BIOSTRATIGRAPHY OF THE GRAFORD FORMATION, MISSOURIAN, WISE COUNTY, TEXAS

by

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THESIS

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ABSTRACT

Several biofacies and lithofacies are present in the Graford Formation, Lower-Middle Missourian of the Canyon Group, around Lake Bridgeport. In the Lake Bridgeport Shale Member a gastropod biofacies and a blue shale and purple shale lithofacies lie to the south of the lake. Outcrops east of the lake contain a coral biofacies (blue shale lithofacies) and a sponge-crinoid biofacies (yellowish-purple shale). The overlying Rock Hill Limestone Member contains a crinoid biofacies in an intramicrite which grades laterally from south to northeast into an algal biofacies in a biomicrite as it approaches the Chico Ridge Limestone. An off-bank facies of interbedded intramicrites and algal micrites is found west of the lake and a biomicrite, with fusulinid rich layers, occurs southwest of the lake. These two units compose the overlying Devils Den Limestone Member of the Graford Formation. Its stratigraphic equivalent, the Jasper Creek Shale Member, is unfossiliferous. However, sandstone, interbedded sandstone and shale, and red shale lithofacies are present. The biofacies were probably formed in destructional deltaic and marine transgressive environments.

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INTRODUCTION

Outcrops of the Pennsylvanian (Missourian) Graford Formation are widespread in Wise. County and comprise most of the Pennsylvanian outcrops in the county. The formation outcrops in an area bounded by Bridgeport, Willow Point, and Chico, in Wise County; and near Wizard Wells and Joplin in Jack County. The study area is approximately 70 miles northwest of Dallas, and 40 miles north of Fort Worth (figure 1).

Cummins (1891) named several units found in the area and Drake (1893) compiled a large faunal list for the area. Bose (1917) described measured sections in Wise County, and Scott and Armstrong (1932) made a detailed description of all rocks found in the county. Sellards (1932) gave a brief summary of the origin of member names, and Cheney (1940) redefined stratigraphic boundaries. Sloan (1955) dealt with paleoecology of the Pennsylvanian formations in North Central Texas. Brown (1973) developed depositional models for Pennsylvanian rocks in North Central Texas.

This report will define and analyse microfacies in the members of the Graford Formation. Fossil assemblages will be described and used to identify environments of deposition of the microfacies. Economic values of the Graford Formation will be reviewed and possible future uses of limestone aggregate, presently discarded, will be suggested.

GEOLOGIC SETTING

Member names applied to the Graford Formation differ from county to county. Therefore, the local member names for Wise County (Scott

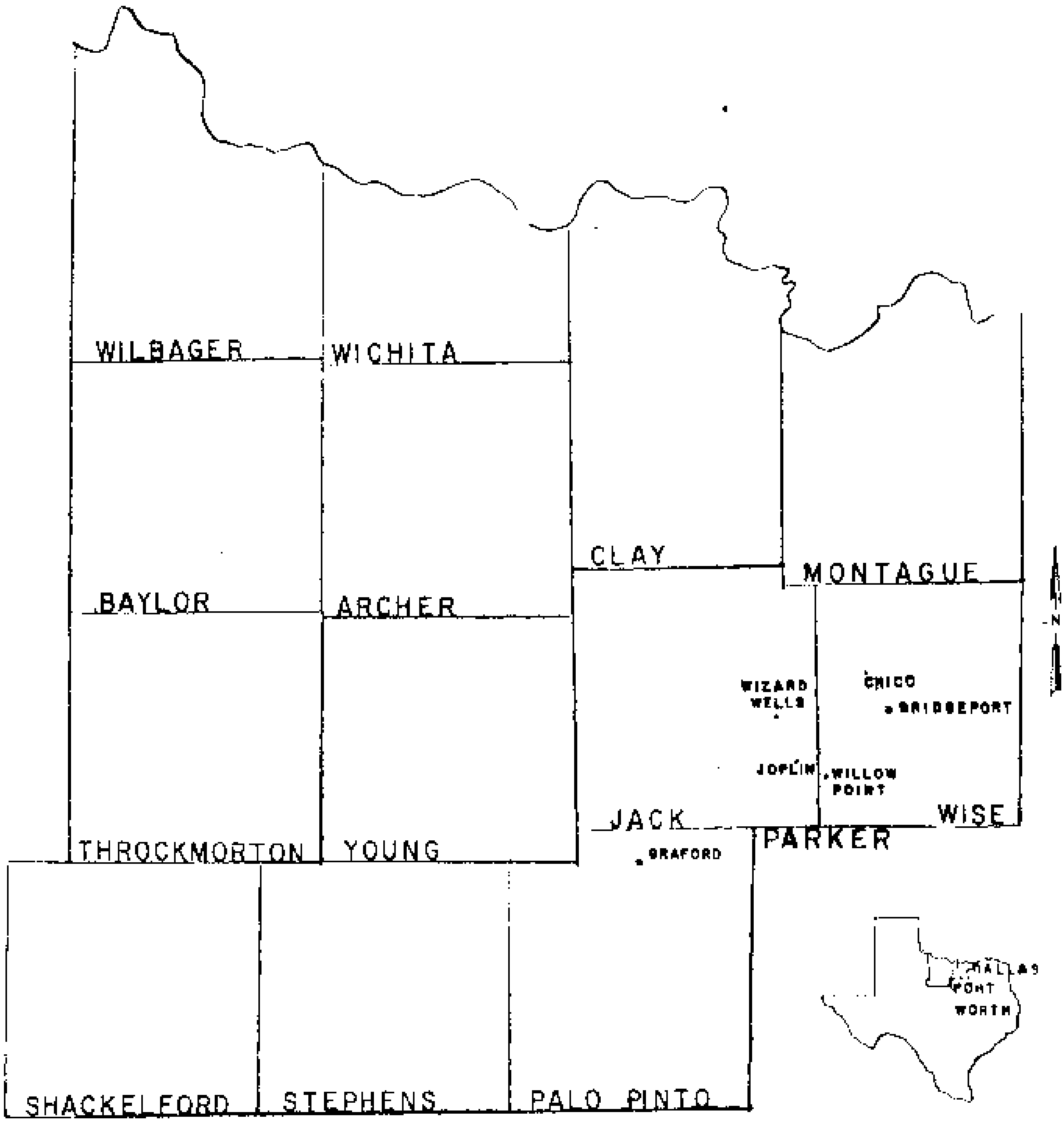


FIGURE I

0 5 10 15
MILES

REGIONAL INDEX MAP

BROWN, 1973

and Armstrong, 1932) will be used in this report. The Graford Formation is Missourian in age and is part of the Canyon Group (Cummins, 1891). Members of the Graford Formation in Wise County are shows in table I and reflect the changing nomenclature of the Pennsylvanian formations in North Central Texas.

BOSE, 1917	ARMSTRONG & SCOTT, 1932	BROWN, 1973
DEVILS DEN LS.	DEVIL DEN LIMESTONE	WINCHELL LIMST.
UNNAMED SHALE	JASPER CREEK SHALE AND CHICO RIDGE LIMESTONE	WOLF MOUNTAIN SHALE
ROCK HILL LS.	ROCK HILL LIMESTONE	
UNNAMED SHALE	LAKE BRIDGEPORT SHALE	

TABLE I

Major depositional areas in North Central Texas during the Missourian were the Concho Platform, the Midland Basin, and the Fort Worth Basin. Major source areas were the Ouchita, Wichita, and Arbuckle Mountains, and the Llano Uplift (figure 2).

From the Early Paleozoic until Early Pennsylvanian, sediments deposited on the Concho Platform were chiefly carbonates. Clastic sediments became important during deposition of the Early Pennsylvanian Atoka Group (Brown, 1973). The Atoka Group was deposited into the subsiding Fort Worth Basin, which lay adjacent to the rising Ouchita Fold Belt. Clastic wedges of the Atoka Group shifted westward as they

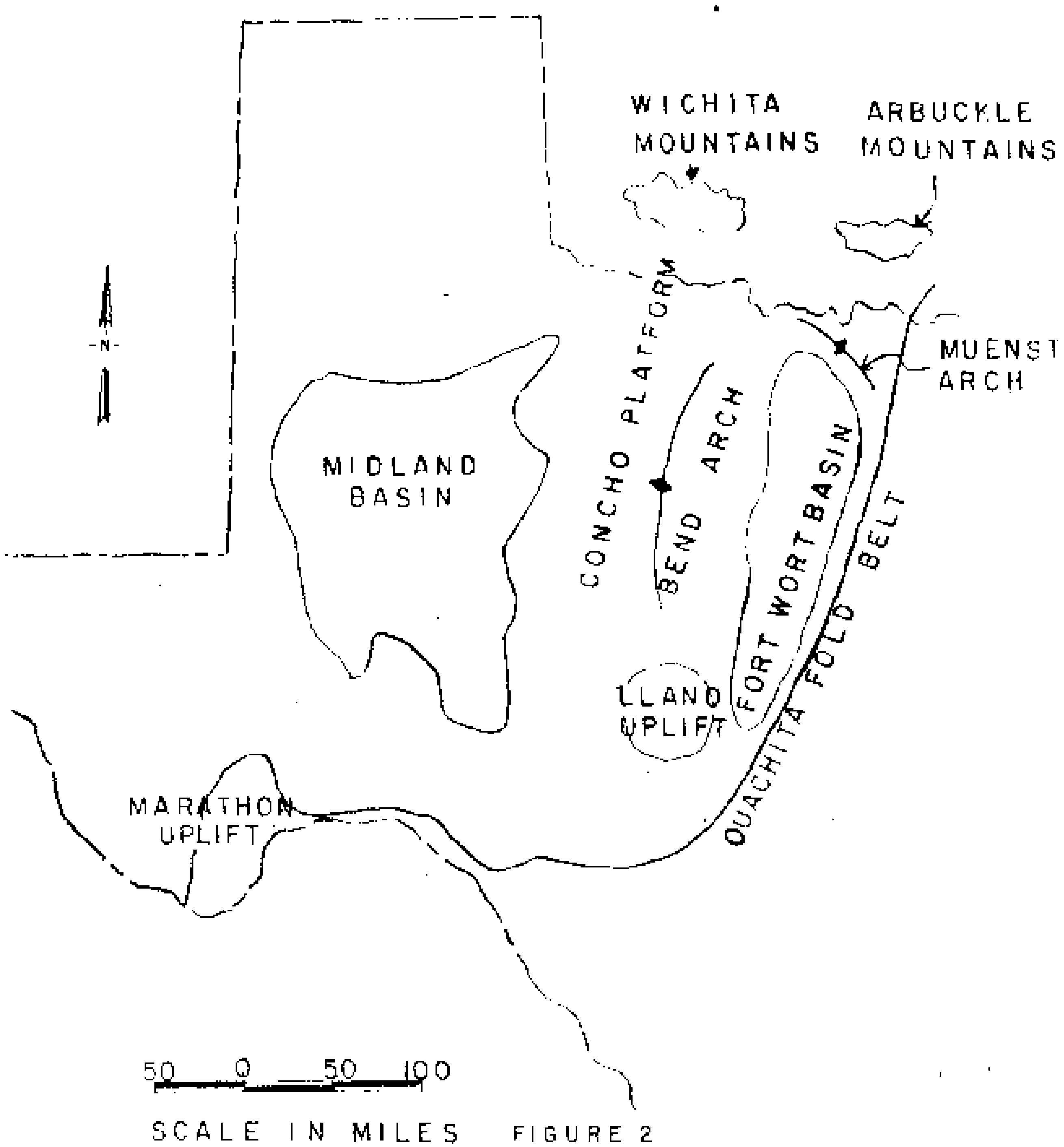


FIGURE 2

LATE PALEOZOIC STRUCTURE MAP

BROWN, 1973

were deposited. This westward facies migration is characteristic of formations deposited in the Fort Worth Basin during the Pennsylvanian. Facies migration is due to westward progradation (Brown, 1973), and epeirogenic uplift of the Ouchita Fold Belt (Hendricks, 1956). The formation of the Bend Flexure (Jenke, 1955) also contributed to the thick accumulation of Des Moinesian (Strawn Group) and Missourian (Canyon Group) sediments in the Fort Worth Basin. However, the Strawn Group accumulated the thickest, sediments in the Fort Worth Basin (Hendricks, 1956). These sediments were deposited primarily as fluvial-deltaic systems which prograded over the Concho Arch (Brown, 1973). Subsidence of the Fort Worth Basin slowed during Des Moinesian time and sediment supply from the Ouchita Fold Belt decreased.

At the start of the Missourian, epeirogenic uplift of the Ouchita Fold Belt decreased resulting in eastward thinning of the Canyon Group (Hendricks, 1956). Continued uplift throughout the Missourian is indicated by deep channels in the upper portion of the Canyon beds (Jenke, 1955), and resulted in withdrawal of the sea from the Fort Worth Basin area by the end of the Pennsylvanian Period (Cheney, 1952).

Structures influencing sedimentation during the Missourian had their origin before the Canyon Group was deposited. The Fort Worth Basin originated after filling of the Ouachita Fold Belt in Late Mississippian and Early Pennsylvanian time (Hendricks, 1956). Down-warping, centered west of the Midland Basin, depressed the eastern portion of the basin and the western limb of the Bend Flexure.

Canyon Group sediments in North Central Texas can be divided into three systems: the Perrin Delta, the Henrietta Fan-delta, and the carbonates (Brown, 1973). The Perrin Delta is a high, constructive delta which prograded to the northwest through both Wise and Jack Counties. Rock units included in the Perrin Delta system are the Colony Creek Shale, Placid Shale, and the Wolf Mountain Shale. Inter-bedded with the Perrin Shale units are the Home Creek Limestone, Colony Creek Limestone, Winchell (Chico Ridge) Limestone, and the Rock Hill Limestone. These limestones are ledgeformers which were deposited on abandoned delta platforms in shallow water. The Graford Formation includes only the Wolf Mountain Shale and the Winchell Limestone.

North of Wise County the prograding Henrietta Fan-Delta consists of high gradient aprons of coarse arkosic clastics which were shed to the north and south from the Arbuckle and Wichita Mountain Ranges. The area south of the Muenster Arch was an unstable remnant of the Fort Worth Basin in Missourian time. As the Henrietta system prograded southward, subsidence took place, allowing wedges of very thick arkosic sediments to form. The Henrietta Fan-Delta was fed by high gradient streams, indicated by coarse, poorly sorted sediments, and braided streams which crossed a narrow coastal plain of coalescing and buried alluvial fans. The delta advanced as far south as Montague and Archer Counties, Texas. The northern equivalents of the Henrietta system are the Deese and Hoxbar Formations of Oklahoma.

The Perrin Delta was fed by a low gradient stream which crossed a broader coastal plain (Brown, 1973). Shales and limestones constitute the third (Pennsylvanian) depositional facies in North Central Texas.

The type area of the Graford Formation, described by Moore and

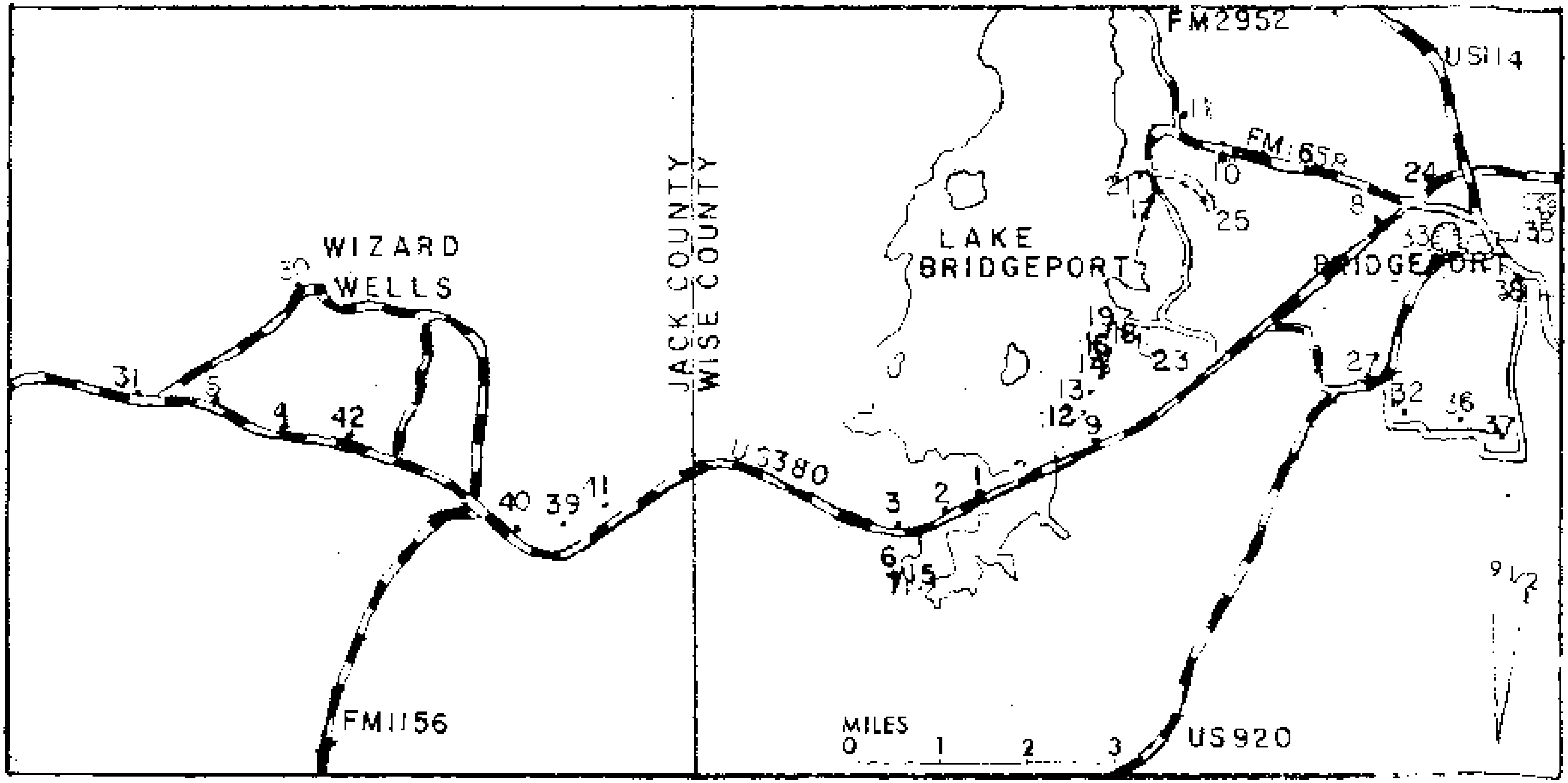
Plummer (1921), is located in Palo Pinto County. It consists of the basal Rochell Conglomerate, overlain by the Brownwood Shale and capped by the Adams Branch Limestone. The term Brownwood Shale has been abandoned by most workers and replaced by the Wolf Mountain Shale (Laury, 1962). Also, the top of the Graford Formation is now placed at the top of the Devils Den Limestone, approximately 100 feet (30.5 m) above the top of the Adams Branch Limestone. The Merriman (Clear Creek) Limestone is the present upper boundary in the type locality.

METHODS

Stratigraphic sections were measured on forty-two outcrops of the Graford Formation. In addition to thickness, strike and dip were measured, and a collection of the fauna was made. Special attention was given to paleocurrent indicators, bedding type, lithology, and any unusual features present. Samples for thin sections were taken at two foot intervals (if available) or at the next convenient level in the limestones. Colors were determined using the GSA Rock Color Chart in the laboratory.

In the laboratory, grain size analysis was done for shales (pipette analysis) and sandstones (sieve analysis). A 100 gram sample of shale and a 50 gram sample of sandstone (shaken for 15 minutes) was used for grain size analysis. Thin sections of 250 limestone samples were cut for microfacies analysis.

Localities of measured sections are shown in figure 3. Sections are described in appendix I. Facies are defined on the basis of litho-logic and paleontologic data gathered in the field, and will be used to



LOCALITY INDEX MAP

FIGURE 3

analyse the different environments present.

GRAIN SIZE ANALYSIS

Grain size analysis of the shales from different facies were made to determine the energy levels present in each depositional environment. Samples of each type of shale lithology were used to determine whether or not lithology and energy levels correspond. Larger grains require more energy to be transported than small grains. Therefore, samples with large median diameters indicate high energy levels in the environment. Table II shows the distribution of the size classes with respect to phi units (the smaller the phi numbers, the larger the diameter).

All data is taken from shale samples in the Lake Bridgeport Shale Member. The median diameter (M), fiftieth percentile of a cumulative frequency curve, reflects the relative energies between the different facies.

Samples in table II represent different shale lithologies. Blue and purple shales occur in localities 6 and 7. Blue 7 and purple 7 represent those lithofacies (blue shale and purple shale biofacies, respectively). A blue shale facies is found at localities 16, 18, and 19. Locality 18 represents this lithofacies (coral biofacies). Yellowish-purple shale is found at localities 11, 17, 21, and 23. Locality 23 represents the lithofacies (a sponge-crinoid biofacies).

A blue shale lithofacies, in the middle portion of the Lake Bridgeport Shale Member, locality 38, was chosen to represent this lithofacies (bivalve biofacies). A blue shale lithofacies (gastropod biofacies) is present at localities 1, 2, 9, 12, 13, and 14.

SAMPLE	BLUE 7	PUR. 7	Loc. 18	Loc. 23	Loc. 38	Loc. 1
Phi 4	10.4	14.0	8.8	13.6	12.3	11.8
Phi 4.5	11.3	11.9	9.8	13.3	11.7	12.4
Phi 5	10.4	11.6	8.4	2.7	9.7	13.0
Phi 5.5	7.5	11.5	8.0	4.2	10.3	9.4
Phi 6	11.8	9.9	8.0	9.5	9.0	11.2
Phi 6.5	11.8	10.9	7.4	9.5	7.0	9.8
Phi 6	6.3	8.7	7.2	6.8	6.5	5.9
Phi 7.5	2.8	7.5	6.4	6.8	4.5	5.4
Phi 8	4.5	4.4	4.8	5.9	5.2	4.2
Phi 8.5	4.3	3.8	3.3	5.4	5.2	4.2
Phi 9	3.2	3.8	4.8	5.0	3.2	0.3
Phi 9.5	2.2	3.3	3.7	5.0	3.2	3.0
Phi 10	1.6	3.3	4.2	5.0	2.8	3.5
Phi 10.5	9.6	3.0	4.2	4.0	6.5	3.0
Phi 11	1.6	0.4	11.4	3.2	2.8	3.3
M	5.9 phi	5.7 phi	6.5 phi	6.1 phi	5.9 phi	5.7 phi

TABLE II

(PHI VALUES IN GRAMS)

Comparing the grain size distribution of the different shale facies shows that the gastropod facies (locality 1) has the coarsest sediment and therefore the highest energy level of all the facies. Locality 38, the bivalve facies, and locality 23, the sponge-crinoid facies, were formed in quieter environments, indicated by finer median grain sizes, than the gastropod facies. Locality 18, the coral facies, has the finest sediment and represents the lowest energy level of all the Lake Bridgeport Shale Member environments. Contrasting the blue 7 and purple 7 shales, the grain size in the purple shales is larger than the blue shales, indicating a higher energy depositional environment than the blue shale.

Median diameter values complement the grain size analysis in that the relative energies among the environments have the same relationship as they did with the grain size analysis. Purple 7 has a higher median phi value than blue 7. Among the other localities the gastropod facies (locality 1) has the highest value followed in decreasing order by locality 38 (bivalves), locality 23 (sponge-crinoid), and locality 18 (corals). The data shows clearly the corals had the quietest environment.

Sandstones occur chiefly as lenses in the Lake Bridgeport Shales. Locality 25 contains the largest of these lenses. Jasper Creek Shale sandstones are more massive in outcrop and are thicker than those in the Lake Bridgeport Shale. Localities 32 and 30 represent the Jasper Creek Shale, Larger diameters indicate higher energies in the environment. Samples were taken at 10 foot intervals or at the next convenient level. Localities and levels are indicated in table III. Table III shows the results for the three largest sandstone sections in the area. Sorting (So), median (M), and kurtosis (K) were determined. Vacant spaces in the columns are due to aggregates in the samples.

SAMPLE	1mm	.5mm	.25mm	.125mm	.0625mm	PAN	So	M	K
25-55'				10.3	34.2	17.9		.04	
25-40'			.4	54.2	26.8	4.6	.73	.13	
25-30'			.6	65.6	12.3	1.2	.73	.14	
25-20'				54.6	22.0	3.8	.71	.12	
25-10'				20.1	11.3	1.9		.09	
32-60'				.7	27.7	11.9		.30	
32-50'		1.8	81.1	14.2	1.0	.1	.97	.35	4.8
32-40'	1.5	13.8	67.8	14.4	.7	.4	.82	.41	-2.2
32-30'	1.5	9.5	56.1	31.1	.06	.1	.77	.36	-1.7
32-20'	2.0	5.2	50.6	35.2	3.1	.7	.75	.34	-2.4
32-10'		.1	67.6	29.7	1.1	.3	.82	.31	-3.9
30-130'		2.9	32.2	55.7	3.8	1.7	.72	.25	-3.1
30-120'		.8	67.1	20.8	1.6	2.0	.65	.3	-1.8
30-70'			.6	51.2	18.5	4.0		.12	
30-60'			29.7	26.4	15.8	4.7		.18	
30-50'			57.3	29.4	1.8	1.7	.85	.27	-6.0
30-40'			.6	38.7	26.8	10.6		.1	
30-30'			21.6	50.8	9.6	3.4	.7	.18	
30-20'			.9	49.5	12.2	3.7		.11	
30-10'			29.3	52.3	5.8	2.2	.8	.21	
30-BAS			1.2	40.7	28.9	6.6		.11	

TABLE III

The lower 40 feet (12.2 m) of the section at locality 25 consists chiefly of sand in the 0.25 to 0.125 mm size interval. In the upper

15 feet (4.6 m) the dominant grain size becomes finer. This indicates a drop in energy as deposition took place. The drop in energy may have been caused by channels meandering out of the locality area into another lobe of the delta.

Localities 32 and 30 are within the Jasper Creek Shale and show different geometries than the Lake Bridgeport Shale. Sandstones are usually present as blanket sands in the Jasper Creek Shale and as lenses in the Lake Bridgeport Shale. At locality 32 the average grain size is 0.34 mm. In the first 40 feet (12.2 m) the median value increases stratigraphically upward from 0.31 mm to 0.41 mm, and decreases to 0.30 mm in the last 20 feet (6.1 m). Sorting increases from 0.82-0.75 at the base of locality 32 to 0.97 at the top. Sorting (So) increased as deposition took place due to a decrease in the amount of material being deposited. This allowed sediments to be more thoroughly reworked by current activity.

A different pattern of grain size distribution is present in the section at locality 30. A pulsation between very fine to fine sand sediments is present. The pulsation is best demonstrated in the 0.25 mm class between levels on the order of 20-60 percent. This same pulsation is evident in the median as the grain size centers around 0.1 mm for the very fines and 0.2 mm for the fines. Meanders of a stream into and out of the area are the most likely cause for these events. A similar effect is seen in shale partings in limestone produced by meandering delta lobes (Brown, 1973).

LITHOFACIES

Microfacies can be distinguished in the Graford Formation by differences in lithology and fossils. Microfacies boundaries based on lithology and paleontology do not always coincide stratigraphically. Most lithologic contacts are well bedded and sharp. However, the contact between the Lake Bridgeport Shales and the Rock Hill Limestone is locally gradational with limestone pebbles like those of the Rock Hill Limestone present in a Lake Bridgeport Shale matrix.

Fossils indicate that marine transgressions occur in the upper portion of the Jasper Creek Shales, and in the Devils Den Limestone. Along the lithologic contact between the Jasper Creek Shale and the Devils Den Limestone, fossils of the same species occur in both the shale and in the limestone. The brachiopods, echinoids, and crinoids found in both lithologies probably represent pioneer organisms that were present before the accumulation of limestone. The organisms helped prepare a suitable environment for the accumulation of limestone.

Several lithofacies occur in the different Graford members. Four are found in the Lake Bridgeport Shale Member. The first is a fissile blue and purple shale lithofacies interbedded with large iron claystone nodules and iron claystone beds. Discordant claystone dikes occur and follow fractures in the shales. The shales are mottled, obscuring an alteration of blue and purple shales found within the Lake Bridgeport Shale Member. Reworked, unfossiliferous, sandstone lenses and blankets occur within the shales.

Fossils are present in the shales and claystones. Purple shales contain a pyritized fauna that has smaller fossils than those of the same species in the blue shale. Flute casts and ripple marks occur in sandstone blankets and false bedding occurs on some weathered slopes. Abundant fossils are: Worthenia, Trepospira, and Glabrocingulum.

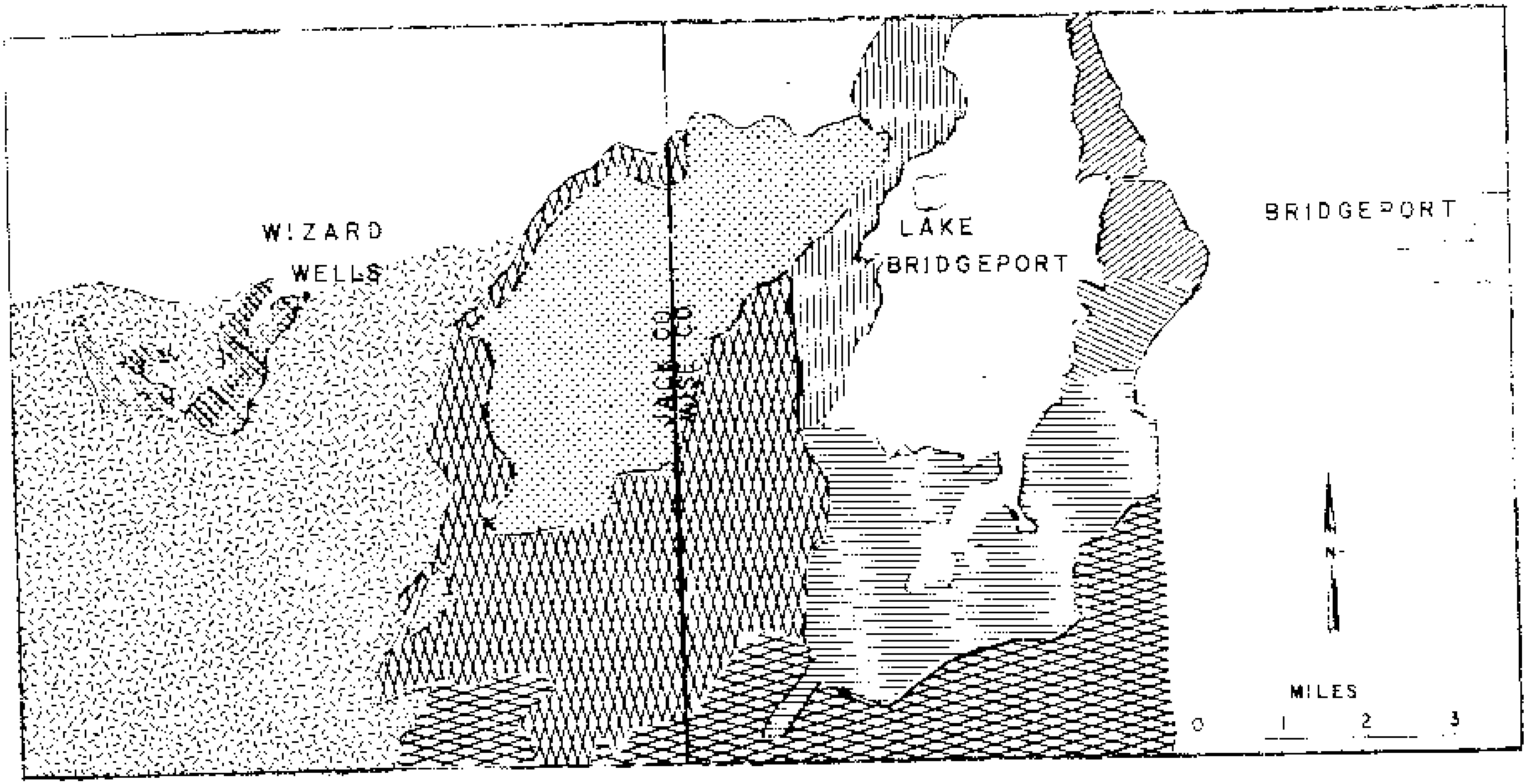
The facies is present at the following field localities: 1, 2, 6, 7, 9, 12, 13, and 16.

The second major facies is a yellow shale facies containing red mottling and limestone nodules. The fissile shales contain numerous fossil bryozoans, crinoids, and brachiopods. The facies is cut by a delta lobe (locality 25) characterized by interbedded shales and sandstones containing plant fossils. The facies is present at localities 11, 17, 21, and 23.

Blue fissile shales distinguish the third lithofacies. Interbedded with the shales are thin iron claystone beds. Discordant claystone dikes follow breaks in the shale. The shales contain medium bedded blanket sandstones with Calamites (Pteridophyta). The sandstones have flute casts and ripple marks, and claystones have veins of recrystallized calcite within the nodules. Abundant fossils are Zaphrentis and Lophophyllum. This lithofacies is exposed at localities 14, 15, and 18.

The fourth facies is a sandstone-blue shale facies which contains interbedded thin bedded claystones. Claystone dikes, which are discordant to the bedding planes, are present. These shales are overlain by a ledge-forming sandstone which grades into a quartz conglomerate cemented by iron and silica. No fossils have been observed in this facies. The facies is present at localities 20 and 22. Distribution of these facies is shown in figure 4.

The Rock Hill Limestone is a conglomeratic limestone that has gradational lithofacies distinguished by changing pebble size. The pebbles are composed of limestone fragments and increase in diameter moving away



LAKE BRIDGEPORT BLUE & PURPLE SHALE

LAKE BRIDGEPORT BLUE SHALE & SANDSTONE

LAKE BRIDGEPORT BLUE SHALE

LAKE BRIDGEPORT YELLOW SHALE

JASPER CREEK SHALE

JASPER CREEK RED BED SHALE

JASPER CREEK SHALE & SANDSTONE

DEVILS DEN BIO-INTRAMICRITE LIMESTONE

DEVILS DEN BIOMICRITE LIMESTONE

LITHOFACIES MAP FIGURE 4

from the greatest thickness of limestone.

Table 4 is a comparison of pebble diameters between localities 7, 17, and 18. The long axis (LA) and the short axis (SA) were measured on twenty-five pebbles per locality. Locality 7 is the furthest from the thickest accumulations of limestone and locality 17 is the closest. Pebbles in locality 7 are very large compared to the other localities and their size decreases moving toward the Chico Ridge Limestone.

South of Lake Bridgeport, the Rock Hill Limestone is an intramicrite, which changes to a biomicrite at the northeast side of the lake. The pebbles weather from a heavily pitted to smooth surface, some retain color, but others have the color weathered from them. The limestone shows differential compaction everywhere and is a ledgeformer.

LOC. 7	LA	SA	LOC. 17	LA	SA	LOC. 18	LA	SA
1	7.5	3.5	1	3.2	1.5	1	1.3	.8
2	6.0	3.0	2	2.5	1.8	2	.9	.5
3	4.2	2.1	3	2.0	1.3	3	1.0	.5
4	3.2	2.1	4	1.1	.8	4	1.0	1.0
5	4.5	3.0	5	2.2	1.0	5	1.0	.7
6	5.2	2.5	6	1.5	1.2	6	1.5	1.1
7	3.3	1.8	7	3.5	1.8	7	2.4	1.7
8	3.5	1.7	8	.8	.8	8	1.4	1.1
9	1.8	.7	9	1.7	1.1	9	1.0	.8
10	4.0	1.6	10	1.0	.95	10	1.1	1.0
11	4.0	1.6	11	2.7	1.5	11	.9	.6
12	2.2	1.4	12	2.5	1.7	12	.6	.6

LOC. 7	LA	SA	LOC. 17	LA	SA	LOC. 18	LA	SA
13	4.4	2.0	13	1.5	1.2	13	1.2	1.0
14	3.8	2.5	14	1.6	1.3	14	1.4	.8
15	2.8	1.8	15	2.1	1.1	15	1.0	.4
16	2.8	2.6	16	1.4	.95	16	1.2	.4
17	3.1	1.4	17	1.8	1.2	17	1.0	.8
18	3.2	1.9	18	1.2	1.2	18	2.0	1.0
19	3.5	2.8	19	2.0	.95	19	1.2	.6
20	3.2	2.5	20	2.3	2.4	20	1.5	1.0
21	4.0	2.2	21	2.0	1.5	21	1.2	.7
22	4.1	2.9	22	3.0	1.8	22	2.2	1.0
23	1.9	1.4	23	2.0	1.1	23	2.4	1.6
24	4.2	3.8	24	1.4	1.0	24	2.0	1.5
25	7.5	4.5	25	1.4	1.3	25	1.3	1.0
AVERAGE	3.9	2.3		1.9	1.3		1.3	.9

TABLE IV

(ALL MEASUREMENTS IN CM)

The Jasper Creek Shale Member is usually unfossiliferous and contains three main lithofacies. First, a sandstone facies overlies shales near Wizard Wells (locality 30). This sandstone grades to the south into interbedded fissile mottled shales, with thin iron claystone beds and sandstones. West of Joplin, the shales turn very dark red and are interbedded with bluish white sandstone. This lithology persists to the east until it is covered by the Cretaceous overlap at locality 37.

In the study area two lithofacies are found in the Devils Den

Limestone. First is a biomicrite in the southern part of the area at localities 5, 28, 29, 31, and 34. The biomicrite is usually present above the red shales of the Jasper Creek Shale. The second facies is an interbedded biomicrite and intramicrite, which occurs at localities 39, 40, and 41. The interbedding is present in the northern part of the study area. Biomicrites and red shales are present in the south. However, the red shales grade into yellow shales to the north. Biomicrites persist going northward until they interfinger with the inter-bedded bio- and intramicrites. Pebbles occur within the intramicrites that are similar to those found in the Rock Hill Limestone, but are less easily recognized. Each interbedded locality has a basal intramicrite.

BIOFACIES

Biofacies are most evident in the upper portion of the Lake Bridgeport Shale Member. Collections of the megafauna were made. Fossils were identified, counted, and the percentages of the species at the different localities were determined. Biofacies were determined on the basis of the type of fossils present, their relative abundances, and their associations. Appendix II documents the different biofacies and their faunal composition.

South of Lake Bridgeport is a gastropod facies which conforms to the blue and purple shale lithofacies. Gastropods comprise 64% to 78% of the fauna in the southern exposures, but along the eastern lake shore, the percentage of the gastropods decreases to 40% and the number of corals increases. Gastropods are less abundant in the purple shales

(40%) than in the blue shales (76%), and cephalopods are more abundant in the purple shales (31%) than the blue shales (11%). This facies is found at localities 1, 6, 7, 9, 16, and 19.

The coral facies is present along the eastern shores of Lake Bridgeport. Corals make up 34% to 59% of the fauna. Dominant forms are Lophopyllum and Zaphrentis. The biofacies corresponds to the blue shale lithofacies, and is present at localities 14, 15, and 18.

The third biofacies of the upper Lake Bridgeport Shale is the sponge-crinoid facies. This facies corresponds to the yellow shale lithofacies and lies to the north of the corals on the eastern shore. Crinoid stems are abundant in this facies and make up the main portion of the crinoid ossicles present. The important sponges are Heterocoelia and Coelocladia. Crionids contribute 12% to 100% of the individuals while sponges add 0% to 36% of the individuals in the fauna. The bio-facies is present at localities 11, 12, 21, and 25. Strata at locality 23 contain a mixed sponge-crinoid and coral fauna, and are thought to represent a transition zone between the two biofacies.

A fourth biofacies is found in the middle portion of the Lake Bridgeport Shale. It is dominated by bivalvia which compose 31% of the fauna. The genera Nuculopsis and Astartella contribute 10% and 18%, respectively, of the individuals present. The facies is found at locality 38.

Study of limestone thin sections reveals several microfacies, discussed below. Within the Rock Hill Limestone a crionidal biofacies and an algal biofacies can be distinguished. The crinoidal biofacies is present south of Lake Bridgeport (localities 1, 2, 6, 7, and 9) and grades into the algal biofacies on the eastern shore of the lake. The algal facies is present at localities 117, 17, 18, and 21. The Chico Ridge Limestone still further to the northeast is,a large reef. The Rock Hill Limestone forms the basal portion of the reef (Scott and Armstrong, 1932).

A representative crinoid facies sample from the Rock Hill Limestone contains crinoids, phylloid algae, and intraclasts in a microcrystalline calcite matrix and is a wackestone (Dunham, 1962) or intramicrite (Folk, 1962). Other fossils found in the crinoid biofacies are: stromatolites, solenoporaceans, bryozoans, echinoid plates, brachiopods, green algae, protozoa (Triticites), and ostracods. A representative algal facies sample contains crinoids, phylloid algae, and intraclasts in a micro-crystalline calcite matrix and is a mud- or wackestone (Dunham, 1962) or a biomicrite or intramicrite (Folk, 1962). Other fossils found in the algal facies are: ostracods, gastropods, bryozoans, uniserial foraminifera, protozoa (Triticites), brachiopods, echinoid plates, and solenoporaceans.

The Devils Den Limestone biofacies likewise has algae and crinoids dominant in the fauna. Spiriferid brachiopods are abundant at the southern localities (28, 29, and 34). Triticites (Protozoa) is abundant at the northern localities 5 and 31. Algae and crinoids occur at all localities. A southern locality sample typically has: algae, bryozoans, phylloid algae, and brachiopods in a microcrystalline calcite matrix, and is a wackestone or biomicrite. Other fossils present are: ostracods, sponges, solenoporaceans, gastropods, and stromatolites.

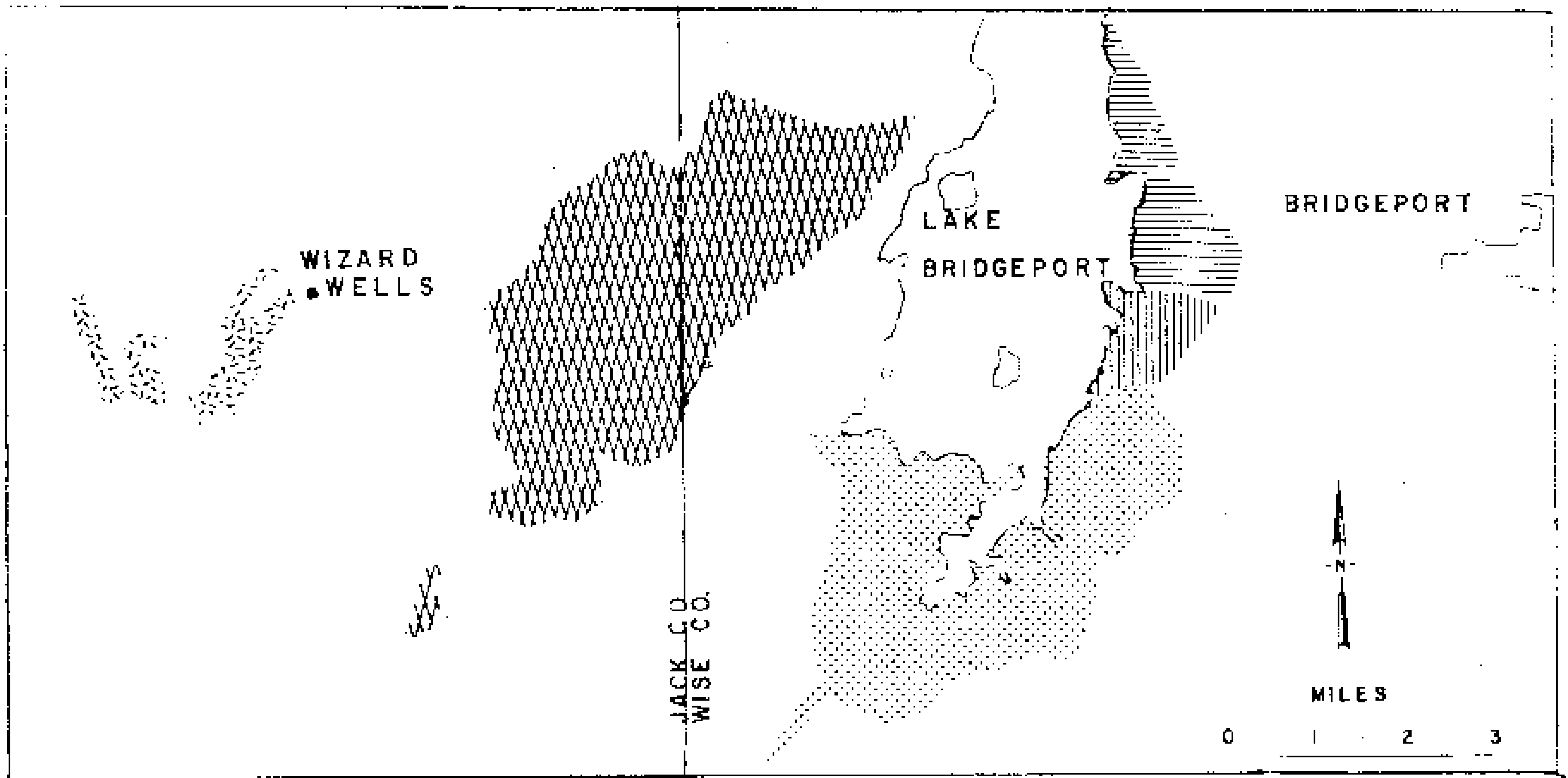
Northern locality samples typically have crinoids, phylloid algae, and protozoa (Triticites) in a microcrystalline calcite matrix, and are wackestones or biomicrites. Other fossils present are: gastropods, solenoporaceans, brachiopods, echinoid plates, sponges, green algae, uniserial foraminifera, and corals.

Localities 39, 40, and 41 (west of the lake) consist of a series of interbedded intramicrites and biomicrites. A typical intramicrite consists of crinoids, phylloid algae, intraclasts, in a microcrystalline calcite matrix. Other fossils observed are: bryozoans, stromatolites, solenoporaceans, echinoid plates, ostracods, protozoa (Triticites), sponges, and brachiopods. A typical biomicrite consists of crinoids and phylloid algae in a microcrystalline calcite matrix. Other fossils observed are: solenoporaceans, bryozoans, ostracods, green algae, uniserial foraminifera, and gastropods. Biofacies are shown in figure 5.

MICROFACIES ANALYSIS

Brown (1973) has described an idealized depositional model for Canyon age sediments in North Central Texas. The model recognizes three stages: first, the constructional phase of a delta; second, a destructive reworking of the delta; and third, a marine transgression which produced shelf carbonates (figure 6). All of these stages can be seen in the Graford Formation.

In the constructional stage, deposits include an unfossiliferous prodelta of silty mud, plant hash, and ironstone nodules. Locality 33 exhibits all of these characters and is the lowest stratigraphic section in the study area. Next is the Distal Delta-Front portion characterized by graded beds, sole marks, and flow rolls. All of these features are



LAKE BRIGEPORT SHALE MEMBER:

GASTROPOD FACIES

SPONGE-CRINOID FACIES

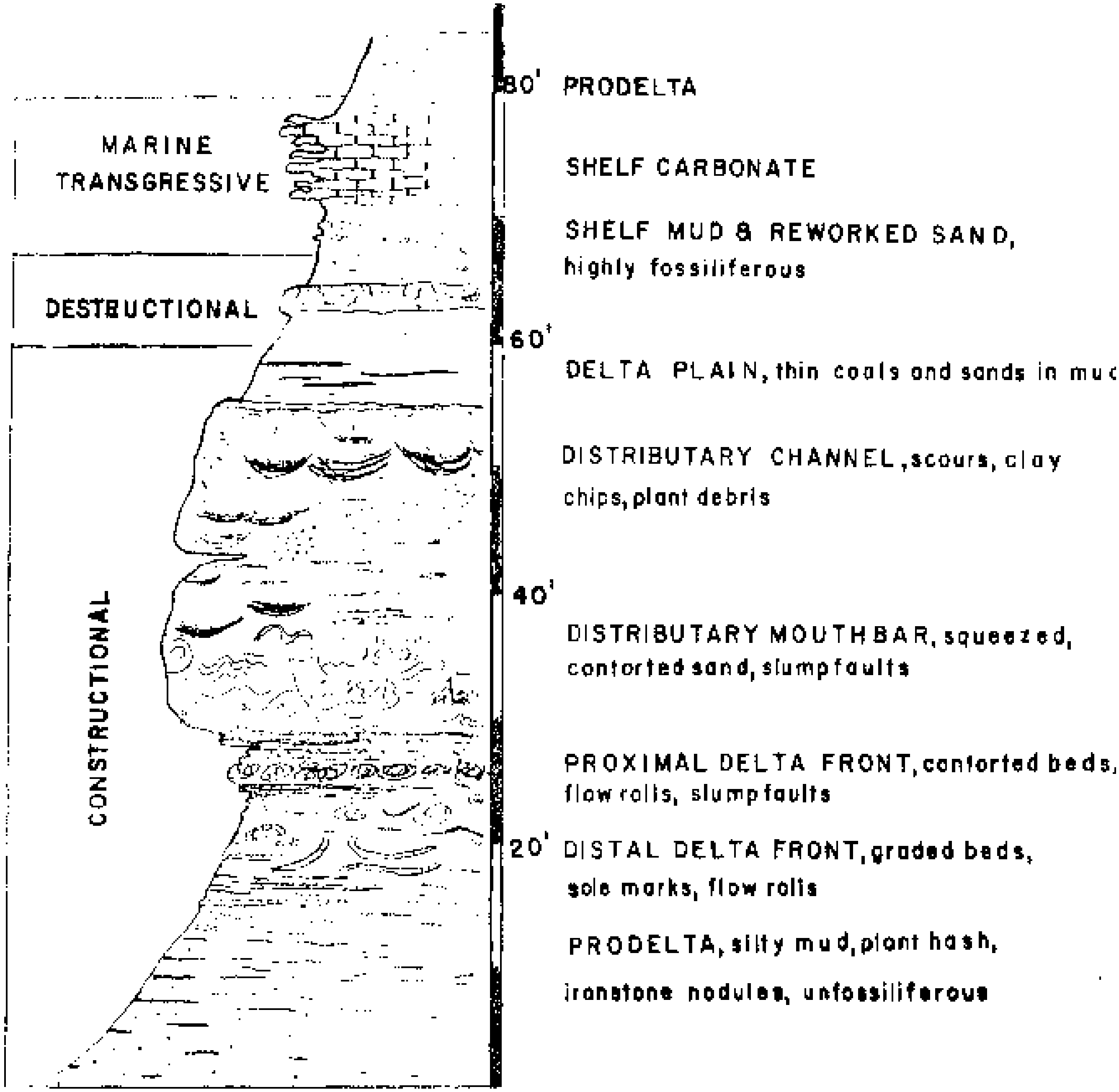
CORAL FACIES

DEVILS DEN LIMESTONE MEMBER:

ALGAE-CRINOID FACIES

FUSILINID-RICH ZONES

FIGURE 5 BIOFACIES MAP



CANYON DEPOSITIONAL MODEL

BROWN, 1973

FIGURE 6

present in locality 8 which is stratigraphically the next highest locality. Also present is the ichnofossil Scalarituba missouriensis, a marine worm that probably lived in a tidal flat environment (Conkin, 1968). The Proximal Delta-Front has contorted beds, flow rolls, and slump faults. These features are exhibited at locality 24. Distributary Mouth Bars and Distributary Channels have not been observed by the author. The Delta Plain, with its thin coals and sands in mud, is present at locality 25 and has prograded across the sponge-crinoid facies.

Shelf Muds and reworked sands, which are highly fossiliferous, are the most abundant in outcrop and are present at localities 1, 2, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 21. The Shelf Muds and reworked sands, found at these localities, are in the Upper Lake Bridgeport Shale Member.

The marine transgressive stage of shelf carbonates is represented by the Rock Hill Limestone and the Devils Den Limestone. The limestones are characterized by differential compaction and shale parting caused by meanders into and out of the area (Brown, 1973). The Marine Transgressive localities are 1, 2, 5, 6, 7, 9, 11, 14, 16, 17, 18, 19, 21, 28, 29, 31, 34, 39, 40, and 41.

The conglomeratic nature of the Rock Hill Limestone is common for Canyon age limestones in North Central Texas. Echinoid spines are present in the limestone. These biological crushers broke loose the limestone intraclasts from the forming reef. However, destruction of partially consolidated bottom sediments by mechanical agents during periods of intense current or wave activity was a contributing factor to the formation of intraclasts (Brentsky, 1962). A purely physically sorted intraclast unit should show preferred orientation, graded bedding, and homogeneity of texture within a given layer (Bretsky, 1962). Although none of these features are observed intraclasts were influenced by physical activity. Therefore intraclasts originated by biologic and physical activity (Brooks, 1966).

Calcareous facies of the Devils Den Limestone (Winchell Limestone) have been described by Wermund (1962). These facies are defined by both lithology and paleontology. The first facies is the band facies that consists of clastic limestones with thin shale beds. This facies does not occur in the study area but there is an increase in the amount of algae accompanying the facies moving toward the Chico Ridge Limestone just northwest of the study area. The Off-Bank facies is composed of algal-micrites and intramicrites, and is present at localities 39, 40, and 41. The third facies is characterized by several beds that are formed entirely of fusulinids bound in a micritic matrix, and is present at localities 5 and 34.

PALEOECOLOGY

The upper portion of the Lake Bridgeport Shale is the most fossiliferous level and was formed in the destructional phase of the delta. The gastropod facies were formed in the highest energy environment, as indicated by grain size analysis. Vagrant epifaunal creatures, like gastropods, are able to cope with shifting sediments better than a *sessile* infauna or epifaunal filter feeders, such as brachiopods, crinoids, and bryozoans. The gastropods Glabrocingulum, Worthenia, and Trepospira are depth indicators. The first two organisms were shallow water dwellers while Trepospira indicates intermediate depth (Sloan, 1955). These taxa are most abundant in the gastropod facies because they could cope with a changing physical environment. Normal salinity water is indicated by the crinoid stems (Tasch, 1973).

The coral facies contains Lophophyllum and Zaphrentis. Both of these taxa were eurybathic and may be found at almost any depth (Sloan, 1955). Corals are limited by the amount of suspended clastic particles in the environment. Crinoids are also present and indicate normal salinity. Both the corals and crinoids utilized each other as substrates in the facies. In plate I figure A, the coral is the substrate for the crinoid. This facies seems to have formed in the calmest of all the environments. However, storms did effect the facies as indicated by a large number of damaged corals (figure B). These damaged corals have a stair-stepped appearance and may represent several storm events.

The sponge-crinoid facies is cut by a Delta-Plain progradation at locality 25. The facies was deposited in a quiet water environment as indicated by grain size analysis. Also the presence of corals, bryozoans, and crinoids compliments the grain size analysis in that these taxa are limited by the amount of suspended material present in the environment. Bryozoans often encrust the stems of crinoids and sponges.

Johnson (1962), working with Pennsylvanian fossil assemblages from the mid-continent, compiled groups of fossils by cluster analysis based on their association with one another. Although no locality in the study area has all of the fossils that define his groups, similar assemblages are present. In Johnson's group I, the fauna is associated with limestone and calcareous shales. It consists of 13 species, 9 of

FIGURE A

FIGURE B

PLATE I

which are found in the sponge-crinoid facies. Therefore the sponge-crinoid facies closely resembles the first group of Johnson's. This indicates there is a close faunal association between the mid-continent and North Central Texas.

Blue and purple shales are common in Pennsylvanian sediments. Elias (1937) attributed Kansan purple shales to red soil which had eroded off a higher landmass while blue shales were the result of reducing action of organic matter on iron oxides in the original silt. The purple shales of the Lake Bridgeport Shale had a high iron content, indicated by the abundance of iron nodules, when deposition took place. A high iron content in the water retards the growth of the organisms present (Tasch, 1953). The iron probably first formed as pyrite in a negative Eh environment. A later shift to a positive Eh allowed oxidation and hydration of the original sulphides to produce limonite (Krumbein and Garrels, 1952). Iron-containing feces extruded by sessile and free-swimming animals add to the amount of particulate iron on and near the bottom and was broken down by filter feeders (digestive juices) and bacteria (Tasch, 1953).

Fossils in the purple shales are smaller than those of the blue shales. Nektonic organisms (cephalopods) are more abundant in the purple shale, suggesting that benthonic conditions were less favorable than those associated with blue shale deposition.

X-ray diffraction analysis of the Lake Bridgeport Shale reveals the presence of the following material: illite, kaolinite, a trace of montmorillonite, abundant organic material, quartz, dolomite, and gypsum (Hamilton, 1958). Kaolinite is characteristic of oxidized red

As already noted, the Rock Hill Limestone is the basal unit for the Chico Ridge Limestone, but limestone intraclasts also form the basal unit of the Devils Den Limestone on the western side of the lake (localities 39, 40, and 41). The Devils Den Limestone at these localities is a series of interbedded intramicrites and biomicrites.

The southern and western exposures of the Devils Den Limestone are differentially compacted biomicrites (localities 5, 28, 29, 31, and 34). All limestones were deposited within the photic zone which is indicated by the presence of algae. Unbroken Eugonophyllum (Chlorophyta) blades indicate quiet water deposition (Wray, 1961).
The bottom sediments over which the first bank sediments were deposited are fossiliferous shales. These shales form firm bottoms for organisms (Wermund, 1962). Echinoids, crinoids, brachiopods, and sponges are found in the shales below areas of limestone accumulation and are pioneer organisms to limestone accumulation. Crinoids and bryozoans seem to provide the framework for the reef and the algae are binders. The red algae Archaeolithophyllum missouriensum grew as small irregular crustose patches which were unattached on the sea bottom. These indicate normal salinity in waters rich with calcium carbonate (Johnson, 1960).

AGE DETERMINATION

The Graford Formation of Wise County contains Triticites (Biledo, 1961) in all its limestone members as well as Chonetina and Prouddenites. All are index fossils of the Missourian (Moore, 1970). Heliospongia excavata is found in the Lake Bridgeport Shale and the Rock Hill Limestone and has a range of Lower to Middle Missourian (Finks, 1960)

Archeolithophyllum missouriensum occurs in the Rock Hill Limestone and Devils Den Limestone and has a range of Lower to Middle Missourian (Johnson, 1960). Other fossils found throughout the Graford Formation are typical of the Pennsylvanian. The age of the Graford Formation is therefore established as Lower to Middle Missourian.

ECONOMIC GEOLOGY

Missourian rocks are a chief contributor to the economic resources of Wise County. Coal was mined by the Bridgeport Coal Company until 1932. Most of the coal was sold to the railroad (Scott and Armstrong, 1932). Clay from the Lake Bridgeport Shale is mined for brick making in and around the town of Bridgeport, Texas. Brick operations were first started by the Bridgeport Brick Company, but are now carried out by the Acme Brick Company. The company produces 30 million bricks (60,000 yards) per year and has over 100 years of reserves available (Capps, Acme Brick Company plant manager, oral communication, 1974).

Missourian limestones are also economically important to the area. Quarries are present in the Chico Ridge Limestone with operations centering around Chico, Texas. The Devils Den Limestone is quarried by the TXI plant near Joplin in Jack County. The Chico Ridge Limestone is the principle source of limestone aggregate for the Dallas-Fort Worth area (Brown, 1973).

In making limestone aggregate, numerous size fractions are not utilized so that up to 50% of the limestone is wasted. Table 5 is a suggested list of possible applications for these waste aggregates in Wise County. Although no one application can consume all the available aggregate, it is hoped that the whole list of uses will lead to a better utilization of this resource.

US STANDARD SIZE IN MM	US STANDARD SIEVE MESH	USAGE
size not critical		abrasives for buffing and cleaning
2.38-0.84	20-8	agricultural limestone: applied to correct acidity of soil and for obtaining the desired ratios of fertilizers
2.38	8	barnstone-absorbent of organic wastes.
i16-2	10-4	poultry grit
18.9-3.8	5-4	filter stone in sewage plants
3.59	30	asphalt filler.
size not critical		athletic field marking
size not critical		bulb growing--small attractive chips
size not critical		fill material--for land fill

(Lamar, 1961)

TABLE V

CONCLUSIONS

Microfacies can be defined by lithology and paleontology. Lithologic microfacies of the Lake Bridgeport Shale Member are blue shale, purple shale, yellow shale, and sandstone-blue shale. Paleontologic microfacies are the gastropod-, bivalve-, coral-, and sponge-crinoid-biofacies. The Rock Hill Limestone has biomicrite and intramicrite microlithofacies and a crinoidal algal microbiofacies. The Devils Den Limestone has an off-bank biofacies and fusulinid rich zones.

Biofacies in the shales were deposited in the destructive phases of deltaic deposition and represent many different microenvironments. Limestones were deposited in marine transgressive phases where little deltaic deposition was taking place. Repetitions of lithology can be demonstrated in most members and represent recurring conditions during Graford time.

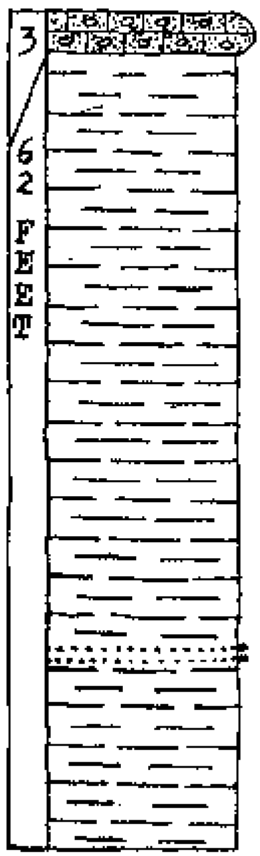
The Lower to Middle Missourian Graford Formation is an important source of revenue for the area. Limestone aggregate has different utilizations and should be marketed where there is a current waste of crushed rock.

APPENDIX I

The measured stratigraphic sections used in the study will be described in this appendix. Color descriptions are in terms of the GSA Rock Color Chart. Colors, unless otherwise noted, were determined in the lab. Precise geographic locations for each section are given. All sections are drawn to a vertical scale of 1 inch equal 15 feet. Sections are drawn in accordance with Compton's (1962) Manual of Field Geology.

Locality 1: 0.9 miles west of Lake Bridgeport on US 380, 0.4 miles west of the entrance to Runaway Bay. Section begins at lake level.

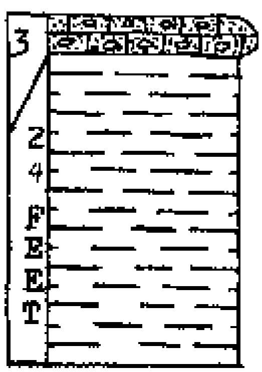
A 65 foot (19.8 m) thick section of Rock Hill 'Limestone and Lake Bridgeport Shale is exposed at locality 1. The Lake Bridgeport Shales are light bluish gray when fresh and light olive gray when weathered. Weathering out of the fissile shales are large iron claystone nodules which are *very* dark red or moderate reddish orange. Diameters of the nodules range from 3 inches (7.6 cm) to 8 inches (20.3 cm). Two inch thick (2.5 cm) ledge-forming claystone beds lie 16 feet (4.9 m) and 17 feet (5.2 m) above the base of the section. Interbedded with the shales are lenses of reworked sandstone which are very light gray when fresh and light olive gray when weathered. The shales are mottled in outcrop and have a total thickness of 62 feet (18.9 m).



Locality 1

Fossils are present in both the shales and in the iron claystone nodules.

The Rock Hill Limestone, a ledge-forming limestone conglomerate, caps the section. Fresh matrix is moderate yellowish brown which weathers to pale yellowish brown. Fresh pebbles are moderate yellowish brown and pale red and weather to pale yellowish brown. Some pebbles have a smooth weathered surface, others are pitted. Differential compaction is exhibited in the limestone giving its beds a wavy appearance. The member is 3 feet (0.9 m) thick. Strike is N 80 E, and the dip is less than 5° to the northwest.



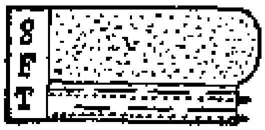
Locality 2

Locality 2: 0.9 miles west of the Lake Bridge-port on US 380, 0.4 miles west of entrance to Runaway Bay. Section begins at lake level, 200 yards west of locality 1.

A 27 foot (8.2 m) thick section of Rock Hill Limestone and Lake Bridgeport Shale is exposed at locality 2. The Lake Bridgeport Shales are light bluish gray when fresh and weather light olive gray. Moderate reddish orange iron claystone nodules weather out of the fissile shales; The shales are mottled in outcrop and have a total thickness of 24 feet (7.3 m).

Fresh matrix of the Rock Hill Limestone is moderate yellowish brown that weathers to pale yellowish brown. Fresh pebbles are moderate yellowish brown and weather pale yellowish brown. Differential compaction is exhibited in the limestone giving its beds a wavy appearance. The member is 3 feet (0.9 m) thick.

Locality 3: 1.9 miles west of shore of Lake Bridgeport on US 380. Section begins at lake level.

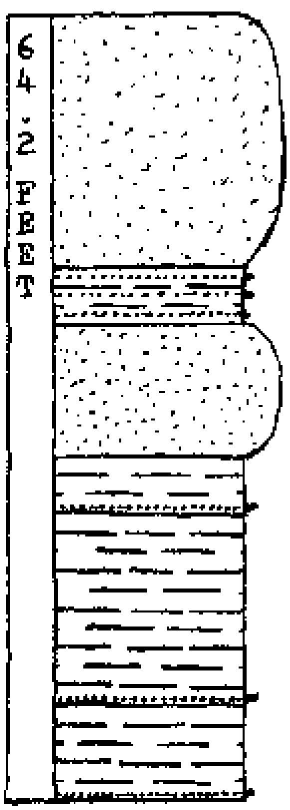


A 8 foot (2.4 m) thick section of Jasper Creek

Locality 3 Shale is exposed at locality 3. The section contains a basal 4 inch (10.2 cm) thich sandstone which is pinkish gray fresh and grayish orange weathered. It is overlain by a 1 foot (0.3 m) of light olive gray weathered shale, 6 inches (15.2 cm) of grayish orange weathered sandstone overlain by 1 foot 0.3 m) of light olive gray weathered shale and 5 feet (1.5 m) of grayish orange weathered sandstone. The Jasper Creek Shale Member is unfossiliferous in this section.

Locality 4: 11.1 miles west of lake shore on US 380, road cut exposure begins at road level on east end of the road cut.

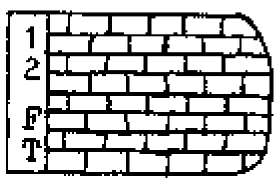
A 64.2 foot (19.6 m) thick section of Jasper Creek Shale is exposed at locality 4. The section begins with a 2 inch (5 cm) thick basal sandstone that is light gray fresh and yellowish gray weathered. Outcropping over the basal sandstone is an 8 foot (2.4 m) thick shale that is light olive gray with iron claystone nodules (moderate reddish orange) weathering out of fissile shale. A 2 inch (5 cm) thick sandstone, that is a ledge-former, with iron stained joints is overlain by a 15 foot (4.6 m) light olive gray shale with claystone dikes following the joints in the fissile shale. The shale is over-lain by a 4 inch (10.2 cm) ledge-forming yellowish



Locality 4

gray sandstone, and is overlain by a 5.5 foot (1.7 m) fissile light olive gray shale that is overlain by a 10 foot (3 m) yellowish gray sandstone with worm borings. Next is a 5 foot (1.5 m) interval of interbedded sandstone and shale. A 20 foot (6.1 m) yellowish gray sandstone caps the section.

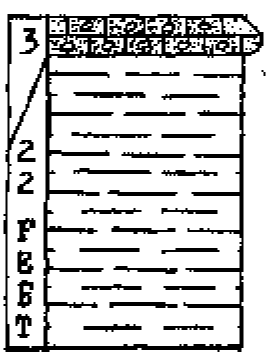
<u>Locality 5:</u> 11.5 miles west of lake shore on US 380, section is a road cut, and begins at road level.



Locality 5

A 12 foot (3.7 m) thick section of Devils Den Limestone is exposed at locality 5. The limestone is pale yellowish brown when fresh and grayish orange when weathered. Differential compaction, that produces wavy bedding in the limestone, is present.

<u>Locality 6:</u> 1.1 miles west of lake shore off US 380 in Runaway Bay complex at Lanai and Lanai Circle. This section is a road cut and begins at road level.

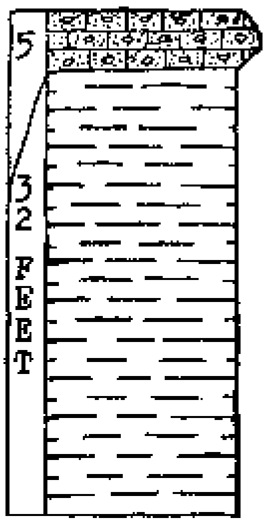


Locality 6

A 25 foot (7.6 m) thick section of Rock Hill Limestone and Lake Bridgeport Shale is exposed at locality 6. The upper portion of the Lake Bridgeport Shale is 22 feet (6.7 m). The fissile shales are mottled, and are light gray and pale red purple in outcrop. Weathering out of the shales are moderate reddish orange iron claystone nodules 2 inches (5 cm) in diameter. Fossils are abundant in the shale and in the iron claystone nodules.

The Rock Hill Limestone is 3 feet (0.9 m) thick and is a dark yellowish brown fresh. Pebbles are moderate yellowish brown matrix which weathers to a pale yellowish brown. The average diameter of the pebbles is 1 inch (2.5 cm).

<u>Locality 7:</u> 1.1 miles west of lake shore off US 380 in Runaway Bay complex at the corner of Blue Fathom and Bayside Drive. The section is a road cut and begins at road level.

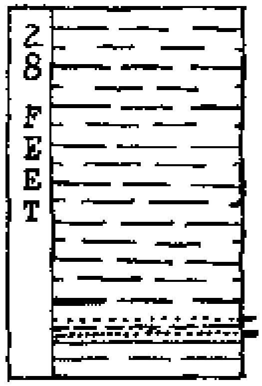


Locality 7.

A 37 foot (11.3 m) thick section of Rock Hill Limestone and Lake Bridgeport Shale is exposed at locality 7. The upper Lake Bridgeport Shale begins with 12 feet (3.7 m) of light bluish gray fissile shale. Secondary gypsum is present along with iron claystone nodules which are very dark red or moderate reddish orange. These weather out of the shales. The claystones are about 6 inches (15.2 cm) in diameter. The next 20 feet (6.1 m) is a pale red purple fissile shale with a pyritized dwarf fauna.

The Rock Hill Limestone is 5 feet (1.5 m) thick, and has a gradational contact with the underlying shales. Pebbles in the contact are in a shale. The matrix is grayish orange when fresh and weathers pale yellowish brown. The fresh pebbles are pale red, or moderate yellowish brown, and weather pale yellowish brown. Some of the pebbles contain fossils that are found in the matrix, and one pebble was composed of crinoidal hash. The limestone pebbles are larger here than in any other section, ranging from 1.5 inches (3.8 cm) to 3 inches (7.6 cm) in diameter.

Locality 8: 0.5 miles west of intersection of FM 1658 and US 380 on US 380. Section is a road cut and begins at road level.

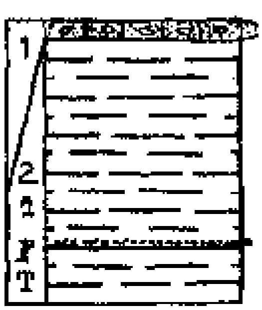


Locality 8

A 28 foot (8.5 m) thick section of the Lake Bridgeport Shale is exposed at locality 8. The section begins with 3 feet (0.9 m) of light olive gray shale with iron claystone nodules that are moderate reddish orange. Overlying the shale is a 1 foot (30.5 cm) thick sandstone that is very pale orange fresh and grayish orange weathered. Next is a 0.5 foot (15.2 cm) light olive gray shale and a 0.5 foot (15.2 cm) grayish orange sandstone. The section is capped by a 23 foot (7 m) light olive gray shale. Iron claystone nodules weather out of all the shales. The sandstones are ledge-formers which contain feeding trails of Scalarituba missouriesis and flute casts (both were observed as float). Sandstone lenses are also present indicating old stream channels in the delta. All shales are fissile and unfossiliferous. The upper 7 feet (2.1 m) have a pale red purple tint in outcrop.

Locality 9: 4.7 miles west of intersection of FM 1658 and US 380 on US 380. Section is a road cut and begins at road level.

A 22 foot (6.7 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 9. The Lake Bridgeport Shale is 21 feet (6.4 m) thick. The basal 6 foot (1.8 m) thick shale is a light olive gray in outcrop, and is overlain by a 1 foot (30.5 cm) ledge-forming sandstone that is a



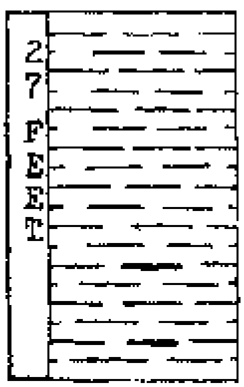
Locality 9

pale orange fresh and grayish orange weathered. Next in the section is 14 feet (4.3 m) of light olive gray fissile shale which changes color in the upper 5 feet (1.5 m) to pale red purple. Moderate reddish orange iron claystone nodules weather out of all the shales and are 2 inches (5 cm) in diameter. Sandstones have flute casts which indicate a paleo-current direction of N 50 W.

The Rock Hill Limestone is 1 foot (0.3 m) thick and has a pale yellowish brown weathered matrix with pale yellowish brown weathered pebbles. The fresh matrix is a dark yellowish brown and the fresh pebbles are moderate yellowish brown. Strike is N 45 W, and the dip is less than 5° to the southwest.

Locality 10: 1.9 miles west of intersection of US 380 and FM 1658 on FM 1658. Section is a road cut and begins at road level.

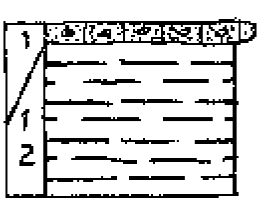
A 27 foot (8.2 m) thick section of the Lake Bridgeport Shale is exposed at locality 10. The fissile shale is a light olive gray in outcrop, and is interbedded with thin bedded moderate reddish orange iron claystones (0.4 inches (1 cm) thick). Iron claystone nodules and fossils are present.



Locality 10

Locality 11: intersection of FM 1658 and FM 2952 on FM 2952. Section is a road cut and begins at road level.

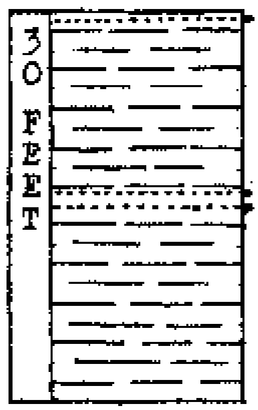
A 13 foot (3.9 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 11. The Lake Bridgeport Shale is grayish



Locality 11

orange, with patches of pale red purple shale in the upper 3 feet (0.9 m). Weathering out of the fissile shales are very light gray unfossiliferous nodules. However, the shales are abundantly fossiliferous.

The Rock Hill Limestone is 1 foot (30.5 cm) thick and has a pale yellowish brown weathered matrix and pebbles. The fresh matrix and pebbles are moderate yellowish brown.

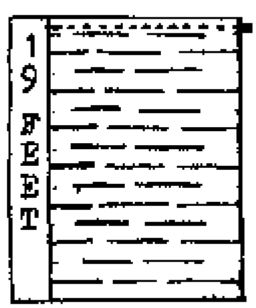


Locality 12

<u>Locality 12:</u> 0.5 miles off US 380 on east side of lake shore on dirt road that runs by tank battery next to lake bridge. Section begins at lake level.

A 30 foot (9.1 m) thick section of the upper portion of the Lake Bridgeport Shale is exposed at locality 12. Interbedded with the shales are three grayish orange sandstones which are ledge-forming and occur at the 17 foot (5.2 m), 18 foot (5.5 m), and 30 foot (9.1 m) levels. The sandstones have a thickness of 2 inches (5 cm). Ripple marks in the sandstone indicate a paleocurrent direction of N 85 W and flute casts show a N 40 E direction. Moderate reddish orange iron claystone nodules weather out of the fissile shales and are 1 inch (2.5 cm) to 1.5 inches (3.8 cm) in diameter.

<u>Locality 13:</u> 1 mile off US 380 on dirt road of locality 12 on east side of the lake shore. Section begins at lake level.

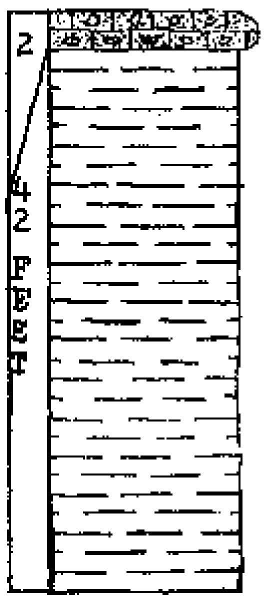


Locality 13

A 19 foot (5.8 m) thick section of the Lake Bridgeport Shale is exposed at locality 13. The fissile shales are light olive gray and the iron claystone beds (1 cm thick) are moderate reddish orange. Sandstone blankets are very pale orange fresh and grayish orange weathered, and occur at the 15 foot (4.6 m) and 19 foot (5.8 m) level and is 8 inches (20.3 cm) thick. Flute casts and ripple marks show a N 46 E paleocurrent direction. Secondary gypsum is present in the shales.

Locality 14: 1.5 miles off US 380 in large ditch off dirt road of locality 12 on east side of lake shore. Section begins at lake level.

A 44 foot (13.4 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 14. The Lake Bridgeport Shale is 42 feet (12.8 m) thick with 1 cm thick iron clay-stone nodules. The fissile shales are light olive gray and the nodules are moderate reddish orange. Minor sandstone beds, about 2 cm thick, are present and contain flute casts and ripple marks indicating a N 44 E paleocurrent direction.



Locality 14

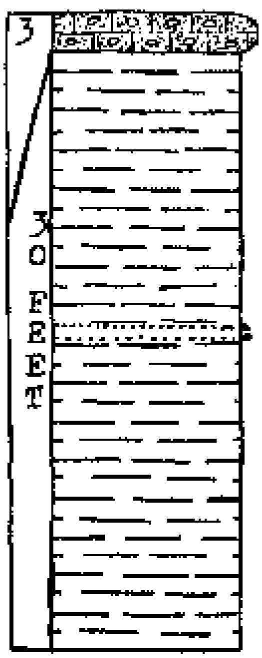
The Rock Hill Limestone is 2 feet (0.6 m) thick and has a pale brown matrix that weathers pale yellowish brown. Their average diameter is 0.2 inches (0.6 cm) to 0.5 inches (1.3 cm). The Lake Bridgeport Shale is 42 feet (12.8 m) thick with 1 cm thick iron claystone nodules.

Locality 15: 1.1 miles west of lake shore off US 380 in Runaway Bay complex at the corner of Blue Fathom and Bayside Drive, section is a road cut and begins at road level. A 12 foot (3.7 m) thick section of the Lake Bridgeport Shale is exposed at locality 15. The fissile shale is light bluish gray with iron claystone nodules (moderate reddish orange) weathering out of the shale.

Locality 15

Locality 16: 2 miles off US 380 on dirt road of locality 12 on east side of lake shore. Section begins at lake level.

A 33 foot (10.1 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 16. The Lake Bridgeport Shale is fissile light olive gray shales that contain iron claystone dikes which follow fractures within the shale. Iron claystone beds (moderate reddish orange) are interbedded with the shales and have a thickness of 1 cm. Dikes cut both the shales and claystones and are 1 cm thick. There are two small sandstone blankets (white fresh that weather to grayish orange) at the 24 foot (7.3 m) and 25 foot (7.6 m) levels which form two small ledges.

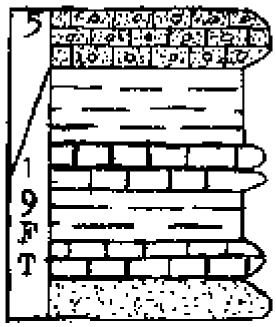


Locality 16

The Rock Hill Limestone is 3 feet (0.9 m) thick with a weathered grayish orange matrix and pale yellowish weathered pebbles. The fresh matrix is a dark yellowish orange and the fresh pebbles are moderate yellowish brown.

Locality 17: south side of Lake Bridgeport Dam on FM 1658 at boat launching site. Section begins at lake level.

A 24 foot (7.3 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 17.



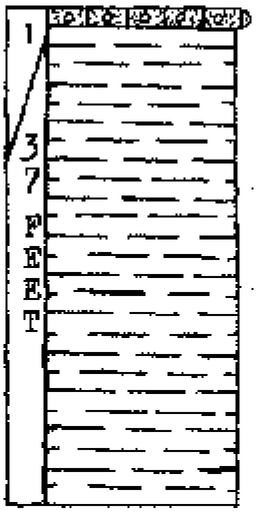
Locality 17

The basal portion is a 3 foot (0.9 m) thick grayish orange sandstone which is very pale orange on a fresh surface. Next is a 3 foot (0.9 m) grayish orange limestone that is pale brown fresh. Next is a grayish orange fissile shale that is 5 feet (1.5 m) thick. Next in the section are two limestones, each of which is 1 foot (30.5 cm) thick. Both are dark yellowish brown fresh and pale yellowish brown weathered. Overlying the limestones is a fissile grayish orange shale that is 6 feet (1.8 m) thick.

The Rock Hill Limestone is 5 feet (1.5 m) thick. Pebbles are not as apparent here as at other localities in this section. The fresh limestone is moderate yellowish orange which weathers pale yellowish orange. Strike is N 80 W and the dip is less than 5° to the southwest.

Locality 18: 0.8 miles south of Lake Bridgeport Dam on dirt road (west fork) on Twin Peaks Hill. The section begins at lake level.

A 38 foot (11.6 m) thick section of the Rock Hill Limestone and the Lake Bridgeport Shale is exposed at locality 18. The Lake



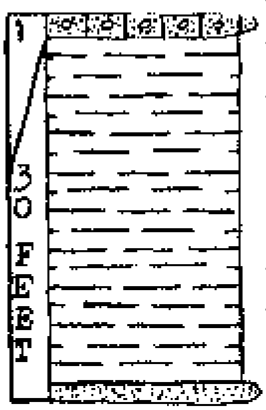
Locality 18

Bridgeport Shale is 37 feet (11.3 m) thick and is a light olive gray fissile shale. Interbeded with the shales are iron claystone beds (1 cm) thick which are moderate reddish orange.

The Rock Hill Limestone is 1 foot (30.5 cm) thick and has a grayish orange weathered matrix and pale yellowish .orange weathered pebbles. The fresh matrix is a moderate yellowish brown with olive gray pebbles.

Locality 19: 1.2 miles south of Lake Bridgeport Dam on dirt road (west fork) on Twin Peaks Hill. The section begins at lake level.

A 31 foot (9.7 m) thick section of the Rock Hill Limestone and Lake Bridgeport Shale is exposed at locality 19. The Lake Bridgeport Shale is 30 feet (9.1 m) thick and is light olive gray and fissile. The basal portion of the section is a 2 foot (0.6 m) thick sandstone, very pale orange when fresh and grayish orange when weathered. In the sandstone, the plant fossil Calamites (Pteridophyta) occurs. Ripple marks indicate a paleocurrent direction of N 43 W. The fissile shales contain fossiliferous iron claystone nodules that are very dark red and moderate reddish orange.

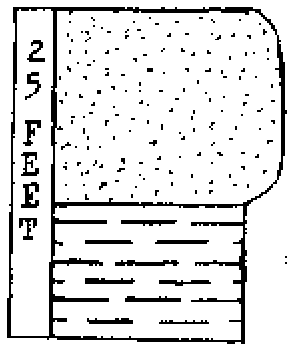


Locality 19

The Rock Hill Limestone is 1 foot (30.5 cm) thick and has a moderate yellowish brown fresh matrix that weathers to a grayish orange. The fresh pebbles are dark yellowish orange and weather to pale yellowish orange.

Locality 20: on dirt road (east fork) off City Service Road off FM 1810, 4.9 miles west of intersection of FM 1810 and US 114. The section begins at road level.

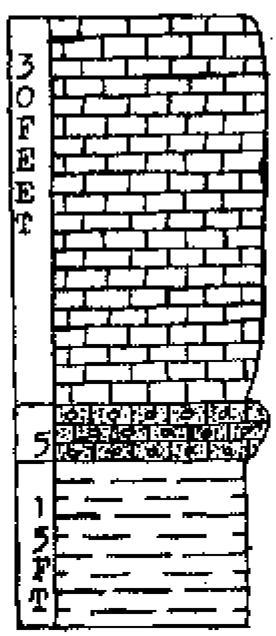
A 25 foot (7.6 m) thick section of the Lake Bridgeport Shale is exposed at locality 20. Inter-bedded with the fissile shales are iron claystone beds (1 cm thick) that are moderate reddish orange. These are overlain by 15 feet (4.6 m) of sandstones which are white (fresh) and weather grayish orange.



Locality 20

Locality 21: at north end of Lake Bridgeport damsite on FM 1658, section begins at lake level.

A 50 foot (15.2 m) thick section of the Devils Den Limestone, Rock Hill Limestone, and the Lake Bridgeport Shale is exposed at locality 21. The Lake Bridgeport Shale is 15 feet (4.6 m) thick and is fossiliferous. The shales are fissile and grayish orange. Next is the Rock Hill Limestone that is 5 feet (1.5 m) thick and shows differential compaction. Capping the section is a 30 foot interval of the Devils Den Limestone that is sporadic in outcrop.



Locality 21

Locality 22: 7.4 miles off intersection of FM 1810 and US 114 on FM 1810. Exposure begins at road level.


Locality 22

A sporadic outcrop of the Lake Bridgeport Shale is composed of a quartz conglomerate that is moderate red and white.

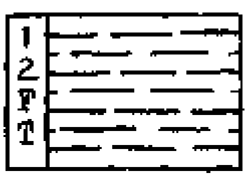
Locality 23: 100 yards east of locality 18 in a large ditch. Section begins at the timberline.

A 16 foot (4.9 m) thick section of the Lake Bridgeport Shale is exposed at locality 23. The fissile shales are highly fossiliferous and contain iron claystone nodules that are moderate reddish orange.

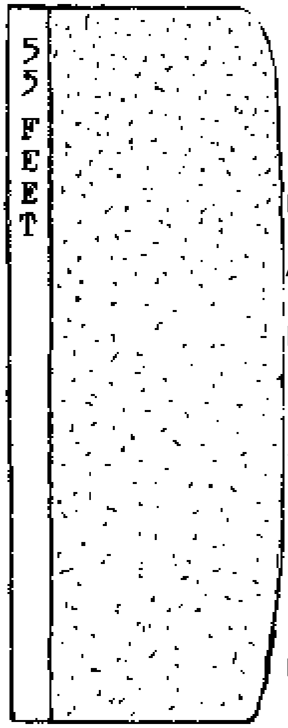
Locality 23

Locality 24: 0.2 miles west of intersection of US 380 and US 114 on US 380. The section begins at road level.

A 12 foot (3.7 m) thick section of the upper portion of the Lake Bridgeport Shale is exposed at locality 24. The fissile shales are both light olive gray and pale red purple. Within the shales are contorted sandstone lenses that are very pale orange and weather grayish orange. Also interbedded within the shales are iron claystone beds (1 cm thick) that are moderate reddish orange.



Locality 24



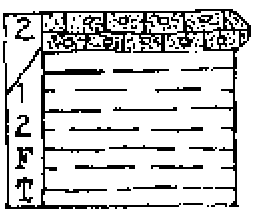
Locality 25

<u>Locality 25:</u> in trench of the Lake Bridgeport Dam off FM 1658.

A 55 foot (16.8 m) thick section of the upper portion of the Lake Bridgeport Shale is exposed, at locality 25. The section is a sandstone lens I that contains the plant fossil <u>Calamites</u> (Pteridophyta).

<u>Locality 26:</u> 1.7 miles west of Trinity River Bridge on US 920, section is a road cut and begins at road level.

A 14 foot (4.3 m) thick section of the Rock Hill Limestone and Lake Bridgeport Shale is exposed at locality 26. The Lake Bridgeport Shale is a pale yellowish orange, and is 12 feet (3.7 m) thick. Weathering out of the fissile shales are iron clay-stone blankets that are interbedded with the shales (1 cm thick) and are moderate reddish orange.



Locality 26

The Rock Hill Limestone has a pale yellowish brown matrix that weathers grayish orange. The pebbles are moderate yellowish brown. The differentially compacted limestone is 2 feet (0.6 m) thick.

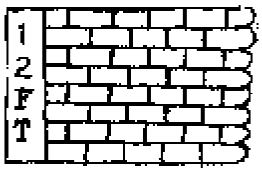
<u>Locality 27:</u> 3.3 miles west of Trinity River Bridge on US 920, section is a road cut and begins at road level.

A 12 foot (3.7 m) thick section of the upper portion of the Jasper Creek Shale is exposed at locality 27. The Jasper Creek Shale is composed of an unfossiliferous pinkish gray sandstone that weathers to moderate reddish orange in this section.

Locality 27

Locality 28: 0.2 of a mile east of intersection of US 199 and US 281 on US 199. This section is on the west side of an abandoned quarry and begins on quarry floor.

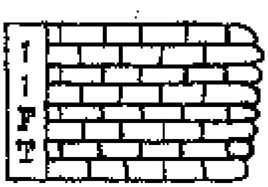
A 12 foot (3.7 m) thick section of the Devils Den Limestone Member is exposed at locality 28. The Devils Den Limestone is pale yellowish brown when fresh and grayish orange when weathered. The limestone has differential compaction that produces wavy bedding.



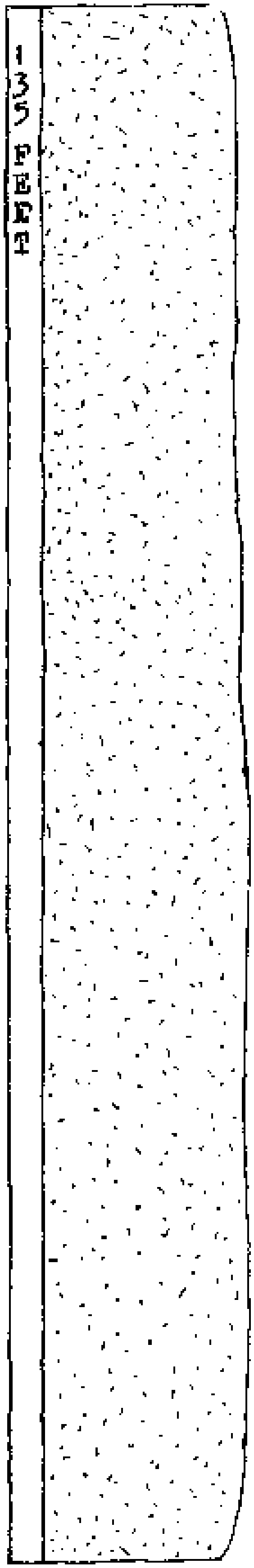
Locality 28

Locality 29: 0.2 of a mile west of intersection of US 199 and US 281 on US 199. The section is on the east side of an abandoned quarry and begins on quarry floor.

An 11 foot (3.4 m) thick section of the Devils Den Limestone is exposed at locality 29. The Devils Den Limestone is a pale yellowish brown (fresh) and grayish orange (weathered). The limestone has differential compaction and pale purple staining.



Locality 29



Locality 30

Locality 30: 1.1 miles west of Wizard Wells, Texas on FM 1156. The section is a road cut and begins at road level.

A 135 foot (41.2 m) thick section of the upper portion of the Jasper Creek Shale is exposed at locality 30. The massive sandstone is a moderate reddish orange (fresh) and a moderate reddish brown (weathered). Crossbedding, trending N 20 W, is evident in the section. Within the sandstone are small lenses of conglomerate, and the outcrop is stained by iron staining. Scott and Armstrong (1932) noted this section and indicated that shales lie under the sandstones.

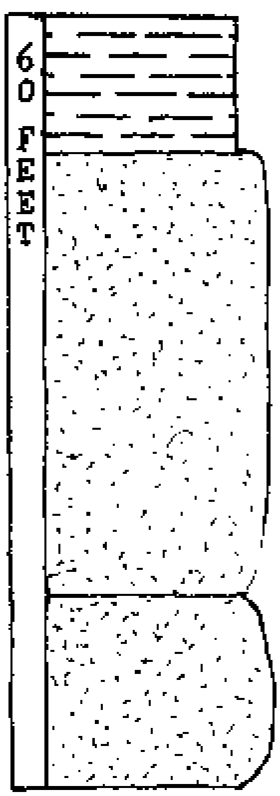
Locality 31: 0.3 miles west of intersection of FM 1156 and US 380 on US 380. The section is a road cut and begins at road level.

A 15 foot (4.6 m) thick section of the Devils Den Limestone and Jasper Creek Shale is exposed at locality 31. The section begins with a basal grayish orange sandstone that is 5 feet (1.5 m) thick. Next is a pale yellowish orange fissile shale, which is 2 feet (0.7 m) thick and fossiliferous. The Devils Den Limestone caps the section and is 8 feet (2.5 m) thick and shows differential compaction.

Locality 31

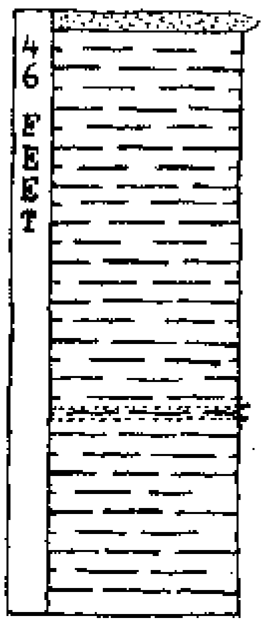
Locality 32: secondary road at Brushy Mound on USGS topographic sheet Bridgeport West, Texas in SE 4, section begins at creek bottom.

A 50 foot (15.2 m) thick section of the upper portion of the Jasper Creek Shale is exposed at locality 32. The section begins with a basal 15 foot (4.6 m) thick white sandstone that weathers grayish orange. The basal sandstone is massive and is stained by the overlying soil. Overlying the basal sandstone is 35 feet (10.7 m) of pinkish gray sand-stone. There are small lenses of conglomerate within this sandstone. Next is a 10 foot (3 m) thick pale yellowish orange, fossiliferous, fissile shale. The Pennsylvanian section is capped by a ledge-forming grayish orange limestone conglomerate that represents an unconformity (Bose, 1917).



Locality 32

Locality 33: in the pit of the Acme Brick Plant, Bridgeport, Texas. The section begins at quarry floor.

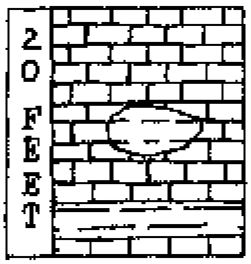


Locality 33

A 46 foot (14 m) thick section of the lower portion of the Lake Bridgeport Shale is exposed at Locality 33. The section begins with a basal 11 foot (3.4 m) thick light bluish gray fissile shale that weathers light olive gray. This "blue shale" extends 55 feet (16.8 m) below the surface to the Willow Point Limestone (Capps, Acme Brick Company plant manager, oral communication). Overlying the "blue shales" are 34 feet (10.4 m) of grayish red purple fissile shale that weathers to pale red purple. The section is capped by a 1 foot (30.5 cm) thick very pale orange ledge-forming sandstone that weathers grayish orange. At the 15 foot (4.6 m) and 16 foot (4.9 m) levels are reworked sandstone blankets that are medium gray that weather grayish orange and contain broken plant fragments. Weathering out of the shales are iron claystone nodules that are moderate reddish orange and have an average diameter of 2 inches (5 cm).

Locality 34: TXI plant off US 199 in active quarry on north wall 0.8 miles east of Joplin. The section begins at quarry floor.

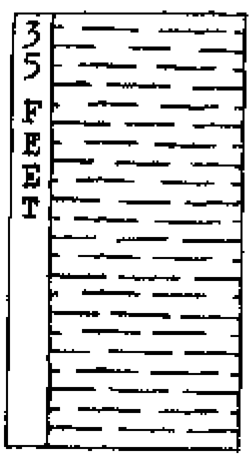
A 20 foot (6.1 m) thick section of the Devils Den Limestone and the Jasper Creek Shale is exposed at locality 34. The Jasper Creek Shale has a basal medium light gray limestone (fresh) that weathers light gray, and is overlain by a fissile shale that is reddish orange with a thickness of 4 feet (1.2 m). The Devils Den Limestone is 16 feet (4.9 m) thick and is pale yellowish brown (fresh) that weathers yellowish gray. At the 9 foot (2.7 m) level is a shale lens that is a pale yellowish orange.



Locality 34

Locality 35: abandoned clay pit 0.5 miles east of the intersection of US 114 and FM 1658 on south gravel road. The section begins at water level in the pit.

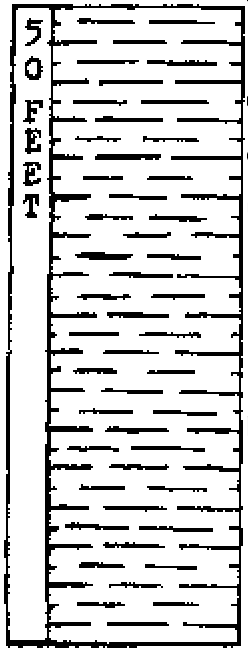
A 35 foot (10.7 m) thick section of the Lower portion of the Lake Bridgeport Shale is exposed at locality 35. The fissile shales are pale red purple that weather grayish red purple. The shales are sparsely fossiliferous. Weathering out of the shales are iron claystone nodules that are moderate reddish orange.



Locality 35

Locality 36: Western Kaker Mound on Kaker Ranch (unnamed mound on Bridgeport West, Texas sheet SE 4), section begins in ditch north of the mound.

A 50 foot (15.2 m) thick section of the Jasper Creek Shale is exposed at locality 36. The shales are grayish red and pinkish gray, fissile and unfossiliferous.

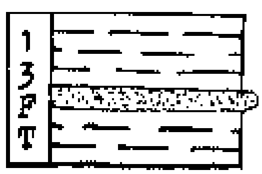


Locality 36

Locality 37: East Mound on Kaker Ranch (USGS topographic sheet Bridgeport West, Texas, SE 4).

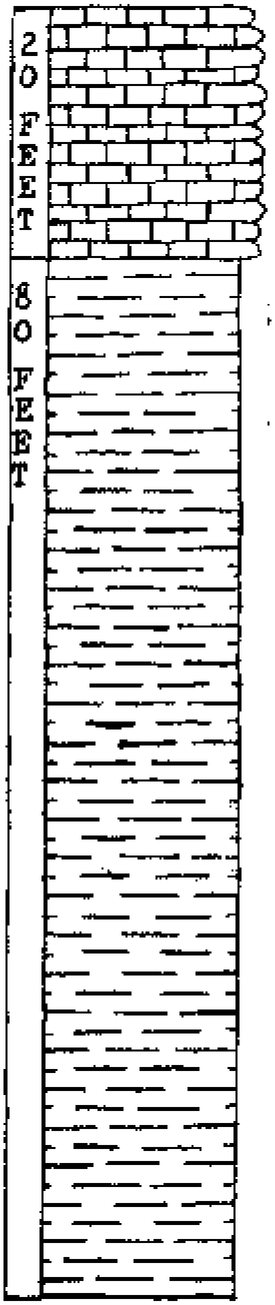
A covered section of the Jasper Creek Shale is present at locality 37. The section is capped by the Glen Rose Formation (Cretaceous).

Locality 38: 0.5 miles north of intersection of US 114 and FM 2123 on FM 2123. The section is a road cut and begins at road level.



Locality 38

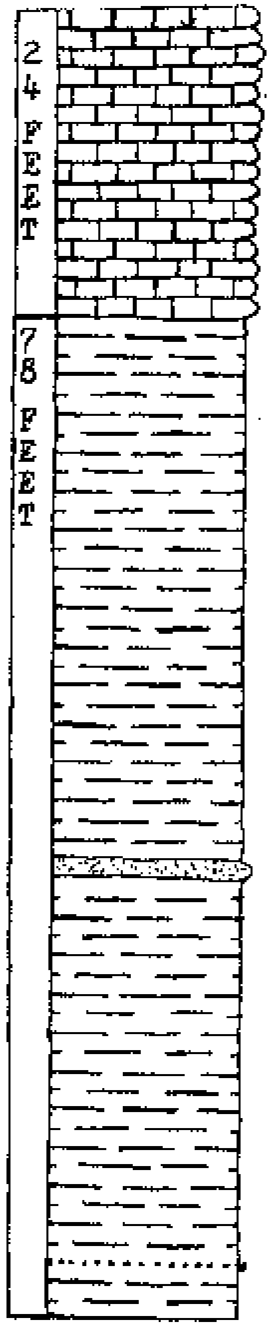
A 13 foot (4 m) thick section of the middle portion of the Lake Bridgeport Shale is exposed at locality 38. The shale is light olive gray and is fossiliferous. At the 5 foot (1.5 m) level is a fossiliferous sandstone that is 1 foot (30.5 cm) thick (light olive gray).



Locality 39

Locality 39: off US 380 on Thortenberry Ranch near old abandoned road northwest of pumping station approximately 2 miles east of the intersection of FM 1156 and US 380 on US 380. The section is a hillside exposure and begins at road level.

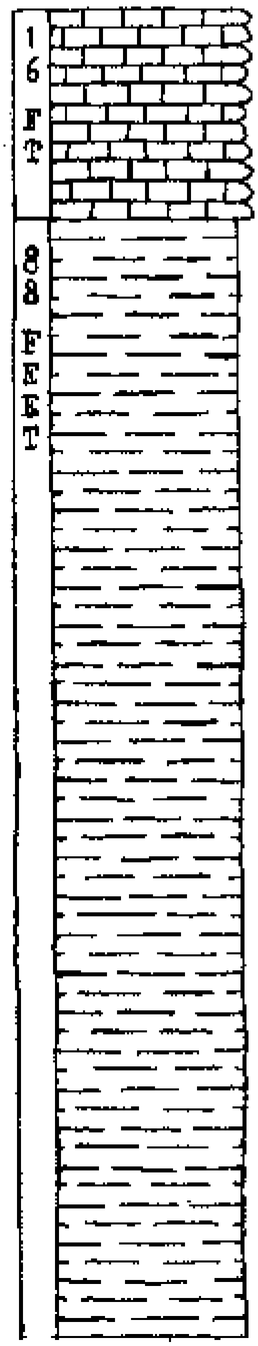
A 100 foot (30.5 m) thick section of the Devils Den Limestone and Jasper Creek Shale is exposed at locality 39. The fossiliferous Jasper Creek Shale is 80 feet (24.4 m) thick. The fissile shales are light olive gray with iron claystone nodules (moderate reddish orange) weathering out of the shales. The Devils Den Limestone is a light olive gray that weathers to yellowish gray, and is 20 feet (6.1 m) thick.



Locality 40

Locality 40: 0.8 miles east of intersection of FM 1156 and US 380 on US 380 west end of Thortenberry Ranch. The section is a hillside exposure and begins at road level.

A 102 foot (31.1 m) thick section of the Devils Den Limestone and the Jasper Creek Shale is exposed at locality 40. The section begins with 78 feet (23.8 m) of Jasper Creek Shale that is light olive gray with iron claystone nodules (moderate reddish orange) weathering out of the shale. Sandstones occur at the 5 foot (0.9 m) and the 35 foot (10.7 m) levels and have a thickness of 6 inches (15.2 cm) and 2 feet (61 cm) respectively. The sandstones are very pale orange (fresh) and weather grayish orange.

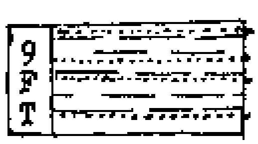


Locality 41

<u>Locality 41:</u> approximately 2.5 miles east of the intersection of FM 1156 and US 380 on US 380, east end of Thortenberry Ranch near pump station. The section is a hillside exposure and begins at creek floor.

A 104 foot (31.7 m) thick section of the Devils Den Limestone and Jasper Creek Shale is exposed at locality 41. The Jasper Creek Shale is light olive gray and fossiliferous. Weathering out of the fissile shales are iron claystone nodules that are moderate reddish brown. The shale is 88 feet (26.8 m) thick. The Devils Den Limestone is light olive gray and weathers olive gray, and is 16 feet (4.9 m) thick.

<u>Locality 42:</u> on US 380, 0.5 miles east of locality 4, section is a road cut and begins at road level.



Locality 42

A 3 foot (2.7 m) thick section of the middle portion of the Jasper Creek Shale is exposed at locality 42. The light olive gray fissile shale is interbedded with sandstones and claystones (grayish orange and moderate reddish orange respectively). The sandstones are 5 inches (12.7 m) thick and occur at the 2 foot (0.6 m), 5 foot (1.5 m), 7 foot (2.1 m), and 9 foot (2.7 m) levels and cap the section.

APPENDIX II

BIVALVE FACIES (LOCALITY 38)

Fossils	%
Coelenterata:	
Conularia crustula	0.4
Lophophyllum profundum	0.6
Echinodermata:	
Delocrinus sp.	0.2
Crinoid Stems	10.
Bryozoa:	
Fistulipora carbonaria	0.2
Brachiopoda:	
Juresania nebrascensis	2.6
Composita elongata	0.2
Chonetinella flemingi	0.6
Eridmatus texanus	0.6
Pelecypoda:	
Conocardium sp.	0.4
Culunama bellistreatia	2.
Nuculopsis girtyi	10.
Myalina sp.	0.2
Astartella varica	18.8
Gastropoda:	
Straparolus pernodosus	0.8
Bellerophon sp.	4.
B. percarinatus	0.8
Euphomites vittalus	4.
Palaeostylus moorei	1.5
Glabrocingulum welleri	1.8
Worthenia tabulata	2.1
Phymatopleura nodosus	17.5
Trepospira depressa	3.9
T. discoidalis	10.
Meekospira peracuta	0.2
Scaphopoda:	
Dentalium indianum	0.8
Plants:	
Plant fragments	0.2

SPONGE-CRINOID FACIES

Localities	11	17	21	23	25
Fossils	%	%			
Porifera:					
Heterocoelia beedei	10.7				
H. sphaerica	10.4				
Meandrostia tortacloaca	1.6	3.		6.	6.
Girtycoelia benjamini	1.9			2.	1.
G. typica	1.9			2.	4.
Coelocladia spinosa	10.1	27.		6.	2.
Heliospongia excavata		1.			
Coelenterata:					
Zaphrentis gibsoni				30.	1.
Lophophyllum profundum	4.6			1.	13.
Echinodermata:					
Delocrinus sp.	1.4				
D. hemisphericus	4.9			2.	
Schiadiocrinus disculus	1.4				
Archeaeocidaris sp.	0.8		16.7	1.	
A. cratis	1.			4.	2
Crinoid Stems	20.8	53	83.3	5.	56
Bryozoa:					
Fistulipora carbonaria	0.2				
Rhombopora lepidendroides	1.6				
Fenestrella mimica	3.3				
Brachiopoda:					
Neospirifer dunbari	4.1				
Eridmatus texanus				1.5	1
Crurithyris planiconvexa	1				
Derbyia crassa	0.2				
Chonetinella flemingi	4.6				
Juresania nebrascensis	0.4				
Chonetina plebeia	2.5				1
Linoproductus pratteninus	2.5				
Pelecypoda:					
Nuculopsis girtyi	0.2				
Culunama bellistriata				0.5	
Conocardium sp..		1			1
Gastropoda:					
Ianthinopsis primogenius	0.2			11	1
Worthenia tabulata				3	3
Straparollus pernodosus pernodosus				0.5	1
Murchisonia missouriensis				1	

Gastropods continued:	11	17	21	23	25
Meekospira peracuta				5	2
Strobeus primogenius	0.2			1	
Trepospira depressa				3	1
T. discoidalis				2	
Bellerophon sp.				1	
B. percarinatus				1	
Euphemites vittalus	1.4			2	1
Pleurotmaria obtusispira	1				
Cephalopoda:					
Gonioloboceras welleri				3	
Pseudorthoceras knoxense	2.2	3		12	3
Shistoceras missouriense				1	
Arthropoda:					
Ditomypge scitulis				2	
Treypetesa caveata				10 of the corals	
Plants:					
Plant fragments				0.5	1

GASTROPOD FACIES

Localities: Fossils	1	6	B-7	P-7	9	16	19
Coelenterata:							
Zaphrentis gibsoni				0.2	1	7	
Lophophyllum profundum	2	12	10	3	4	13	10
Echinodermata:							
Delocrinus hemisphericus			0.2				
Sciadiocrinus disculus				0.2			
Bryozoa:							
Fenestrella sp.			0.2	0.2			
Brachiopoda:							
Eridmatus texanus	2						
Neochonetes granulifer		0.5	2	0.2	1		
Crurithynis planiconvexa		0.5	1	3	1		
Chonetinella flemingi	6						
Juresania nebrascensis		0.5	0.2	2			
Pugnax osagensis				0.2			
Antiquatonia protlockiana		0.2					
Leirhynchus rockymontana			2				
Wellerella osagensis			0.2				

	1	6	B-7	P-7	9	16	19
Pelecypoda:							
Nuculopsis girtyi			2	0.6	1		
Astartella varica		0.5	1				
Culunama bellistriata	8	3	9	0.2	2	7	
Cardiomorpha missouriensis	2				1		
Gastropoda:							
Iathinopsis primogenius	1.6						
Worthenia tabulate					2	7	
Straparollus pernodosus	3.3	0.5	1.7		4		
Meekospira peracuta		2.2	2.5	0.2	3.2		
Trepospira depressa	30	31	28	16	21	20	60
T. discoidalis			14		4	13	
Euphemites vittalus			0.5				1
Glabrocingulum welleri	43	33	29	24	40	30	10
Bellerophon percarinatus		0.5			1		
B. pernodosus			1				
Cephalopoda:							
Gonioloboceras welleri		0.5	0.2	2.6			
Pseudorthoceras knoxense		4.5	5.3	7.6	7.2		1
Euloxoceras grennl			1				
Prouddenites primus				1			
Metacoceras sp.				0.2			
Schistoceras missouriense		0.5	1				
Brachycycloceras normale			0.2	0.9			
Liroceras liratum		3.4	1	1.7			
L. reticulatum		0.5	2	1			1
Gastrioceras angulatum		0.5	0.7	3.3	0.8		
Eoasianites millsi				5.2			
Gastrioceras hyattianum							7.5
Shumardites simondsi		0.5		7.6			
Arthropoda:							
Ditomyge scitulus	3	2	2	2	5		1
Trypetesa caveata						5 on the coral	
Plants:							
Plant fragments	3		12	2			6

CORAL FACIES

Localities	14	15	18
Fossils	%	%	%
Coelenterata:			
Lophophyllum profundum	18	34	16.2
Zaphrentis gibsoni	38		42.8

	14	15	18
Echinodermata:			
Crinoid Stems			1.8
Brachiopoda:			
Eridmatus texanus			0.8
Pelecypoda:			
Culunama bellistiata			0.4
Gastropoda:			
Meekospira peracuta		2.7	1.8
Euphemites vittalus			2.2
Trepospira depressa	18	23	5
T. discoidalis	5.8	5.6	
Worthenia tabulata			6.3
Glabrocingulum welleri	9	17	10.3
Straparollus pernodosus	5.8		0.8
Bellerophon Sp			0.4
Cephalopoda:			
Pseudorthoceras knoxense	7.2	1.9	9
Gonioloboceras welleri			0.4
Liroceras reticulatum		2	0.4
Gastrioceras angulatum		1.9	
Arthropoda:			
Ditomypge scitulus	2		
Trypetesa caveata			12.2 on the corals
Plants			
Plant fragments			0.4

APPENDIX III FAUNAL LIST

LAKE BRIDGEPORT SHALE MEMBER

Protozoa:
Triticites sp. Girty, 1904

Porifera:
Heterocoelia beddei Girty, 1908
H. sphaerica R. H. King, 1932
Meandrostia tortacloaca R. H. King, 1932
Girtycoelia benjamini Girty, 1908
G. typica R. H. King, 1932
Coelocladia spinosa Girty, 1908
Heliospongia ramosa Girty, 1908
H. excavata R. H. King, 1933

Colenterata:
Caninia (Campophyllum) torquia (Owen) 1852
Zaphrentis gibsoni White, 1884
Lophophyllum profundum (Edwards and Haines 1890
Conularia crustula White, 1880

Echinodermata:
Delocrinus sp. Miller and Gurley, 1890
D. hemisphericus (Shumard) 1858
Ulocrinus sp. Miller and Gurley, 1890
U. occidentalis Miller and Gurley,1890
Sciadiocrinus disculus (Moore and Plummer) 1938
Archaeocidaris sp.. McCoy, 1844
A. cratis Hall, 1858
A. aculeata Shumard, 1858
Crinoid Stems

Bryozoa:
Fistulipora carbonaria Ulrich, 1884
Rhombopora lepidodendroides Meek, 1872
Fenestrella sp Lonsdale, 1839
F. mimica Ulrich, 1937

Brachiopoda:
Linoproductus prattenianus Norwood and Pratten, 1932
Composita elongata Dunbar and Condra, 1932
C. tetralobata Hoare, 1960
C. ovata Mather, 1915
Neospirifer cameratus (Morton) 1952
N. dunbari (R. H. King) 1933
Eridmatus texanus (Branson) 1974
Punctospirer kentuckiensis (Shumard) 1932

Neochonetes granulifer (Owen) 1852
Crurithyris planiconvexa (Shumard) 1931
Derbyia crassa (Meek and Hayden) 1884
Chonetinella flemingi Norwood and Pratten, 1855
Jurensania rectangularia (Owen) 1932
Pugnax osagensis Swallow, 1908
Hustedia mormoni (Marcou) 1922
Chonetina plebeia Dunbar and Condra, 1932
Antiquatonia (Productus) portlockiana (Norwood and Pratten) 1960
Leiorhynchus rockymontana Marcou, 1858
Wellerella osagensis (Girty) 1932

Pelecypoda:
Astartella concentrica (McChensney) 1915
A. varica McChesney, 1860
Edmondia ovata Meek and Worthen, 1873
Nuculopsis girtyi (Schenck) 1934
Myalina Koninck, 1842
Culunama (Leda) bellistriata (Stevens) 1858
Conocardium sp. Brown, 1834
Cardiomorpha missouriensis Shumard, 1858

Gastropoda:
Knightites (Cymatospira) montfortianus (Norwood and Pratten) 1855
Iathinopsis (Sphaerdoma) primogenius (Conrad) 1961
I. regularis (Cox) 1961
Worthenia tabulata (Conrad) 1895
Straparollus (Euomphalus) pernodosus (Meek and Worthen) 1934
Phymatopleura nodosus (Girty) 1939
Murchisonia missouriensis Girty, 1915
Meekospira peracuta (Meek and Worthen) 1897
Trepospira depressa Worthen, 1897
T. discoidalis Newell, 1935
Bellerophon sp. Montfort, 1808
(Pharkidonotus) percarinatus (Conrad) 1960
Glabrocingulum. (Ananias) welleri (Newell) 1960
Palaeostylus (Stephanozyga) subnodosa (Knight) 1930
P. (Pseudozygopleura) scitulus (Meek and Worthen) 1961
(P.) moorei (Knight) 1930
Euphemites vittalus (McChesney) 1940
Omphalotrochus (Pleurotmaria) obtusispira (Shumard) 1937

Scaphopoda:
Dentalium indianum Girty, 1911

Cephalopoda:
Gonioloboceras welleri Smith, 1903
Pseudorthoceras Knoxense (McChesney) 1933
Euloxoceras greeni Dunbar and Condra, 1933
Prouddenites primus Miller, 1930
Schistoceras missouriense Miller and Faber, 1940

Brachycycloceras normale Miller, Dunbar, and Condra, 1955
Liroceras (Coloceras) reticulatum (Miller and Owen) 1937
L. (C.) liratum (Girty) 1940
Gastrioceras sp.. Hyatt, 1884
G. angulatum Girty, 1911
G. hyattianum Girty, 1911
Metacoceras sp. Hyatt, 1883
M. carinatum Girty, 1933
Shumardites simondsi Smith, 1903
Peritrochia (Marthonites) ganti (Miller) 1940
Eaosianites(Gastrioceras) millsi (Miller and Cline) 1950

Arthropoda:
Ditomypge (Griffithides) scitulus (Newell) 1931
Trypetesa caveata Tomlinson, 1963

Ichnofossils:
Scalarituba missouriensis Weller, 1899

Plants:
Plant fragments

ROCK HILL LIMESTONE MEMBER

Protozoa:
Triticites sp. Girty, 1904

Porifera:
Heliospongia excavata King, 1933
H. camosa Girgy, 1908

Echinodermata:
Archaeocidaris cratis Shumard and Swallow, 1858
Crinoid Stems

Bryzoa:
Polypora spinulifera Ulrich, 1890

Brachiopoda:
Condrathyris perplexa McChesney, 1860
Composita tetralobata Hoare, 1960
Juresania nebrascensis Owen, 1852

Plants:
Rhodophycophyta:
Archaeolithophyllum missouriensum Johnson, 1956

Chlorophcophyta:
Epimastopora sp.. Pia, 1922
Eugonophyllum sp. Koniski and Wray, 1961

DEVILS DEN LIMESTONE MEMBER

Protozoa:
Triticites sp.. Girty, 1904

Porifera:
Heliospongia excavata King, 1933

Echinodermata:
Delocrinus sp. Miller and Gurley, 1890
Archaeocidaris sp. McCoy, 1844
Crinoid stems and cirri

Bryozoa:
Fenestrella sp. Orbigny, 1849

Brachiopoda
Composita subtalita Dunbar and Condra, 1932
C. tetralobata Hoare, 1960
C. ovata Mather, 1915
Meekella striatocostata Cox, 1857
Neospirifer cameratus Mortan, 1836
Derbyia crassa Meek and Hayden, 1859
Neochonetes granilifer Owen, 1852
Juresania recatangularia Owen, 1852
Pulchatia (Juresania) symmetrica (McChesney) 1960
Chonetinella flemingi Norwood and Pratten, 1855
Linoproductus prattenianus Norwood and Pratten, 1855

Pelecypoda:
Wilkingia terminale (Hall), 1959

Plants:
Rhodophycophta:
Archaeolithophyllum missouriensum Johnson, 1956

Chlorophycophyta:
Epimastopora sp.. Pia, 1922
Eugonophyllum sp. Konishi and Wray, 1961

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