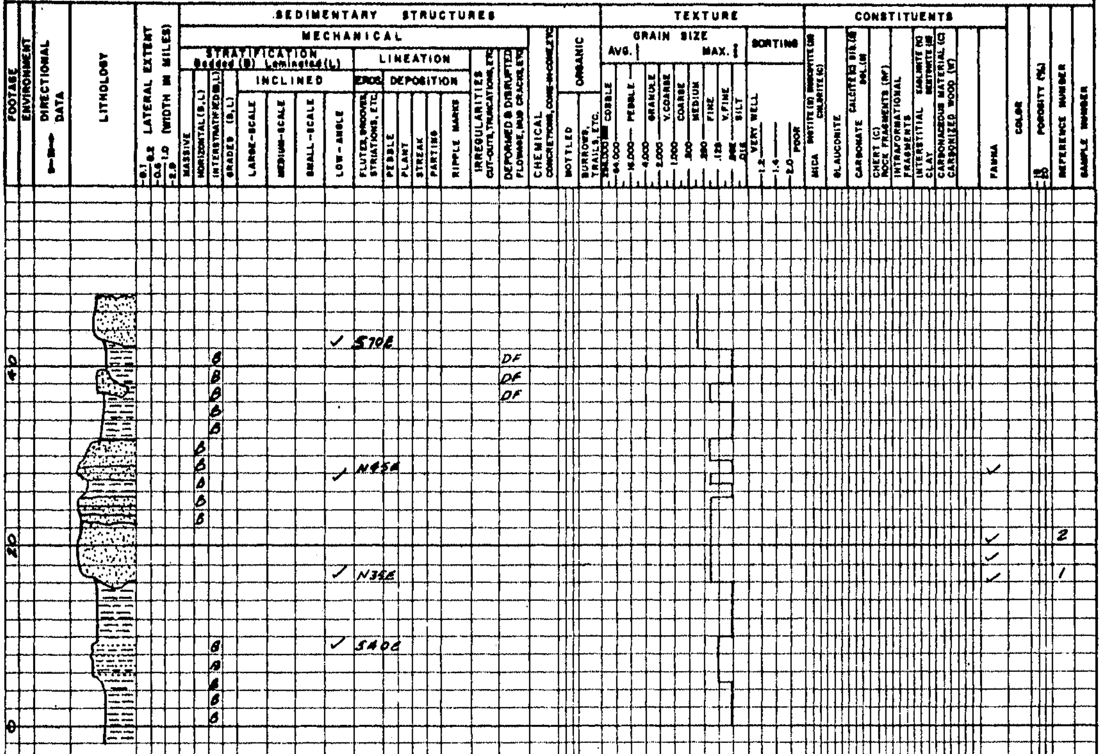
KEY MEASURED SECTIONS

NE Sec. 5 T. 25N R. 9E Map ____ Photo ____

OSAGE Co., OKLAHOMA Section No. 1

Area NORTH PAWHUSKA Structural Dip ____ By DON M. TERRELL

Outcrop Pattern - - Linear ____ belt ____ Formation ____



REF. NO. 1 ABUNDANT BRACHIOPODS, AND PELECYPODS AT CHANNEL BASE.

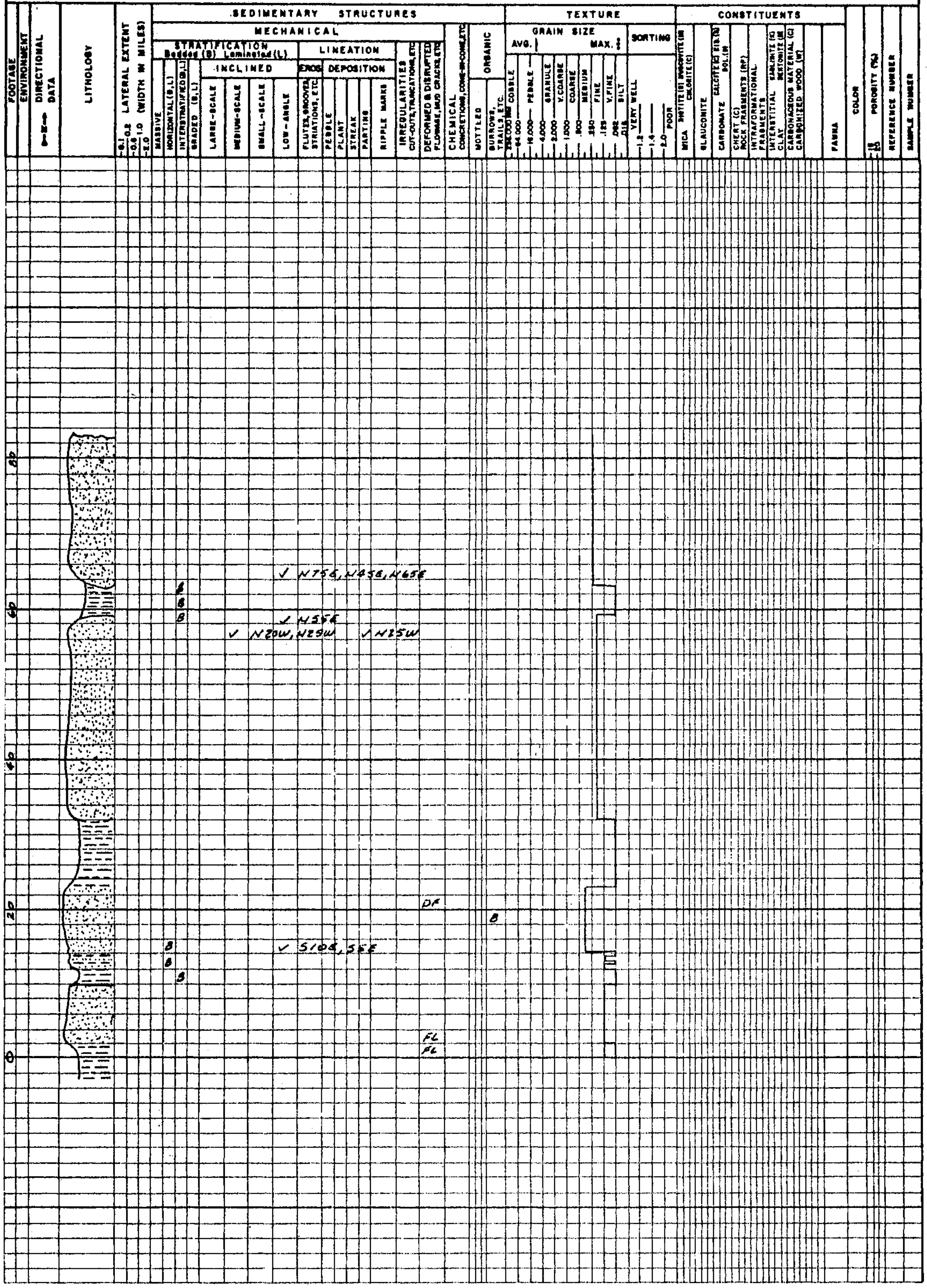
2 SHARP BASE WITH SOME SHALE INTERBEDS. CRINOID STEM PRESENT.

SW SE Sec. 16 T. 24N R. 9E Map Photo

OSAGE Co., OKLAHOMA Section No. 2

Area WEST OF WYNONA Structural Dip By DON M. TERRELL

Outcrop Pattern--Linear belt Formation

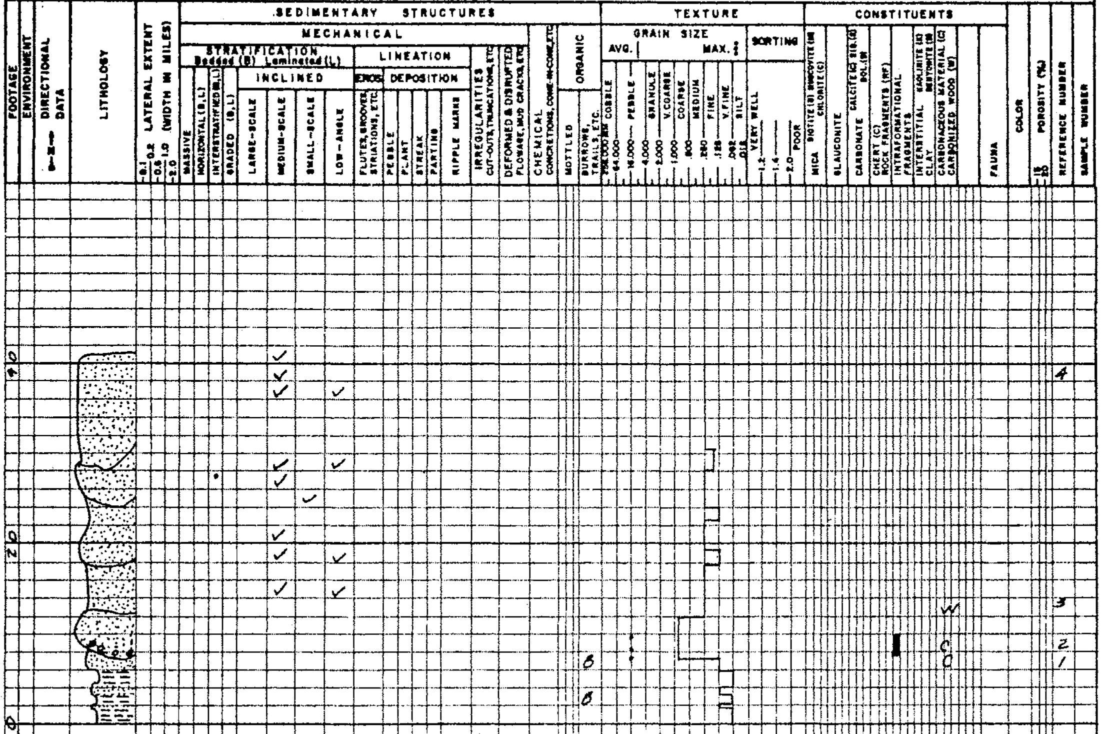


SWSE Sec. 15 T. 23N R. 8E Map ____ Photo ____

OSAGE Co., OKLAHOMA Section No. 3

Area ____ Structural Dip ____ By DON M. TERRELL

Outcrop Pattern--Linear ____ belt ____ Formation ____



REF. NO.	1	FINELY LAMINATED PLANT MATERIAL ALSO SECONDARY CALCITE.				
	2	CHANNEL DEPOSIT, FRAGMENTS OF UNDERLYING INTERBEDS THINS 50' WEST, TREND N 25° W.				
	3	CAST OF LOG, TREND N 80° W.				
	4	ABUNDANT FESTOON CROSS-BEDDING.				

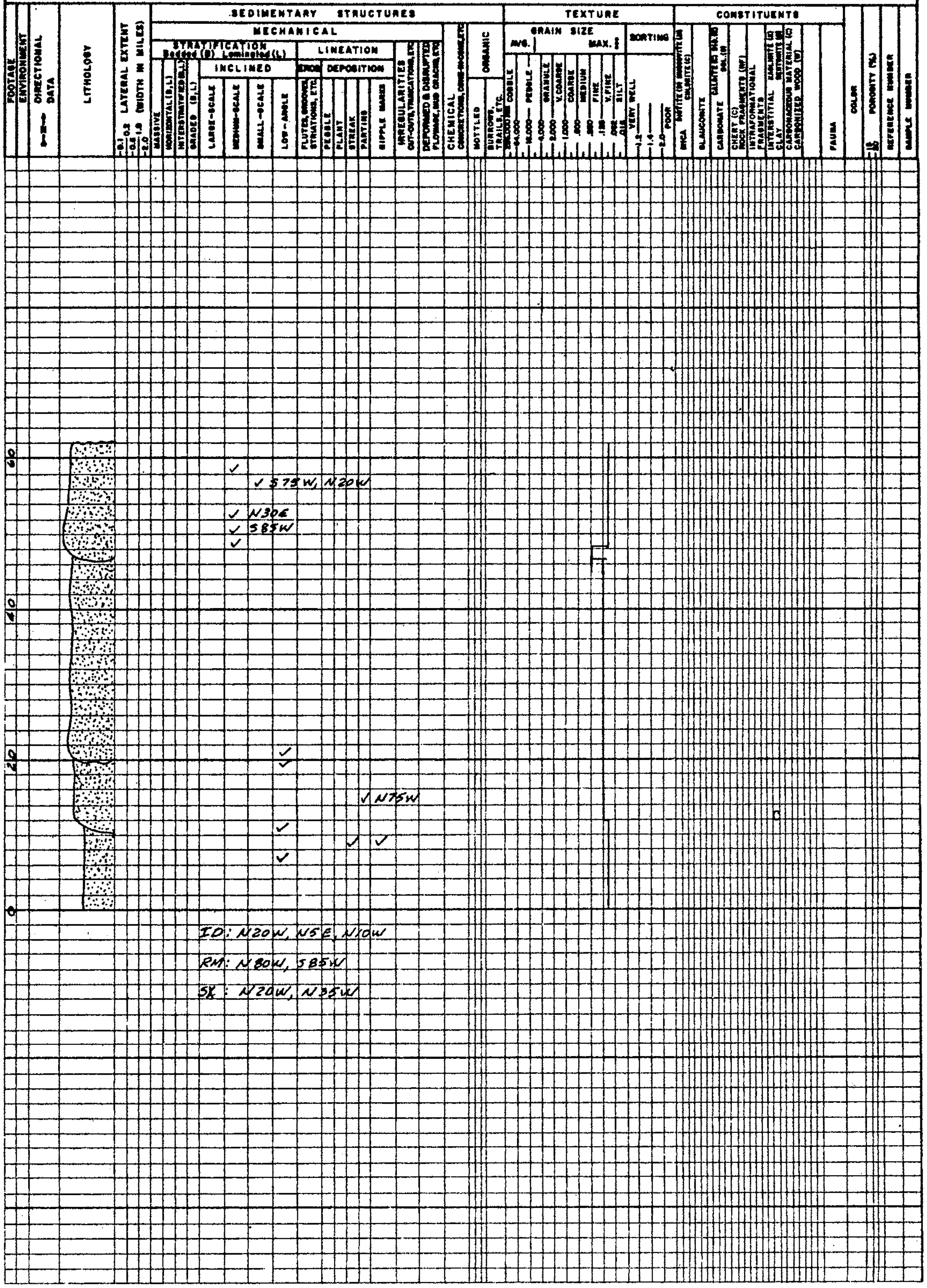
FX AND MX:	N45W	N75W	ID:	N40W	SX:	S5E
	S10E	N40W		S20W		
	N80W	S80E		S30W		
	S30W	N5E		S25W		
	N20W	N25W		N25E		
	N15W	N5W		S65W		
	N85E	S80E		N55E		
	S45E	S65W				
	S15E	N85W				
	N55W	N70E				

NE SW Sec. 34 T. 23N R. 8E Map _____ Photo _____

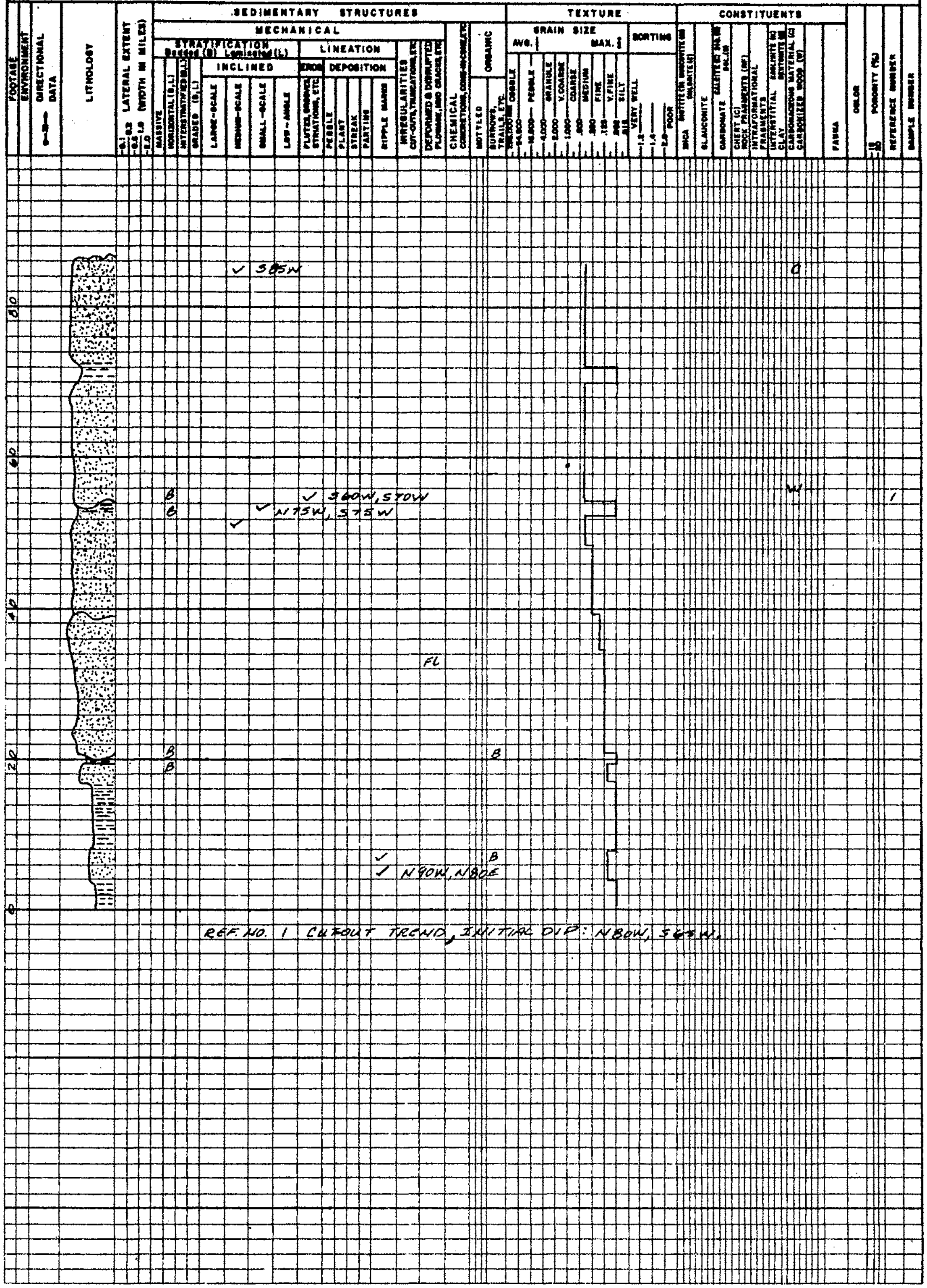
OSAGE Co., OKLAHOMA Section No. 4

Area BELOW DAM OLD HOMINY LAKE Structural Dip _____ _____ By _____

Outcrop Pattern- -Linear _____ belt _____ Formation J. W. SHELTON AND D. M. TERRELL

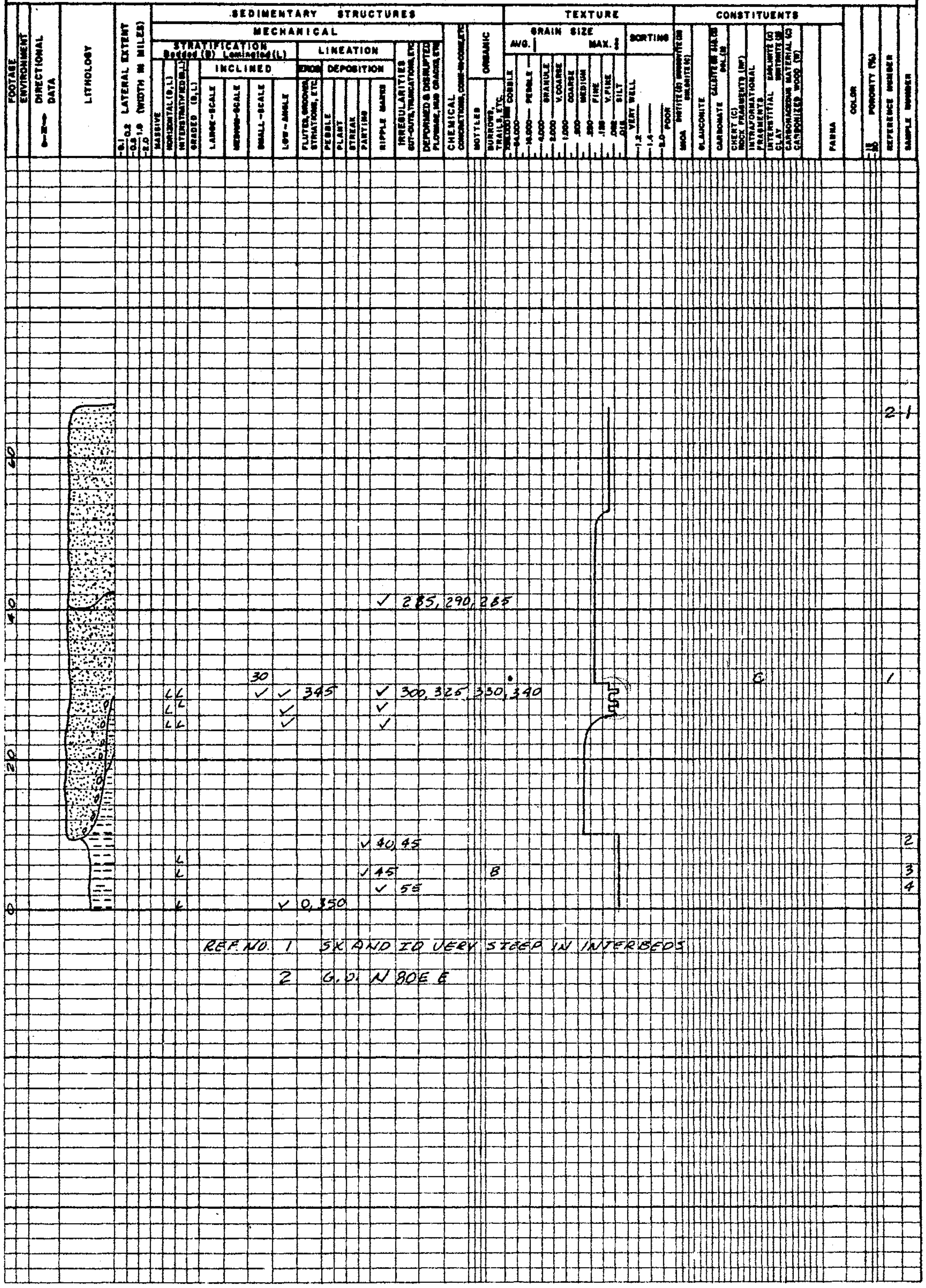


SW NE Sec. 29 T. 22N R. 8E Map Photo
OSAGE Co., OKLAHOMA Section No. 5
Area Structural Dip By DON M. TERRELL
Outcrop Pattern--Linear belt Formation



REF. NO. 1 CUTOUT TREND, INITIAL DIP: N80W, S65W.

NE Sec. 4 T. 21N R. 8E Map Photo
OSAGE Co., OKLAHOMA Section No. 6
Area CLEVELAND - ARKANSAS RIVER Structural Dip By J. W. SHELTON
Outcrop Pattern--Linear belt Formation



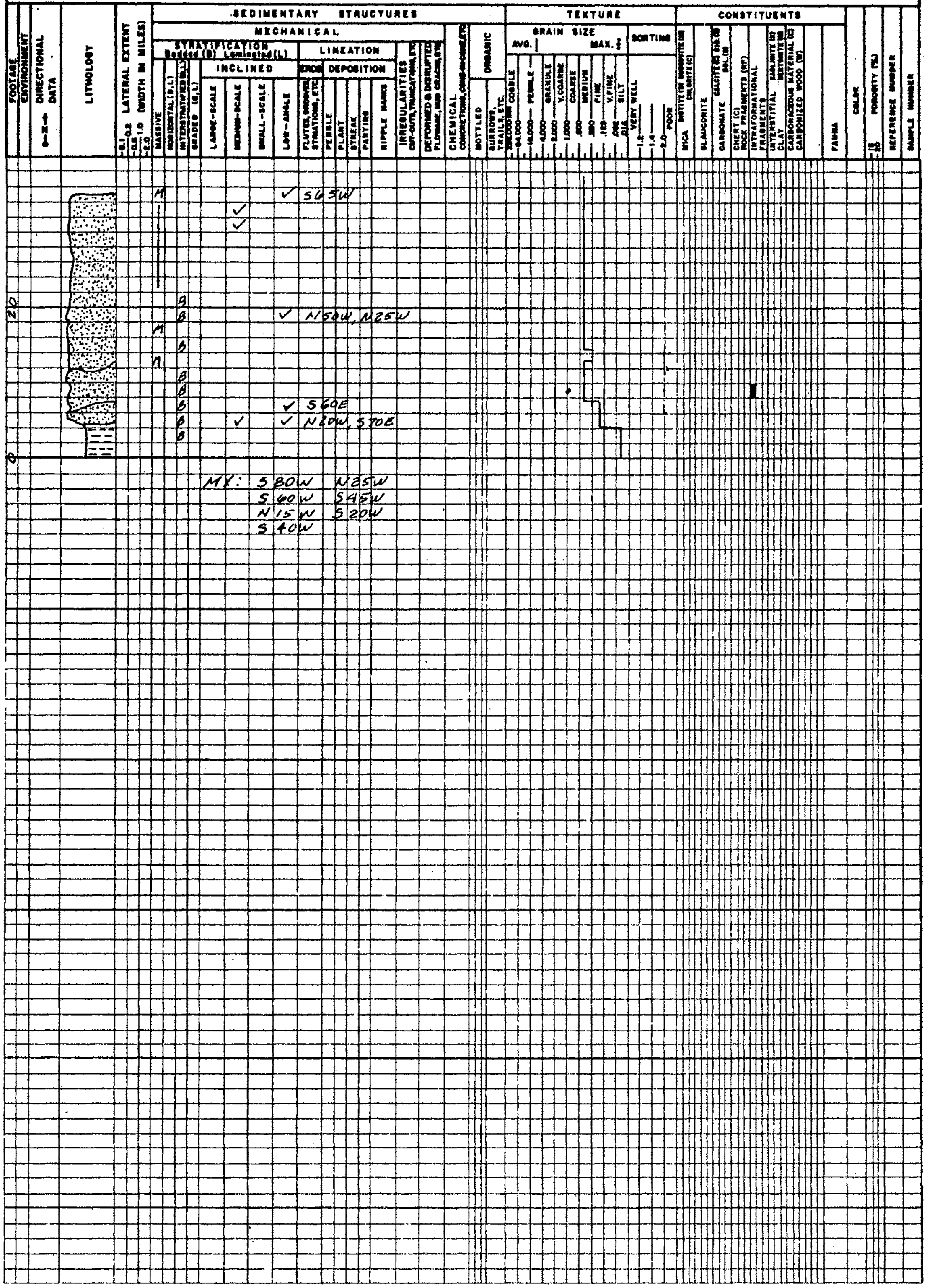
REF. NO. 1 SK AND ID VERY STEEP IN INTERBEDS
2 G.D. N 80E E

NE SW Sec. 16 T. 21N R. 8E Map ______ Photo ______

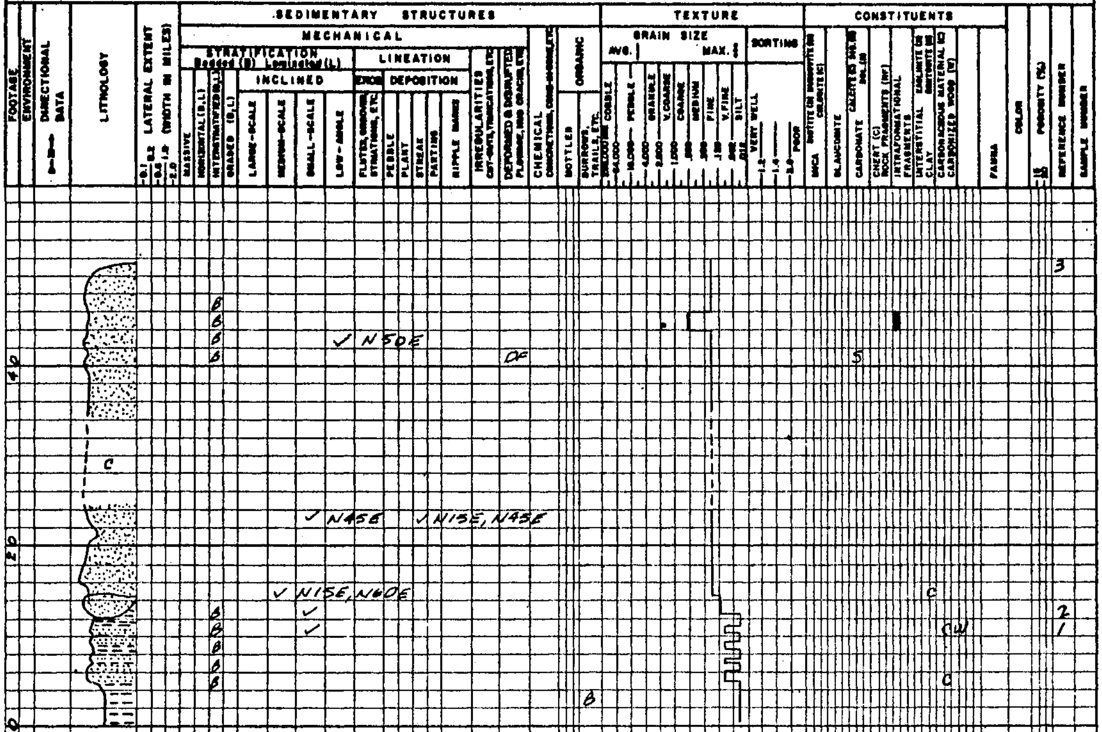
PAWNEE Co., OKLAHOMA Section No. 7

Area ROAD CUT WEST OF R.R. BRIDGE Structural Dip ______ ______ By DON M. TERRELL

Outcrop Pattern--Linear ______ belt ______ Formation ______



SW NW Sec. 3 T. 20N R. 8E Map ______ Photo ______
PAWNEE Co., OKLAHOMA Section No. 8
Area ______ Structural Dip ______ By DON M. TERRELL
Outcrop Pattern - - Linear ______ belt ______ Formation ______



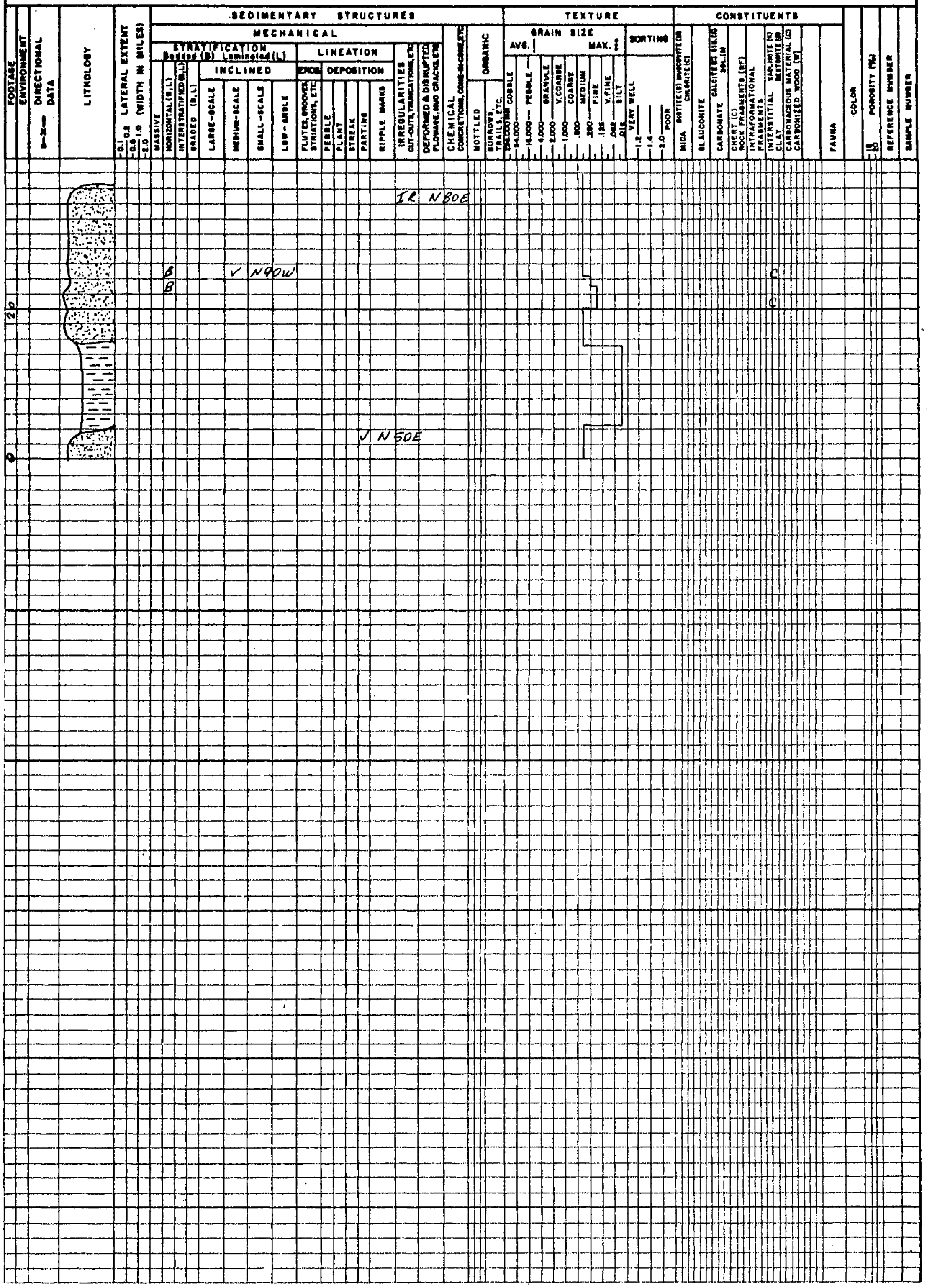
REF. NO. 1 WOOD FRAGMENTS IN INTERBEDS, TREND N5E.
2 INTERBEDDED UNIT CUTOUT TO THE NORTH.
3 HEMATITE CRUST ¼" THICK, SECONDARY.

SWNW Sec. 22 T. 20N R. 8E Map Photo

PAWNEE Co., OKLAHOMA Section No. 9

Area Structural Dip By DON M. TERRELL

Outcrop Pattern--Linear belt Formation

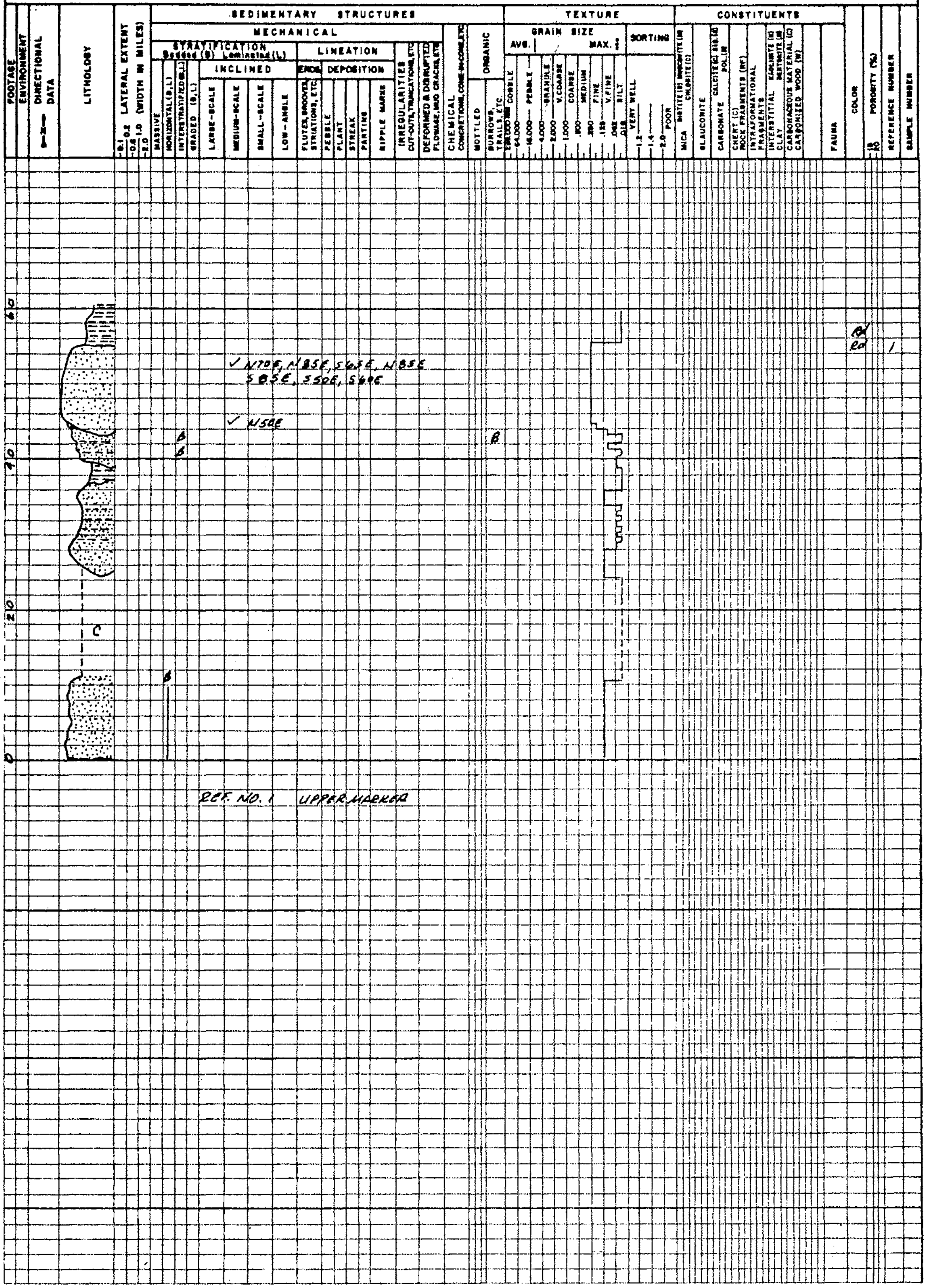


SW SE Sec. 6 T. 19N R. 8E Map Photo

CREEK Co., OKLAHOMA Section No. 10

Area NORTHEAST OF OILTON Structural Dip By DON M. TERRELL

Outcrop Pattern--Linear belt Formation



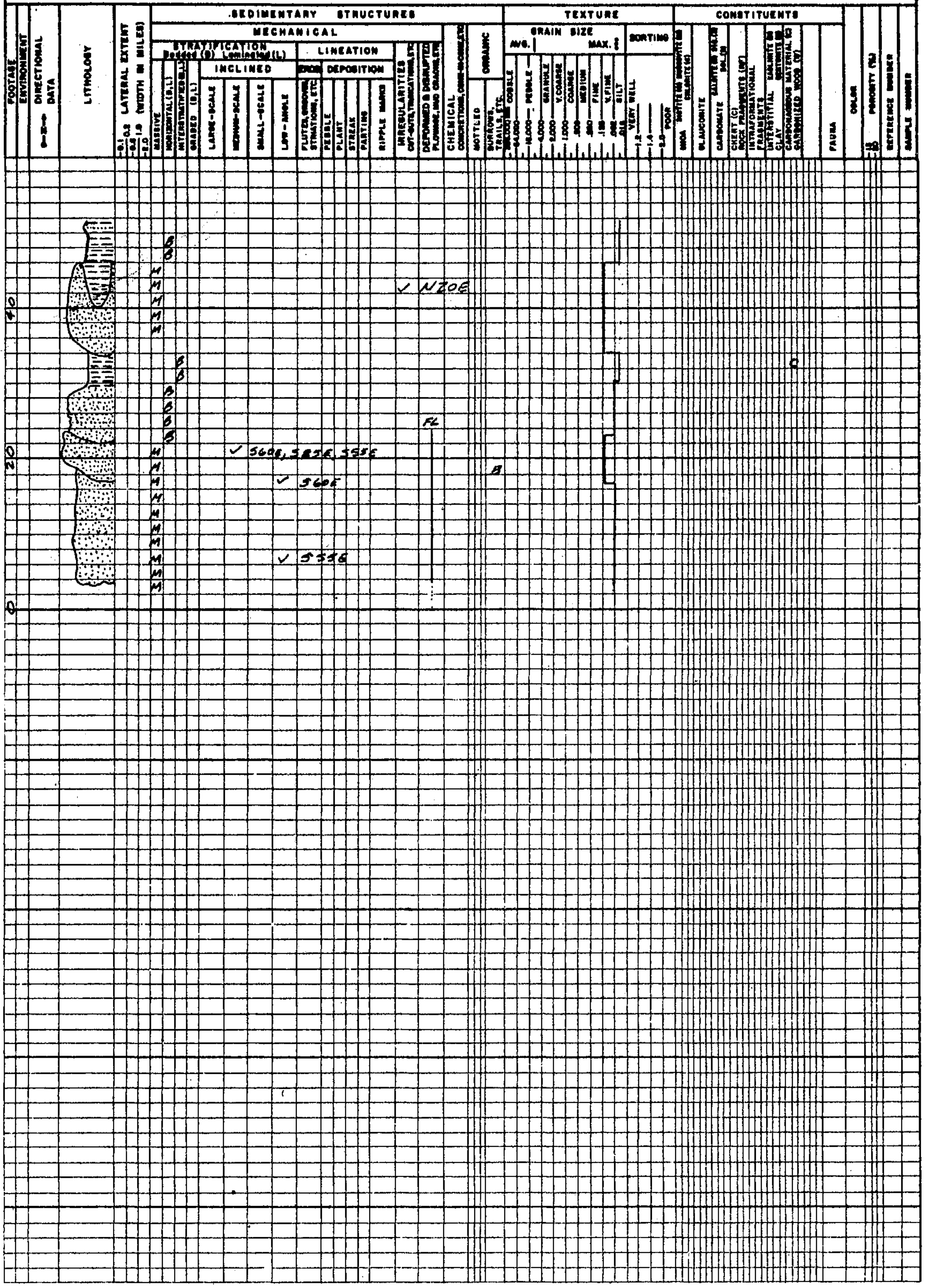
REF. NO. 1 UPPER MARKER

SW SW Sec. 19 T. 19N R. 8E Map ______ Photo ______

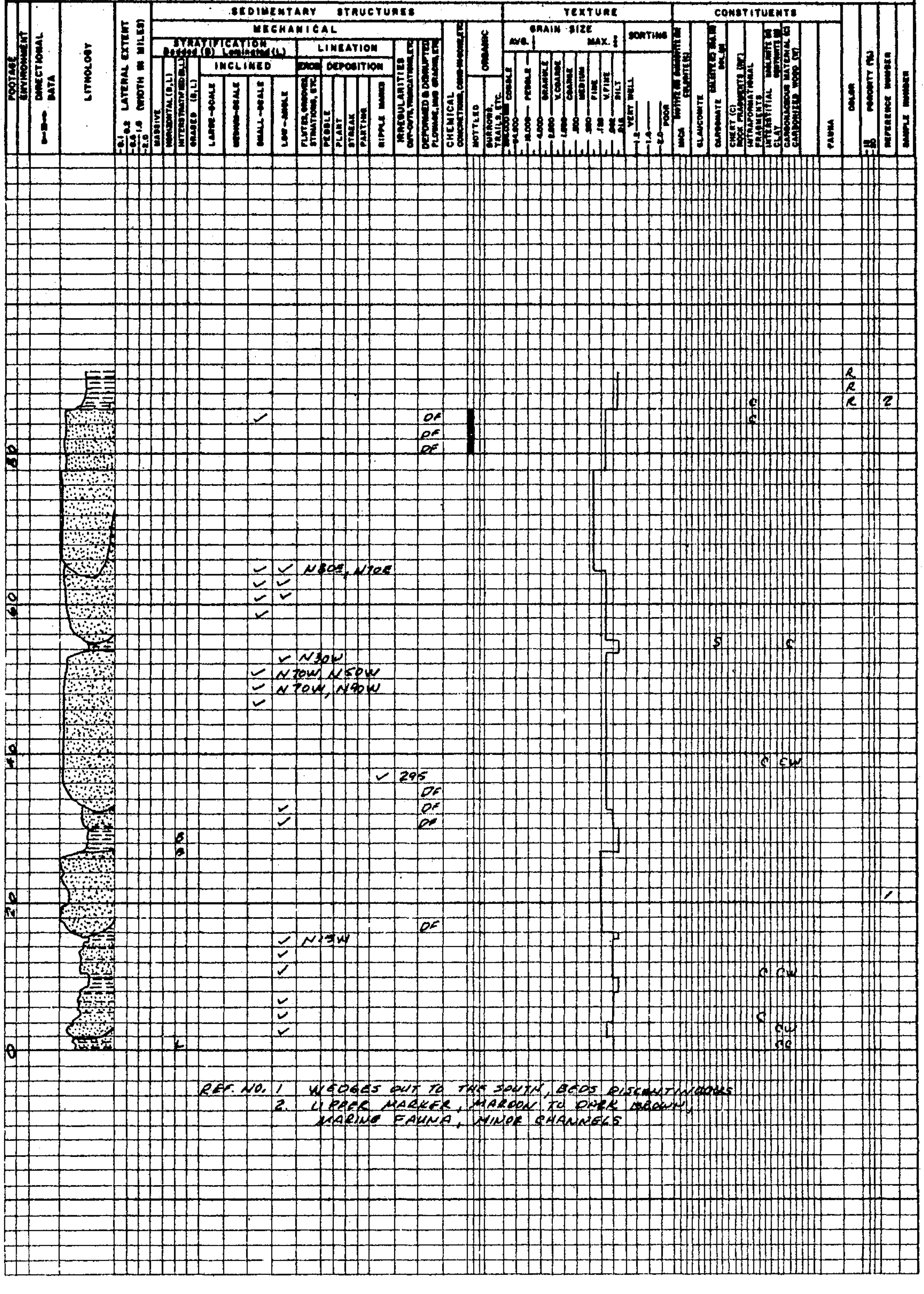
CREEK Co., OKLAHOMA Section No. 11

Area EAST OF OILTON Structural Dip ______ ______ By DON M. TERRELL

Outcrop Pattern--Linear ______ belt ______ Formation ______



NW NE Sec. 8 T. 18N R. 7E Map Photo
CREEK Co., OKLAHOMA Section No. 12
Area NORTH OF DRUMRIGHT Structural Dip By DON M. TERRELL
Outcrop Pattern - - Linear belt Formation



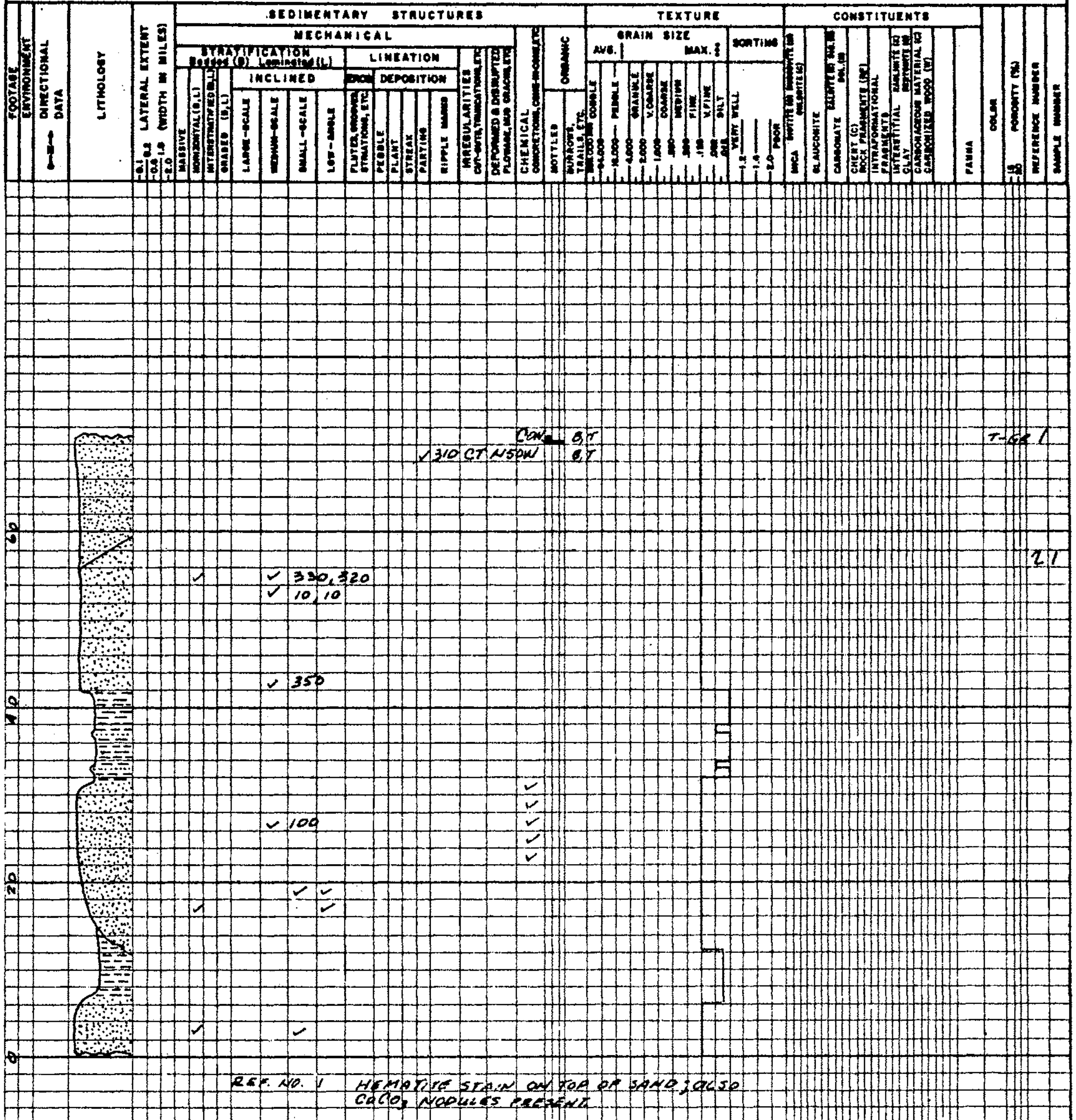
REF. NO. 1 WEDGES OUT TO THE SOUTH, BEDS DISCONTINUOUS
2. UPPER MARKER, MAROON TO DARK BROWN, MARINE FAUNA, MINOR CHANNELS

SW 9
SE Sec. 8 T. 18N R. 7E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 13

Area NORTH OF DRUMRIGHT Structural Dip ______ ______ By J. W. SHELTON

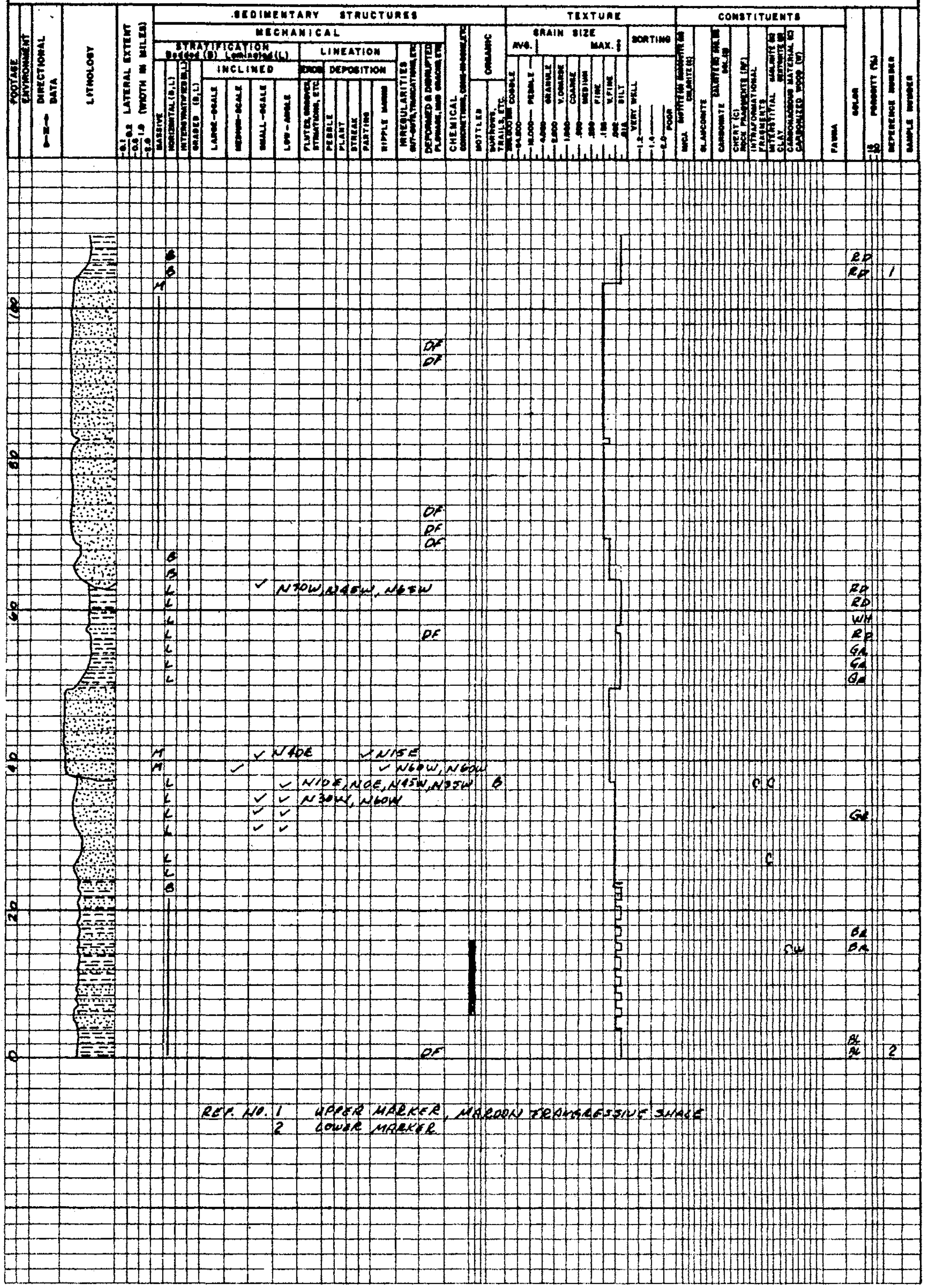
Outcrop Pattern--Linear ______ belt ______ Formation ______



REF. NO. 1 HEMATITE STAIN ON TOP OF SAND; ALSO
CaCO$_3$ NODULES PRESENT.

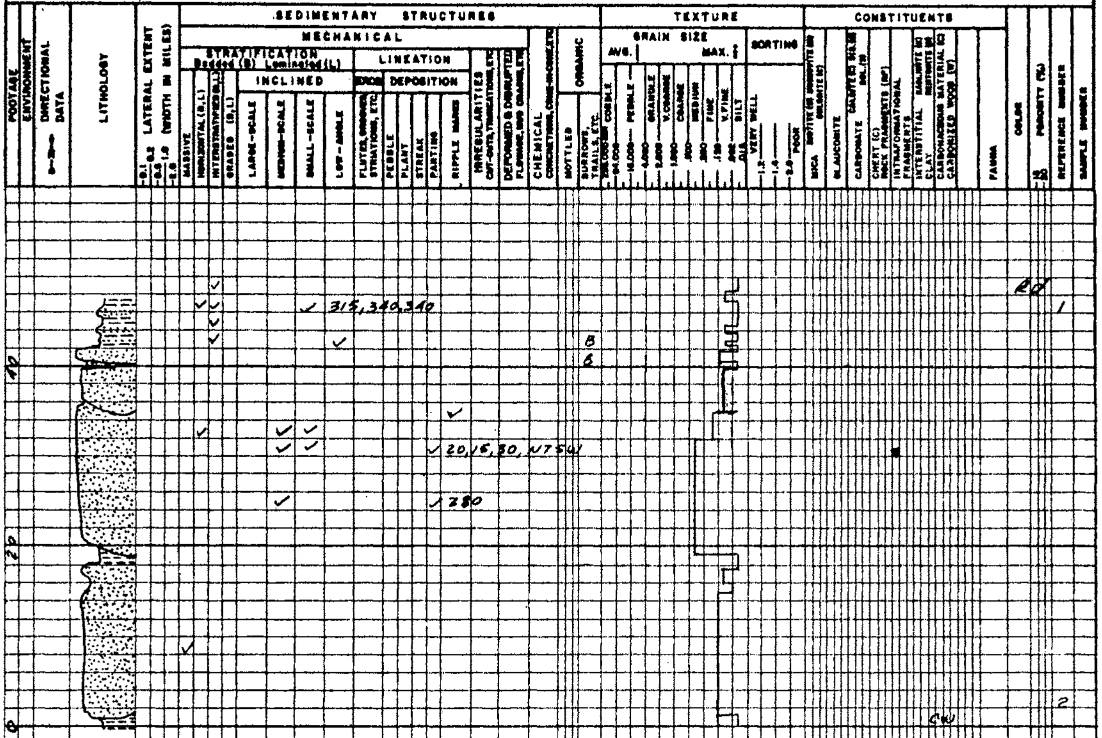
2 G.O. N34WE

SWNE Sec. 17 T. 18N R. 7E Map ________ Photo ________
CREEK Co., OKLAHOMA Section No. 14
Area BEGINS AT EDGE OF FLOOD PLAIN Structural Dip ________ ________ By DON M. TERRELL
Outcrop Pattern - - Linear ________ belt ________ Formation ________



REF. NO. 1 UPPER MARKER, MAROON TRANSGRESSIVE SHALE
2 LOWER MARKER

SENE Sec. 29 T. 18N R. 7E Map Photo
CREEK Co., OKLAHOMA Section No. 15
Area Structural Dip By J. W. SHELTON
Outcrop Pattern--Linear belt Formation



REF. NO 1. TRANSGRESSION, DELTA-FRINGE, VERY IRREGULAR, UPPER MARKER.
2. TREND APPROX. N 30W

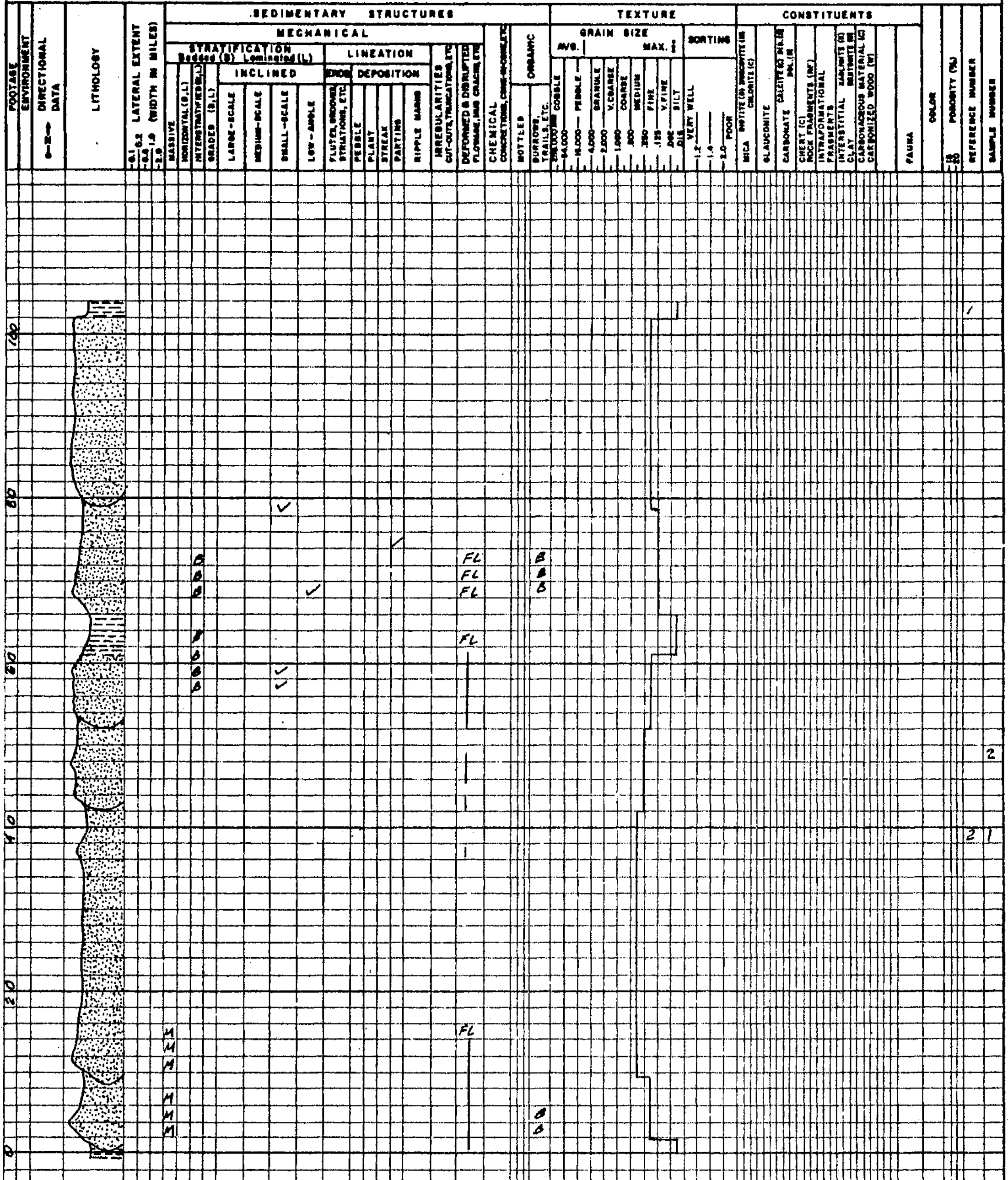
RIPPLES: N55E, N40E
N45, N15E

SX: N15E, N30E, N40W

Sec. 35 T. 18N R. 7E Map Photo
CREEK Co., OKLAHOMA Section No. 16
Area EAST OF DRUMRIGHT Structural Dip By
Outcrop Pattern - - Linear belt Formation J.W. SHELTON AND D. M. TERRELL

REF. NO. 1. ALLUVIAL SAND - SOME QUITE COARSE
2. CARBONIZED MATERIAL, FINELY DIVIDED, SOME OCCURING IN THIN BEDS.
3. HEMATITE STAINED UPPER SURFACE
4. UPPER MARKER

SWSE Sec. 2 T. 17N R. 7E Map Photo
CREEK Co., OKLAHOMA Section No. 17
Area EAST OF DRUMRIGHT Structural Dip By DON M. TERRELL
Outcrop Pattern--Linear belt Formation



SK: N50W
N45W
N40W
N10W
N20W

PT: N20W N30W
N35W N30W
N25W N35W
N20W N45W
N45W N40W

ID: S60W
S40W
S40W

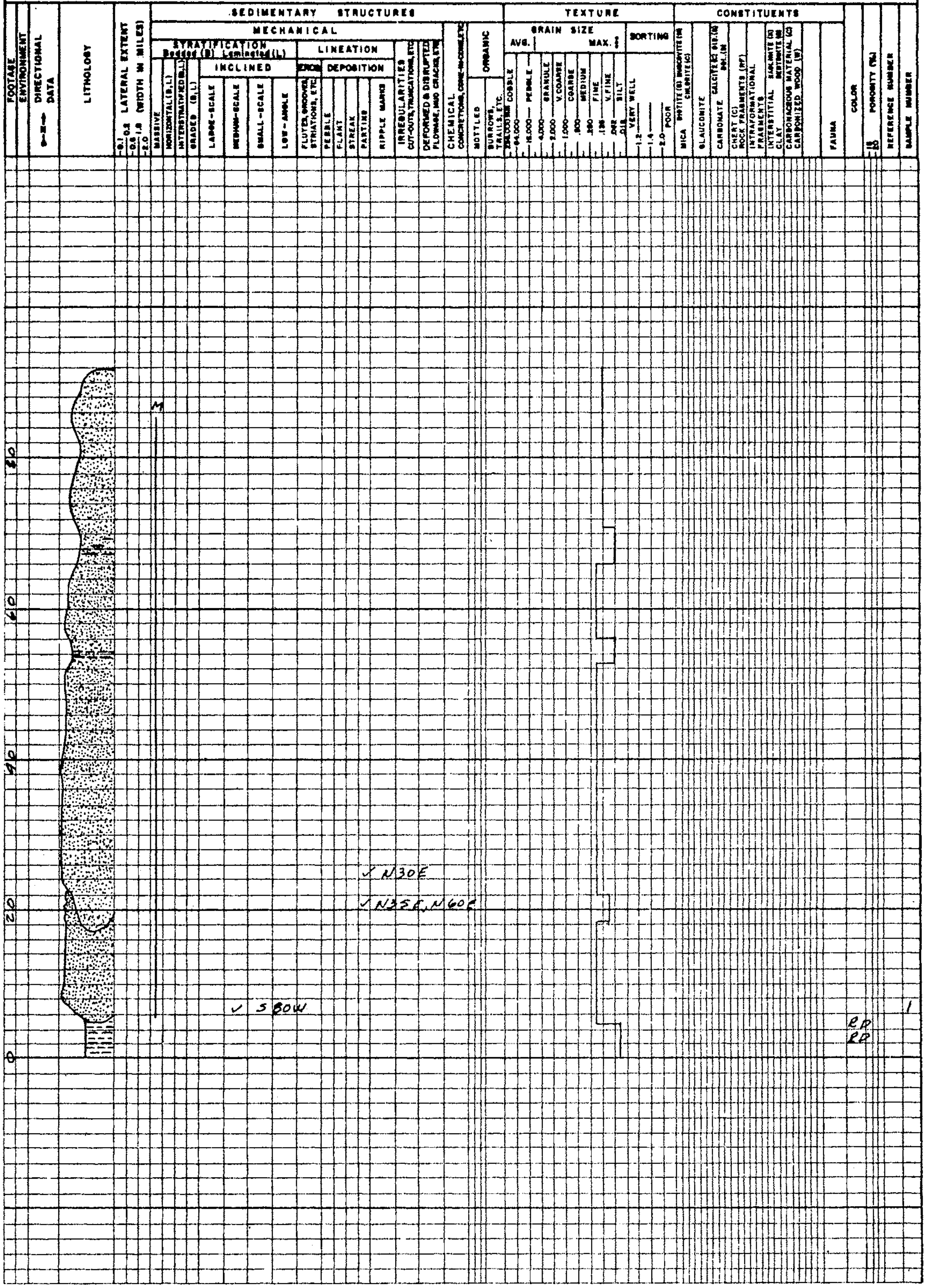
REF. NO. 1 UPPER MARKER
2 IRON OXIDE CONC., 10" to 12" IN DIAMETER

SW NW Sec. 29 T. 17N R. 8E Map Photo

CREEK Co., OKLAHOMA Section No. 18

Area SOUTHEAST OF DRUMRIGHT Structural Dip By DON M. TERRELL

Outcrop Pattern--Linear belt Formation



NE Sec. 1 T. 16N R. 7E Map Photo

CREEK Co., OKLAHOMA Section No. 19

Area ALONG HIGHWAY 16 Structural Dip By J. W. SHELTON

Outcrop Pattern--Linear belt Formation

MX: 210 240
205 295
275 245.
230 245
280 240
230

PT: 310 315
330 350

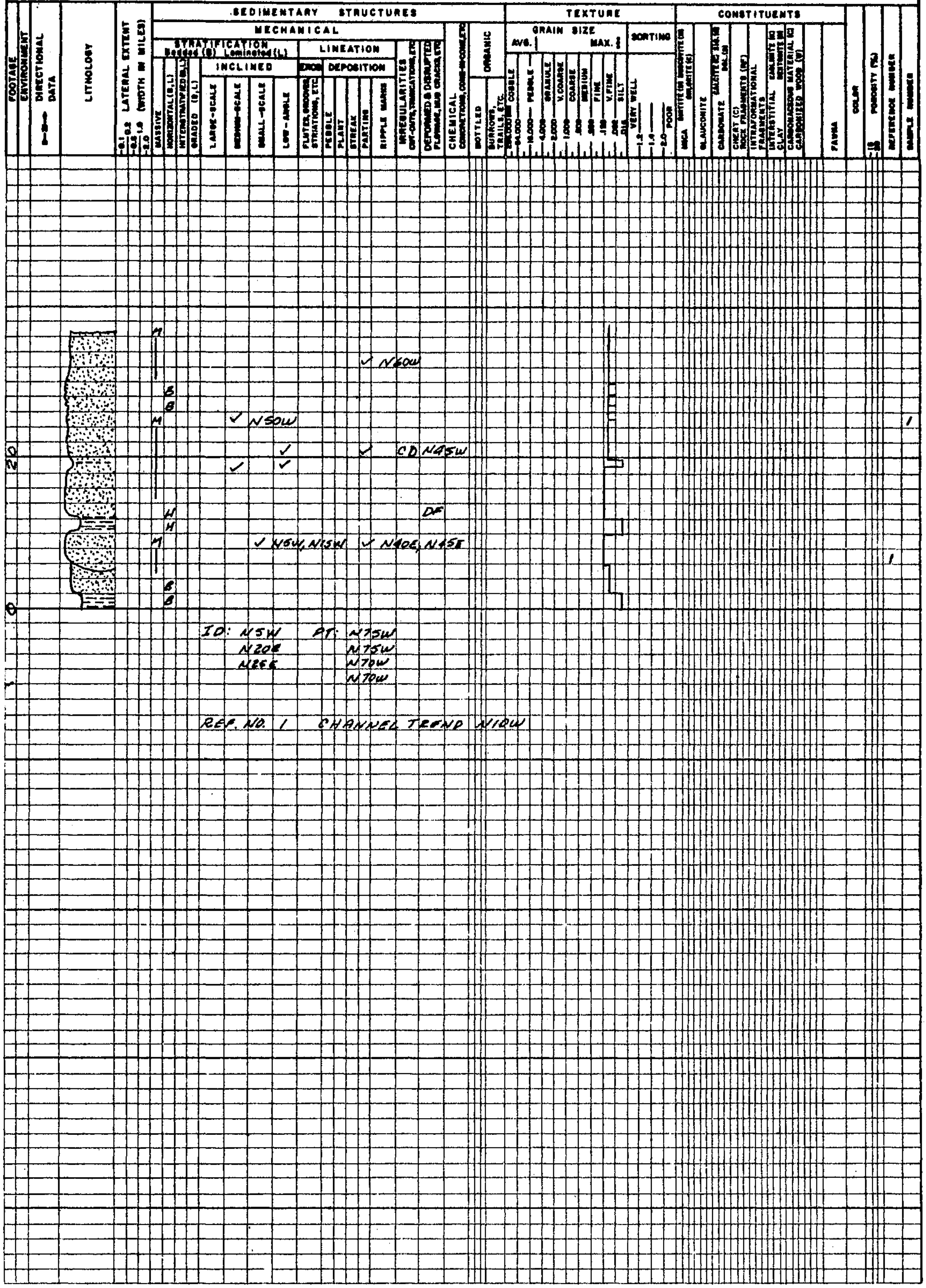
REF. NO. 1 G.D. N65W E

SW NW Sec. 19 T. 16N R. 8E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 20

Area SOUTH OF SHAMROCK Structural Dip ______ ______ By D.M. TERRELL

Outcrop Pattern- - Linear ______ belt ______ Formation ______



ID: N5W
N20E
N25E

PT: N75W
N75W
N70W
N70W

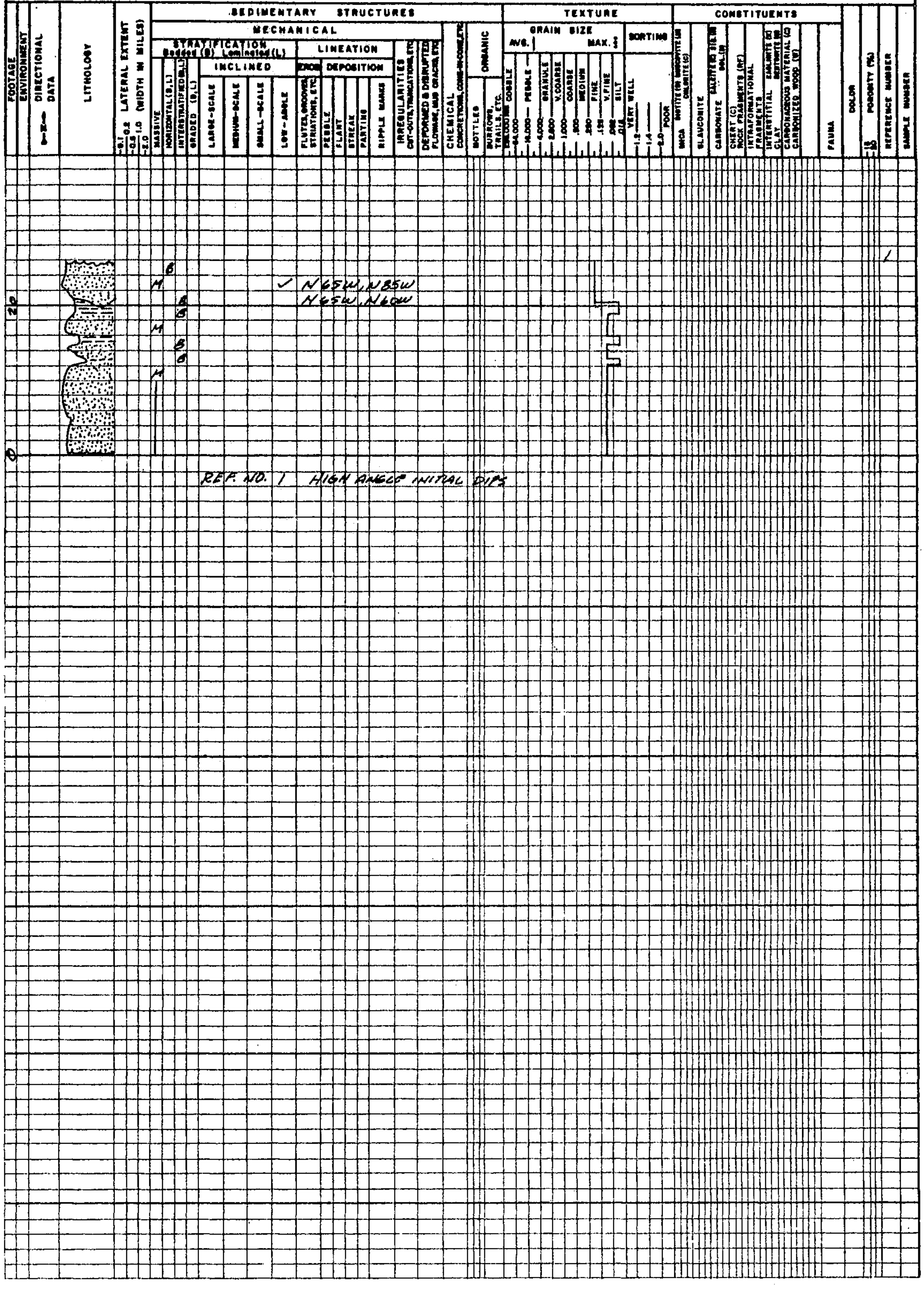
REF. NO. 1 CHANNEL TREND N10W

SW Sec. 11 T. 15N R. 7E Map ____ Photo ____

CREEK Co., OKLAHOMA Section No. 21

Area SOUTHWEST OF DEPEW Structural Dip ____ By DON M. TERRELL

Outcrop Pattern--Linear ____ belt ____ Formation ____



✓ N65W, N85W

N65W, N60W

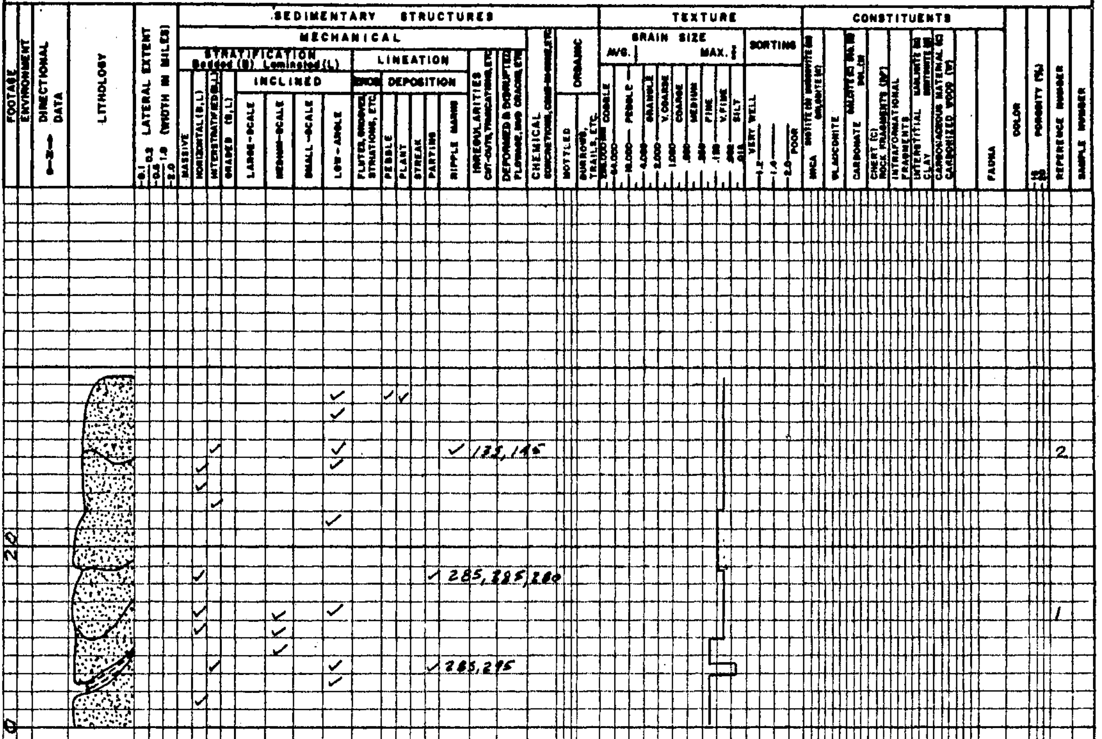
REF. NO. 1 HIGH ANGLE INITIAL DIPS

SE NE Sec. 26 35 T. 16N R. 7E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 22

Area SOUTH OF DEPEW Structural Dip ______ ______ By J. W. SHELTON

Outcrop Pattern--Linear ______ belt ______ Formation ______

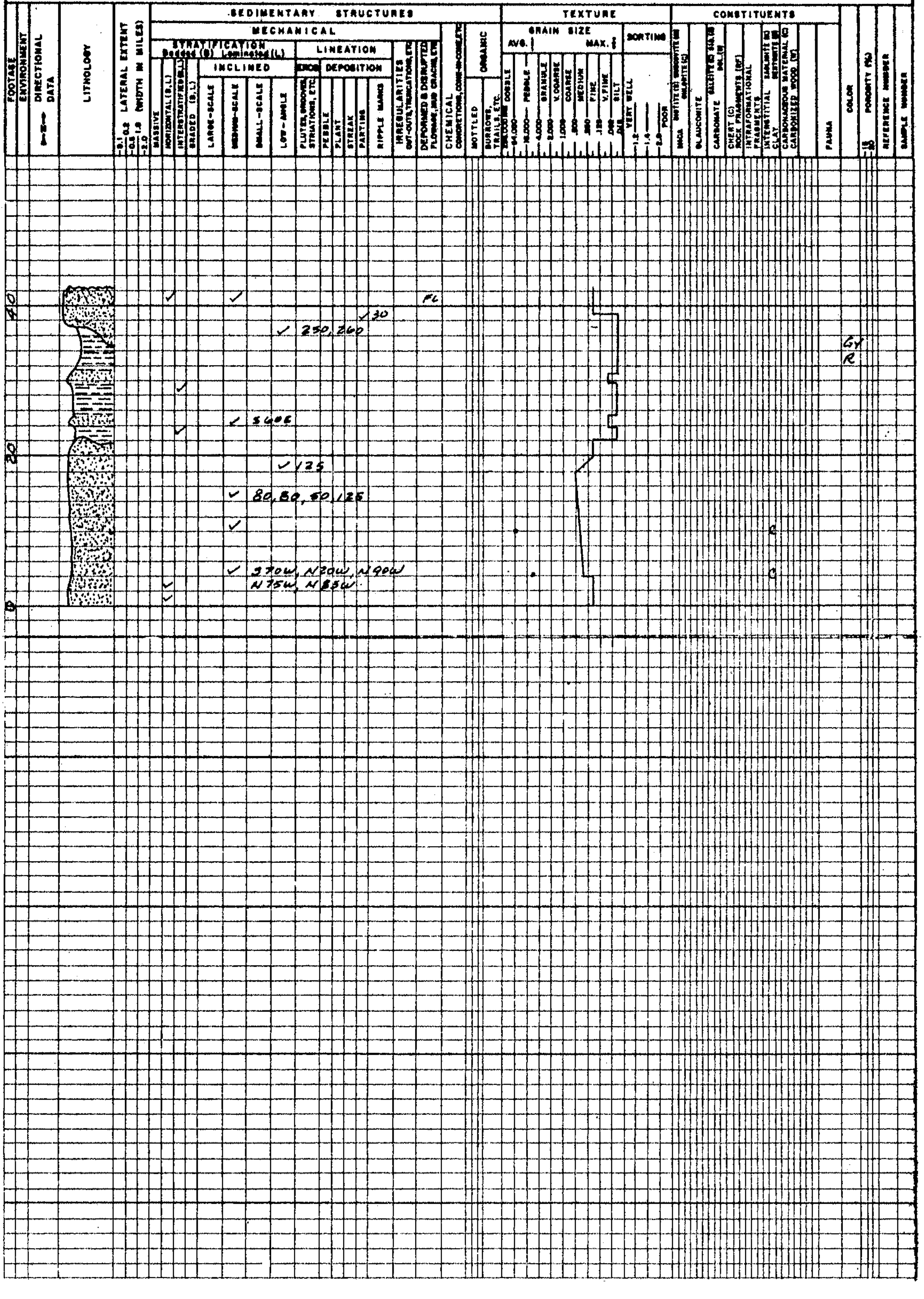


MX: 280 130
270 270

ID: 290 215
205 115
260 65
80 120
40 75
50 75
105

REF. NO. 1 MX - SPILLOVER
2 ID ON BOTH SIDES OF CUT AND FILL - GOOD

SWSESE 3
NWNENE Sec. 10 T. 14N R. 7E Map Photo
CREEK Co., OKLAHOMA Section No. 23
Area SOUTH OF DEPEW Structural Dip By J. W. SHELTON
Outcrop Pattern--Linear belt Formation



SE Sec. 22 T. 14N R. 7E Map ______ Photo ______

CREEK Co., OKLAHOMA Section No. 24

Area ______ Structural Dip ______ By J. W. SHELTON

Outcrop Pattern--Linear ______ belt ______ Formation ______

REF. NO. 1 UPPER MARKER, TOP OF ELGIN SANDSTONE

APPENDIX B

WATER ANALYSIS

TABLE V

CHEMICAL ANALYSIS OF WATER IN THE ELGIN SANDSTONE

Spl. No.[1]	Na ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	NO_3 ppm	TDS ppm	Hardness		SAR meq/ℓ	S.C. µmhos/cm	pH	T°C
							$CaCo_3$	Non-Carbonate				
2	40	388	120	28	12	560	400	87	.9	862	8	27
3	8	24	7	7	1	60	20	1	.8	84	6.9	16.5
4	72	376	28	31	7	408	230	0	2.1	708	8.1	19
5	102	50	58	360	20	998	390	350	2.2	1360	6.9	33
6	32	72	91	90	4.2	382	210	150	1	591	7.3	26.5
8	81	44	66	220	26	676	280	240	2.1	1030	7	18
13	250	30	19	620	6.6	1400	410	386	5.4	2030	7.2	15
14	4.9	46	11	90	.8	77	50	12	.3	110	7.4	18
15	26	306	24	16	2.2	324	260	5	.7	536	8.2	25

[1] Well descriptions are given on the following page.

Sample No. 2. Location: West of Wynona, SW SW Sec. 33, T24N, R8E, Osage Co. Depth: 20'-30'. Remarks: Hand dug. Member at Surface: IPvke.

Sample No. 3. Location: Northwest of Hominy, Okla., West of Mt. Pleasant School, SW Sec. 2, T23N, R8E, Osage Co. Member at Surface: IPe.

Sample No. 4. Location: North of Keystone Lake, NE Sec. 33, T22N, R8E, Osage Co. Owner: Alex Mitchell, Route 1, Hominy, Okla. Date Drilled: 1920. Depth: 100'. Remarks: Water stands 20'. Member at Surface: IPe.

Sample No. 5. Location: SE NE NE Sec. 29, T21N, R8E, Pawnee Co. Depth: 60'-70'. Member at Surface: IPve-3.

Sample No. 6. Location: SE NW Sec. 20, T21N, R8E, Pawnee Co. Owner: H. C. Walker, Route 2, Cleveland, Okla. Date Drilled: 1966. Depth: 85'. Use: Domestic. Remarks: Well 1/2 miles south of house. Member at Surface: IPve-3.

Sample No. 8. Location: SE SW SE Sec. 9, T20N, R8E, Pawnee Co. Owner: Lana Wilkins, Route 1, Terlton, Okla. Date Drilled: Prior to 1942. Depth: 20' to sandstone. Use: Domestic. Member at Surface: IPve-2.

Sample No. 13. Location: East of Shamrock, SW SW NW Sec. 31, T17N, R8E, Creek Co. Source: Seep (concrete). Member at Surface: IPvm-2d.

Sample No. 14. Location: Northwest of Depew, Okla., SW NE Sec. 21, T16N, R8E, Creek Co. Owner: Alvin Cobble, Route 1, Box 45, Depew, Okla. Date Drilled: 1967. Depth: 117'. Member at Surface: IPvm-4.

Sample No. 15. Location: NE SE SE Sec. 33, T16N, R8E, Creek Co. Date Drilled: 1968. Depth: 98'-100'. Member at Surface: IPvm-4.

APPENDIX C

LOCATION OF ELECTRIC LOGS USED IN PREPARATION OF CORRELATION SECTIONS

Well Number	Operator	Lease	Location
1.	Orville H. Parker	Lafoon 1	NE NE SW Sec. 26-14N-6E
2.	Harvey McElreath	Turnbull 1	NW NW SE Sec. 32-15N-6E
3.	Big Bend Pet. Co.	Cook 1	SW SW NE Sec. 3-16N-6E
4.	F. A. Gillespie & Son	Newson 2	NW NW SE Sec. 26-17N-6E
5.	T. N. Berry & Co.	Davenport 1	SE SW NE Sec. 34-18N-6E
6.	Falcon-Seaboard	Martin 1	NE NE SW Sec. 14-19N-6E
7.	W. O. Allen	Perry 1	SW SW SW Sec. 12-20N-6E
8.	Western Oil & Gas Co.	Walker 1	NW SW NE Sec. 12-21N-6E
9.	G. Gillespie & Son	Hugh Ross 1	SE SE NW Sec. 29-22N-7E
10.	Producers Pipe & Supply	Thompson 1	SW Sec. 8-23N-7E
11.	Kewanee Oil Co.	Gross 1	NW NW NE Sec. 1-24N-7E
12.	Texaco Inc.	Oliphant 9	SE SE SE Sec. 19-25N-8E
13.	T. N. Berry & Co.	Long 1	NW NE SE Sec. 31-15N-6E
14.	Big Bend Pet. Co.	Smith 1	NE NE SW Sec. 34-15N-6E
15.	T. N. Berry & Co.	Gerhardt 1	NE NE NE Sec. 35-15N-6E
16.	Graybol Contracting Corp.	McVaey 1	NW NW SE Sec. 30-15N-7E
17.	Davon Oil Co.	Movey C-2	NE SW NE Sec. 29-15N-7E
18.	Blackwell Oil & Gas Co.	Gecbhar 1	SW SW SW Sec. 30-17N-6E
19.	T. O. Lilly	Mize 1	NE NW SE Sec. 29-17N-6E
20.	Foster Drilling Co.	Sadie 1	NW NW SE Sec. 28-17N-6E
21.	Big Bend Pet. Co.	Cook 2	NE NE SW Sec. 27-17N-6E
22.	Mid-Continent Pet. Co.	Sawyer 14	SW SW NE Sec. 27-17N-7E
23.	T. N. Berry & Co.	Long 1	SW NW NW Sec. 18-19N-6E
24.	Creekmoore-Rooney	Douglas 1	SW SE SE Sec. 17-19N-6E
25.	J. Simmons	Anthis	NW SE SE Sec. 7-19N-7E

Well Number	Operator	Lease	Location
26.	Cobett Oil Co.	Oller 1	NW NE NE Sec. 10-19N-7E
27.	Mid-Continent Pet. Co.	Holler 1	NW NW SE Sec. 6-21N-6E
28.	J. R. Porter	School Land 1	NW NW NW Sec. 16-21N-6E
29.	Western Oil & Gas Co.	Meadors 1	SE SW SW Sec. 10-21N-6E
30.	Texkan Oil Co.	Bejeck 1	NW SE SE Sec. 20-21N-7E
31.	Harris & Suppes	Speed 1	SE SE SW Sec. 22-21N-7E
32.	White Star Oil Co.	McKinley 1	SE SE SE Sec. 6-23N-6E
33.	K. S. Adams, Jr.	C. C. Bledsoe 1	NE NE SW Sec. 1-23N-6E
34.	Gulf Oil Corp.	Emma 3	SE NE NE Sec. 16-23N-7E
35.	Toomely Oil Co.	Russell 1	NE NE NE Sec. 24-23N-7E
36.	A. G. Oliphant	S. Dillaplain 2	SE SW SW Sec. 7-25N-6E
37.	Sinclair Oil & Gas Co.	Fairfax Unit D-7	NE SE SE Sec. 15-25N-6E
38.	Gross Drilling Co.	Osage C-1	SE SE SE Sec. 13-25N-6E
39.	Gross Production Co.	Osage A-3	NW NW NE Sec. 18-25N-7E
40.	W. P. Ballard, Jr.	Allred 1	NE NE NE Sec. 27-25N-7E
41.	Oceanil Oil Co.	Faulkner 2	SW SW SW Sec. 7-25N-8E

VITA

Don Michael Terrell

Candidate for the Degree of

Master of Science

Thesis: TRENDS AND GENESIS OF THE PENNSYLVANIAN ELGIN SANDSTONE IN THE WESTERN PART OF NORTHEASTERN OKLAHOMA

Major Field: Geology

Biographical:

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Education: Graduated from Okmulgee High School, Okmulgee, Oklahoma, in May, 1964; completed the requirements for a Bachelor of Science degree in geology from Oklahoma State University, Stillwater, Oklahoma, in August, 1970, received degree in January, 1971; completed requirements for the Master of Science degree at Oklahoma State University in May, 1972, with a major in geology.

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