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Guidebook to the Depositional Environments of Selected Pennsylvanian Sandstones and Carbonates of Oklahoma

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GUIDEBOOK TO THE DEPOSITIONAL ENVIRONMENTS OF SELECTED PENNSYLVANIAN SANDSTONES AND CARBONATES OF OKLAHOMA

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CONTENTS

FIGURES

PLATES

INTRODUCTION

The purpose of this field trip is to examine selected Pennsylvanian sandstones and carbonates for criteria for recognition of depositional environments. Both sandstone and carbonate units are included for study (1) so that workers in one area are afforded the opportunity to raise their level of understanding by examining rock types outside their area of concentration and (2) so that workers in one area can benefit from the observations and techniques of the "uninitiated" worker from another area of sedimentology.

The object of this guidebook is to describe significant features of the selected Pennsylvanian sandstones and carbonates, which are thought to represent various depositional environments. The localities for study of the sandstones and carbonates, or stops, are shown on the location index map of the field trip area (fig. 1), and the stratigraphic position of each unit studied is noted on a correlation chart (fig. 2). Because description of most geometric features requires data from several localities, emphasis at each stop is necessarily placed on internal features. Paleocurrent indicators are noted at most sandstone stops because of their importance in estimating paleogeography and trend. Photomicrographs of selected beds of each carbonate unit are included because of the importance of texture and constituents in interpreting carbonate environments. General description and environmental reconstruction are given of the Elgin Sandstone, Atoka Formation, Bluejacket-Bartlesville Sandstone, Lecompton Limestone, and Wapanucka Limestone.

The following depositional environments are thought to be represented by units studied during the field trip: alluvial plain, deltaic distributary, delta-fringe, shallow marine to delta-fringe, and deep marine for sandstones; subtidal, intertidal, shallow marine, and slope-to-basin for carbonates. Also, changes in lithologic type which reflect depositional conditions are exhibited by the carbonate units.

Appreciation is expressed to the following for assistance: William D. Rose, Roy Davis, and David Deering, Oklahoma Geological Survey; JoAnn Jordan, Betty Boethel, Arthur Astarita, Dan Morganelli, Dale Shipley, and Todd Wilson, Department of Geology, Oklahoma State University.

Explanation for Paleocurrent Diagrams and Symbols

A 30-degree sliding average was usedin preparation of the rose diagrams. The number of measurements is given for each feature. The following is a list of abbreviations used in guidebook:

CB = Convolute bedding
CO = Cut-out
F = Flute
FMX = Festoon medium-scale crossbedding
G = Groove
GO = Grain orientation
ID = Initial dip
MX = Medium-scale crossbedding
PL = Parting Lineation
RF = Rib-and-furrow
RM = Ripple marks
SM = Sole marks
SX = Small-scale crossbedding
XB = Crossbedding
XS = Large-scale cross-stratification

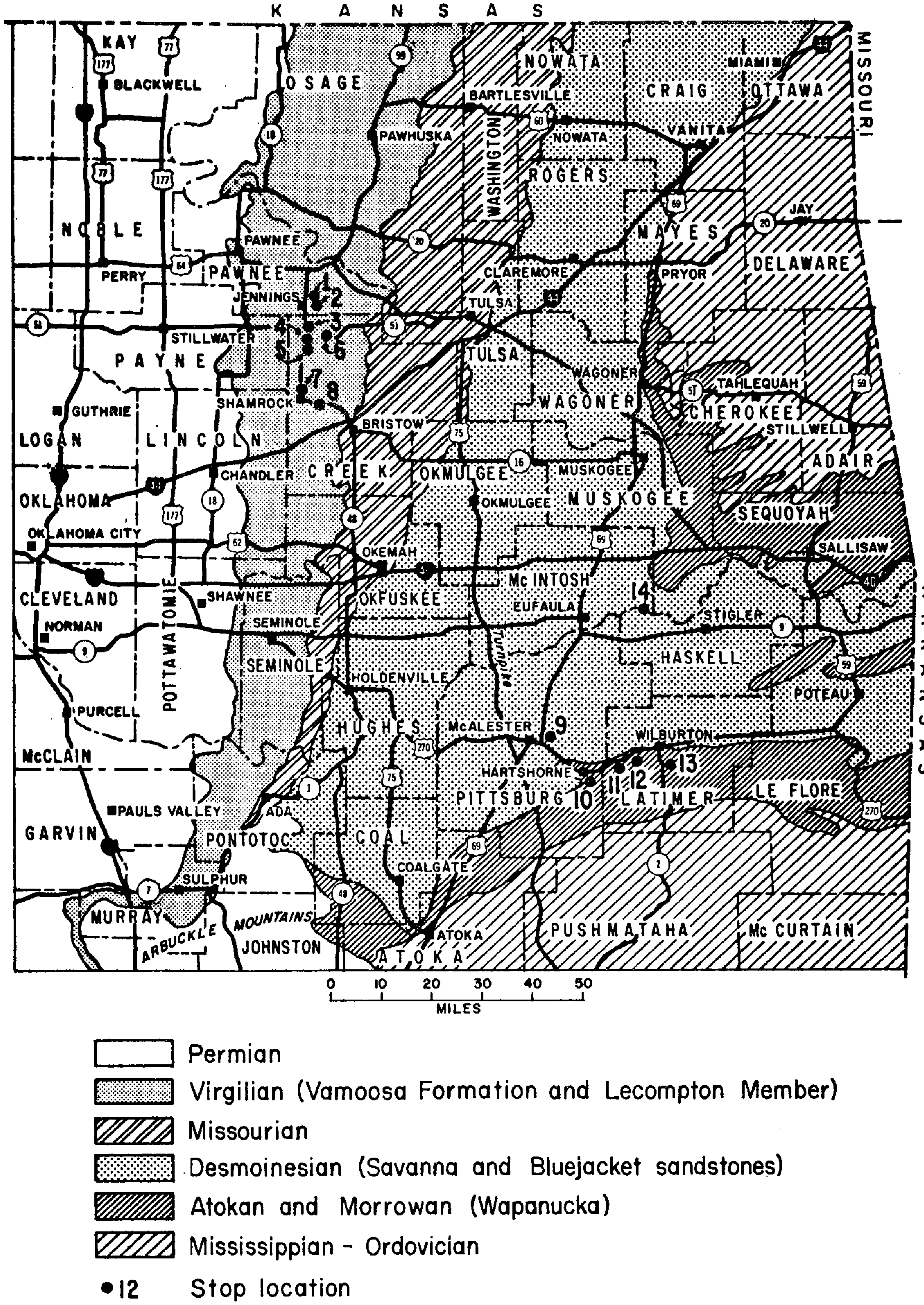

FIGURE 1
GENERALIZED GEOLOGIC MAP
NORTHEASTERN OKLAHOMA

	SERIES	GROUP		STOP
PENNSYLVANIAN	Virgilian	Wabaunsee		
		Douglas-Shawnee	Pawhuska Formation Lecompton Member Vamoosa Formation Elgin Sandstone	2,3,6,7 1,8 4,5
	Missourian	Ochelata Skiatook		
	Desmoinesian	Marmaton Cabaniss		
		Krebs	Boggy Formation Bluejacket Sandstone Savanna Formation McAlester Formation Tamaha Sandstone Warner Sandstone Hartshorne Sandstone	14 9
	Atokan		Atoka Formation	11,13
	Morrowan		Wapanucka Johns Valley	10,12

Figure 2. Correlation chart of Pennsylvanian rocks on outcrop in the Ouachita Mountains, Arkoma basin, and Central Oklahoma platform. Stratigraphic units studied during field trip are indicated by stop numbers.

DEPOSITIONAL ENVIRONMENT OF THE ELGIN SANDSTONE IN THE WESTERN PART OF NORTHEASTERN OKLAHOMA***

Don M. Terrell and John W. Shelton

Stratigraphic Framework

On outcrop in Oklahoma the Elgin Sandstone is a member of the Virgilian Vamoosa Formation. 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).

The stratigraphic interval of interest, herein regarded as a transgressive-regressive couplet in the Vamoosa Formation, is 100 to 170 ft thick and consists of lenticular sandstone with shale. The upper transgressive marker lies approximately 130 ft below the base of the Lecompton Limestone (fig. 3).

On outcrop, 80 to 100 ft of the interval is exposed. The top of the couplet is a well defined unit, characterized by a maroon, marine, fossil-bearing shale.

Geometry

Sandstone on outcrop extends beyond the study area both to the north and the south. Although sandstone is present throughout the study area, it is best developed in the southern part, where trends are diverse in orientation. The most significant, however, are northerly and northwesterly (fig. 4).

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, representing multilateral and multistoried units, contain 100 to 150 ft of sandstone and range in width from 1 to 3 mi. The Elgin is less than 20 ft thick in 2 areas in the northern part of the study area.

The upper boundary of the couplet is generally sharp, both on outcrop and in subsurface, whereas the lower contact is neither so abrupt nor so well defined. 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. The laterally persistent sandstone units are characterized by gradational lower and lateral boundaries.

Internal Features

Prominent sedimentary structures in lenticular sandstones are medium-scale crossbedding, high-angle initial dip, cut-outs, and small-scale crossbedding.

***The Elgin Sandstone is described more fully in the work by Terrell (1972).

Thin-bedded sandstones are characterized by small-scale crossbedding, ripple marks, interstratification, parting lineation, and an occasional trace fossil.

Lenticular sandstone bodies are commonly characterized by an overall upward decrease in grain size from fine- to medium-grained to very fine-grained. The thin-bedded sandstones are dominantly very fine- to fine-grained throughout the study area. They are finer grained and are more poorly sorted than the lenticular sandstones. The average Elgin sandstone is very fine-grained and well sorted.

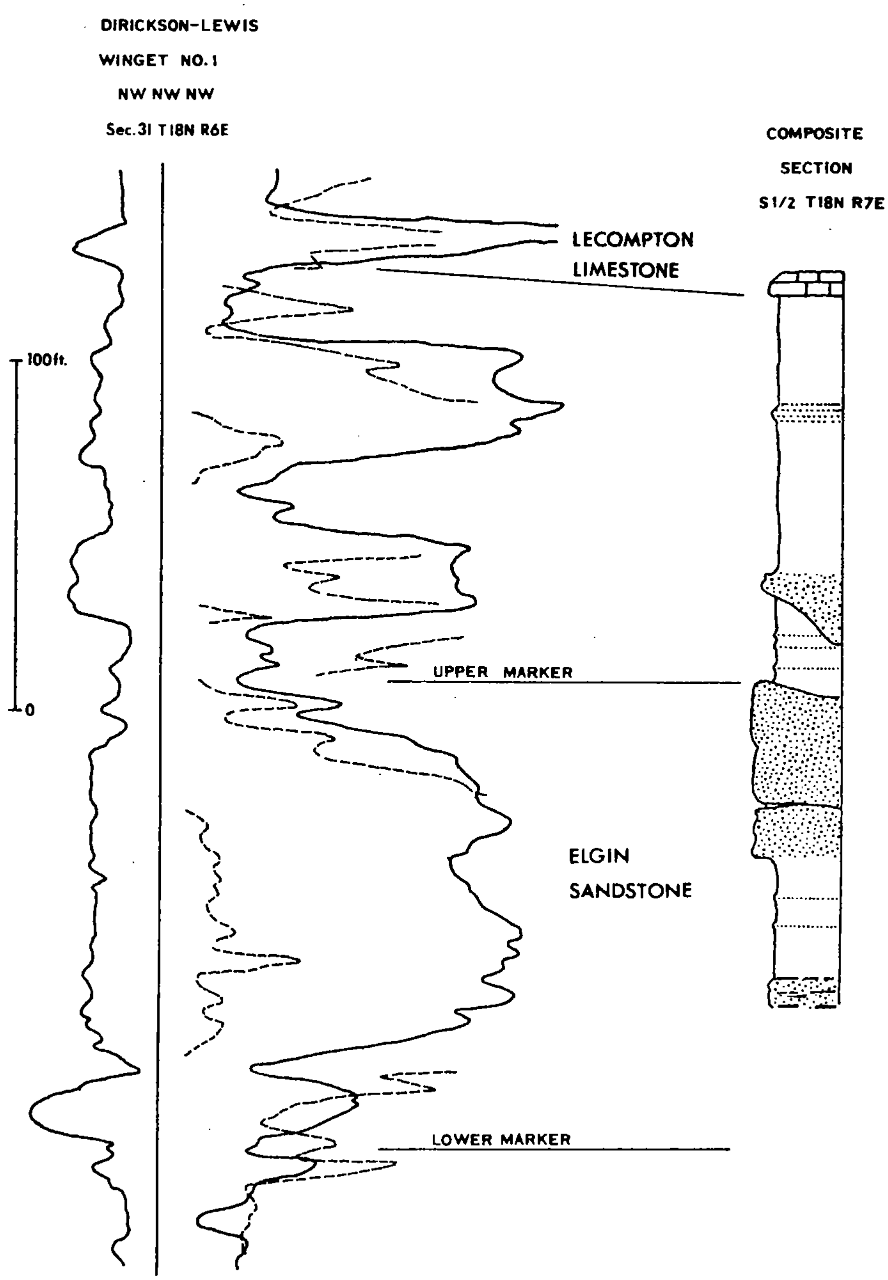

Fig. 3.--Stratigraphic interval of Elgin Sandstone, outcrop to subsurface, showing upper and lower contacts. From Terrell (1972).

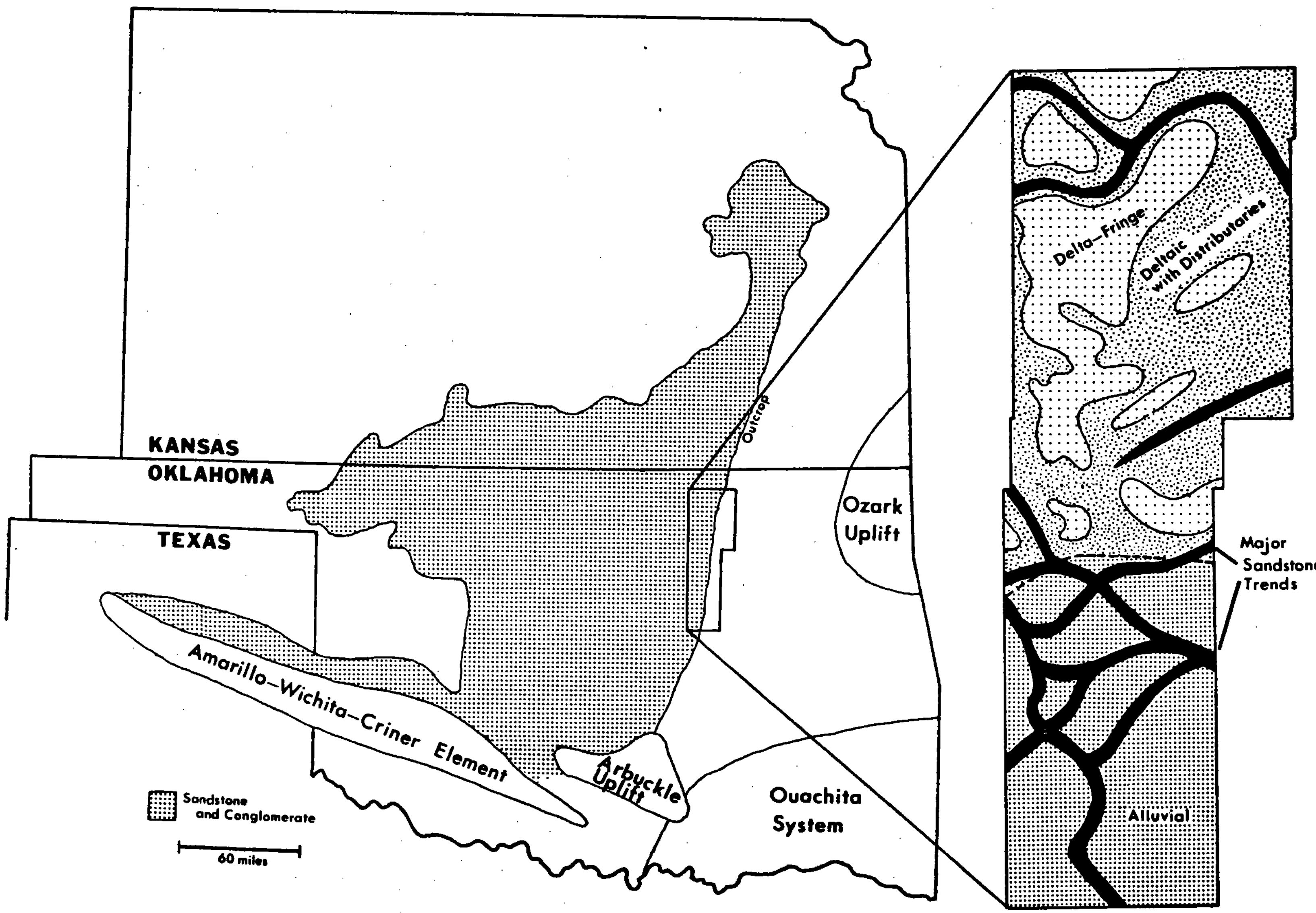

Fig. 4.--Paleogeographic map of Elgin Sandstone during maximum regression. From Terrell (1972).

Prominent constituents of the thin-bedded sandstones are finely divided plant material, small wood fragments, and very fine-grained muscovite on upper bedding surfaces. In the basal part of some lenticular sandstones are locally derived clay pebbles and casts of small logs. In parts of the southern area, where the Elgin is coarse-grained, chert is recognized on outcrop as a significant constituent. Overall the sandstones contain 90.5 percent quartz, quartzite, and chert, 3 percent feldspar, 4.5 percent rock fragments, and 2 percent accessories, such as muscovite, tourmaline, and ziron.

Depositional Environment and Paleogeography

Lenticular sandstones, which comprise the bulk of sandstone in the Elgin interval, 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. Stream width probably averaged 200 ft for Elgin distributaries and 300 ft for Elgin rivers. The distributary sandstones are commonly represented by fine- to very fine-grained narrow bodies, whereas the alluvial sandstones are coarser grained and more extensively developed laterally. 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.

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. However, the riverine input is considered to have been dominant because channel deposits are the major sandstone type.

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. 4). Sandstone forms a narrow fringe along the southern flank of the Anadarko basin but extends as a prominent westward bulge into northwest Oklahoma. 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). 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. 4). 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. A westward shift in paleocurrents in the northern part of the area suggests sediment contribution from the east, possibly the low-lying Ozark province (Hicks, 1962) or the eastern extension of the Ouachita uplift.

DEPOSITIONAL FRAMEWORK OF THE ATOKA FORMATION IN EASTERN OKLAHOMA

John W. Shelton

On outcrop in eastern Oklahoma the Atoka Formation of the Morrowan and Atokan Series reflects 3 structural-stratigraphic frameworks. On the southwest flank of the Ozark uplift, or the northeastern Oklahoma platform, is a relatively thin sequence of alluvial, or deltaic, to shallow-marine deposits. A thick sequence of deep marine units is present in the Ouachita Mountains on the south (fig. 5). The Atoka in the Arkoma basin is a southward-thickening sequence deposited contemporaneously with faulting in the delta-marine environments.

The Atoka Formation in the shelf area north of the Arkoma basin overlies the Morrowan Bloyd Formation, composed of shale with interbedded limestone and locally developed sandstone. There the Atoka shows a southward increase in thickness from 40 to 900 ft. In the western part of the Arkoma basin and the frontal zone of the Ouachita Mountains the Atoka overlies the Wapanucka Limestone, and a sandstone, commonly termed the "Spiro," is present either as the basal unit of the formation or as the uppermost unit of the Wapanucka. The Hartshorne Sandstone overlies the Atoka in the Arkoma basin and the southern part of the Ozark uplift in Oklahoma. The Atoka Formation in the basin is subdivided lithologically into 3 gross units, each of which contains considerably more shale than sandstone. It is estimated that the Atoka may be as much as 15,000 ft thick near the Choctaw fault (Buchanan and Johnson, 1968). In much of the Ouachita Mountains in Oklahoma the Atoka Formation is underlain by the Johns Valley Shale and is subdivided into a lower, sand-rich unit and an upper, shale-rich unit. Total formational thickness is greater than 5,000 ft (Hart, 1963).

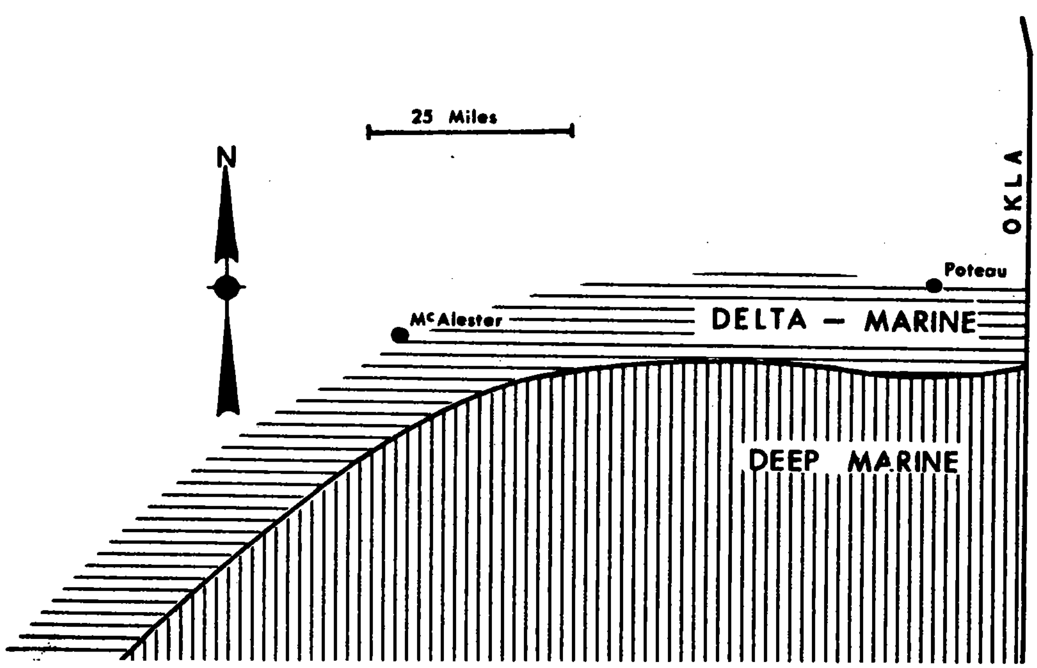

Fig. 5.--Depositional environmental map for Atoka sandstones. Geographic position of deep marine units in overthrust sheets is unrestored. (After Briggs and Cline, 1967.)

Sandstone, which is more common than shale, increases in percentage toward the north and east in the area north of the Arkoma basin. Occasional thin limestones and thin coals developed at widely separated intervals, along with sandstone and shale units represent cyclic, or repetitious, depositional conditions. Some sandstones are conglomeratic, crossbedded, and medium-grained, whereas others are fine-grained and contain fossils and/or burrows (Blythe, 1959).

In the Arkoma basin sandstone is present in repetitious, interbedded sequences with dark gray shale and siltstone. Sandstone beds on outcrop contain an abundance of ripple marks and burrows, several medium-scale crossbeds and intraformational fragments, and an occasional marine fossil (pl. 1, figs. A and B). Paleocurrent indicators exhibit a predominant southerly transport direction (Briggs, 1962; Briggs and Cline, 1967). The repetitious development suggest a subtle deltaic influence; the depositional environment for deposition of sandstones on outcrop is thought to be distal delta-fringe to shallow marine. Undoubtedly distributary sandstones are present in the subsurface between the outcrop belt on the southern flank of the Ozark uplift and the belt adjoining the Ouachita frontal zone.

Sandstone units in shale-rich parts of the Atoka Formation in the Ouachita Mountains show characteristics of distal turbidity-current deposits in that each contains sole marks along a sharp basal contact, horizontal bedding, convolute bedding, small-scale crossbedding, and a gradational upper contact (pl. I, C and D). The microfauna in dark gray shale of foraminfera, sponge spicules, and radiolaria indicates deep marine (Stark, 1966). Sandstones in sand-rich parts of the Atoka contain graded bedding along with the other features of the thinner bedded sandstone units. The upper contacts may not be gradational because of the development of multistoried units. This type of sandstone is the product of turbidity-current deposition downcurrent from any proximal deposits but upcurrent from the distal deposits of shaly Atoka units. Paleocurrents are dominantly westerly, subparalleling the structural framework (Briggs, 1962; Briggs and Cline, 1967). The average direction changes to a southwesterly direction in the western part of the Ouachita province, where the structural trend also changes from west to southwest.

Paleocurrents indicate that the general source area for the Atoka on the shelf and in the Arkoma basin was the craton to the north and northeast. Currents in the Oklahoma part of the Ouachita geosyncline during deposition of the Atoka were primarily axial even though source areas included the craton and a tectonic belt to the south and southeast (Walthall and Bowsher, 1966) as well as the Appalachians to the east.

DEPOSITIONAL ENVIRONMENT OF THE BLUEJACKET-BARTLESVILLE SANDSTONE, NORTHEASTERN OKLAHOMA*

John W. Shelton

Stratigraphic Framework

The Desmoinesian Series in northeastern Oklahoma, with cyclothem-like sequences, includes the Krebs, Cabaniss, and Marmaton groups, in ascending order. The older two groups, commonly referred to as the Cherokee Group, are characterized by

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*Description is taken in part from the work of Visher (1968) and Visher _et al._ (1971).

PLATE 1

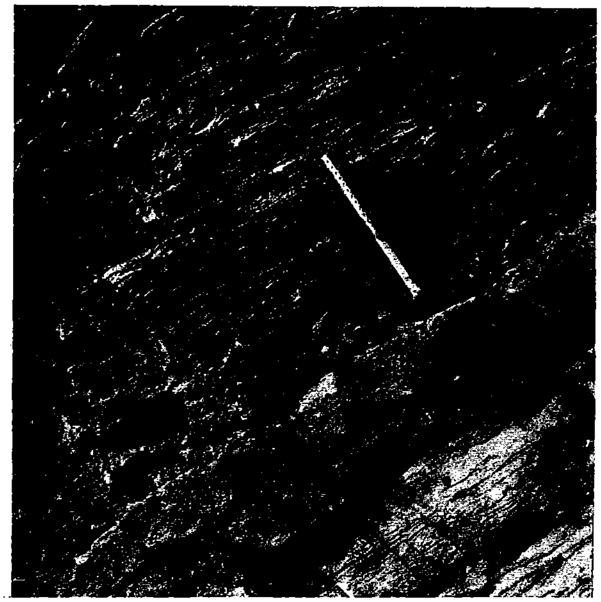
Fig. A.--Interbedded Atoka sandstone and shale, Arkoma basin, deposited in distal delta-fringe or shallow marine environment. Ripple marks and burrows are present in sandstone.

Fig. B.--Sharp top of sandstone in Atoka, Arkoma basin, with thin shale interbeds; overlying shale with interlaminated siltstone. Units deposited in shallow marine or delta-marine environments.

Fig. C.--Representative sandstone and interbedded shale in deep-marine, shale-rich Atoka, Ouachita Mountains. Sharp base at hammer (arrow), gradational top, and upward fining characterize the sandstone.

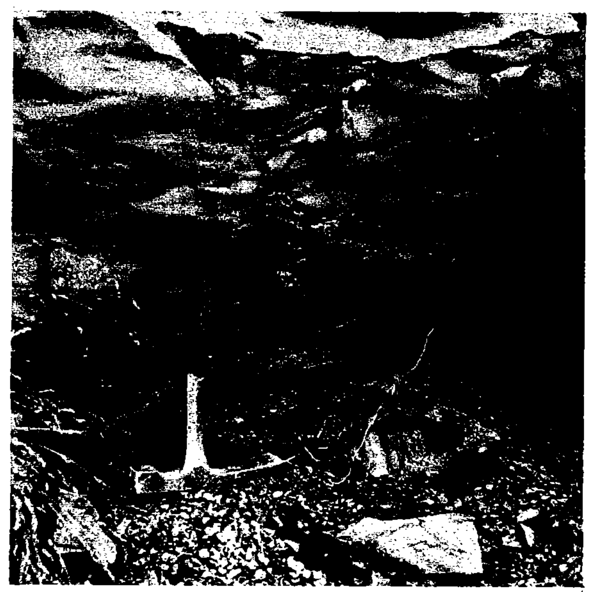
Fig. D.--Sole marks on underside of thin Atoka sandstone, Ouachita Mountains, with turbidity-current current direction toward the right (west).

A



B

C



D

lenticular sandstones, shales, coal beds, and thin but persistent limestones, whereas the Marmaton is characterized by shale, limestone, and minor amount of sandstone.

The Bluejacket Sandstone on outcrop and the equivalent Bartlesville in subsurface constitute the basal member of the Boggy Formation, the uppermost formation of the Krebs Group. The Bluejacket on outcrop is underlain by shale and siltstone in the upper part of the Savanna Formation and is overlain by a variable section of unnamed Boggy units. Most commonly the sandstone is a ridge-former; in the subsurface the Bartlesville Sandstone composes the major part of a sequence between the Inola Limestone above and the "Brown Lime" below. The Bluejacket-Bartlesville is composed of a large number of genetic, multistoried, and multilateral sandstone units, formed in several specific depositional environments.

Geometry

In Oklahoma the Bluejacket-Bartlesville Sandstone is developed in two general areas, one with major channels and the other with minor channels (fig. 6). Within the larger area in the east sandstone is locally absent, and sandstone is not developed at numerous localities in the smaller area which adjoins the Nemaha ridge. In the northern part of the larger area, the overall sandstone trend for the many genetic units present is north-northeast. The trend in the southern part is southeast, with even an easterly trend in the southeasternmost part. Sandstone has been recognized in the larger eastern area of development for a distance of 180 mi along the arcuate trend of major channels (fig. 6), and the Bluejacket extends northward beyond the study area. However, sandstone is thin or is not developed in the southernmost part.

The sandstone-bearing interval ranges in thickness from 0 to more than 200 ft. The thickest section is present as a branching pattern in an area south of Tulsa. The channels are narrower than the intervening areas of rather uniform sandstone development, where average thickness is approximately 50 ft. The basal contact is generally sharp along the channels; the upper contact may be gradational or sharp. Away from thick trends, the base most commonly is gradational. Lateral boundaries of the Bluejacket-Bartlesville complex are sharp only where channels are present near the sandstone edge.

Internal Features

Medium-scale crossbedding, along with cut-outs, is a common feature in channel sandstones. Present also is massive bedding with irregularly distributed carbonized filaments or with clay pebbles (fig. 7). Considerable variation exists in local paleocurrent directions on outcrop, but the average of S30°E to S35°E corresponds quite well to the average of channel trends (fig. 6). The more uniform sandstone contains parting lineation, rib-and-furrow, current and wave-generated ripples, burrows, and interstratification. The channel sandstones are commonly coarsest at the base. Pebbles and cobbles of intraformational fragments may be present at several levels in that type of sandstone. Average sand size is fine- to medium-grained, and the sandstones are well sorted. The uniform sandstone units between thick trends, above or below well developed sandstone, and in the southeastern part of the area are very fine-grained, moderately sorted, and they commonly show an upward increase in grain size. In addition to intraformational clay fragments, accessory materials in the coarser grained sandstone include carbonaceous

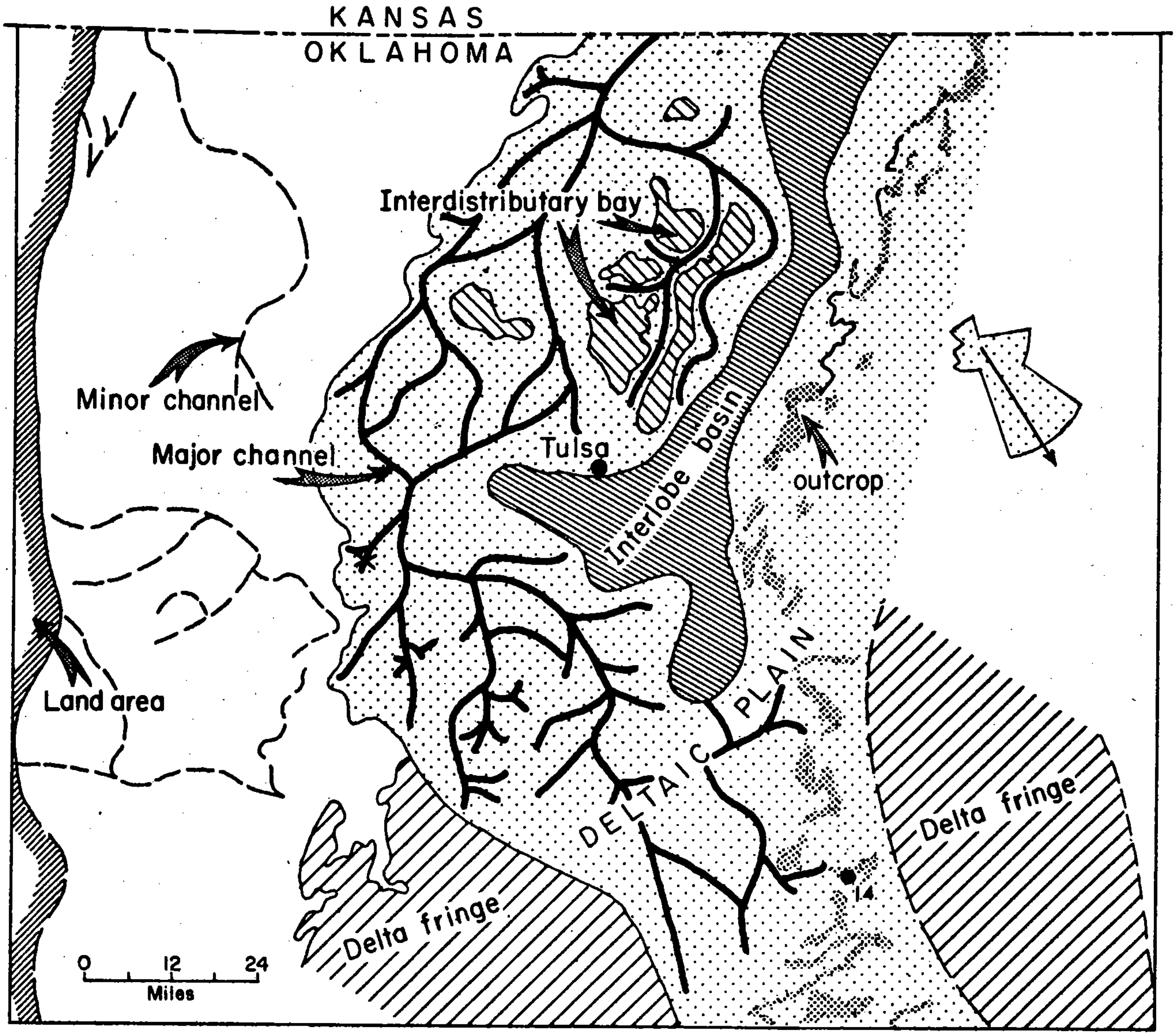


Fig. 6.--Paleogeographic map for Bluejacket-Bartlesville complex. Modified after Visher (1968).

material and carbonized wood, pyrite (in cores), and siderite or iron oxide. In the finer grained sandstone and interbedded shale concretionary siderite (or iron oxide) is rather common.

Depositional Environment

The Bluejacket-Bartlesville Sandstone is thought to represent various units of a deltaic complex (fig. 6). The channels are deltaic distributaries for the most part. A genetic distributary sandstone for the Bluejacket-Bartlesville is thought to be less than 70 ft thick. A sandstone body, 200 ft in thickness, probably represents a minimum of 3 genetic units. The thinner, more widespread sandstone units are considered to be delta-fringe and/or interdistributary. The former includes delta front, distributary mouth, and marginal deltaic plain deposits.

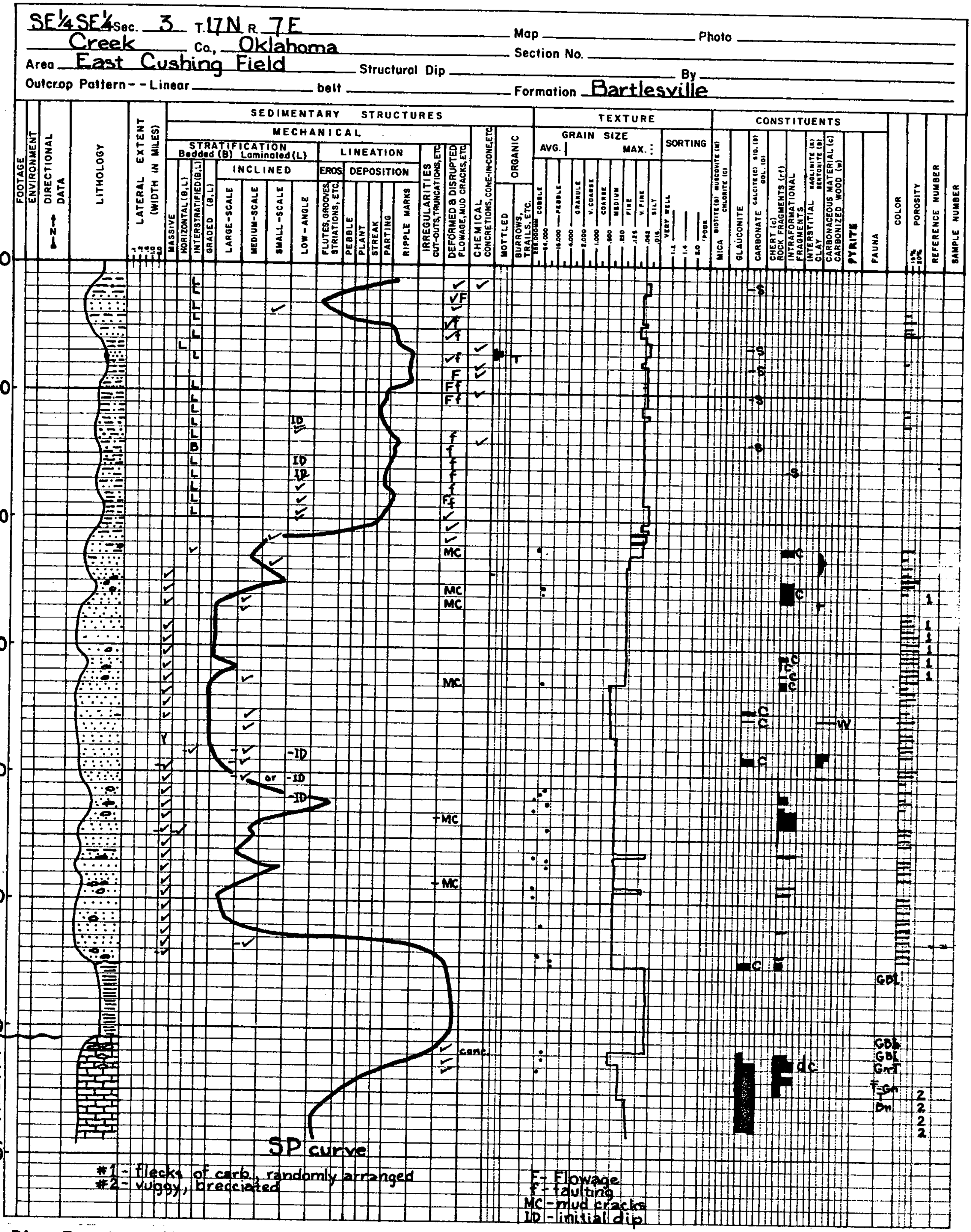


Fig. 7.--Core description of Bartlesville Sandstone, East Cushing field, in the northwestern part of the study area.

The southerly deltaic advance may have been determined by the Ozark uplift and the Nemaha ridge. During maximum regression, depositional conditions in the northern part of the study area became indistinguishable from those of an alluvial plain. In a vertical section distributary sands overlie or occupy channels cut into delta-fringe sandstones. Interbedded sandstone and shale in the southeastern part represent distal delta-fringe deposits bordering prodelta clays.

STOP 1

Location: NW NW Sec. 25, T20N, R7E, Pawnee County, on paved road between Jennings and Terlton, 2.8 mi east of Jennings

Exposure: Shallow roadcut on both sides of road

Structural Dip: Gentle, less than 1° west

Formation: Sandstone in unnamed upper unit, Vamoosa Formation

Description: Horizontally bedded and crossbedded sandstone with interbedded shale

Depositional Environment: Delta-fringe

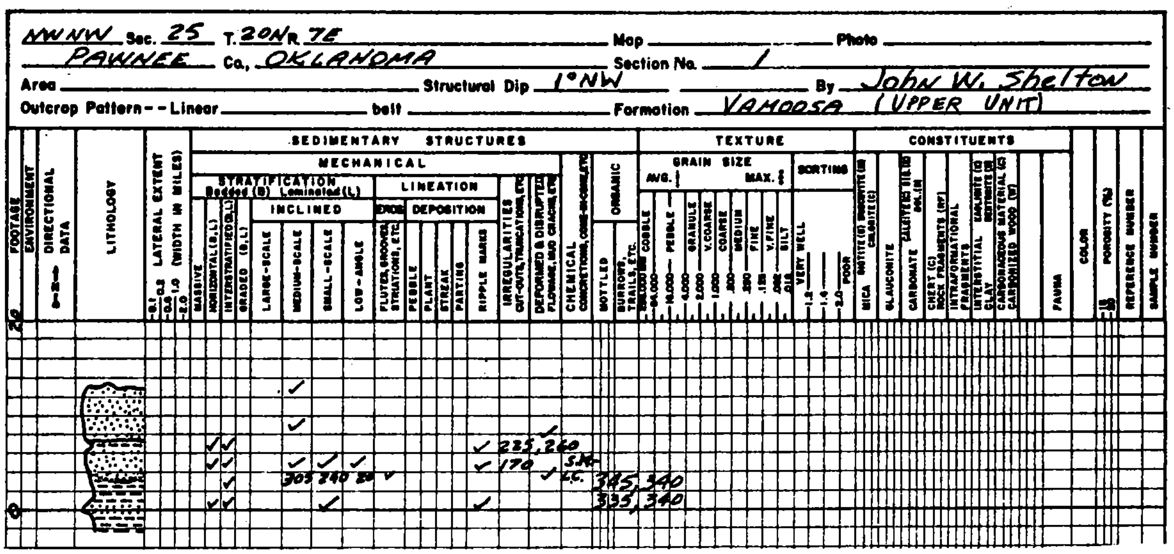


Fig. 8.--Measured section of a sandstone in upper unit of Vamoosa Formation. The unit is characterized by interstratification and gradational base. The uppermost sandstone bed is the thickest unit. See Plate 2, figs. A and B for photographs.

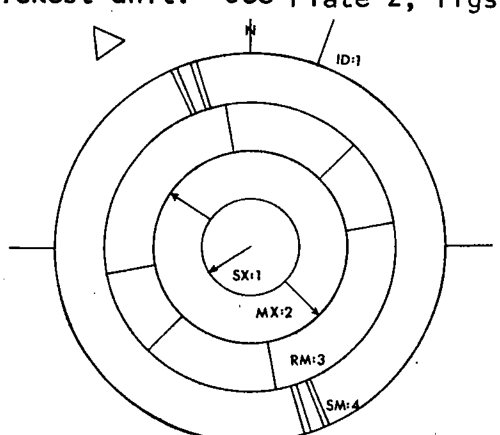


Fig. 9.--Paleocurrent diagram of sandstone in upper unit of Vamoosa Formation suggests an overall direction of N35°W.

PRELIMINARY INVESTIGATION OF THE LECOMPTON MEMBER OF THE PAWHUSKA FORMATION (UPPER PENNSYLVANIAN) IN THE JENNINGS-SHAMROCK AREA, OKLAHOMA

T. L. Rowland

INTRODUCTION

The Pawhuska Formation of the Virgilian Series, Upper Pennsylvanian (fig. 2), consists of a series of interbedded limestones, shales, and some sandstones. The Lecompton Member forms the basal unit of the Pawhuska and has been mapped from Douglas County, Kansas, into northern Oklahoma across central Osage and Pawnee Counties, and southward into western Creek and Okfuskee Counties (fig. 1).

The Lecompton is principally a carbonate with thin shale interbeds and ranges in thickness across Oklahoma from 20 feet to 6 inches. Some local thickening up to 30 feet has been measured. In the Jennings-Shamrock area the Lecompton ranges in thickness from 20 feet to 1½ feet and crops out in bench-plateau outliers and north-south continuous patterns (fig. 10). Many ledges can be found in natural outcrops, but the top and base are normally covered. Roadcuts and abandoned or working quarries afford good exposures in which to examine the unit in this area.

The Shamrock-Jennings area was chosen for the field trip because of thickness, exposures, and rapid change in lithologic type. In southern Pawnee County, east of Jennings (fig. 10) the unit is principally limestone with some shale interbeds, whereas in the Drumright area (fig. 10) the unit is dolomite with thin shale partings.

Four stops will examine the Lecompton Member: Stops 2, 3, 6, and 7 (figs. 1, 10). This trip and report are only of a preliminary nature, as the lithostratigraphic and petrographic framework has not been investigated in detail. A project to study this unit in detail is currently under way as a Master of Science thesis at The University of Oklahoma. Each stop is discussed separately and the generalized stratigraphic and depositional environments are given in the summary.

STOP 2

The Lecompton is well exposed in three abandoned quarries in the C N½ N½ sec. 36, and C S½ S½ sec. 25, T. 20 N., R. 7 E., 3½ miles east of Jennings, Pawnee County, Oklahoma (fig. 10). The large quarry south of the section-line road constitutes Stop 2.

At this locality the Lecompton has a maximum thickness of 20 feet. It is composed of a basal 2 to 3 feet of quartz-sandy, skeletal calcarenite. Another 2 feet of skeletal calcarenite overlies the basal unit, and in various parts of the quarry a shale separates these two units and varies from 2 inches to 1½ feet in thickness. In some parts of the quarry these lower beds exhibit crossbedding, and some zones in the upper calcarenite are dolomitic.

Overlying the lower beds is a thin-bedded, algal calcilutite that varies from 6 to 12 feet in thickness, depending on which part of the quarry is examined. This unit contains a few thin shale partings. Plate 5, fig. A, shows the east face of the quarry north of the road, with the upper thin algal beds (upper part of photo) in contact with the upper portion of the lower beds (lower part of photo). Plate 5,

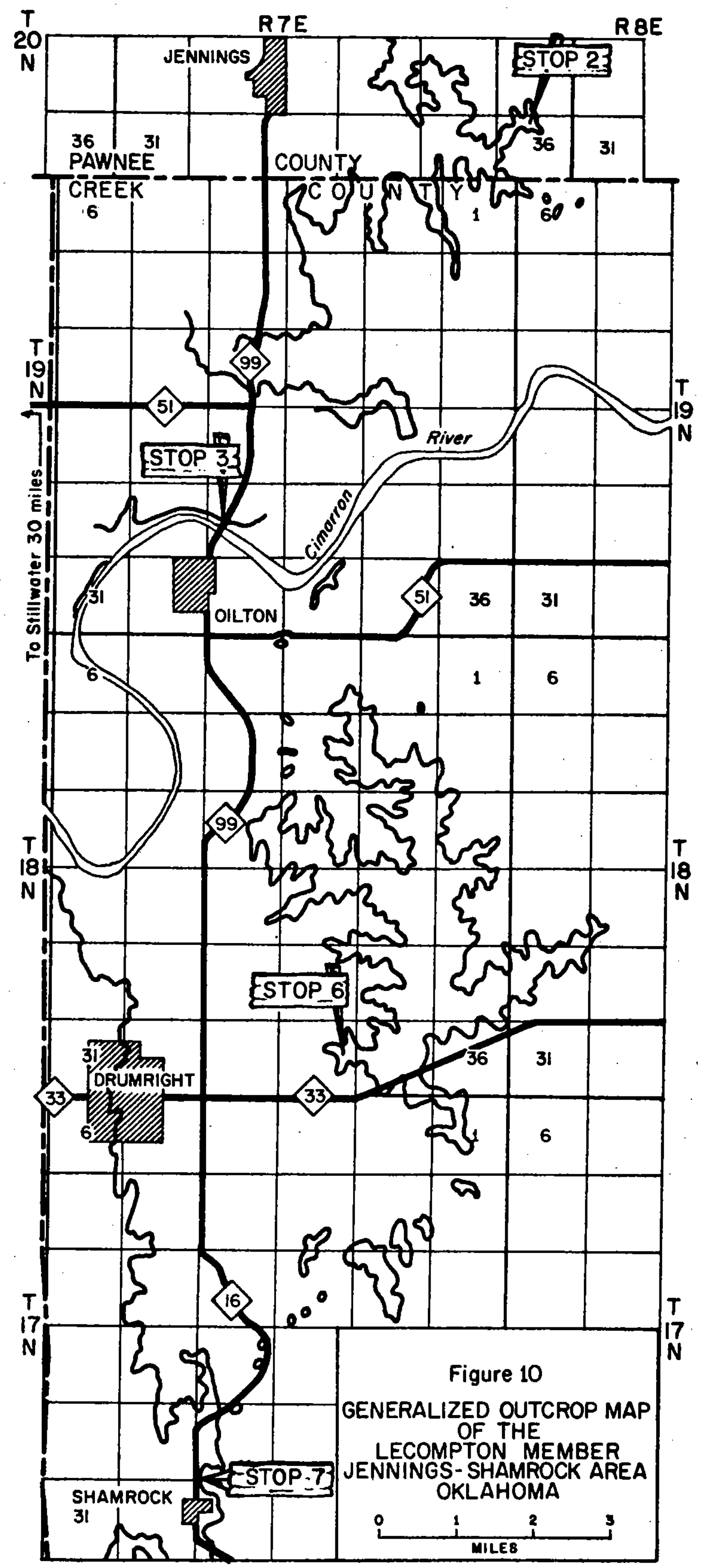


Figure 10

GENERALIZED OUTCROP MAP OF THE LECOMPTON MEMBER JENNINGS-SHAMROCK AREA OKLAHOMA fig. B, shows the crossbedding found in the lower beds in some parts of the quarry.

Overlying the algal limestone is 2½ feet of shaly, coarse-grained, skeletal calcarenite found only in the abandoned quarry, southwest of the stop. Figure 11 is a generalized composite stratigraphic section of these units taken from examination of all the quarries. It must be kept in mind that the details of the relationships of the members in the quarries have as yet to be studied.

Petrographically, the lower beds are medium- to coarse-grained, skeletal grain-supported rocks cemented with sparry calcite and contain some micrite matrix. One thin section from the basal beds, Plate 7, fig. A, shows it to be a medium- to coarse-grained, skeletal, intraclastic grainstone. It consists of closely packed grains of rounded micrite intraclasts, many of which are recrystallized partially or totally. Recrystallization consists of microspar and dolomite. Abundant pelmatozoan debris is present along with brachiopods and other skeletal debris. Scattered fine- to medium-grained quartz sand is present in this basal bed.

The upper beds appear to be mud-supported rocks. A section from one of the beds (pl. 7, fig. B) is an algal, skeletal wackestone with some silicification. It consists of medium to coarse grains set in a micrite matrix. Many of the grains are recrystallized algal blades. Also present in minor amounts is brachiopod, mollusk, foraminifer, ostracode, bryozoan, and pelmatozoan debris. The recrystallized algal blades have the same shape and form as the common Pennsylvanian genus Archaeolithophyllum. Some of these areas have a faint cell structure remaining, indicating this genus. Many grains have a thick coating, as shown in Plate 7, fig. B, upper right. These may be oncoliths formed from encrusting algae. Some recrystallization to microspar has occurred along with scattered dolomite rhombs. Other irregular sparry calcite areas may be filled burrows.

The stone was quarried to produce road-base aggregate and bituminous and concrete aggregate for local roads and building construction.

STOP 3

A well-exposed section of the Lecompton can be examined in the roadcut along both sides of State Highway 99 north of the Cimarron River bridge. It is in the C W½ sec. 28, T. 19 N., R. 7 E., 3/4 mile north of Oilton, Creek County, Oklahoma, 9 miles from Stop 2. The unit crops out for several hundred yards along the roadcut, so it can be studied in considerable detail.

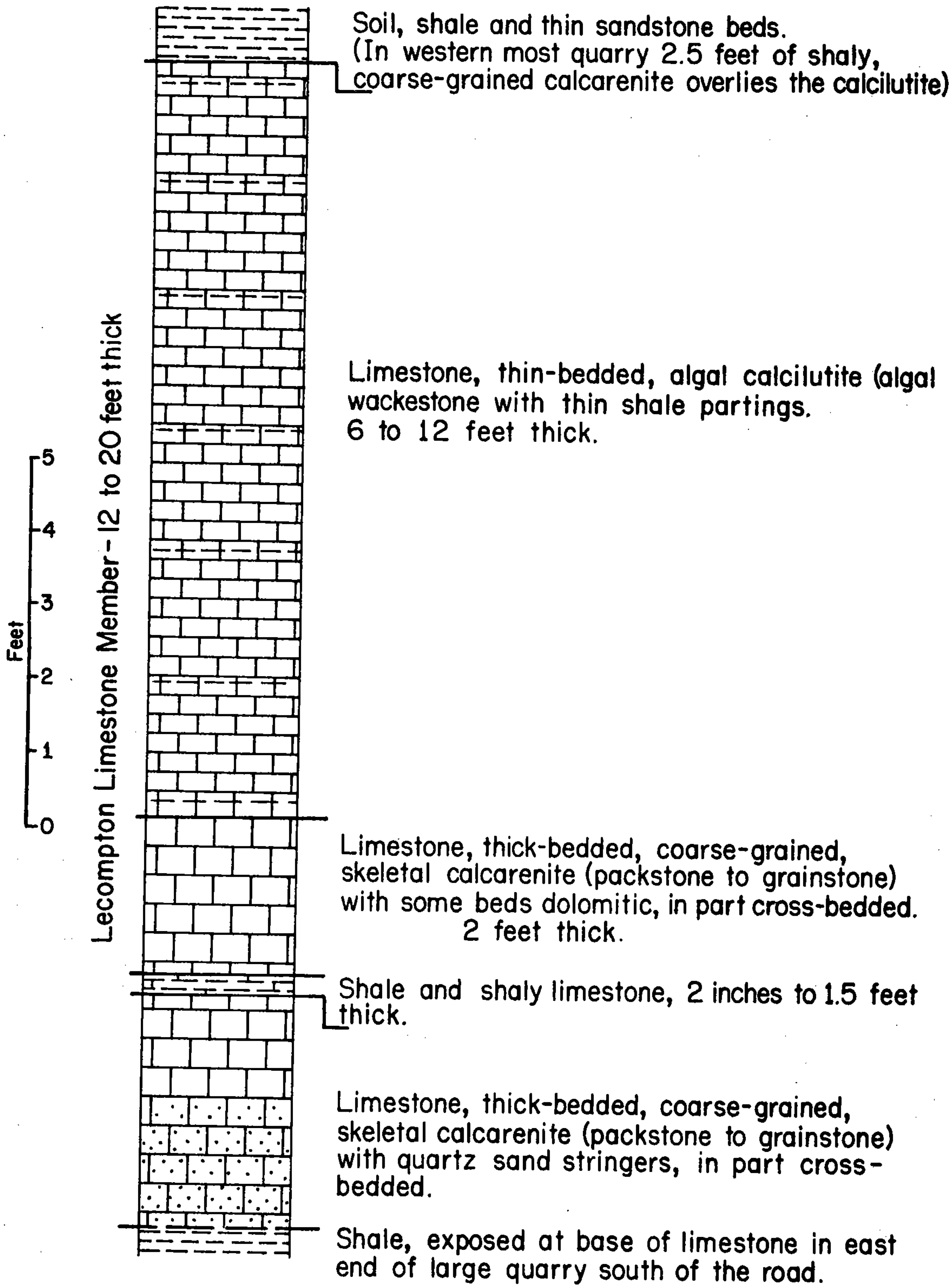
At this locality the Lecompton is 12 feet thick. It is composed of a lower 4 feet of dolomite, a middle 4 feet of limestone with shale partings, and an upper 4 feet of dolomite (fig. 12). Shale underlies and overlies the unit. Plate 6, fig. A, shows the west outcrop of the highway cut. The lower, darker beds are dolomite, the middle, lighter beds are limestone, and the upper, darker beds are dolomite.

The basal 4 feet consists of thin- to medium-bedded, fine- to coarse-grained, skeletal, micritic dolomite. The lower 1 foot is separated from the overlying 3 feet by shale containing dolomite and limestone nodules. This lower 1-foot bed is quartz sandy.

Plate 7, fig. C, shows the basal bed at Stop 3. It is a quartz-sandy, skeletal, micritic dolomite, consisting of fine to coarse grains set in dolomite with some

FIGURE II

COMPOSITE GENERALIZED STRATIGRAPHIC SECTION
LECOMPTON LIMESTONE MEMBER
Three abandoned quarries, sections 25 and 36, T. 20N., R. 7 E.
STOP 2



micrite and microspar. Skeletal debris of pelmatozoans, brachiopods, mollusks, and other invertebrates is present, and the larger clasts shown in the photomicrograph are probably the intraclasts now replaced by dolomite. Some pelmatozoan debris is also replaced by dolomite.

The dolomite above the shale is a fine- to coarse-grained, skeletal, micritic dolomite. Skeletal debris includes pelmatozoans with some mollusks and brachiopods all floating in a matrix of fine to medium dolomite and micrite. Plate 7, fig. D, shows pelmatozoan debris partially replaced by dolomite. Darker areas between rhombs are micrite.

The middle limestone beds grade from the underlying dolomite. Plate 7, fig. E, shows this gradation; this bed consists of fine to coarse, skeletal, algal, dolomitic wackestone. The photomicrograph shows fine to medium dolomite partially replacing the algal oncoliths and replacing the micrite matrix of the wackestone.

The beds above the basal dolomitic wackestone consist of skeletal, algal wackestone like the algal beds at Stop 2. Plate 7, fig. F, shows one of these beds, a fine- to coarse-grained, skeletal, algal wackestone. The clast that may be an algal oncolith is shown in fig. E, along with recrystallized algal blades in the upper part of the photomicrograph. This unit grades upward into more of a skeletal calcarenite.

The upper beds consist of medium- to coarse-grained, skeletal dolomite (pl. 8, fig. A). The detailed relationship with the underlying limestone is unknown.

Figure 12 is a generalized stratigraphic section of the roadcut. Only the gross features are noted, as the detailed relationships have not yet been studied.

STOP 4

Location: SW and NW Sec. 9, T18N, R7E, Creek County, on Oklahoma Highway 99, approximately 4.2 to 4.6 mi north of intersection with Oklahoma Highway 33 at Drumright

Exposure: Upper part of sandstone sequence and overlying shale in 2 roadcuts

Structural Dip: Gentle; approximately 2° northwest

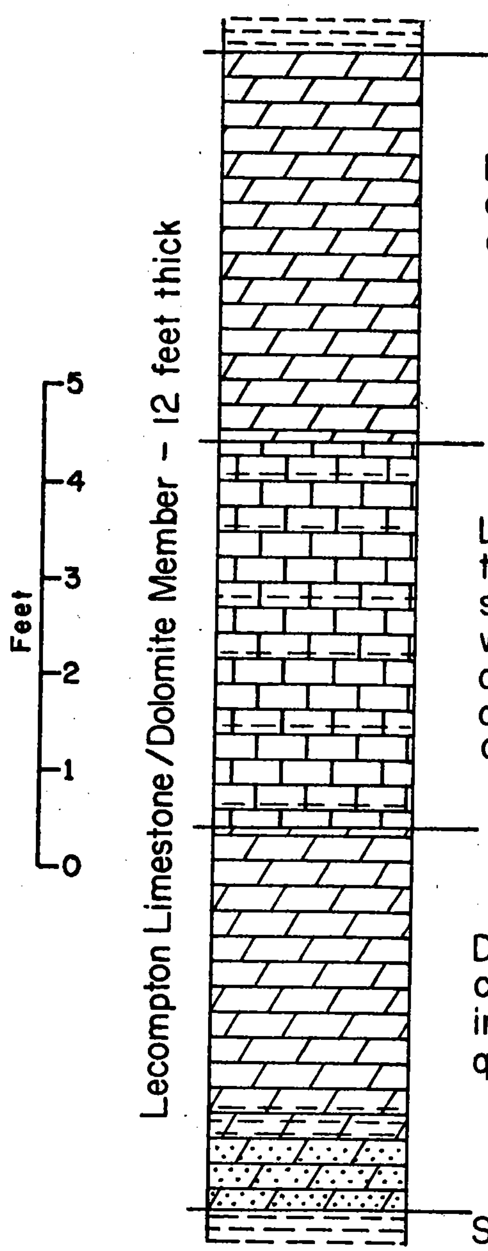
Formation: Elgin sandstone and overlying unnamed shale (of upper unit), Vamoosa Formation

Description: Massive and crossbedded sandstone (in southern exposure); overlying maroon and gray shale with fossiliferous sandstone and very narrow sandstone lens

Depositional Environment: Alluvial-plain sandstone and shallow marine to prodeltaic shale with distributary sandstone

FIGURE 12

GENERALIZED STRATIGRAPHIC SECTION
LECOMPTON LIMESTONE/DOLOMITE MEMBER
HIGHWAY 99 ROADCUT
North of the Cimarron River in section 28, T. 19N., R.7E.
STOP 3



Shale and overlying thick sandstone.
(Not measured)

Dolomite, thick-bedded, fine to medium-grained, with scattered coarse skeletal debris. 4 feet thick.

Limestone and dolomitic limestone, thin to medium-bedded, fine to coarse-grained, skeletal, algal calcilutite (algal wackestone) with thin shale partings. Basal beds are calcitic dolomite as grades from lower dolomite unit. Grades upward into a skeletal calcarenite. 4 feet thick.

Dolomite, thin to medium-bedded, fine to coarse-grained, skeletal, micritic. Grades into limestone above. Basal beds are quartz sandy. 4 feet thick.

Shale, dark gray, fissile.

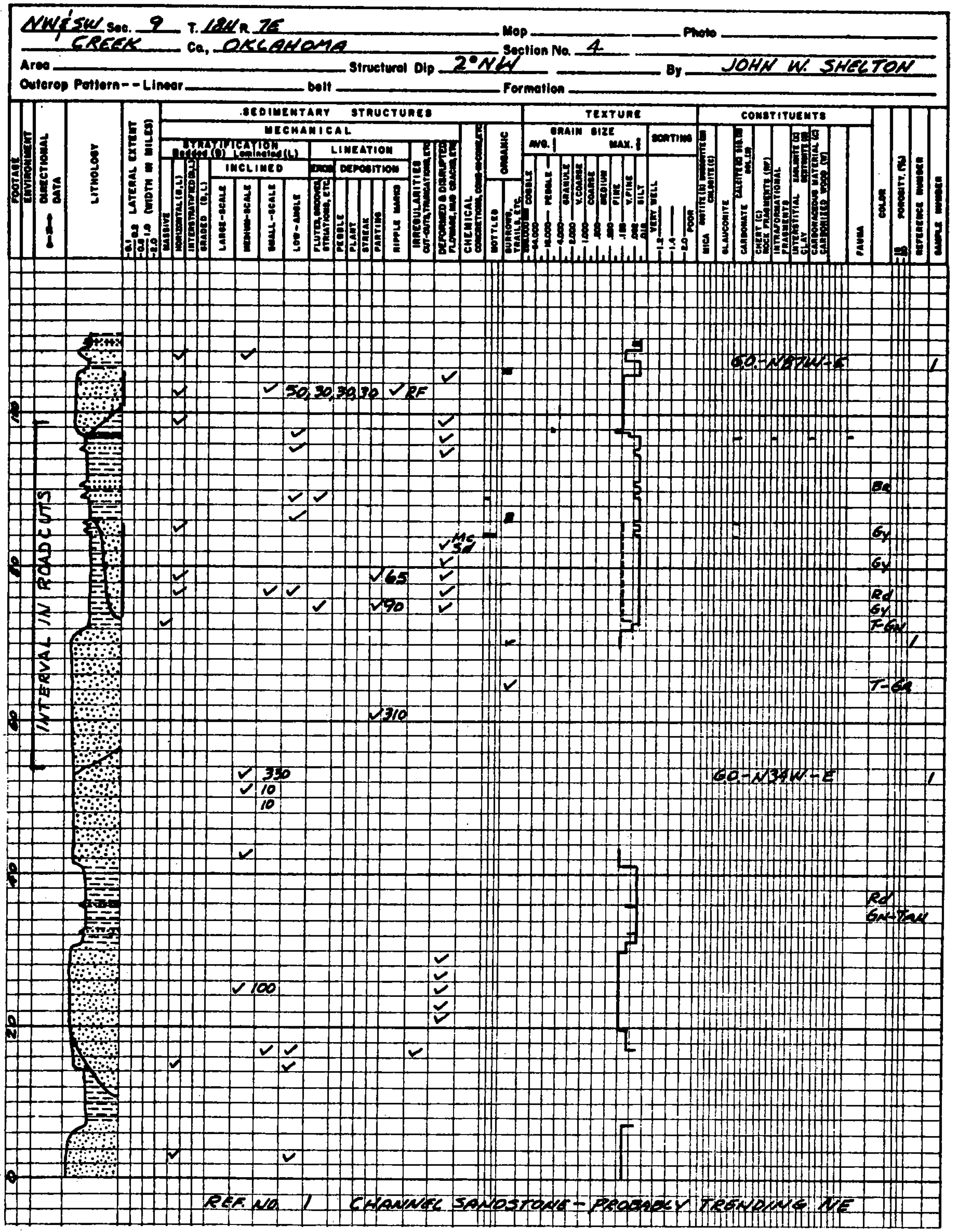


Fig. 13.--Measured section of the upper part of the Elgin Sandstone and overlying section of shale and sandstone (of upper unit of Vamoosa Formation). Alluvial-plain sandstone is overlain abruptly by maroon shale which grades upward into a bluish-gray unit. An overlying sequence of interbedded shale and sandstone contains a thin fossiliferous sandstone and 2 lenticular sandstones, one of which locally cuts out most of the underlying shale. See Plate 2, figs. C, D, E, and F for photographs of section.

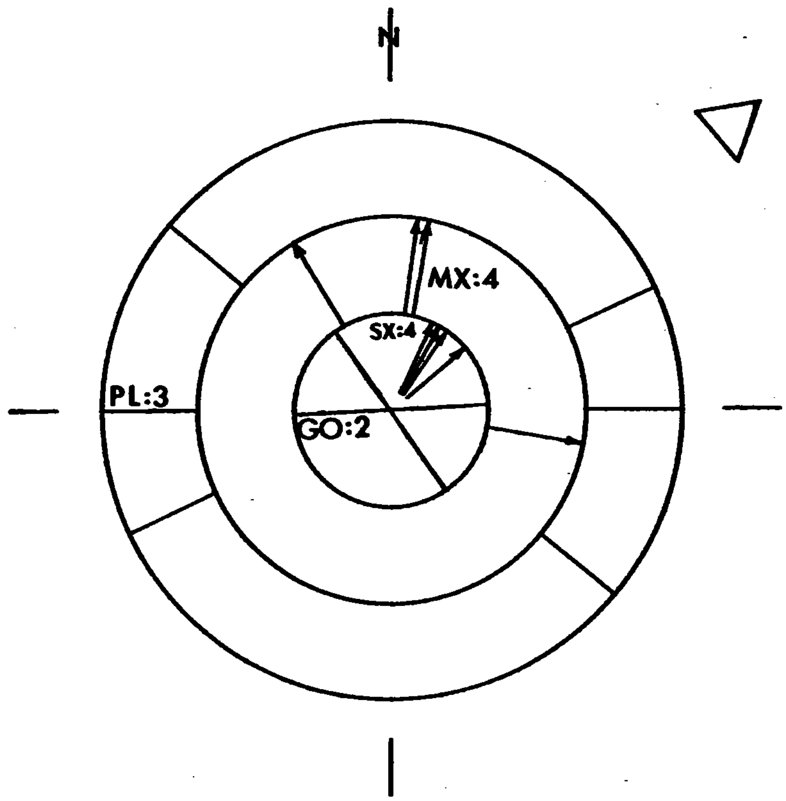


Fig. 14.--Paleocurrent diagram indicates a combined average direction of N50°E for the alluvial sandstone and overlying deltaic sandstone at Stop 4.

STOP 5

Location: NW NW Sec. 4 and NE NE Sec. 5, T17N, R7E, at intersection of Oklahoma Highways 33, 99, and 16, east of Drumright, and SW Sec. 33, T18N, R7E, .5 mi east of intersection on Highway 33

Exposures: Upper part in roadcut at prominent intersection and lower part in eastern roadcut on both sides of Highway 33.

Structural Dip: Gentle, as much as 3° to the west

Formation: Elgin Sandstone Member, Vamoosa Formation, and lower part of overlying upper unit, Vamoosa Formation

Description: Section of sandstone (upper unit) cutting downward into marine shale, with small channel in uppermost part of subjacent Elgin Sandstone, which consists of a very fine-grained, narrow sandstone below medium- to coarse-grained sandstone.

Depositional Environment: Alluvial plain overlying deltaic distributary for Elgin Sandstone; prodeltaic shale, with tidal-creek channel (at top of Elgin Sandstone) and deltaic distributary for upper unit of Vamoosa

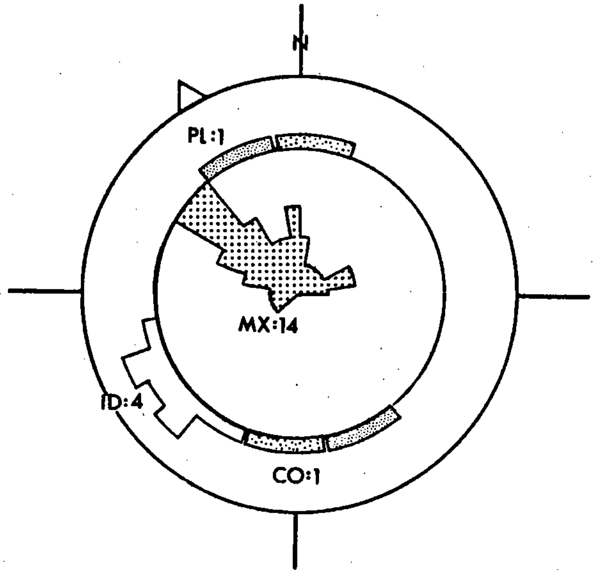


Fig. 15.--Composite paleocurrent diagram of alluvial-plain and distributary sandstones in Elgin Sandstone showing an average direction of N30°W.

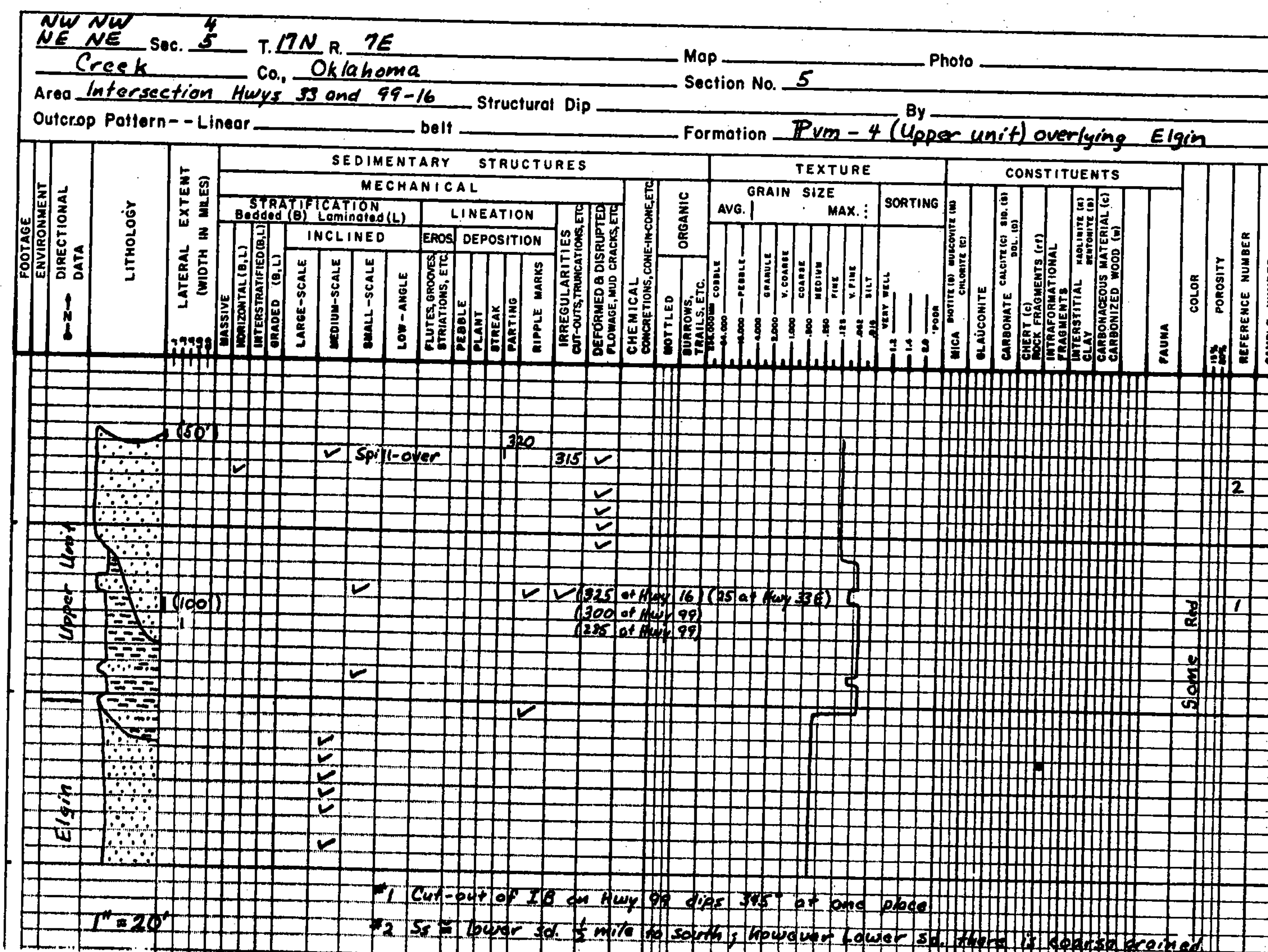


Fig. 16.--Measured section of the lower part of upper unit, Vamoosa Formation, and underlying Elgin Sandstone, showing two major sandstone bodies and intervening shale.

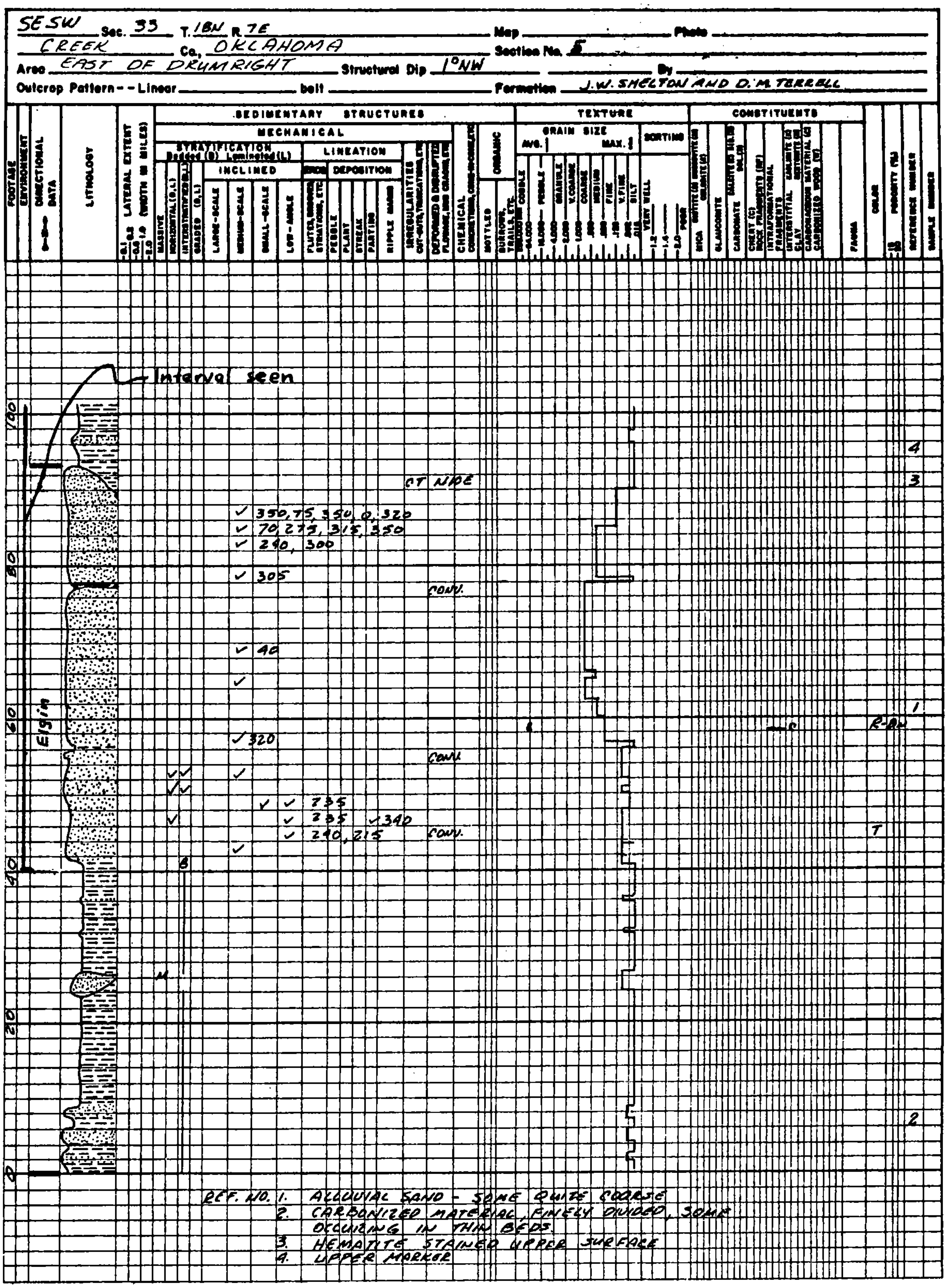


Fig. 17.--Measured section of Elgin Sandstone, which exhibits a regressive sequence with coarse-grained alluvial-plain sandstone overlying a fine-grained, lenticular distributary sandstone. The latter overlies a poorly exposed sequence of prodeltaic and delta-fringe units. Sharp, irregular top of alluvial-plain sandstone is due to subsequent, minor transgression, See Plate 3 for photographs of section.

STOP 6

The Lecompton is well exposed in many abandoned faces at this locality. The Quapaw Stone Company is presently working the Lecompton in this area. The plant and quarry are in the E½ sec. 34, W½ sec. 35, and W½ sec. 26, T. 18 N., R. 7 E., 2½ miles east of Drumright, Creek County, Oklahoma (fig. 10). Many of the previously abandoned faces have now been filled, as the land is being reclaimed, while quarry operations proceed.

Throughout the quarry area the Lecompton is 10 to 12 feet thick. About 11 feet is quarried, the basal 1 foot being left as quarry floor. It is underlain by shale and overlain by soil, shale, and sandstone. Plate 6, fig. B, shows one of the abandoned quarry faces along a haulage road.

At this locality the Lecompton is composed of fine- to coarse-grained, thin- to medium-bedded dolomite with some remnant pelmatozoan debris and abundant, variously sized vugs. Shale partings are also present, and a few shale stringers are noted in the dolomite beds. Plate 8, fig. D, shows the texture and vuggy nature of the dolomite. Figure 18 is a generalized stratigraphic section of the Lecompton from the quarries.

The stone is worked by the Company to produce construction aggregate, as the Lecompton makes a good, tough grade of aggregate.

STOP 7

The Lecompton is exposed in the west borrow ditch along State Highway 16, 0.4 mile north of Shamrock, in the NE¼ NE¼ NE¼ sec. 32, T. 17 N., R. 7 E., Creek County, Oklahoma.

At this locality the Lecompton consists of 1 bed 1½ feet in thickness. This bed is fine- to coarse-grained, quartz silty and sandy, skeletal dolomite. The grains are set in dolomite and consist of pelmatozoan debris either totally or partially replaced by dolomite. Scattered quartz silt and sand is present, and some larger coarse, rounded dolomite areas may be dolomitized micrite intraclasts. This bed may be the same as the basal bed at Stops 2 and 3; it certainly is in the lower stratigraphic portion of the unit. Plate 8, figs. E and F, show the general texture of this bed and the partial replacement of skeletal debris.

SUMMARY

In the Jennings-Shamrock area the Lecompton Member ranges in thickness from 20 feet to 1½ feet. It is composed of limestone in the Jennings area (Stop 2), where it is 20 feet thick. It goes completely to dolomite southward, where it has a consistent thickness of 10 to 12 feet (Stop 3 and south of Stop 6). However, it is only 1½ feet thick just north of Shamrock.

Both grain-supported and mud-supported limestones are present in the Lecompton, and some shale interbeds also occur. Quartz sand and silt grains are common in the basal beds. Dolomite textures range from fine to coarse mosaics, some with filled voids and others with open vugs. The dolomite also has thin shale partings.

Figure 18

COMPOSITE GENERALIZED STRATIGRAPHIC SECTION
LECOMPTON DOLOMITE
QUAPAW STONE COMPANY QUARRIES
Sections 34 and 35, T. 18 N., R. 7 E.
STOP 6

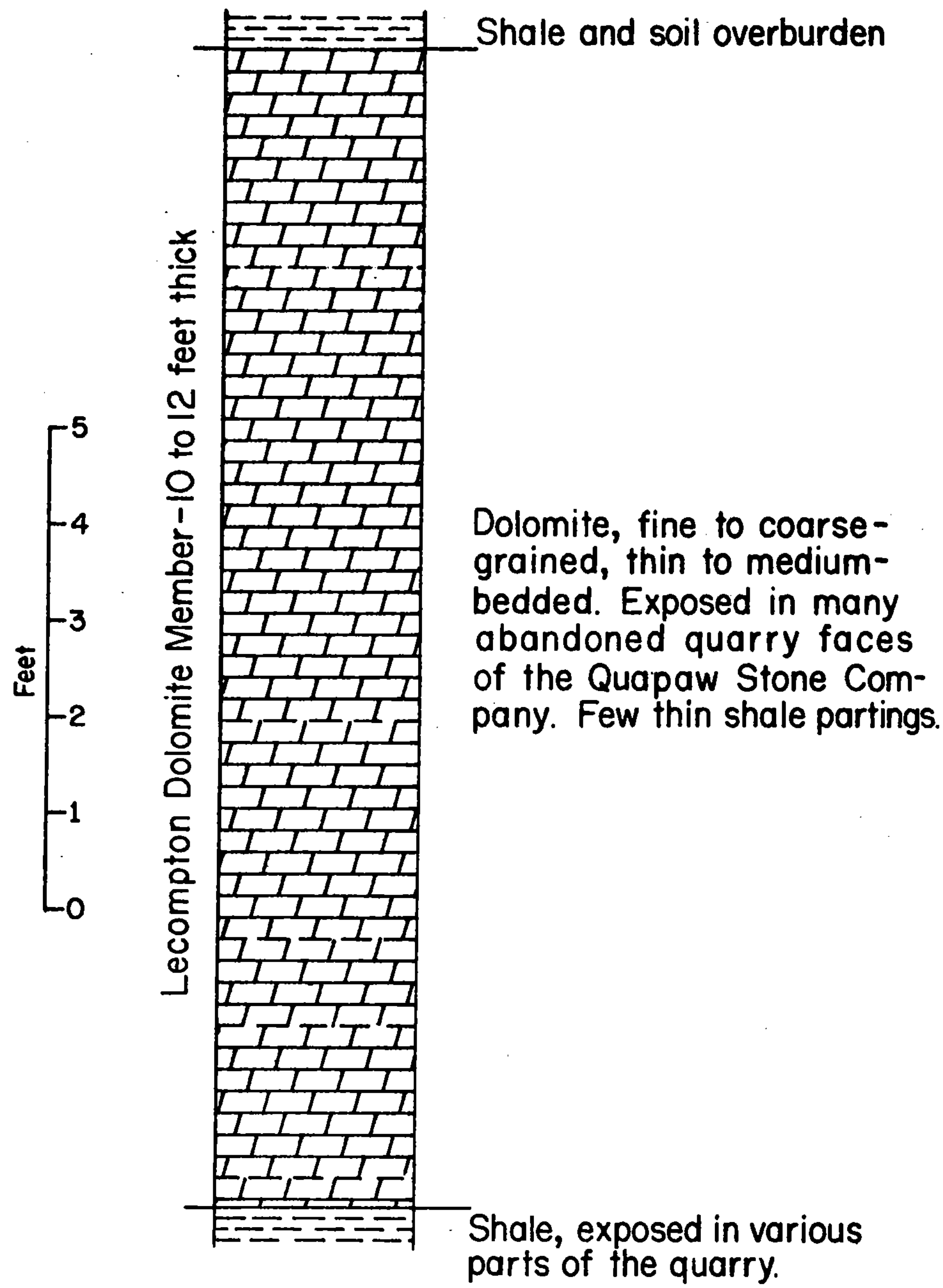


Figure 19 shows generalized stratigraphic relationships in the field-trip area. Southward the upper part of the section goes to shale; it is thought that the lowermost bed of intraclastic grainstone at Stop 2 (pl. 7, fig. A) is in the same stratigraphic interval as the basal dolomite bed at Stop 3 (pl. 7, fig. C) and the 1½-foot dolomite bed at Stop 7 (pl. 8, figs. E, F). In some parts of the southern area a quartz-silty, dolomitic siltstone to quartz-silty dolomite a few inches thick forms the very base of the Lecompton.

The depositional environment of the basal beds in the Jennings area probably represents well-winnowed, subtidal-shelf conditions, and the crossbeds may represent tidal channels cutting the shelf. The overlying algal beds may represent shallow subtidal to low intertidal environments. Much of the algal material is probably Archaeolithophyllum, a common Pennsylvanian genus. This alga is usually found in rocks representing shallow subtidal to intertidal zones (Wray, 1964). Burrowing may have also occurred, as many irregular areas filled with sparry calcite probably represent the filling of burrows. In a more detailed study the rocks will be closely examined for these types of features and others that are indicative of these environments.

The dolomite portion of the Lecompton undoubtedly is a dolomitization of the northern limestone facies, as partial dolomitization of these beds can be seen at Stop 3 (pl. 7). The time and mechanisms of the dolomitization are as yet unknown.

It must again be emphasized that this report is only preliminary. The more detailed study now under way may change the interpretations of the gross lithostratigraphic framework and generalized depositional environments given here.

STOP 8

Location: SE SW Section 33, T.17N, R7E, along Highway 16, Southeast of Shamrock, Creek County

Exposure: Roadcut on north side of road

Structural Dip: Gently to the west

Formation: Upper unit, Vamoosa Formation

Description: Sandstone with shale. The main sandstone unit (20 ft thick) cuts downward into underlying shale and is channeled itself by an overlying shale

Depositional Environment: Deltaic channel for prominent sandstones; tidal flat and channel for thin sandstones and shale.

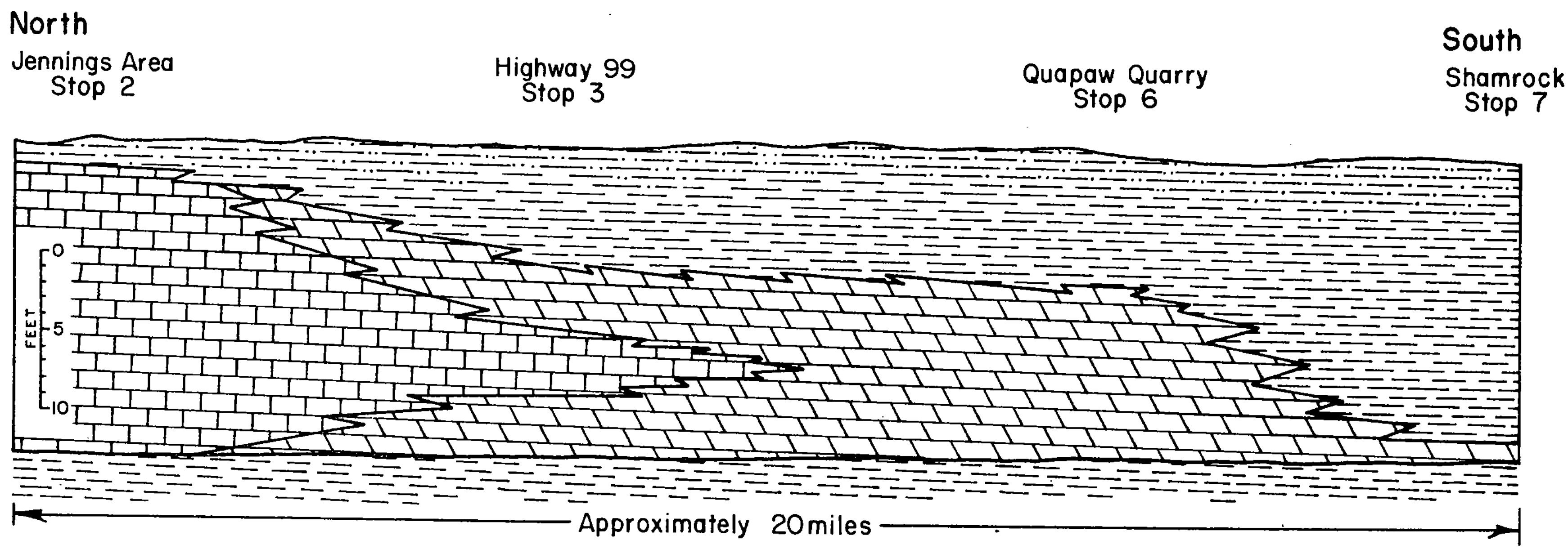


Figure 19
GENERALIZED STRATIGRAPHIC RELATIONSHIP OF THE LECOMPTON MEMBER (PAWHUSKA FORMATION) JENNINGS – SHAMROCK AREA, OKLAHOMA

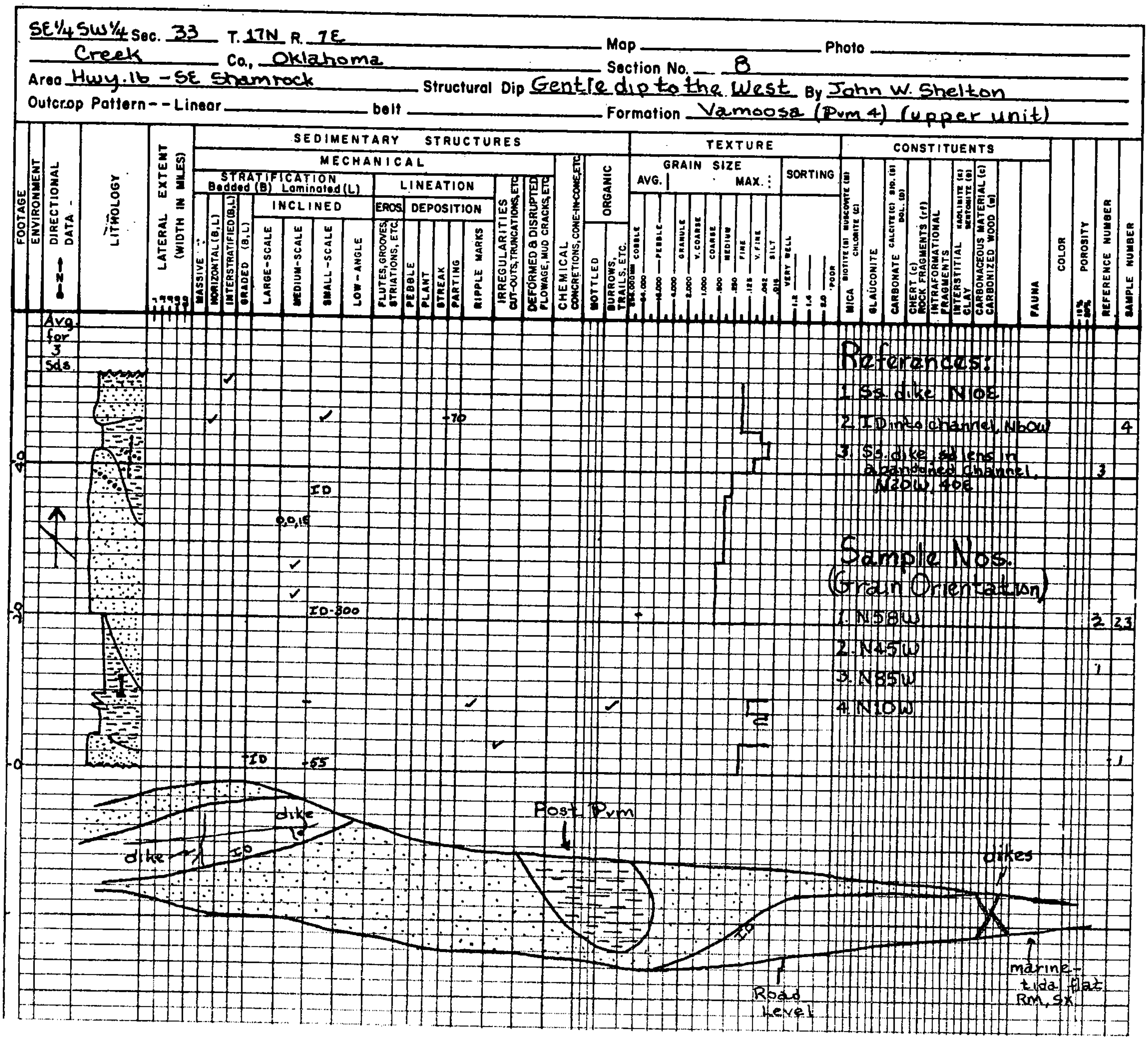


Fig. 20.--Measured section of part of upper unit, Vamoosa Formation, and a sketch of the roadcut. See Plate 4, figs. A, B, C, and D, for photographs of section.

STOP 9

Location: SW SW SW Sec. 4, T5N, R15E, on U. S. Highway 270, approximately .2 mi east of U. S. Highway 69, just east of McAlester

Exposure: Roadcut on north side of highway

Structural Dip: Approximately 10° west

Formation: Unnamed sandstone, Savanna Formation

Description: Narrow sandstone body composed of lenticular sandstone beds overlying shale with thin coal

Depositional Environment: Deltaic distributary sandstone overlying thin delta-fringe (interdistributary bay) or flood-basin sandstone

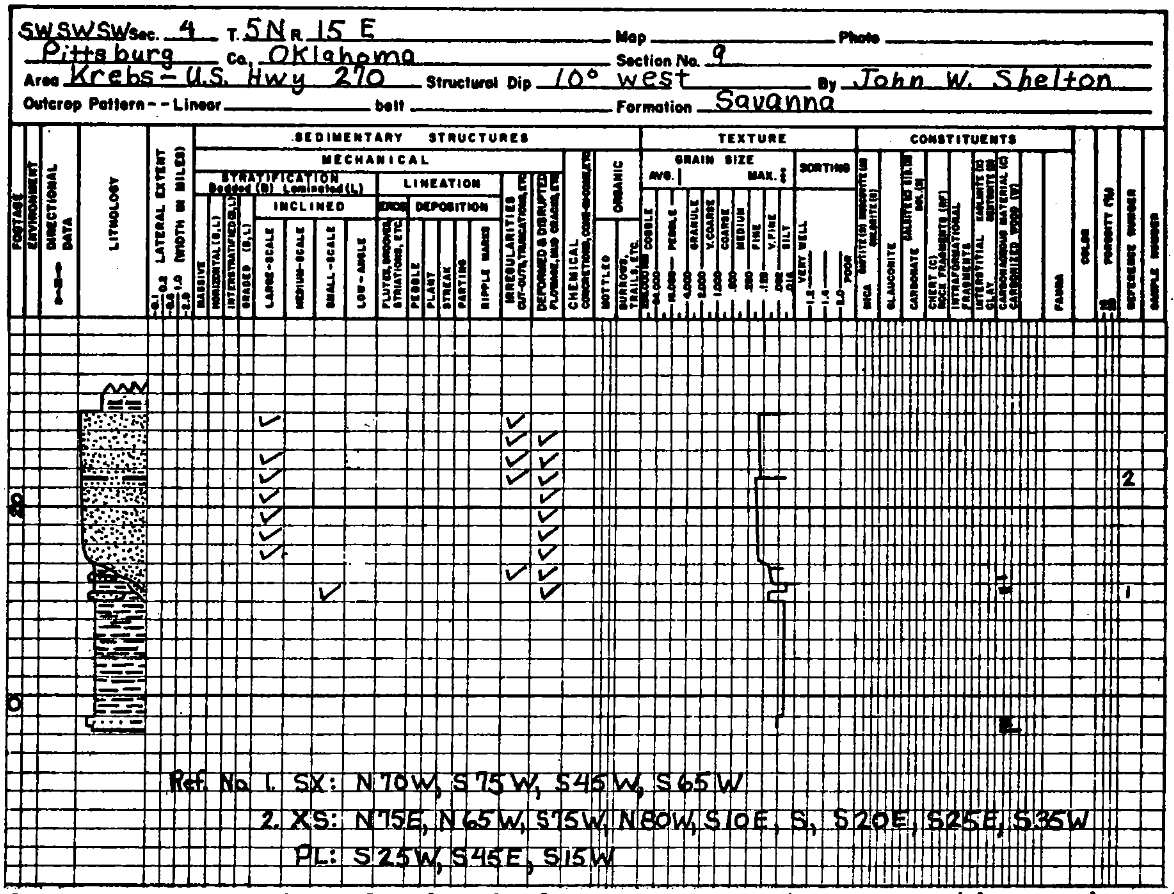


Fig. 21.--Measured section of a lenticular Savanna sandstone, a thin section of interbedded sandstone and shale, in descending order. See Plate 4, figs. E and F, for photographs of section.

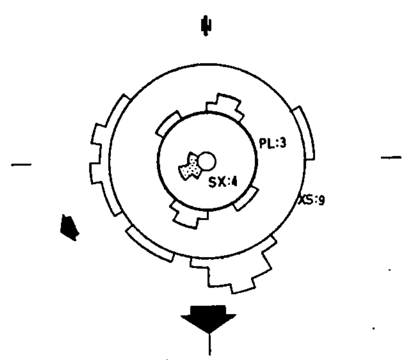


Fig. 22.--Paleocurrent diagram indicates a southerly direction for lenticular, channel sandstone and a west-southwesterly direction (small arrow) for the underlying thin delta-fringe or flood-basin sandstone.

PLATE 2

Fig. A.--Interstratification and gradational base of a sandstone in the upper unit, Vamoosa Formation at Stop 1. Roadcut is approximately 15 ft high.

Fig. B.--Interstratification, horizontal bedding, and sole marks (sm), at Stop 1. Approximately 8 ft of sandstone section is exposed.

Fig. C.--General view of Elgin Sandstone at southern roadcut at Stop 4. Small-scale channel (c) is present at top of alluvial-plain sandstone. Sharp upper contact is associated with minor transgression.

Fig. D.--View of the northern roadcut at Stop 4, where a very lenticular sandstone, deposited by a small distributary, is developed in the shale overlying the Elgin Sandstone.

Fig. E.--Uppermost part of Elgin Sandstone with sharp top at Stop 4. Burrows (b) in sandstone near hammer.

Fig. F.--Sharp base of small distributary sandstone, which is characterized by horizontal bedding below convolute bedding at Stop 4.

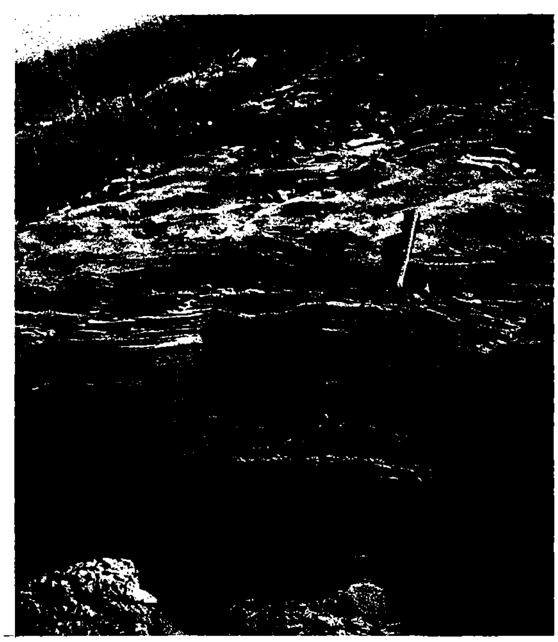
A

B

C

D

E



F

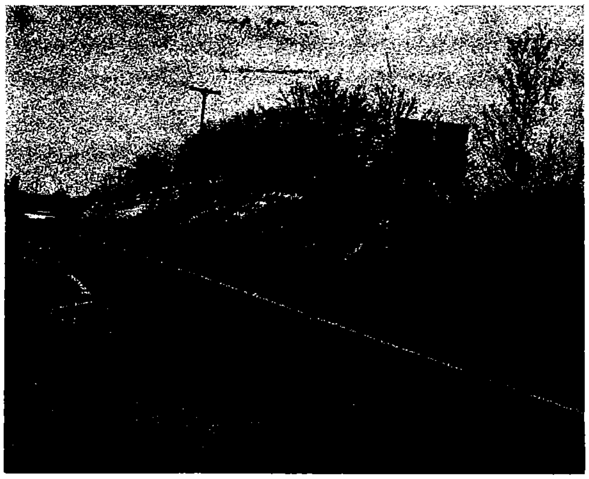
PLATE 3

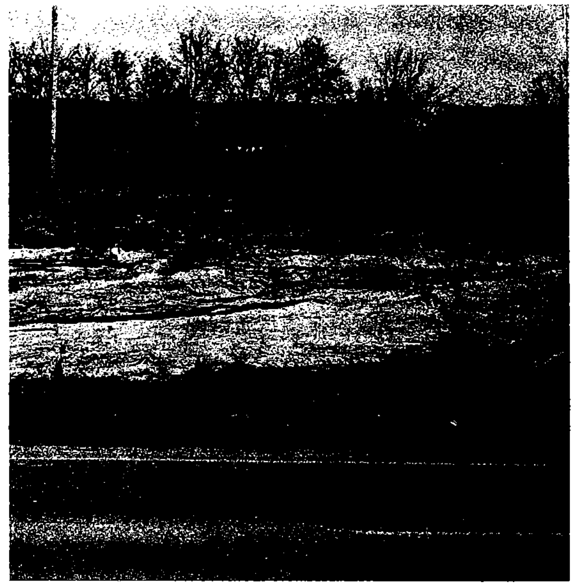
Fig. A.--General view of distributary sandstone in Elgin sandstone at Stop 5. View is toward the west. Edge of sandstone is at highway sign; sandstone shows prominent westerly initial dip.

Fig. B.--General view of Elgin Sandstone (looking north) at Stop 5, where distributary sandstone, with sharp base and initial dip, is overlain by the lower part of an alluvial-plain sandstone. Height of roadcut is approximately 20 ft.

Fig. C.--Prominent set of initial dip, at hammer, above crossbedding with different orientation in distributary sandstone at Stop 5.

Fig. D.--Erosional contact between coarse-grained alluvial sandstone and the lighter colored, fine-grained distributary sandstone at Stop 5.


A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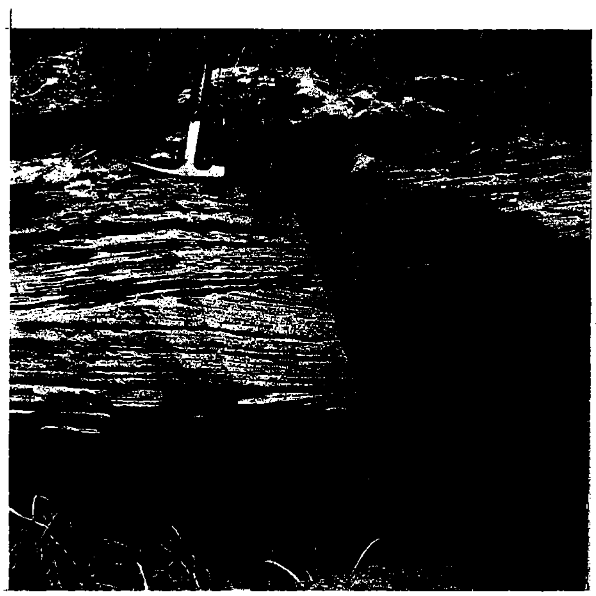

C


D

PLATE 4

Fig. A.--Sandstone dikes in shale below most prominent sandstone, upper unit, Vamoosa Formation at Stop 8. Dike trend is northerly.

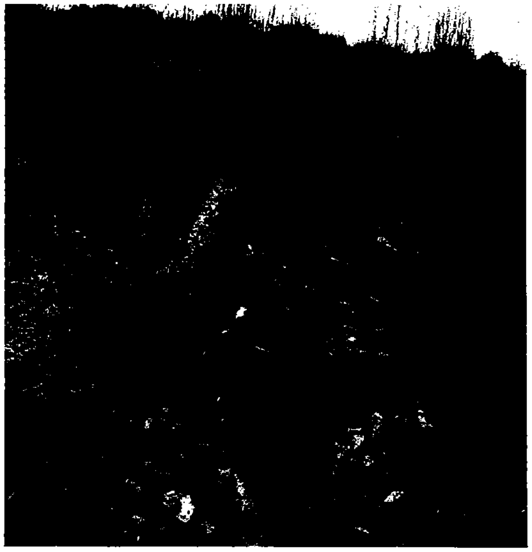
Fig. B.--Base of most prominent (distributary) sandstone at Stop 8 exhibits channeling into underlying shale.

Fig. C.--Deformed festoon, medium-scale crossbedding in most prominent distributary sandstone at Stop 8.

Fig. D.--Erosional top of most prominent sandstone, with small tidal-creek channel filled with shale and thin sandstones at Stop 8. Base of overlying distributary sandstone overlies tidal-flat deposits.

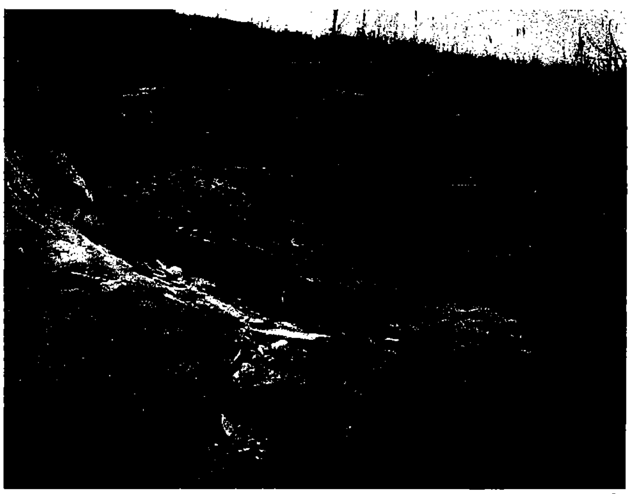
Fig. E.--Distributary sandstone with deformed trough cross-stratification in a Savanna sandstone, Stop 9.

Fig. F.--Thin delta-fringe, or flood-basin, units underlie distributary sandstone at Stop 9.



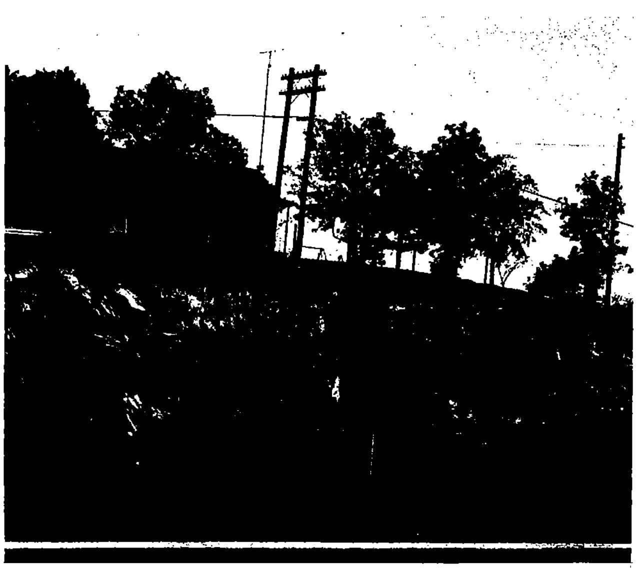
A

B



C

D



E

F

PLATE 5

Fig. A.--Abandoned east quarry face north of section-line road, Stop 2. Upper thin beds are algal calcilutite (upper part of photo) in contact with lower thicker beds of calcarenite (bottom part of photo).

Fig. B.--Close view of crossbedding in bottom thicker calcarenites at Stop 2. This face is in quarry south of road. Hammer rests on first bed of overlying algal limestone.

A

B

PLATE 6

Fig. A.--West side of roadcut along State Highway 99, Stop 3. Lower darker beds are dolomite, middle lighter beds are limestone, and upper darker beds are dolomite.

Fig. B.--Abandoned quarry face along haulage road at Stop 6. Unit consists of 10-12 feet of dolomite with thin shale partings.

A

B

PLATE 7

Fig. A.--Basal bed at Stop 2. Medium to coarse, skeletal intraclastic grainstone. Rounded dark areas are micrite intraclasts, some showing partial recrystallization. At middle right is a pelmatozoan fragment. Whitish subrounded grains are quartz sand; sparry calcite cement is in light areas between grains.

Fig. B.--From upper algal limestone, Stop 2. Skeletal, algal wackestone. Skeletal hash set in micrite matrix. Recrystallized algal blades in upper left. Coarse rounded grains in upper right may be algal oncolith. Some lighter areas may represent recrystallization or filled burrows.

Fig. C.--Basal bed, Stop 3. Fine- to coarse-grained, quartz-sandy, skeletal, micritic dolomite. Light subangular grains are quartz sand, and larger rounded clast of dolomite may be dolomitized intraclast and pelmatozoan debris. Some darker matrix is micrite.

Fig. D.--Bed from above shale in lower 4 feet, Stop 3. Fine- to coarse-grained, skeletal, micritic dolomite. Pelmatozoan debris, upper left and right, partially replaced by dolomite. Light small grains are dolomite, whereas darker fine material is micrite.

Fig. E.--Basal bed of middle limestone, Stop 3. Fine- to coarse-grained, skeletal, algal, dolomitic wackestone, fine to medium dolomite replacing micrite matrix. Dark rounded clasts are partially replaced by dolomite, and these clasts may be algal oncoliths.

Fig. F.--Bed from middle limestone, Stop 3. Fine- to coarse-grained, skeletal algal wackestone. Clasts in lower part of photograph may be algal oncoliths. Light areas in upper part are recrystallized algal blades. Mollusks fragment at upper left.

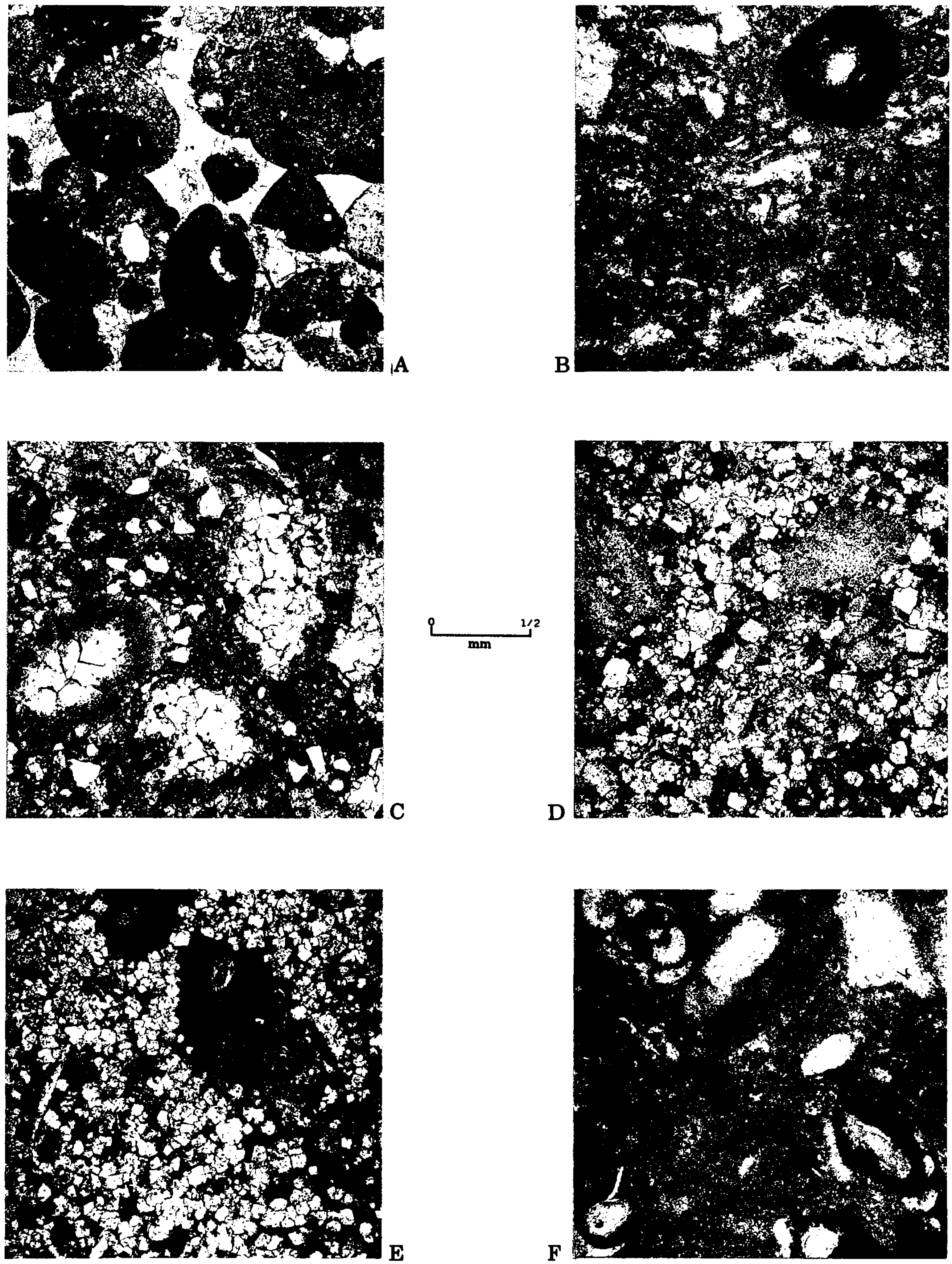

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PLATE 8

Fig. A.--From upper dolomite beds, Stop 3. Medium- to coarse-grained, skeletal dolomite. Mosaic of dolomite with floating pelmatozoan debris. Many are only ghosts of original pelmatozoan hash.

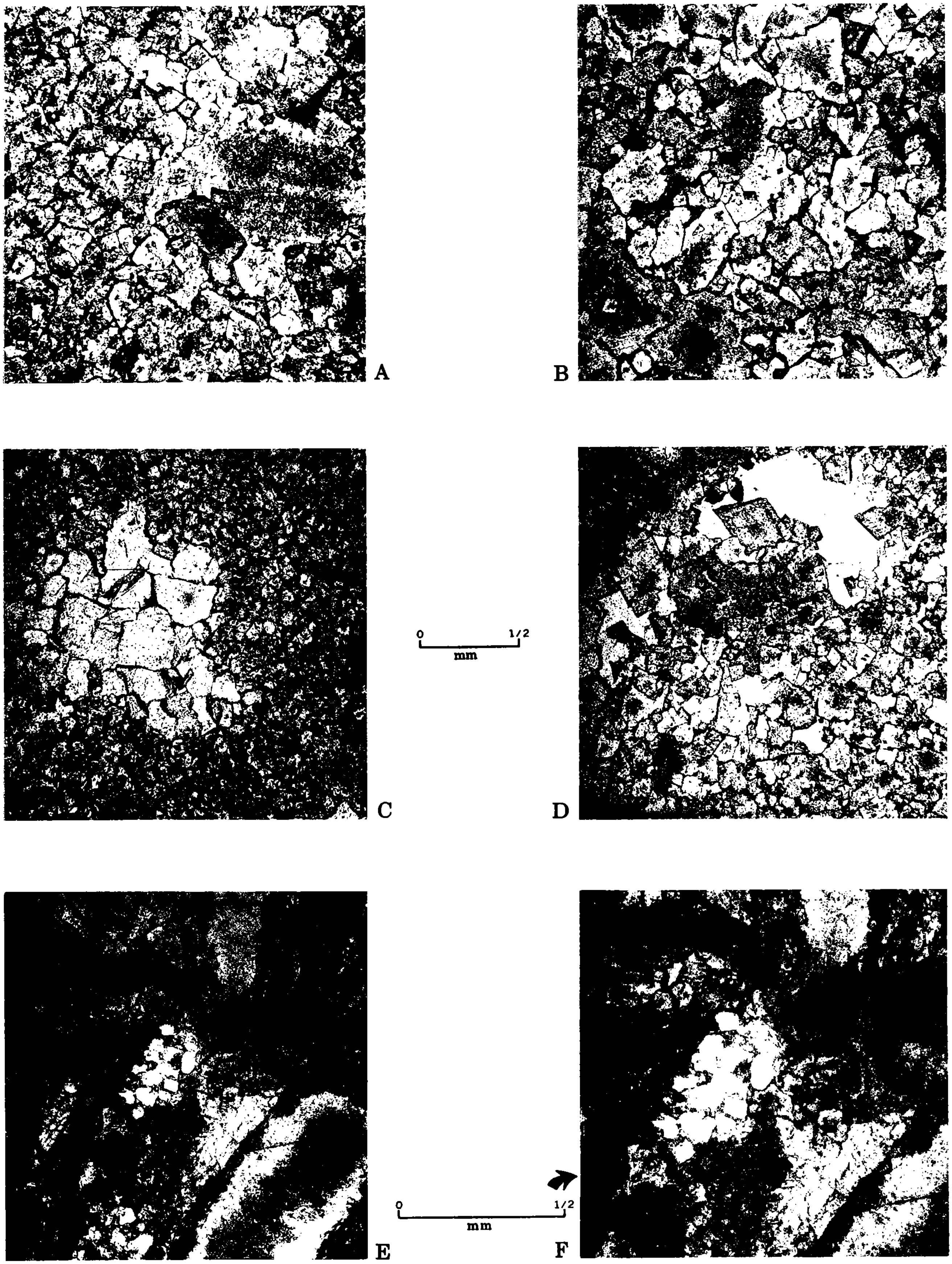
Fig. B.--From abandoned quarry in sec. 11, T. 18 N., R. 7 E., Creek County, Oklahoma. Dolomite shows remnant pelmatozoan debris, much like texture in fig. A.

Fig. C.--From same locality as fig. B. Texture shown in this photo is finer grained, and a void is filled with coarse dolospar. Possibly a dissolved pelmatozoan fragment caused the void.

Fig. D. From Quapaw Stone Company quarry, Stop 6. Fine to coarse, vuggy texture of dolomite.

Fig. E. From 1½-foot bed of Lecompton at Stop 7. Light subangular grains are quartz silt, whereas larger light areas are dolomite. Partial replacement of pelmatozoan debris and intraclast (upper left) are also shown.

Fig. F.--Close view of fig. E, showing details of partial replacement of pelmatozoan fragments and intraclasts (X60).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DEPOSITIONAL FACIES IN THE WAPANUCKA FORMATION (LOWER PENNSYLVANIAN) IN THE HARTSHORNE-WILBURTON AREA, OKLAHOMA

T. L. Rowland

INTRODUCTION

The type Morrowan (Early Pennsylvanian) on the south flank of the Ozark dome is represented by limestones, sandstones, and shale, of which the limestones are typical of the shelf environment. They consist dominantly of oolitic bryozoan, pelmatozoan, grain-supported calcarenites, either well washed, and calcite cemented, or with a micrite matrix. The calcarenites are interbedded with calcilutites and skeletal mudstones. Phylloid algae are locally common, and in a few places calcilutite mounds of low relief are present. Quartz sand in variable amounts is intermixed in the skeletal calcarenites, but chert is notably absent and nowhere characterizes the Morrowan limestones of this stable shelf region. The strata on the domal flank are gently tilted to the south, then dip more steeply into the Arkoma basin, where they are covered by about 10,000 feet of Atokan and Early Desmoinesian sediments.

Equivalent Morrowan limestones next crop out to the south and southwest in the Oklahoma portion of the Ouachita Mountains frontal belt and in the eastern part of the Arbuckle Mountains. Here they constitute the Wapanucka Formation. Over much of southeastern Oklahoma the Wapanucka consists of several lithologic types, including oolites, skeletal calcarenites, and algal calcilutites typical of the shelf but also including thick spiculites, mostly with a high chert content. The cherty spiculites are typical deposits of deeper basins or of the shelf-to-basin slope, thus indicating that the water depth in which some of the Wapanucka strata were deposited was generally much greater than that of the shelf.

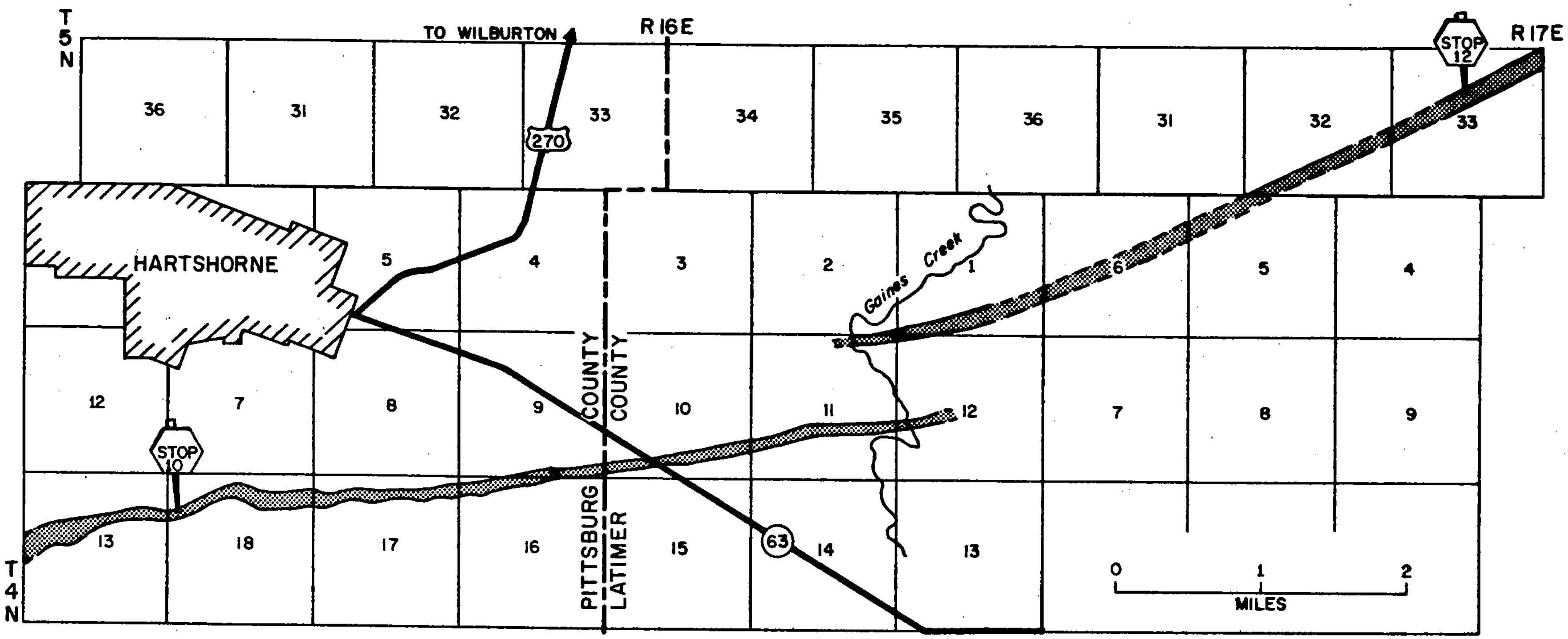
FRONTAL OUACHITA MOUNTAINS

The frontal ridge of the Ouachita Mountains consists of the Wapanucka Formation (figs. 1, 23). The Wapanucka has been studied in detail from Hartshorne, eastern Pittsburg County, to east of Wilburton, eastern Latimer County, a distance of approximately 25 miles. The formation is now being studied southwest of Hartshorne, and a manuscript is in preparation on the geology and economic mineral resources of the Wapanucka Formation.

The Wapanucka in this area has been informally divided into an upper sandstone member, a middle shale member, a limestone member, and a lower shale and limestone member. The total measured outcrop thickness ranges from 223 to 688 feet; the thickness range of each division is illustrated on Figure 24. The contact with the underlying Mississippian does not crop out, and the contact with the overlying Atoka likewise does not crop out, so the exact thickness of the formation is unknown in this area. The location of the field-trip stops and generalized outcrop of the Wapanucka is shown in Figure 23.

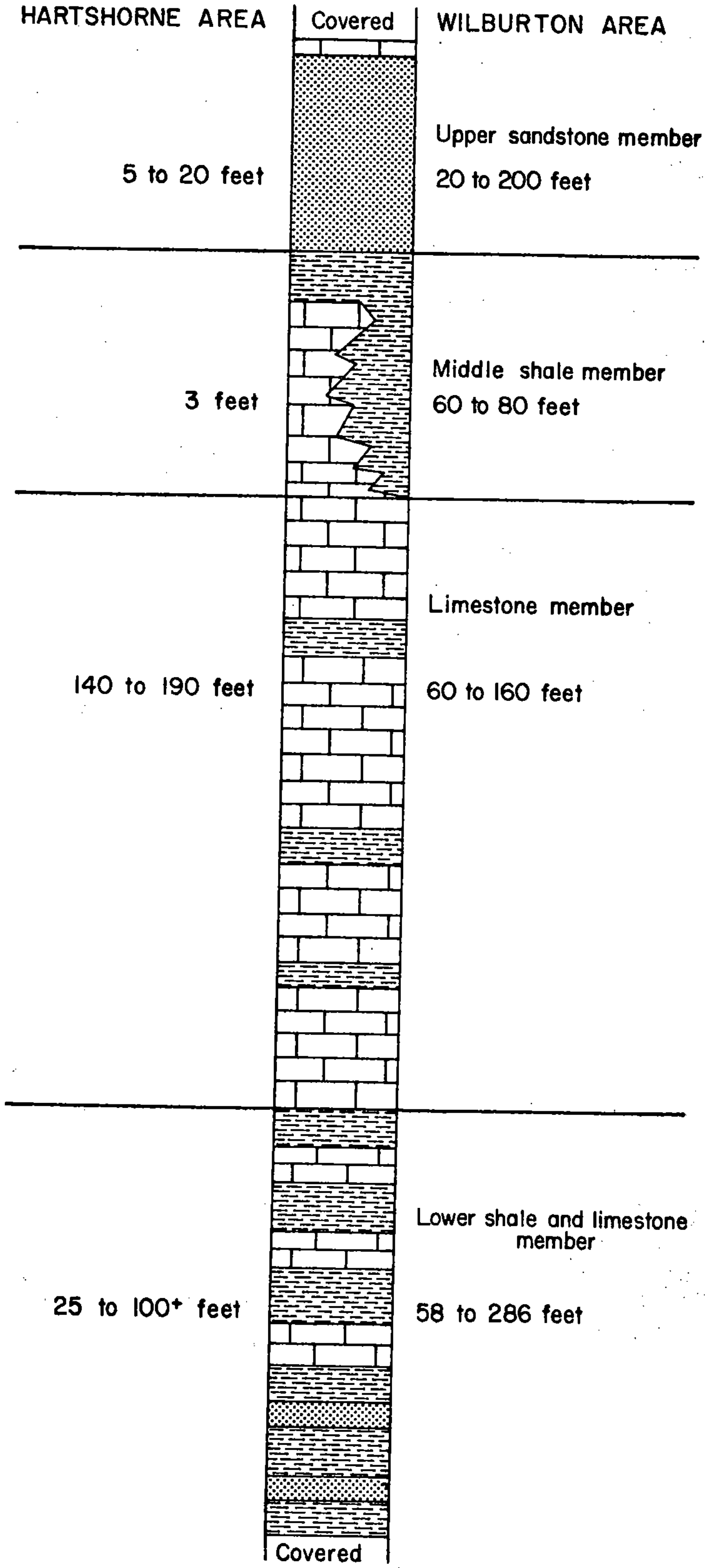
DEPOSITIONAL ENVIRONMENTS

Two stops will examine the rocks of the Wapanucka Formation: Stops 10 and 12. Rocks which have been interpreted to represent slope depositional environment and shelf environment will be seen at Stop 10, whereas only shelf-environment rocks



GENERALIZED OUTCROP MAP OF THE WAPANUCKA FORMATION, HARTSHORNE-WILBURTON AREA, OKLAHOMA
Figure 23

Figure 24
ARBITRARY DIVISIONS OF THE WAPANUCKA FORMATION
(Total thickness range 223 to 688 feet)



will be seen at Stop 12. The field trip will emphasize the limestones of the Wapanucka in the limestone and lower shale and limestone members.

STOP 10

The Wapanucka is well exposed in an abandoned quarry 1½ miles south of Hartshorne, in the S½ NE NW sec. 18, T. 4 N., R. 17 E., Pittsburg County, Oklahoma (fig. 23, pl. 12). In this area the Wapanucka is well exposed in other quarries and natural outcrops, where the limestone is 250 feet thick and consists of the lower three members. At this locality the middle shale member has been replaced by limestone, and it is gradational with the upper sandstone member (figs. 25, 28).

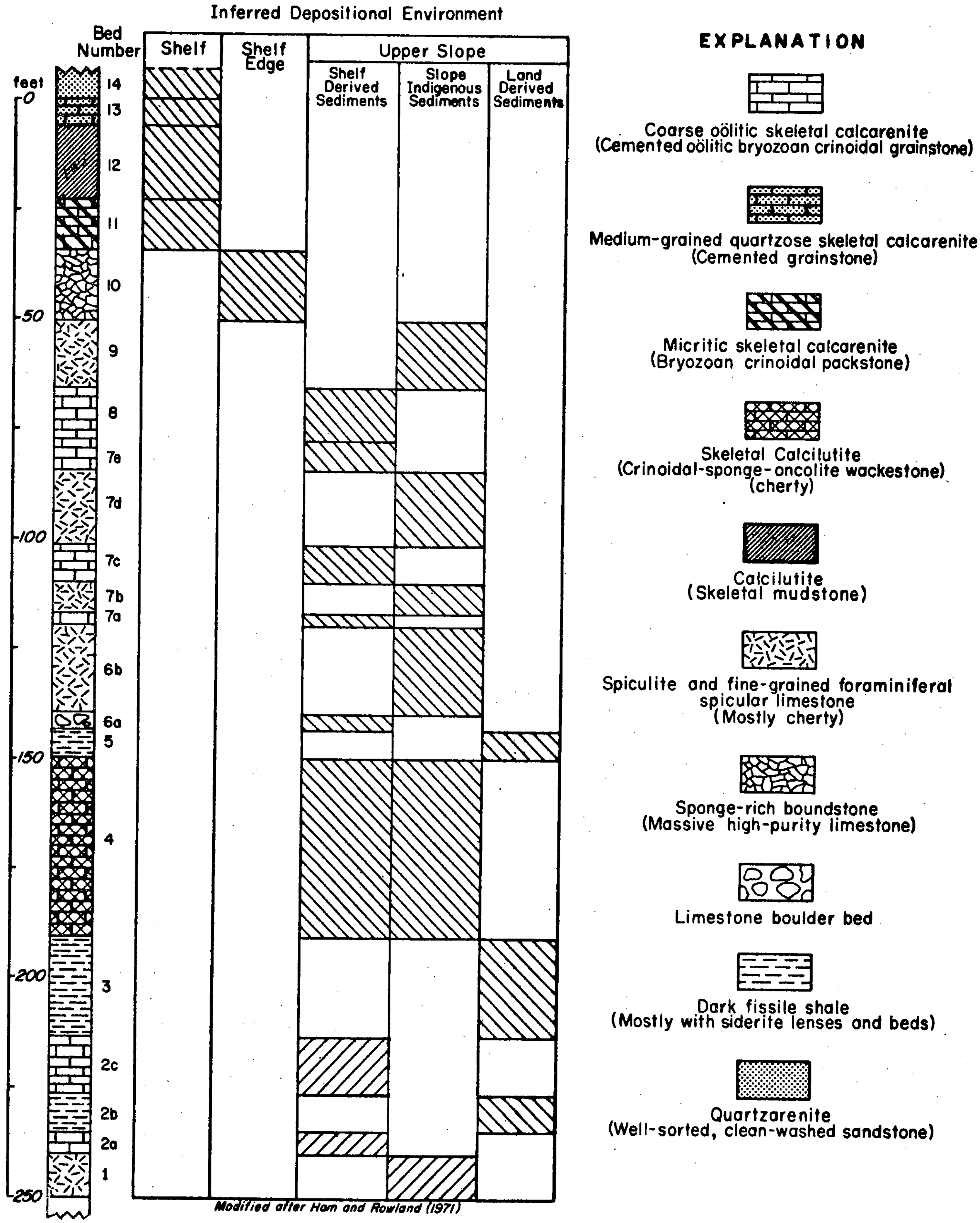
The upper 50 feet (pl. 12, fig. B) consists of noncherty limestone of several types, all interpreted as shelf deposits. In contrast, the lower 200 feet (pl. 12, fig. A) consists of thin skeletal and oolitic grain-supported calcarenites, much like those of the shelf, interstratified with cherty spiculites and other rocks considered from their compositional and depositional character to be deposits of the shelf-to-basin slope (fig. 25). Of these rocks, spiculites are dominant and make up 34 percent of the 200-foot sequence. Next in abundance is a cherty, pelmatozoan-sponge-oncolite wackestone (21 percent), followed by dark shale containing thin siderite beds and plates (19 percent), and a limestone boulder conglomerate (2 percent). These slope-indicator beds make up 72 percent of the sequence, whereas the interbedded calcarenites make up 24 percent. These interbedded grain-supported calcarenites were cemented in a burial environment (Ham and Rowland, 1969, 1970).

Spiculites: These irregularly bedded generally cherty strata are impure limestone with a high content of siliceous sponge spicules (pl. 15, figs A, B). Benthonic foraminifers and radiolarians are conspicuous in some layers, occurring with finely divided pelmatozoan and other skeletal debris. Dark micrite is the matrix, and the calcium carbonate content of the spiculite beds at Hartshorne ranges from 50.9 to 86.9 percent. Abundance of siliceous sponges or their disaggregated spicules in modern seas is indicative of water depths greater than 200 meters (de Laubenfels, 1955, p. E33). In Late Paleozoic seas of the southern United States this assemblage indicates a basinal depositional environment (Finks, 1960, p. 22-34). The siliceous sponges in this area have been collected and studied by Rigby, Chamberlain, and Black (1970).

Wackestone: The wackestone at Hartshorne is a distinctive, cherty, 42-foot bed containing sponges, some stromatolitic oncolites, pelmatozoan columnals, and a few vaguely defined coarse intraclasts, all in an extremely poorly sorted dark matrix of skeletal micrite. Lenses of an oolitic, skeletal packstone are also present in this unit (pl. 15, fig. D). No rock of this type has yet been recognized in Morrowan shelf carbonates. The sponges are probably indigenous in the slope environment, whereas the remaining materials were doubtless derived from the shelf. Calcium carbonate content of a channel sample of the wackestone is 87.2 percent.

Limestone boulder conglomerate: A 4-foot bed of boulder conglomerate at Hartshorne is the first reported occurrence of a boulder bed in the Wapanucka limestone. It cannot be traced horizontally and thus is interpreted as a thin lens. The deposit consists of well-rounded and thoroughly indurated limestone pebbles, cobbles, and boulders, of which the largest observed was measured at 1 x 4 feet. All consist of oolitic, skeletal, or micritic limestones typical of the Morrowan carbonate shelf, and these coarse clasts are embedded in a poorly sorted calcarenitic matrix of the same constituents. This deposit may represent a gravity slide

Figure 25
COMPOSITE STRATIGRAPHIC SECTION AND INFERRED DEPOSITIONAL ENVIRONMENTS IN THE HARTSHORNE AREA



on the slope, the materials having been derived from contemporaneous but already lithified sediments of the shallow shelf. This bed does not crop out at Stop 10 but is present in the working quarry east of the stop.

Oolitic skeletal calcarenite: Overlying the boulder bed in the working quarry is 13 feet of spiculiferous wackestone in contact with a crossbedded, oolitic grainstone grading upward into fine-grained, skeletal, quartz-silty grainstone, the basal bed of the oolite contains limestone pebbles; the entire unit is 42 feet thick. In Figure 25 this bed would be at the same stratigraphic interval as bed 7. This material was also probably from the shallow shelf and may represent a channel down into the slope. It also cannot be traced horizontally, as it is not in the section at Stop 10 nor is it in the next measured section to the east.

Dark shale: At Hartshorne, dark shales interstratified with limestone beds of the Wapanucka Formation differ from Morrowan shelf shales in their content of thin siderite beds and plates, suggesting deposition in deeper water. This is compatible with the slope environment inferred from the interbedded spiculites, wackestones, boulder bed, and calcarenite channel.

Calcarenites: Whereas the spiculites, wackestones, and shales are dark, the interbedded grain-supported calcarenites are mostly light gray. They consist of two types--clean-washed and calcite-cemented oolitic, skeletal grainstones (pl. 15, fig. C) and poorly washed micritic skeletal packstones (pl. 15, fig. E). Three beds of grainstone with an aggregate thickness of 31 feet and 2 beds of packstone with an aggregate thickness of 16 feet occur in the slope-deposited sequence. The dominant skeletal grains are crinoids and echinoids, succeeded by bryozoans and mollusks, and many of these grains have strongly developed micrite envelopes. Both skeletal grains and ooids originated in the shallow waters of the shelf, from which they were swept into the deeper waters of the slope.

Shelf deposits: The upper 50 feet at Stop 10 (pl. 12, fig. B) consists of rocks that are typical of Morrowan carbonates in other areas. These are beds 11, 12, and 13 (fig. 25). Bed 10 is a sponge boundstone that may represent the shelf edge, but it does not occur in Morrowan rocks in other areas.

These shelf rocks are, for the most part, well-washed, grain-supported calcarenites, calcite cemented; however, some beds have a micrite matrix. Only one unit, bed 12 (fig. 25), is mud supported, and it is a mudstone with widely scattered skeletal debris and some bladed algae. The grain-supported rocks are bryozoan, pelmatozoan grainstones and packstones and oolitic grainstones, and some units have abundant quartz sand (pl. 15, fig. E).

These upper-zone rocks in the Hartshorne area are typical of Morrowan rocks in the Ozark dome area, which are interpreted as subtidal deposits.

STOP 11

Location: NW SW Sec. 19, T5N, R18E, Latimer County, on U. S. Highway 270, approximately 7.5 mi east of Hartshorne

Exposure: Low roadcut on south side of highway, .3 mi east of deeper roadcut[1] and .4 mi west of arcuate bridge; fault at the western edge of exposure of sandstone

[1] Western exposure of uppermost Atoka beds grading into the overlying Hartshorne Sandstone exhibits some 40 ft of shale with thin interbeds of very fine-grained sandstone. Sandstone contains ripple marks, small-scale crossbedding and burrows. Upper part of section is characterized by sandstone with shale interbeds.

Structural Dip: Approximately 10° south-southwest

Description: Thin section of very fine-grained sandstone, with interbedded shale, overlying shale with very thin beds of siltstone and/or very fine-grained sandstone

Depositional Environment: Shallow marine or delta-marine (delta-fringe)

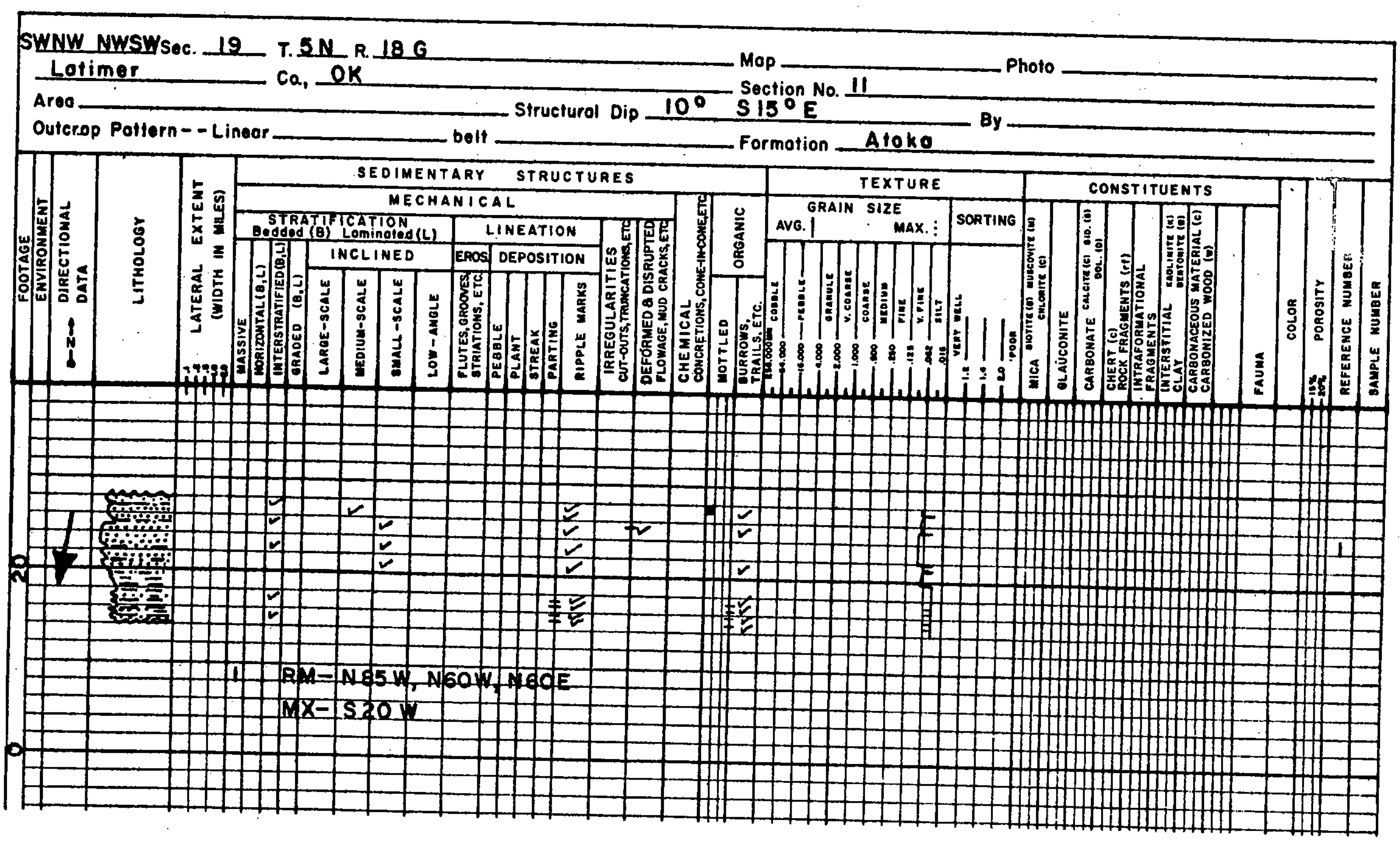


Fig. 26.--Measured section of an Atoka sandstone exposed in low roadcut. Ripple marks, small-scale crossbedding, and burrows chracterize the shallow marine, or delta-fringe, deposits. See Plate 9 for photographs of the sandstone.

STOP 12

The Wapanucka in the Wilburton area is well exposed in natural outcrops and quarries; in addition one core of the formation was taken. Stop 12 is an abandoned quarry 7 miles southwest of Wilburton in the NW SE NE sec. 33, T. 5 N., R. 18 E., Latimer County, Oklahoma (fig. 23; pl. 14, figs. A, B). At this locality the middle shale member consists of siliceous siltstone, except for 5 feet of shale above the uppermost limestone.

The Wapanucka limestones in the Wilburton area are noncherty and consist of limestone types that are like those in Morrowan rocks of other areas; they are interpreted as shelf deposits (fig. 27). They consist of grain-supported calcarenites that are well washed, calcite cemented, or have a micrite matrix. Mud-supported rocks consisting of phylloid algae are common, and some algal boundstone occurs. Abundant shale interbeds are present in the Wapanucka in this area.

Grain-supported calcarenites: The calcarenites in the Wilburton area consist of bryozoan, pelmatozoan grainstones and packstones with abundant other skeletal debris of brachiopods, mollusks, ostracodes, foraminifers, and other small skeletal hash. Abundant oolitic and coated-grain grainstones also occur. Many beds carry abundant quartz-sand grains. Most of these rock types occur in the lower shale and limestone member and in the lower part of the limestone member (fig. 27). Plate 13, figs. A, B, and C, illustrate these limestone types. These units are as thick as 30-40 feet, with thin shale interbeds, and as thin as 2-4 feet.

Mud-supported rocks: In the Wilburton area these rocks mostly occur in the middle and upper part of the limestone member. They consist of algal wackestones and mudstones and some algal boundstones. The algae consist of the common Pennsylvanian genus *Archaeolithophyllum* (pl. 13, figs. D, E). Other types also occur, such as the encrusting *Girvanella*. Oncoliths are also common and consist of *Osagia* and the encrusting foraminifer *Hedraites*.

The upper algal unit can be correlated across the Wilburton area and is about 60 feet thick. Shale interbeds are common in the algal rocks.

Shale interbeds: Abundant shale interbeds occur in the Wapanucka in the Wilburton area. These shales are medium to dark, generally calcitic, and some are silty. They contain skeletal debris much like that found in the limestones. The shales in the algal units contain algal plates. These shale interbeds also vary in thickness.

SUMMARY

The Wapanucka Formation in the Hartshorne-Wilburton area consists of different depositonal facies. Near Hartshorne the lower limestones are indicative of a slope-to-basin environment, whereas the upper units are typical of subtidal shelf deposits.

Near Wilburton the Wapanucka consists of noncherty, nonspiculiferous carbonate types indicative of subtidal to shallow subtidal and intertidal environments. These rocks are similar to other Morrowan carbonate rocks in the Ozark dome area that are typical shelf deposits.

Eastward, the entire formation consists of sandstone and shale. These generalized stratigraphic relationships are illustrated in Figure 28, and the generalized depositional environments are illustrated in Figure 29.

Figure 27

COMPOSITE STRATIGRAPHIC SECTION OF THE SHELF FACIES IN THE WILBURTON AREA

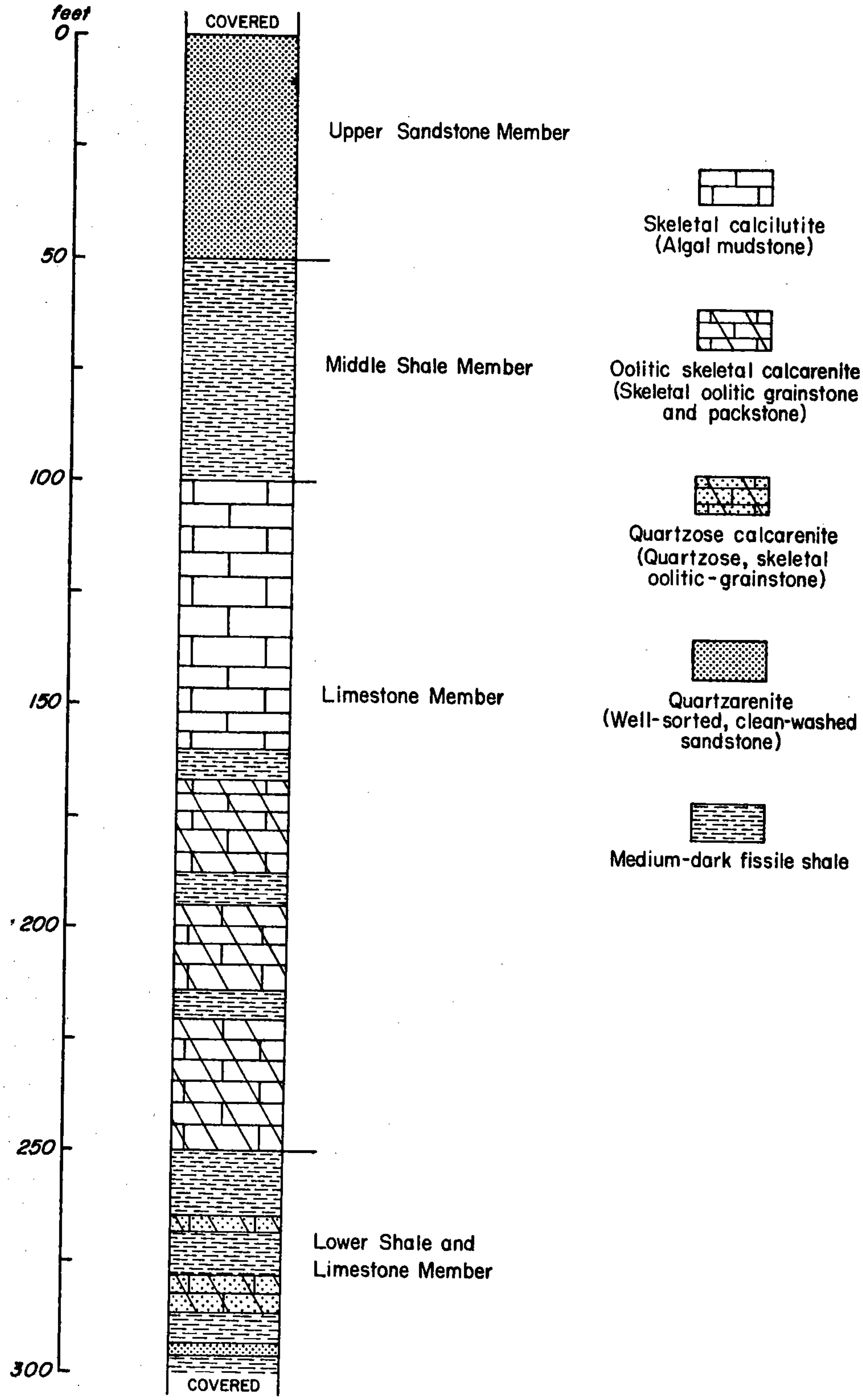
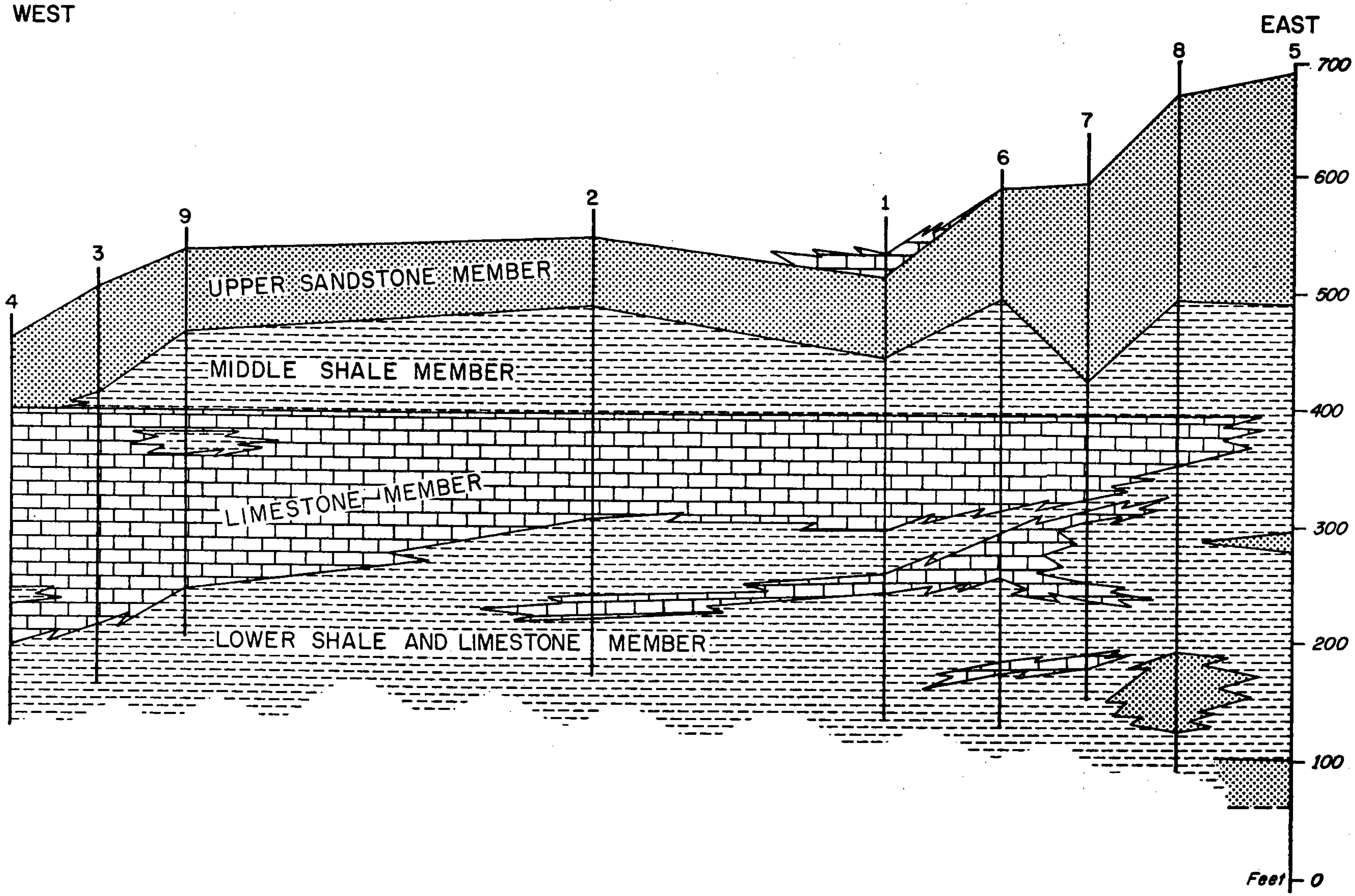


Figure 28

GENERALIZED STRATIGRAPHIC RELATIONSHIPS WAPANUCKA FORMATION



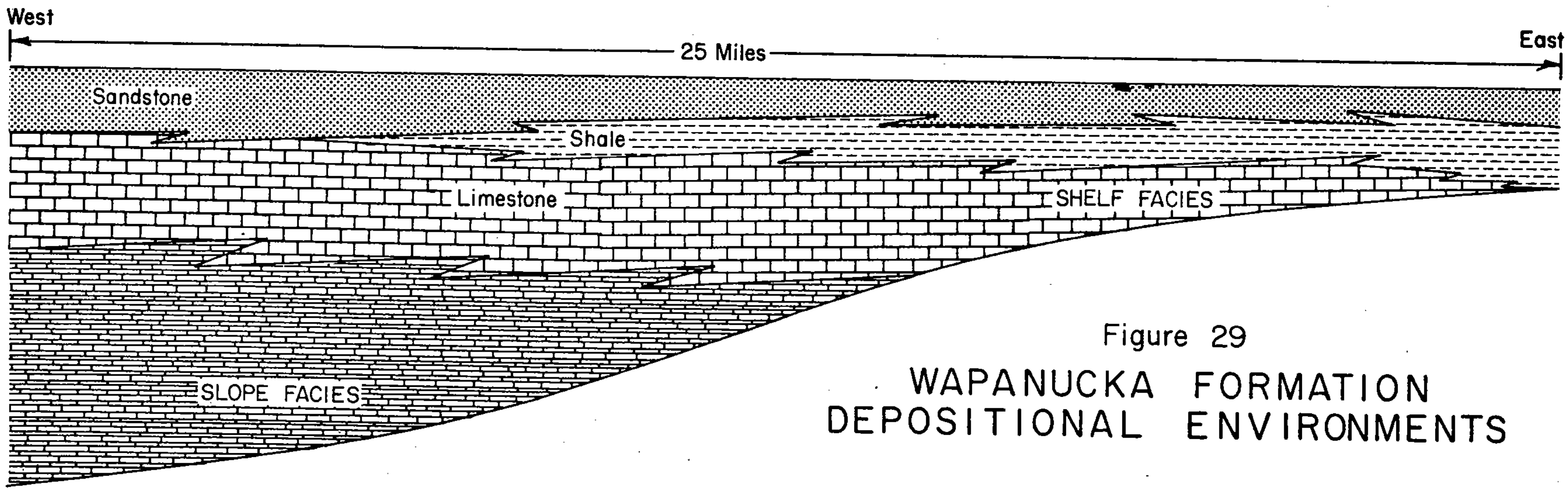


Figure 29
WAPANUCKA FORMATION
DEPOSITIONAL ENVIRONMENTS

STOP 13A

Location: NW NE Sec. 29, T5N, R19E, Latimer County, on Oklahoma Highway 2, approximately 2.5 mi south of intersection with U. S. Highway 270 at Wilburton

Exposure: Low roadcut on west side of highway

Structural Dip: Approximately 40° south

Description: Shale with thin sandstone interbeds. Sandstone is characterized by sharp basal contact, sole marks, horizontal bedding, convolute bedding, and small-scale crossbedding.

Depositonal Environment: Deep marine, distal turbidity-current deposits (for sandstones)

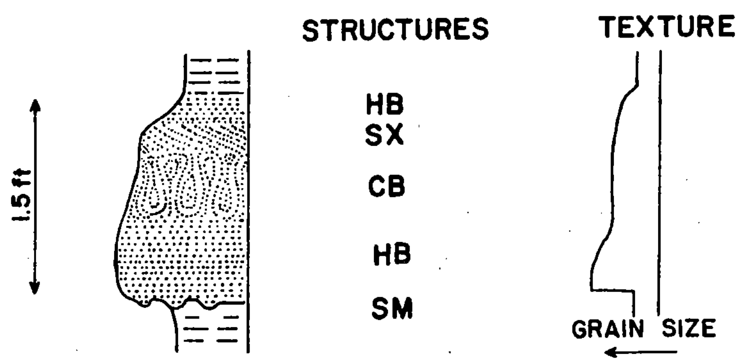


Fig. 30.--Features of typical sandstone bed deposited distally by turbidity current See Plate 10 for photographs of features in deep marine Atoka sandstones.

STOP 13B

Location: SW SW Sec. 27, T5N, R19E, Latimer County, on Oklahoma Highway 2, approximately 4.5 mi south of intersection with U. S. Highway 270 at Wilburton, on Blue Mountain.

Exposure: Roadcut on east side of highway at mountain crest

Structural Dip: Approximately 45° south

Description: Multistoried sandstone unit with shale interbeds, in the 300-ft interval exposed at or near the mountain crest. This sandstone unit, which lies approximately 4000 ft above the base of the Atoka, has been correlated with the subsurface "Red Oak Sand" to the northeast (Bowsher and Johnson, 1968). Individual sandstones are relatively thin and contain sole marks, load casts, horizontal bedding, parting lineation, convolute bedding, small-scale crossbedding, ripple marks, and molds of plants. Sandstone is generally fine-grained and is composed of 85 percent quartz and 15 percent potassium feldspar.

Depositional Environment: Deep marine, turbidity-current deposits

STOP 14

Location: SW Sec. 25, T10N, R18E, on Oklahoma Highway 71 at Eufaula Dam

Exposure: Roadcut on the north abutment of Eufaula Dam

Structural Dip: Approximately 3° north-northwest

Formation: Bluejacket Sandstone, Boggy Formation

Description: Prominent sandstone section, composed of sharply lenticular bodies and sandstone units with interbedded shale, overlies gray shale. Channel-type bodies cut beds which exhibit some lateral persistence although they also show variations in development.

Depositonal Environment: Deltaic distributary; delta-fringe with splay deposits

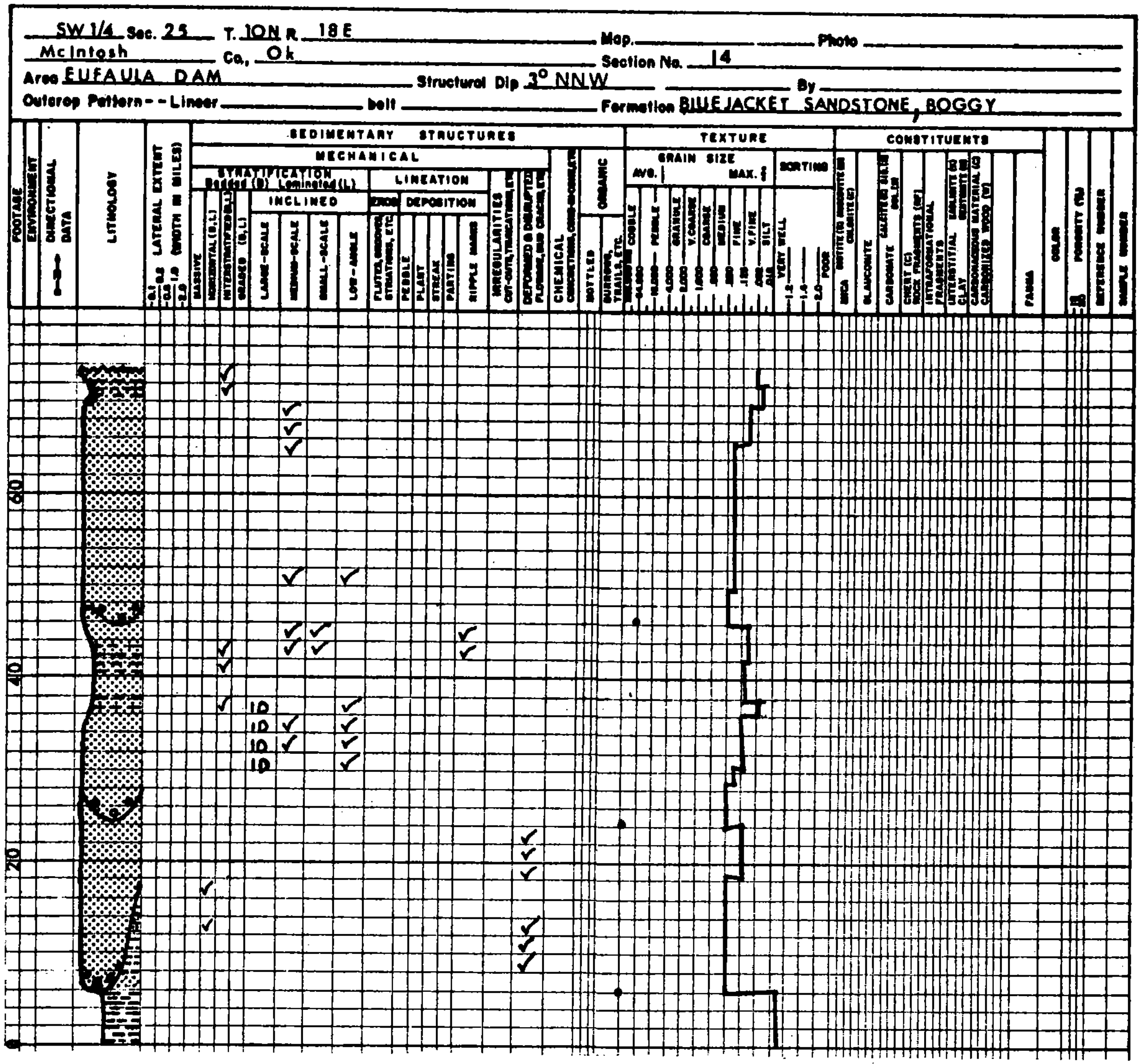


Fig. 31.--Measured section of Bluejacket Sandstone, with 3 channel-like bodies and a delta-fringe unit at 34 to 46 ft.

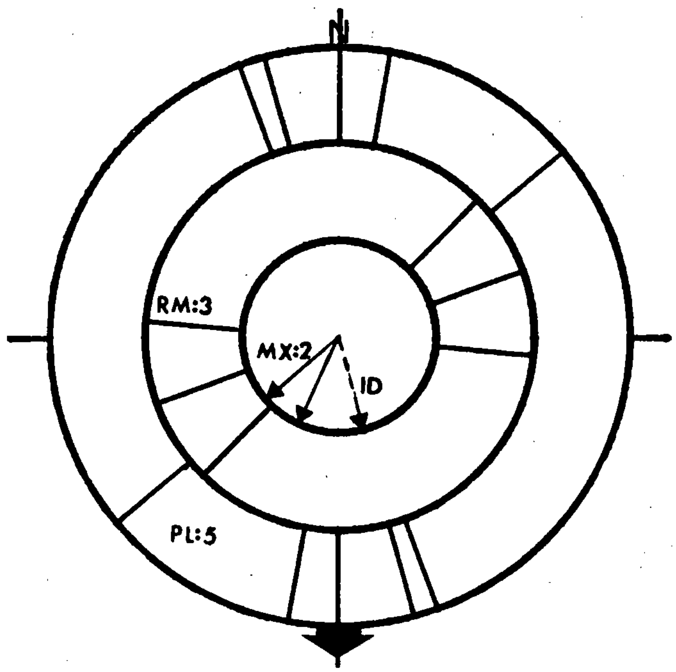


Fig. 32.--Paleocurrent diagram of lower delta-fringe sandstone units, showing a southerly average current direction.

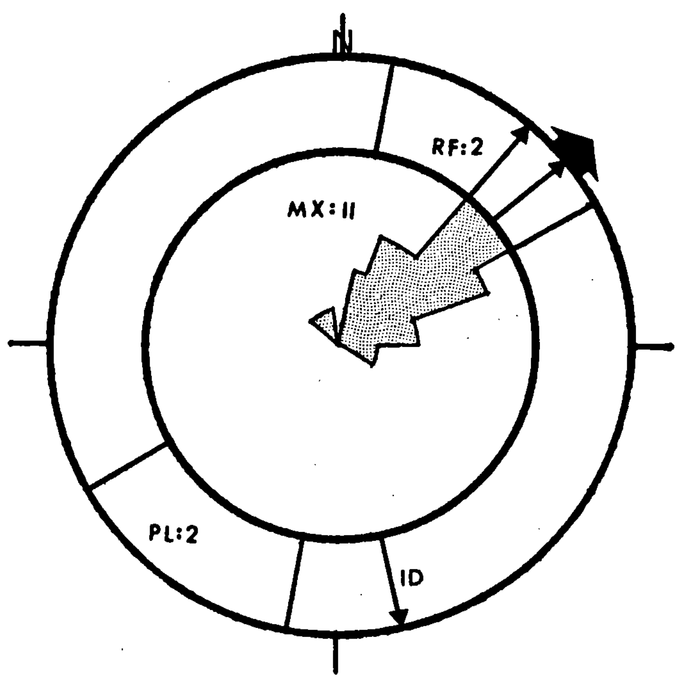


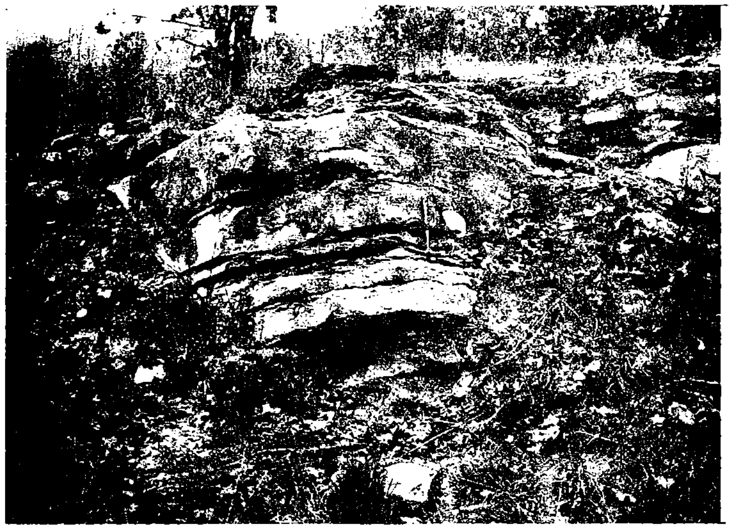
Fig. 33.--Paleocurrent diagram of upper channel sandstone, approximately 25 ft thick, with average direction of N50°E.

PLATE 9

Fig. A.--General view of the Atoka sandstone at Stop 11. Sandstone, with shale interbeds, contains ripple marks, small-scale crossbedding, and burrows.

Fig. B.--Thin beds of sandstone, flaser bedding in interbed, ripple marks on top surfaces of sandstone beds at Stop 11.

Fig. C.--Sandstone pillows in shaly interbed in upper part of section exposed at Stop 11.



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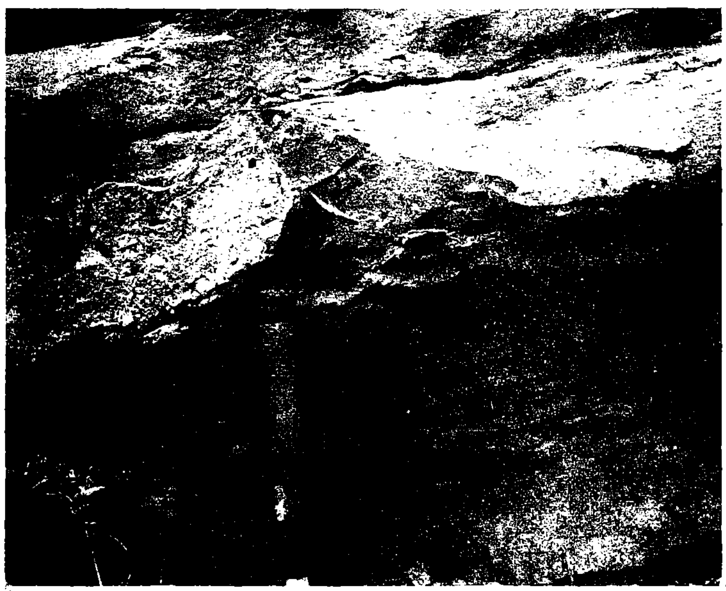

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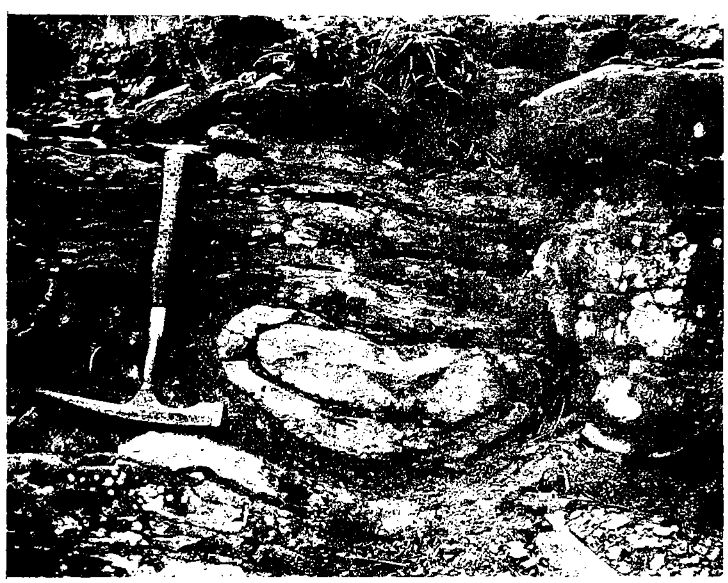


C

PLATE 10

Fig. A.--Excellent development of sole marks, distal turbidity-current sandstone at Stop 13A.

Fig. B.--Typical sandstone bed in shale-rich part of Atoka exposed at Stop 13A; fine-grained sandstone with sharp base and small-scale crossbedding at the top.

Fig. C.--Parting lineation in sandstone in sand-rich part of Atoka exposed at Stop 13B.

Fig. D.--Ripple marks on top surface of sandstone at Stop 13B.

A

B

C

D

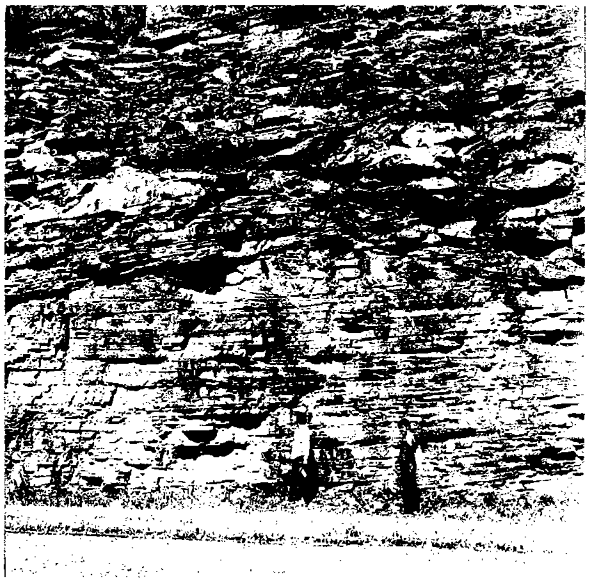
PLATE 11

Fig. A.--Delta-fringe sandstones below distributary sandstone, which exhibits a sharp basal contact, Bluejacket Sandstone at Stop 14.

Fig. B.--Irregular base and edge of upper channel sandstone, which overlies delta-fringe units, at Stop 14.

Fig. C.--Irregular base of sandstone section; splay sandstone unit (s) below major channel deposit (c) of Bluejacket at Stop 14.

Fig. D.--Detailed view of features in fig. C. Initial dip (id) underlies splay deposit.



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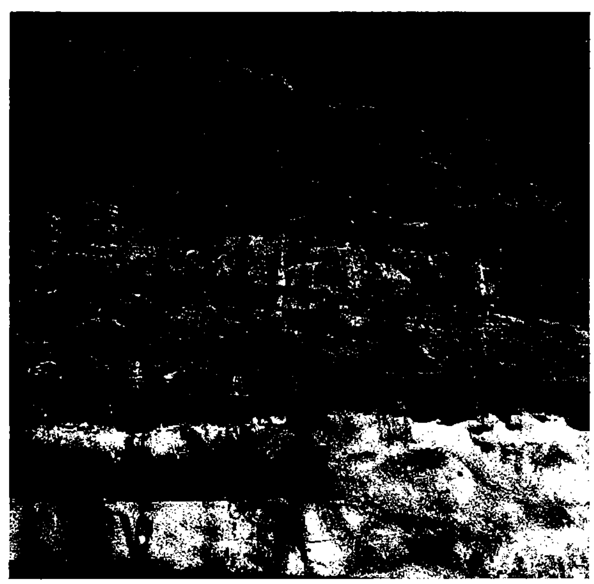
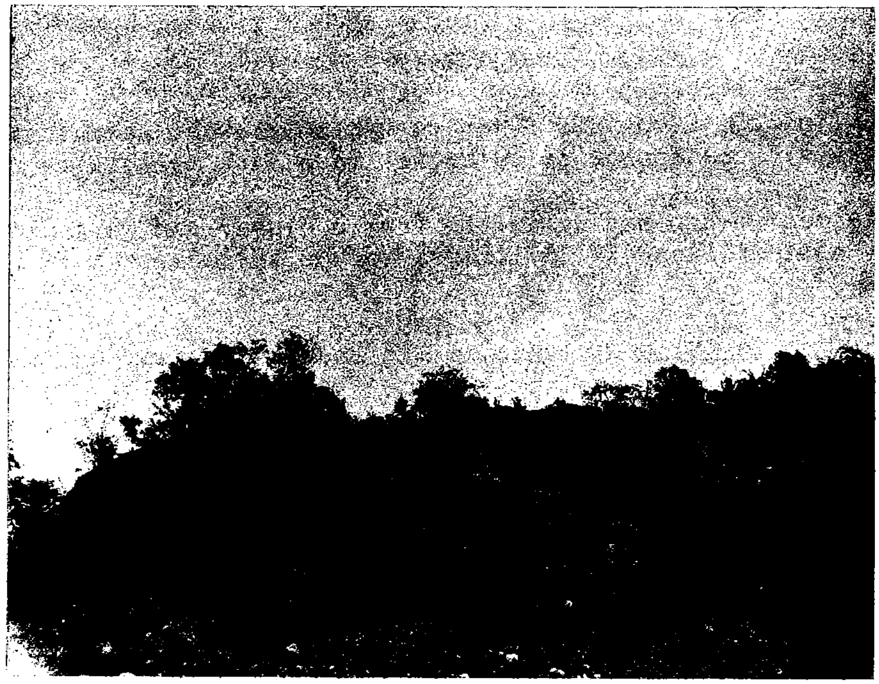


D

PLATE 12

Fig. A.--Abandoned east quarry face of Wapanucka limestones, Stop 10. Beds dip 33° south. Beds in lower three-fourths of photograph are slope deposits, with interstratified calcarenites. Beds in upper one-fourth of photograph are shelf deposits.

Fig. B.--Close view of upper part of slope deposits. Shelf deposits are upper beds in photograph.



A

B

PLATE 13

Fig. A.--Bed 6b, fig. 25, Stop 10. Fine- to medium-grained spiculite. Fine to coarse, siliceous sponge spicules set in a dark micrite matrix.

Fig. B.--Fine- to medium-grained spiculite from a higher bed in another section 3 miles east of Stop 10. Siliceous sponge spicules set in a dark micrite matrix.

Fig. C.--Bed 2c, fig. 25, Stop 10. Medium- to coarse-grained, oolitic grainstone. This is typical of interstratified oolitic calcarenites in slope facies. This rock is interpreted to have been cemented after burial.

Fig. D.--Medium- to coarse-grained, oolitic, skeletal packstone from one of the lenses of calcarenite in bed 4, Stop 10.

Fig. E.--Bed 7c, fig. 25, Stop 10. Medium- to very coarse-grained, bryozoan, pelmatozoan packstone. Very coarse skeletal debris in a micrite matrix. Typical micritic, interstratified calcarenites in slope facies.

Fig. F.--Bed 11, fig. 25, Stop 10. Fine- to medium-grained, quartz-sandy, coated-grain grainstone. Light grains are quartz sand. Typical, shelf-deposited rock in Wapanucka.

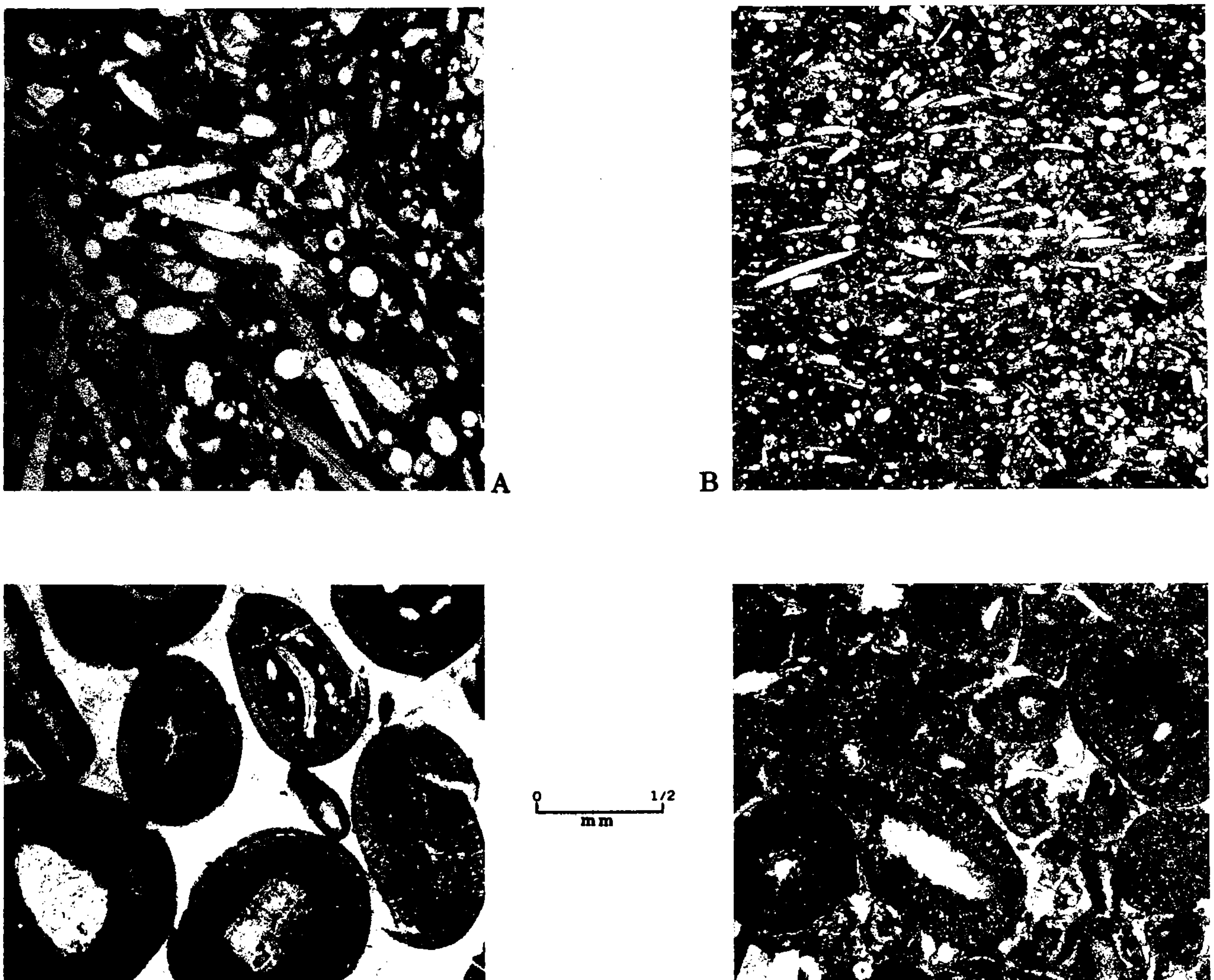

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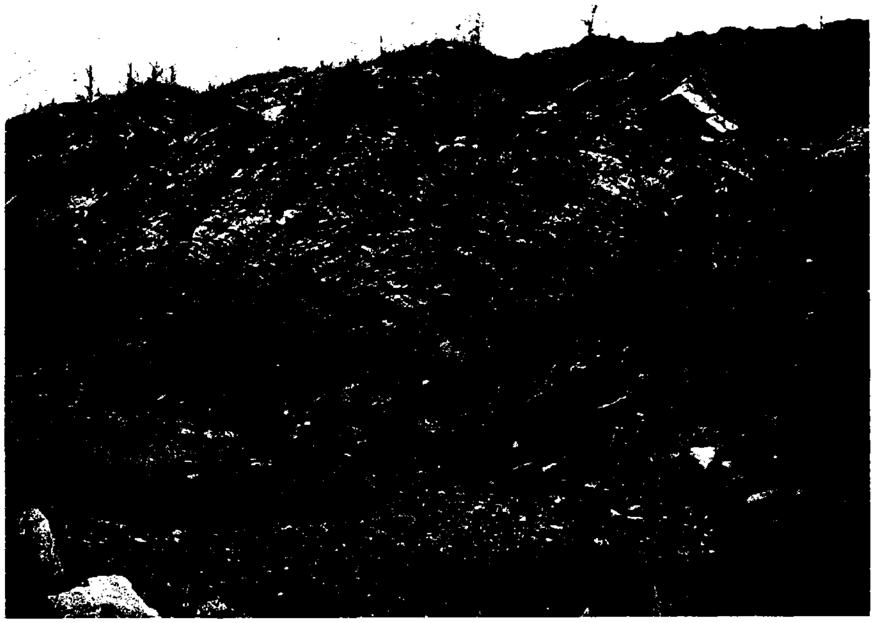
PLATE 14

Fig. A.--General view of limestone member of Wapanucka at Stop 12. Rocks dip 53° southeast.

Fig. B.--Close view of limestone member at Stop 12. Lower beds in photograph are typical grain-supported, shelf-deposited rocks, and middle and upper beds are algal mud-supported rocks, also typical of shelf environment.



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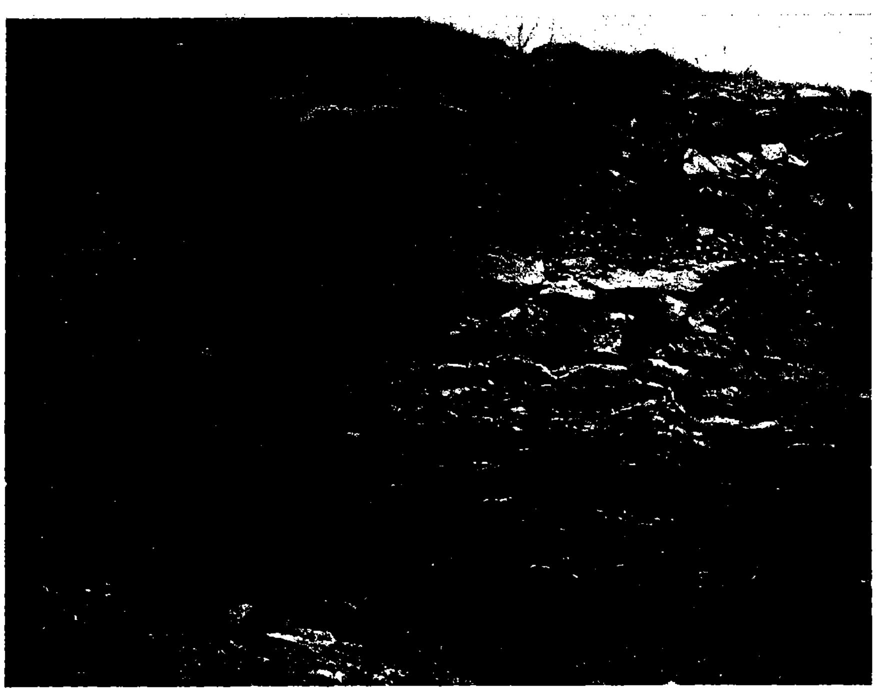


B

PLATE 15

Fig. A.--Bed 3, Stop 12. Fine- to coarse-grained, skeletal, oolitic grainstone. Closely packed ooids and coated grains cemented with sparry calcite. Typical rock of shelf environment.

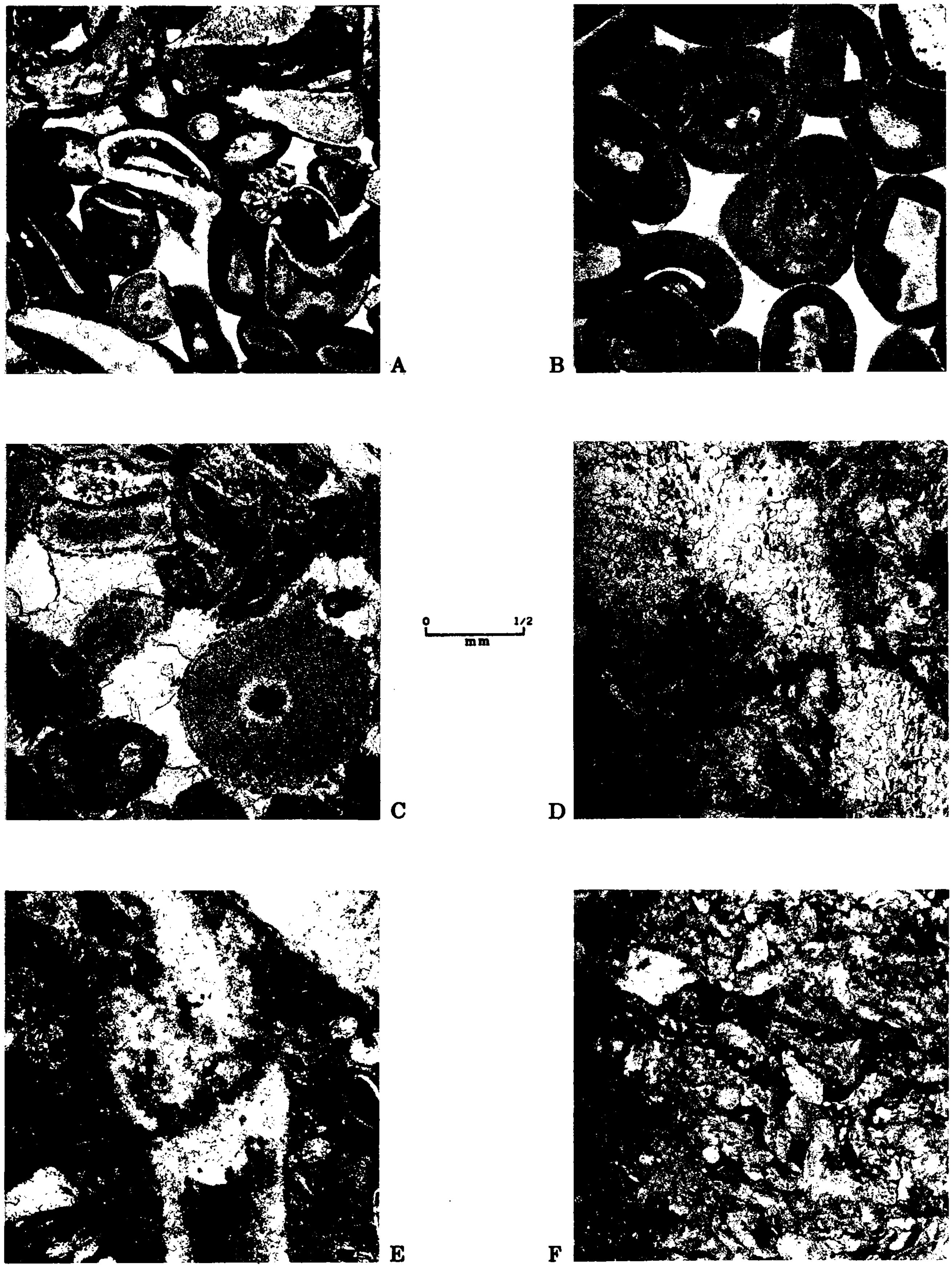
Fig. B.--Bed 5a, base, Stop 12. Medium- to coarse-grained, oolitic grainstone. This bed is only 1 foot thick and is overlain by skeletal packstone. The unit above this bed, 5b, is a crossbedded oolitic grainstone. Typical grain-supported calcarenites of shelf facies.

Fig. C.--Bed 5d, Stop 12. Medium- to coarse-grained, bryozoan, pelmatozoan grainstone. Skeletal debris cemented with sparry calcite cement. This type of rock is abundant in shelf facies.

Fig. D.--Bed 6a, Stop 12. Algal wackestone typical of algal mud-supported rocks in shelf facies. Light areas with faint cell structure are of alga Archaeolithophyllum.

Fig. E.--From algal-limestone interval in core taken from Wapanucka east of Stop 12. This algal wackestone shows good cell structure remaining in Archaeolithophyllum.

Fig. F.--Bed 6d, Stop 12. Uppermost 14-foot bed at top of quarry face. Skeletal packstone consists of closely packed pelmatozoan and algal? material in a micrite matrix.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