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PALEOECOLOGY AND TAPHONOMY OF NON-PRODUCTID BRACHIOPODS FROM THE LATE PENNSYLVANIAN (MISSOURIAN) EUDORA SHALE MEMBER

by

Thomas M. Stanley

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INTRODUCTION

The Eudora Shale Member of the Stanton Formation has been interpreted as a typical deep water, anoxic shale lithofacies belonging to a classic Missourian megacyclothem (Heckel, 1977, Heckel and Baesemann, 1975; Boardman et al., 1983). Based on current models, the Eudora Shale represents the maximum position of transgression and depth developed during Stanton deposition. The Eudora Member is characterized by black, phosphate-rich, fissile shales interpreted as being deposited below an anoxic anoxic boundary, and is bounded by dark to medium gray shales interpreted as being deposited in a dysaerobic zone above the anoxic bottom conditions (Heckel, 1977 and 1984). According to current thinking, the fauna enclosed in the Eudora should consist primarily of pelagic forms such as fish and cephalopods, and ubiquitous assemblages of typical deep water conodonts. This deeper water fauna is replaced vertically by a more normal marine benthos contained within basal and upper gray shale lithofacies. These gray shales have been inferred to represent the initial phases of cyclothem transgression and regression.

Over five Eudora sections were measured and sampled at various locations in northeast and east central Kansas (Figure 1 and Appendix 1). The purpose of this investigation is to test the overall validity of the cyclothem model generalized above, and to a certain extent test the validity of layer-cake Kansas stratigraphy in general. This report pertains specifically on the paleoecology and taphonomy of non-productid brachiopods collected from the measured sections, and deals with their relationship with the overall lithofacies and stratigraphic distribution of the Eudora Shale. All interpretations are based on the authors measured sections and observations.

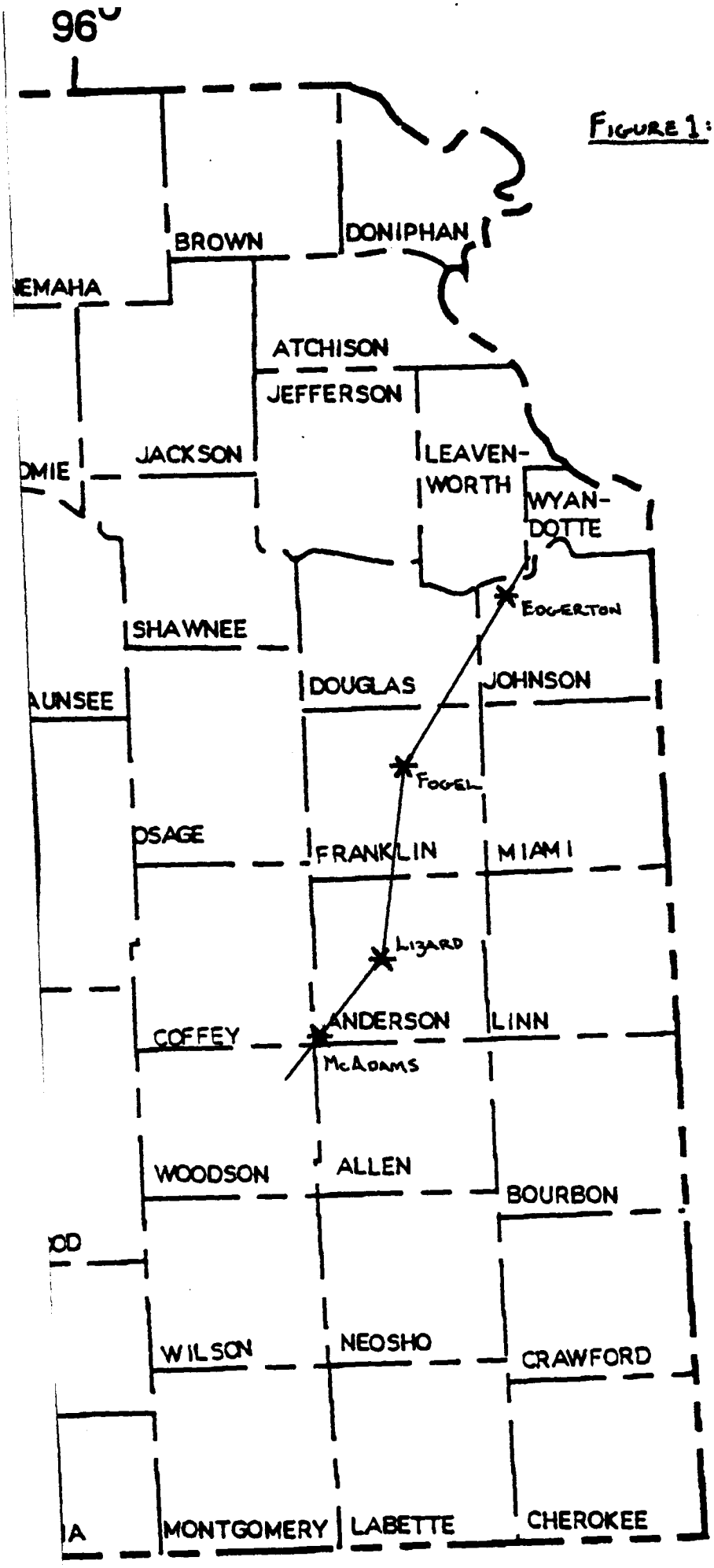


FIGURE 1: LOCATION OF MEASURED SECTIONS.

Consequently no measured sections of the Kill Creek and upper shales at the Lizard quarry will be found in the appendix.

STRATIGRAPHY AND LITHOFACIES

Although a full account of the nomenclatural and stratigraphic history of the Eudora Shale is beyond the scope of this report, the reader is referred to Condra, 1930; Moore, 1936 and 1949; and Heckel, 1984 for an overall historical view. Regionally the Eudora Shale is one of five members belonging to the Stanton Formation of the Lansing Group, Upper Missourian age, which crops out along a north by northeast trending belt throughout eastern Kansas (Figure 1). The Eudora is conformably bounded above and below by the Stoner Limestone and Captain Creek Limestone members respectively. Sections measured in the field course fall into two, broad paleogeographic facies zones as defined by Heckel (1975). The Eudora at Edgerton, Fogel and Kill Creek occur within an inferred open marine facies belt, and the Eudora measured at the Lizard and McAdams Quarries fall in Heckel's algal mound facies belt. Analysis of the five measured sections indicates that four lithostratigraphic units can be discerned in the Eudora based on varying faunal and sedimentological characteristics exhibited between the units (Appendix 1, Section Descriptions; and Figure 2).

Phosphatic Shale Lithofacies

This lithofacies is represented by bed numbers 4, 2 and 1 at the Edgerton, Lizard and Fogel localities respectively (see Appendix 1), and is conspicuously missing at the McAdams and Kill Creek sites. Where it is present, this lithofacies is characterized by laminated, phosphatic-rich, black fissile shale.

Phosphate occurs as nodules or as thin discontinuous laminae. Faunally, the lithofacies encloses a well preserved pelagic or possibly thanatocoenetic assemblage represented by fish remains, conodonts, shrimp, cephalopods and conularids. This lithofacies represents the classic anoxic portion of Heckel's (1977) cyclothem model.

Dark Gray Shale Lithofacies

This lithofacies is represented by bed numbers 7 and 8a at Edgerton, 3 and 5 at Fogel, the upper 10 cm of bed 2 at the Lizard quarry, and bed 2 at McAdams (see Appendix 1). Lithologically it is a black to very dark gray, pyritic to slightly phosphatic, thin-bedded to thickly laminated, well indurated shale. Pyrite occurs as distinct nodules or as fine disseminations replacing shell material. Phosphate is rare in the lithofacies except in bed 3 of the Fogel section, where it occurs as discontinuous, very thin laminations. Enclosed fauna are the same as that found in the phosphatic shale lithofacies described above, except for the occurrence of numerous orbiculoid and lingula inarticulate brachiopods, and occasional articulates represented by *Meekella sp.* and *Huestedia mormoni* (Table 2). Traces of *Chondrites sp.* and *Zoophycus sp.* are common in this lithofacies at the Lizard, Fogel and Edgerton localities. Previous interpretations of this lithofacies is one of a dysaerobic environment of deposition, becoming increasingly aerobic toward the top of the lithofacies (Heckel, 1977). Field observations tend to support this interpretation.

Silty Calcareous Gray Shale Lithofacies

This lithofacies is represented by bed numbers 3, 5 and 6 at Edgerton, 2 and 4 at Fogel, bed 1 at Lizard, and the basal 6 cm at Kill Creek (see Appendix 1). Lithologically the shale is medium gray, poorly indurated, slightly silty and calcareous. Fissility is generally well developed, especially in weathered sections, but a blocky bedding character is also exhibited in specific horizons (Fogel bed 2). Faunally the shale is variable, ranging from a total absence of calcareous macrofossils, to a fairly diverse assemblage consisting of numerous species of inarticulate and small articulate brachiopods, and bryozoans. Where a calcareous fauna is absent, numerous *Chondrites sp.* and ? *Planolites sp.* burrows occur (Fogel beds 2 and 4). The presence of calcite also suggests that a calcareous fauna may have been present, but has subsequently been dissolved by diagenetic events. Although no moldic preservation was noted in this lithofacies at Edgerton and Fogel, the presence of calcite in these shales suggests that a calcareous fauna may have been present at one time, although not to the abundances observed in the Kill Creek and Lizard examples. This is speculative, and it may be that the Edgerton and Fogel representatives of this lithofacies are indeed different from those seen at Kill Creek and Lizard. However, sampling biases precludes a more definitive answer than to say that the shales of this lithofacies are lithologically the same at all locations.

Calcareous Clay Shale Lithofacies

This lithofacies is represented by bed numbers 8b and 8c at Edgerton, all of the McAdams shales, bed 3 and the upper shale units at Lizard, the upper 6 cm at Kill Creek, and bed 6 at Fogel. The lithofacies is typically clay-rich, blocky bedded, medium gray to grayish brown in color, and calcareous. Differentiation between this lithofacies and the silty calcareous shale lithofacies is the

absence of terrigenous material and the high abundance and diversity of the enclosed brachiopod fauna. (Tables 1 and 2). Depending on its stratigraphic location, this lithofacies signifies the initiation or cessation of normal marine conditions within the basic cyclothem model.

STRATIGRAPHIC DISTRIBUTION OF LITHOFACIES

Superficially, the distributions and thicknesses of the individual lithostratigraphic units seem to be influenced by the paleogeographic facies belts. A more definitive answer to this paleogeographic control will only be forthcoming with additional field work. Figure 2 is a lithostratigraphic cross section of the individual shale lithofacies. The figure is self-explanatory, so no elaboration needs to be made, except that the interpretations represented by the section are based on my own section measurements. I am sure that these interpretations will change as individual group sections become more complete. It should also be noted that the section is hung on the occurrence of the first major limestone bed encountered above the Captain Creek Member. Whether this limestone represents the start of Stoner deposition is still a matter of conjecture, and will not be resolved in the confines of this paper.

Using the first limestone as a datum did two things: 1), it placed the thickest section of phosphatic shale seen at Fogel into the deepest and most sheltered part of the basin; and 2), it took the upper shales at the Lizard site and placed them as stratigraphically high in the section as possible (see Table 3 for an explanation). If Heckel's facies belts are correct, then the Captain Creek Member should have been a paleotopographic high during Eudora deposition, due to algal mound build-ups. This seems to be the case based on my interpretations.

One interesting feature of this section is it's support of the Sageman's et al., (1991) black shale model. If time lines are drawn parallel to the datum plane of the cross section, they will laterally intersect shales representing varying degrees of oxygenation. Impling a lateral as well as a vertical gradation from anaerobic to dysaerobic-exaerobic to aerobic bottom conditions (compare facies correlation at the Lizard quarry with figure 6 in Sageman et al., 1991). The lateral sequences are characterized by initial phosphatic shale containing no normal marine benthic organisms, grading into a dysaerobic environment containing numerous *chondrites* burrows and a small shelly brachiopod fauna, which in turn grades into aerobic bottom conditions supporting a normal marine faunal assemblage. This interpretation of the Eudora is pure conjecture based on the limited amount of collected data, and is strongly dependent on how one correlates the individual lithofacies between each section. Yet based on the present level of completeness, a strong argument can be made favoring Sageman's interpretation of black shale deposition.

BRACHIOPOD PALEOECOLOGY AND TAPHONOMY

This section of the report deals specifically on the collected non-productid brachiopod occurrences in the Eudora and probable lower shale horizons of the Stoner Limestone Member. The majority of the enclosed information was obtained through bulk processing of shale samples taken from the GPS sections at the various outcrop locations, and provides the basis of the interpretations found in the general paleoecology section (Table 1). It should be noted that for ease of text referral, samples of shale horizons in Table 1 are designated by TDS bed numbers and not by their actual corresponding GPS section numbers.

	A	B	C	D	E	F	G	H	I	J	K	L
	Suborder	Superfamily	Family	Genera	McAdams Quarry Shale Units					Lizard	Edgerton	Kill Creek
					Up 7	Low 7	Bed 5	Bed 4	Bed 2	15cm f. top	Bed No. 1	Base 5cm
5	Chonetidina	Chonetacea	Chonetidae	Chonetids	6	16	4	32	64	20	0	18
6												
7	Athyridiidina	Athyridacea	Athyrididae	*Composita*	72	130	168	34	26	252	126	30
8												
9	Spiriferidina	Cyrtiacea	Amocoeliidae	*Crurithyris*	0	0	0	0	0	0	10	202
10	Spiriferidina	Spiriferacea	Spiriferidae	*Neospirifer*	64	90	28	56	40	136	26	3
11	Spiriferidina	Reticulariacea	Elythidae	*Phricodothyris*	0	14	0	4	0	0	6	0
12	Spiriferidina	Spiriferinacea	Spiriferinidae	*Punctospirifer*	54	58	28	6	106	96	36	164
13												
14	Strophomenidina	Davidsoniacea	Orthotetidae	*Derbyia*	26	20	0	6	46	92	28	6
15	Strophomenidina	Davidsoniacea	Meekellidae	*Meekella*	0	12	0	0	24	24	8	46
16												
17	Terebratulidina	Dielasmatacea	Dielasmatidae	*Dielasma*	0	18	0	0	4	40	12	0
18												
19	Retziidina	Retziacea	Retziidae	*Hustedia*	56	42	92	14	68	40	28	410
20												
21	Orthidina	Enteletacea	Rhipidomellidae	*Rhipidomella*	0	2	0	0	2	0	0	0
22												
23		Rhynchonellacea	Wellerellidae	*Wellerella*	0	8	0	0	28	16	24	6

Table 2

	A	B	C	D	E	F
1				**FOGLE QUARRY**		
2						
3	**SPECIES**		**TDS SECTION**		**JJG SECTION**	
4		middle unit C	6 cm top unit E	top 6 cm unit F	30 cm below Stoner	upper 40 cm
5						
6	*Linguis carbonaria*	0	6	1	6	0
7	*Orbiculoidis cf. capuliformis*	0	2	0	0	0
8	*O. missouriensis*	3	0	1	2	0
9	*Trigonoglossa sp.*	0	2	2	0	1
10	*Meekella sp.*	0	7	3	0	5
11	*Hustedia mormoni*	0	2	0	0	0
12	*Schuchertella sp.*	0	0	4	0	2
13	*Crurithyris planoconvex*	0	0	1	0	0
14						
15						
16						
17	**FLOAT SAMPLES**	McAdams	Lizard	Kill Creek	Edgerton	
18						
19	*Neospirifer sp.*	x	x			
20	*Composita sp.*	x	x			
21	*Hustedia mormoni*	x	x			
22	*Rhipidomella sp.*	x				
23	*Derbya sp.*	x	x			
24	*Enteletes sp. (poss. Stoner.)*	x				
25	*Punctospirifer kentuckyensis*	x	x	x	x	
26	*Echinetinella fleming*	x	x			
27	*Phricodothyris sp.*		x			
28	*Dielasma sp.*		x			
29	*Meekella sp.*		x	x	x	
30	*Wellerella sp.*		x			
31	*Crurithyris sp.*			x	x	
32	*Crania sp.*	x	x			
33	*Orbiculoidis missouriensis*		x	x	x	
34	*Linguis carbonaria*			x	x	

TABLE 3-Correlation matrix of Table 1

Correlation Matrix for Variables: X_1 X_{12}

	Chonetids	Composita	Cruryth	Derbya	Dielasma	Hustedia	Meekella	Neospiri
Chonetids	1							
Composita	-.457	1						
Crurythy	-.059	-.375	1					
Derbya	.252	.557	-.299	1				
Dielasma	-.067	.795	-.262	.842	1			
Hustedia	-.034	-.35	.978	-.315	-.309	1		
Meekella	.323	-.145	.786	.253	.195	.776	1	
Neospirifer	.033	.647	-.521	.739	.826	-.541	-.139	1
Phricodot	-.178	.071	-.291	-.191	.206	-.315	-.221	.211
Punctospi	.307	-.164	.748	.277	.133	.776	.559	-.122
Rhipidom	.601	-.207	-.23	.103	.076	-.184	.142	.141
Wellerella	.44	.066	-.13	.57	.384	-.165	.355	.036

Correlation Matrix for Variables: X_1 X_{12}

	Phricodo	Punctos	Rhipido	Wellerella
Phricodothy	1			
Punctospirifer	-.331	1		
Rhipidomella	.492	.163	1	
Wellerella	.025	.3	.428	1

CORRELATION COEFFICIANTS BOXED IN RED BELONG TO NEOSPIRIFER-COMMUNITY (SEE FIGURE 3)
CORRELATION COEFFICIANTS BOXED IN ORANGE BELONG TO CRURITHYRIS-COMMUNITY

A CORRELATION COEFFICIANT OF ± 1.00 IS MAXIMUM, ONE OF 0.00 WOULD INDICATE NO CORRELATION EXISTS BETWEEN THE GENERA.

significanceat .707 (alpha= 0.5; df= 6)

Table 4- Multiple comparison of faunal abundance means of shale samples from table 1.

	Up. part 7	Low part 7	Bed5	Bed 4	Bed 2	Edgerton	Lizard
Upper part of bed 7							
Lower part of bed 7	11						
Bed 5	3.5	7.5					
Bed 4	10.5	21.5	14				
Bed 2	10.8	0.17	7.3	21.3			
Edgerton	2.2	8.8	1.3	12.7	8.7		
Lizard	**36.5**	25.5	**33**	**47**	25.7	**34.3**	
Kill Creek	**50.6**	**39.6**	**47.1**	**61.1**	**39.8**	**48.42**	14.1

Table represents a comparative analysis between abundance mean values of the eight shale samples in table 1. Numbers represent the mean difference between the two shales that are being compared. An MSD number greater greater than or equal to 28.071 is significant at an alpha rejection of 0.05 (bold type). This indicates that the shales at the Lizard quarry and at Kill Creek are different from most of the other shales in terms of faunal abundance.

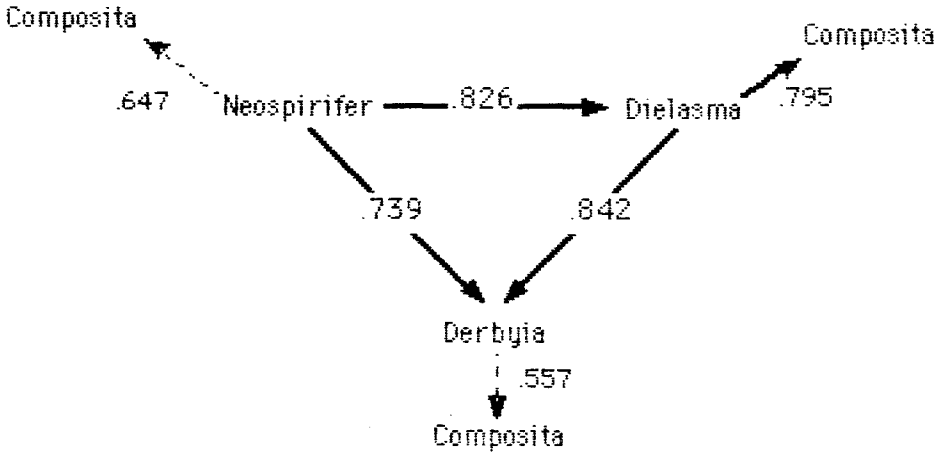
Float and select sample collection provided the bulk of information on brachiopod taphonomy. Although data is far from complete, an approximate idea of the brachiopod paleoecology during Eudora sedimentation can be gleamed.

General Paleoecology

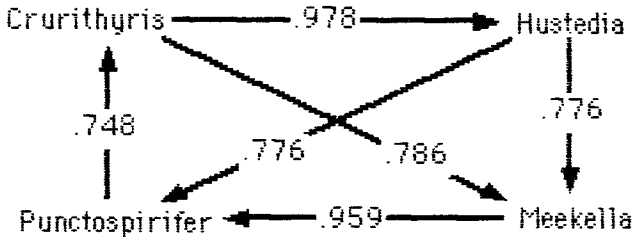
Seventeen non-productid brachiopod genera and at least as many species are represented in the Eudora and Stoner shales (Tables 1 and 2). Approximately 35 percent of the genera are represented by the spirifers with a functional pedicle. The second dominant group is represented by the strophomenids (*Meekella*, *Derbyia* and *Schuchertella*), which had the ability to cemented their pedicle valves to a hard substratum. Only the chonetids and *Wellerella* represent probable free-living forms. It is interesting to note that both of the free-living genera reach their highest abundances in the basal portions of the Eudora Shale, and steadily decline in numbers up-section (see McAdams faunal content in table 1). A reverse trend is seen for the larger pedicle-types like *Neospirifer* and *Composita*, which increase in numbers up-section. This could indicate a lack of firm substrates at the start of Eudora deposition favorable to free-living forms. As deposition continued, concentration of shell material on the substratum would have provided hard-ground surfaces, allowing increased colonization by pedicle-types. If this is indeed the case, then the shale sample from the lower portion of bed 7 at McAdams becomes significant, based on the noticeable increase of abundance in free-living forms, accompanied by a slight decrease in abundance in pedicle-types (*Composita*). This could suggest that a change in the rate of shale deposition occurred above bed 6 at McAdams, creating softer substrates favorable for the free-living brachiopods.

Figure 3 -Eudora communities based on correlation coefficients. significant correlation at .707 (alpha=.05, df= 6).

Neospirifer-Community



Crurithyris-Community



Fairly strong negitive correlations (but statistically not significant)

- Crurithyris and Neospirifer
- Hustedia and Neospirifer

  — between -.500 & -.600

- Chonetids and Composita

  — between -.400 & -.500

- Crurithyris and Composita
- Hustedia and Composita
- Crurithyris and Derbyia
- Hustedia and Derbyia
- Hustedia and Dielasma
- Hustedia and Phricodothuris
- Punctospirifer and Phricodthyris

  — between -.300 & -.400

A correlation matrix was run on the faunal abundances tabulated in table 1, and is illustrated in table 3. The faunal list for Fogel was left out of the matrix because the data illustrated in table 2 represents different sampling techniques than those represented by table 1. The correlation matrix shows two distinct groups of association, which may represent two community types common during Eudora deposition. The first community is termed the *Neospirifer*-community, and is represented by the large attached brachiopods *Neospirifer*, *Dielasma* and *Derbyia* (Figure 3). *Composita* also shows a high positive correlation with each of the three community members (especially with *Dielasma*), although it was not statistically significant at 5 percent rejection. The second community is termed the *Crurithyris*-community (Figure 3). Members include *Crurithyris*, *Hustedia*, *Punctospirifer* and *Meekella*, and all show a statistically strong positive correlation with each other. The important feature of these two communities is not just the strong positive correlation between members within a community, but the fairly strong negative correlation exhibited between the dominant members of the two communities. Noteworthy is the disassociation of *Neospirifer* with *Crurithyris* and *Hustedia*. Also, if the rejection probability is decreased to between -.300 and -.400, then all members of each community are disassociated from each other (Figure 3).

Forms in the *Crurithyris*-community tend to be small, punctate or psuedopunctate and probably had a functional pedicle. The punctate shell structure and small size would be beneficial for respiration in slightly anoxic environments (Alexander, 1977; Fursich and Hurst, 1974). This is supported by the common occurrence of this community in the basal Eudora beds at Edgerton, and basal shale units at Kill Creek. The dominant members from the *Neospirifer*-community tend to be large, and non-punctate. *Dielasma* seems to

contradict this statement, being a punctate form and rather small compared to *Neospirifer* and *Composita*. It may be that because *Dielasma* had a fairly simple terebratuliform loop (implying a simple, inefficient lophophore), it would be excluded from low oxygen environments (Muir-Wood et al., 1965).

Paleoecology of Specific Taxa

Much can be inferred of the paleoecology of the specific taxa collected form the Eudora shales. Unfortunately the data base is limited and narrow for any firm conclusions. So interpretations presented in this section should be viewed with a grain of salt.

Some mention has already been made concerning the chonetids, and to their possible exclusion in firm or hard substrate environments. Interestingly there exists a fairly high negative correlation between *Composita* and the chonetids which may support this hypothesis (Figure 3). Obviously specifics will only gel into a coherent form with additional sampling and bulk processing of the shales. This may also indicate a third community type dominated by free-living articulates.

One of the more interesting disassociations is that observed between *Meekella* and *Derbyia*. Both represent genera belonging to the same superfamily (Davidsoniacea), and potentially represent genera with the same habitat and niche requirements. Superficially they do, in that they attach to hard surfaces by their pedicle valves with the aid of byssal fibers (West, 1977). Consequently, one could conclude that both genera would occur together in relatively equal frequencies. This is not the case for the Eudora shales. Although there was no direct negative correlation between the two genera, there is a conspicuous non-association between the two communities they

frequent (guilty by association?) (Table 3 and Figure 3). The reasons for this apparent disassociation may be due to; 1), differing juvenile recruitment strategies and modes of life; and 2), differences in shell morphology. As a juvenile, *Meekella* does have a functional pedicle that is latter replaced by cementation of the pedicle valve in the adult stage (West, 1977). Evidence from epibiont counts of *Neospirifer* and *Composita* suggests that *Derbyia* cements itself to a hard substrate immediately at spatfall (Figure 4). I found no examples of *Meekella* attached to any of the large brachiopods, as was the case for *Derbyia*. This could indicate that *Meekella* is not as selective about substrate type as *Derbyia* seems to be, and would explain *Meekella*'s presence and *Derbyia*'s absence at the Fogel quarry (Table 2). *Meekella* also possesses a strongly plicate shell morphology compared to *Derbyia*. One of the inferred advantages in having a strongly plicated shell is to increase the opening between the valves with a reduced gape, allowing for efficient respiration and feeding in otherwise low oxygen or highly terrigenous environments (Rudwick, 1964; Fursich and Hurst, 1974). Consequently, *Meekella* is better adapted to Eudora facies exhibiting these environmental traits (ie., Fogel and Kill Creek).

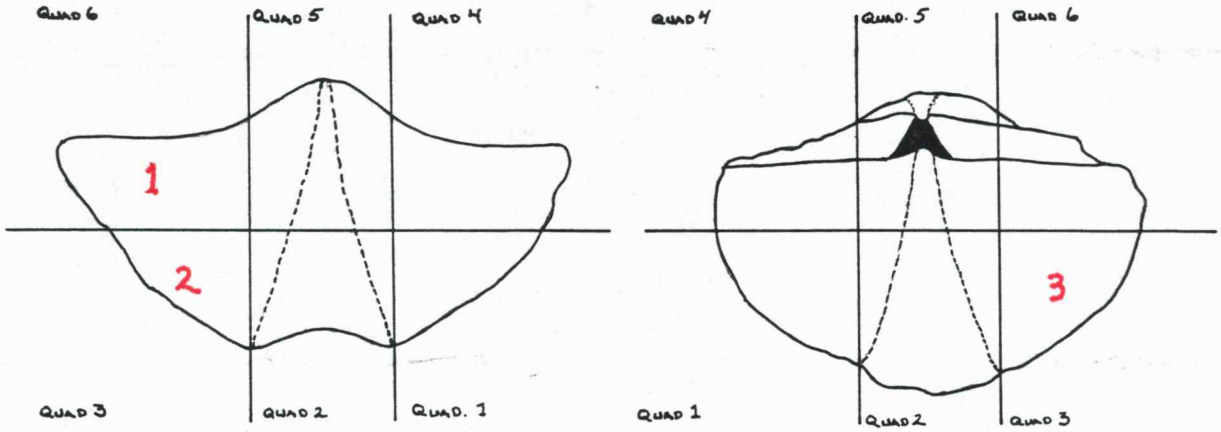
Taphonomy

The analyses presented in this section are based on float and select sample collections at the McAdams and Lizard sites. Specific taxa, namely *Neospirifer* and *Composita* exhibited the greatest degree of taphonomic effects (crushing, encrustation) compared to the other genera present, either due to their ubiquitous at the sample sites, their comparatively large size, or both. Consequently, the bulk of the interpretations were derived from examination of these two genera.

Figures 4 through 9 summarize the findings of epibiont types and their relative numbers attached to the respective genera. Epibionts were divided into four main groups; 1), bryozoans, 2), borings, 3), brachiopods, which include ? *Crania sp.*, *Derbyia sp.* and juvenile productids referable to *Leptalosia ovalis* of Condra and Dunbar (1932), and 4), *Spirorbis sp.* tubes. The purpose of the counts was three-fold: 1), to aid in the understanding of the life habits of *Neospirifer* and *Composita*; 2), to provide some clues as to the amount of transport that was undergone by the Eudora taxa; and 3), to provide some clue to the rate of deposition of the enclosing shales.

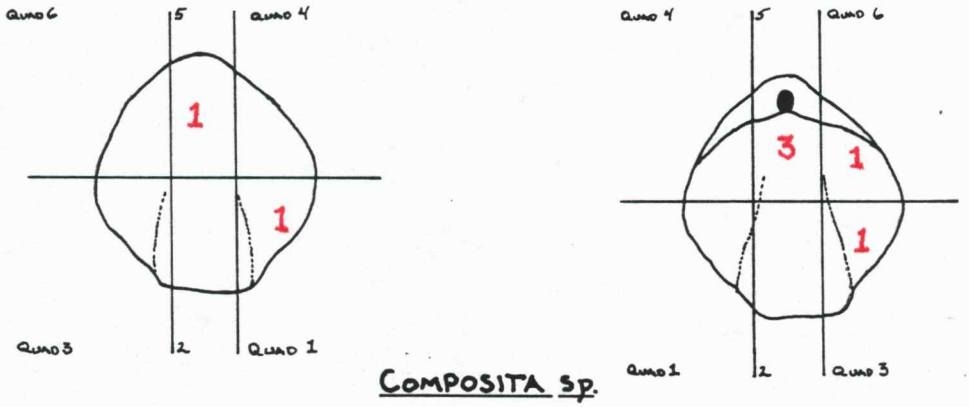
The more interesting results were obtained from epibiont counts on *Composita*. All encrusters and borings show a high degree of segregation relative to valve type, in that the pedicle valve of *Composita* is frequently more encrusted than the brachial valve. This is most likely the of the life position of *Composita*, which rests with the brachial valve down and sheltered by the substrate, while the pedicle valve remained exposed to potential epibiont attachment. Suggesting that *Composita* was not flipped over or rolled around by currents and exposing the brachial valve to the encrusters. Nor was *Composita* exposed on the substrate for any length of time after death. This suggests that sedimentation was fast and episodic at the McAdams and Lizard sites. This is contrary to the slow and continuous deposition characteristic of deep basins. Interestingly, a few of the McAdams' *Composita* show evidence of post-crushing encrustation. More work needs to be done, but if crushing is due to sediment compaction it would indicate that severe episodic erosional and depositional events occurred during Eudora time. It would also make it possible to determine the amount of sediment was eroded to expose the shells, given that crushing was due to compaction alone, and not to predation. Surprisingly, the number of encrusted *Composita* relative to non-encrusted

NEOSPIRIFER sp.



PEDICLE VIEW (x1)

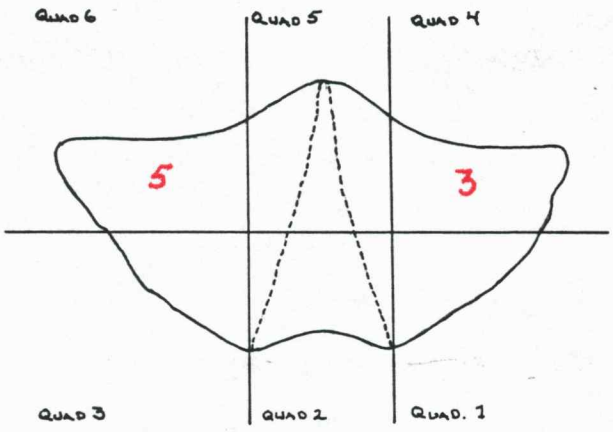
BRACHIAL VIEW (x1)



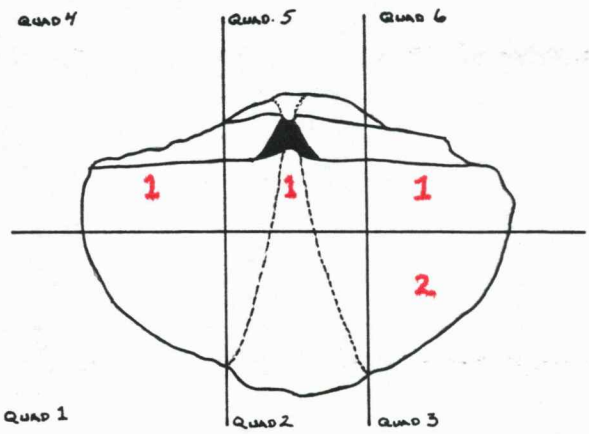
COMPOSITA sp.

FIGURE 4 - LOCATION OF DERBYIA ON NEOSPIRIFER AND COMPOSITA. RED NUMBERS REPRESENT FREQUENCY OF DERBYIA / QUADRANT. TOTAL NUMBER OF ENCRUSTED BRACHIOPODS IS 348 FROM BOTH THE MCADAMS AND LIZARD SITES.

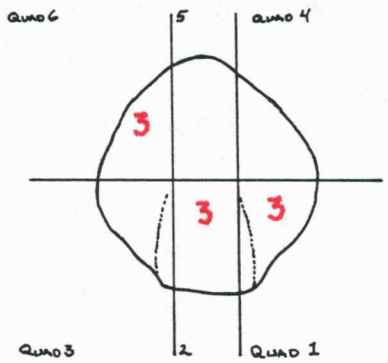
NEOSPIRIFER sp.

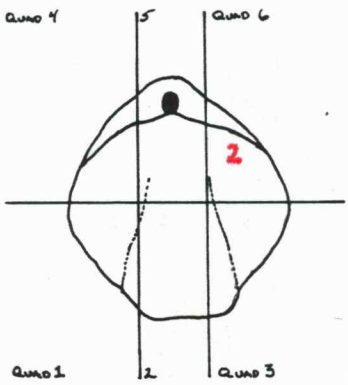


PEDICLE VIEW (x1)



BRACHIAL VIEW (x1)

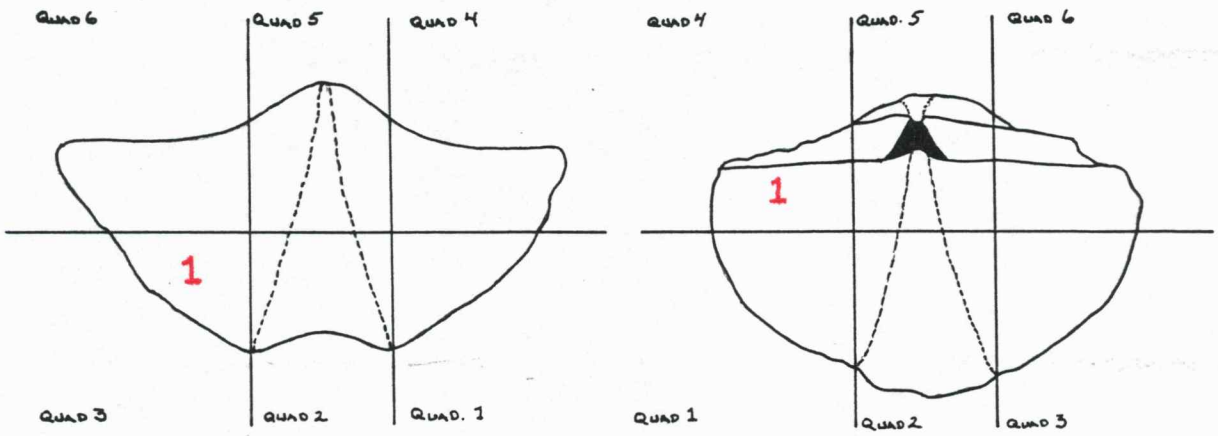




COMPOSITA sp.

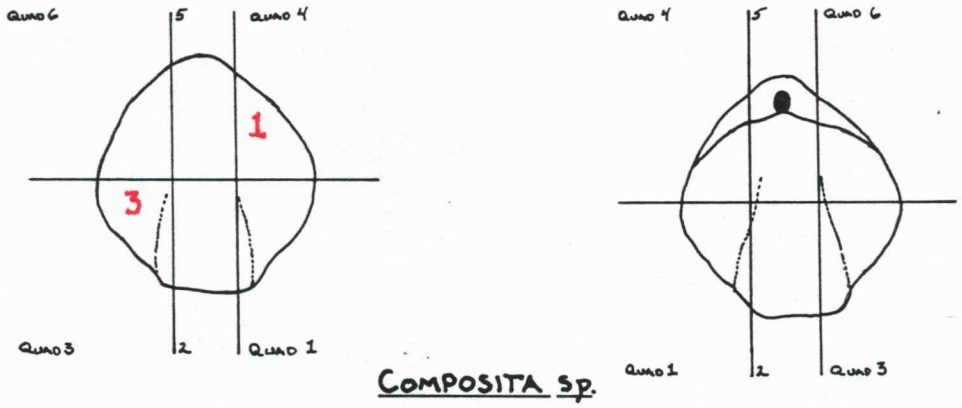
FIGURE 5 - LOCATION OF ?CRANIA ON NEOSPIRIFER AND COMPOSITA.
SEE FIGURE 4 FOR EXPLANATION

NEOSPIRIFER sp.



PEDICLE VIEW (x1)

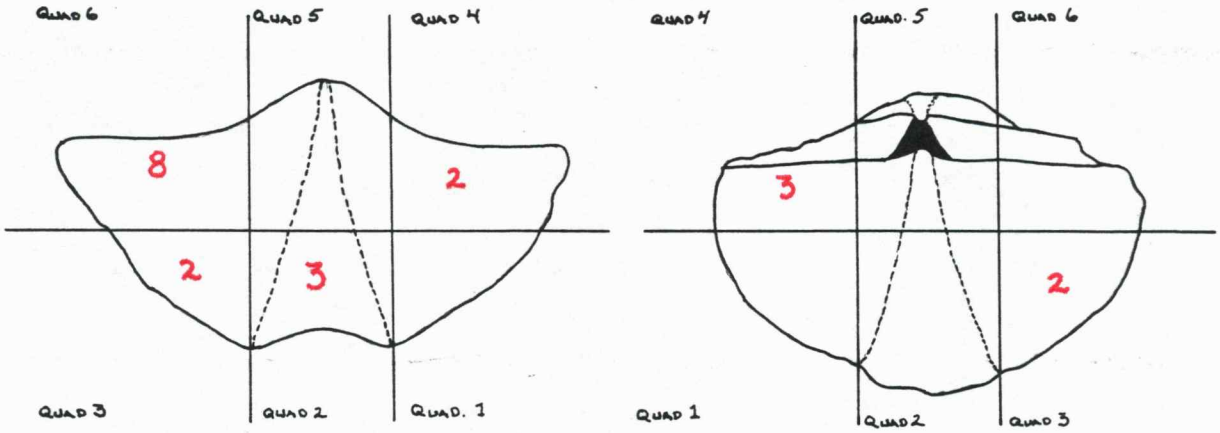
BRACHIAL VIEW (x1)



COMPOSITA sp.

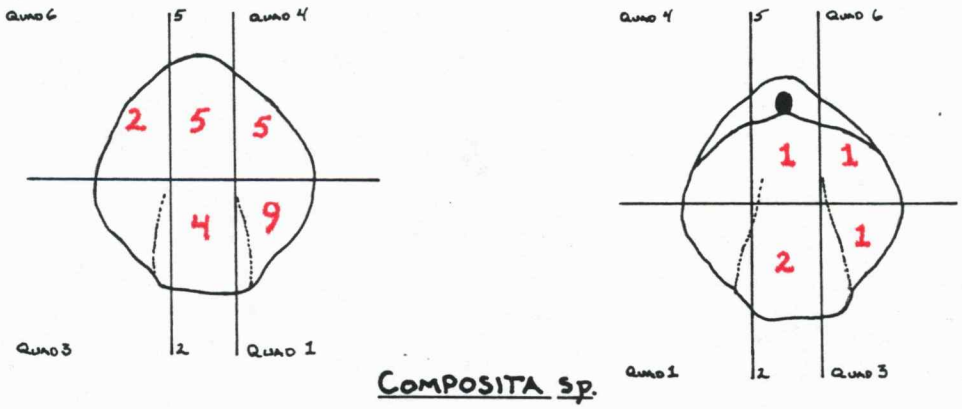
FIGURE 6 - LOCATION OF PRODUCTIDS ON NEOSPIRIFER AND COMPOSITA. SEE FIGURE 4 FOR EXPLANATION.

NEOSPIRIFER sp.



PEDICLE VIEW (x1)

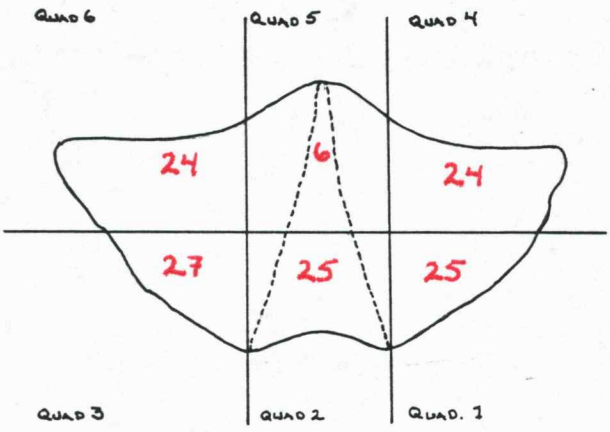
BRACHIAL VIEW (x1)



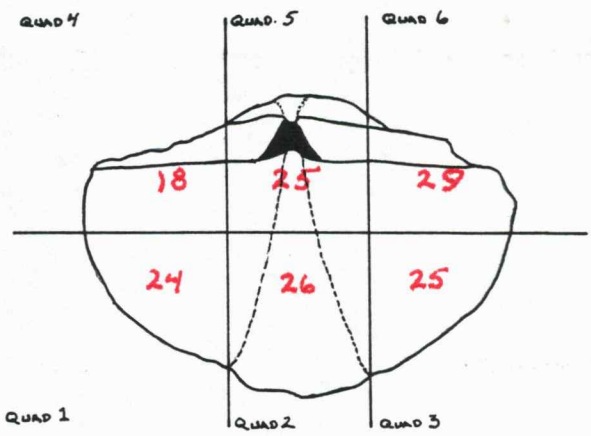
COMPOSITA sp.

FIGURE 7 - LOCATION OF SPIRORBIS ON NEOSPIRIFER AND COMPOSITA. SEE FIGURE 4 FOR EXPLANATION.

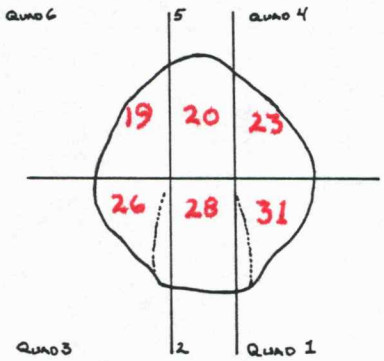
NEOSPIRIFER sp.

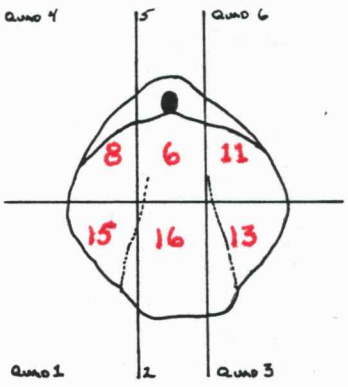


PEDICLE VIEW (x1)



BRACHIAL VIEW (x1)

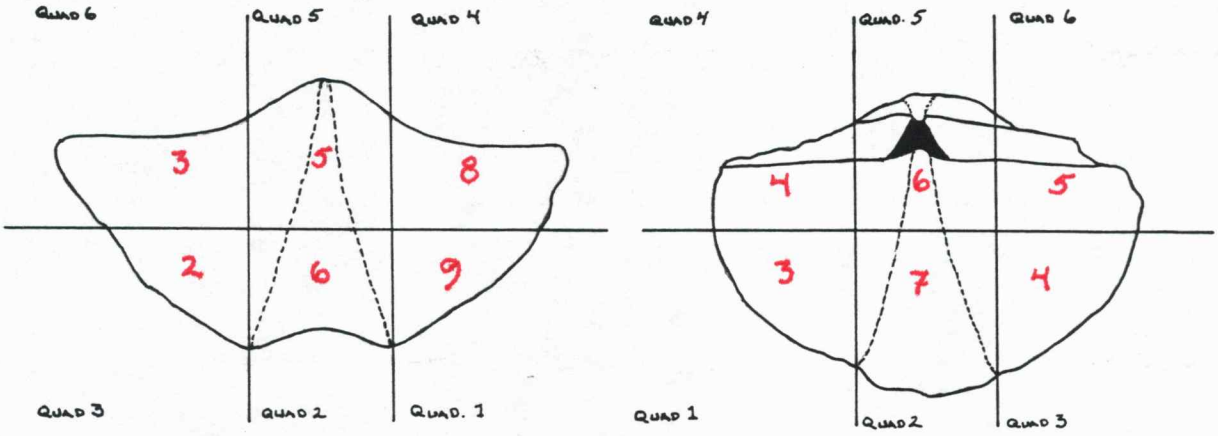




COMPOSITA sp.

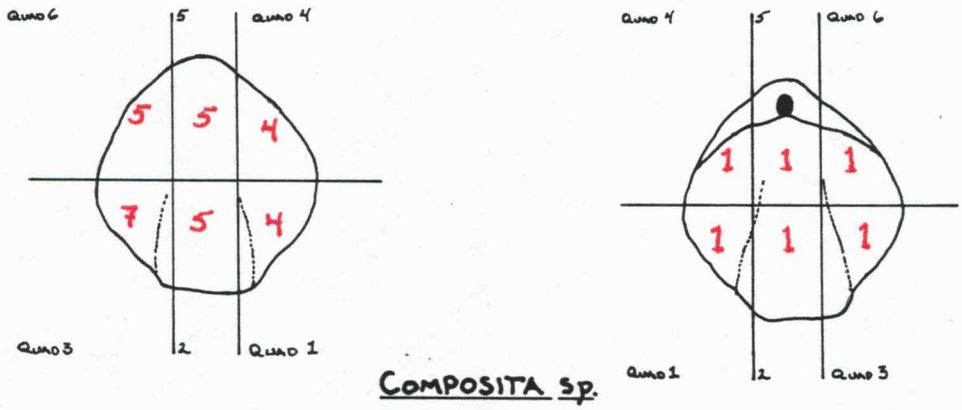
FIGURE 8 - LOCATION OF BRYOZOANS ON NEOSPIRIFER AND COMPOSITA.
SEE FIGURE 4 FOR EXPLANATION

NEOSPIRIFER sp.



PEDICLE VIEW (×1)

BRACHIAL VIEW (×1)



COMPOSITA sp.

FIGURE 9 - LOCATION OF BORINGS ON NEOSPIRIFER AND COMPOSITA.

Composita was the same at the McAdams and Lizard locations, with 42 percent of the collected *Composita* exhibiting the same degree of epibiont attachment at both sites.

Examination of the degree of crushing of shells at both sites did reveal marked differences, in that the Lizard *Composita* exhibited very little post-depositional crushing compared to the McAdams site. Suggesting that the majority of the float specimens collected at the Lizard quarry weathered out of the overlying limestone rather than from the shale lithologies. This conclusion is supported by the select samples of the measured shales, as all *Composita* collected out of the Lizard shales were crushed flat.

Neospirifer showed little differentiation of valve encrusters, with approximately an equal frequency of epibionts occurring on both the pedicle and brachial valves. Again this is largely due to *Neospirifer*'s mode of life, as the genus tends to rest on the interarea rather than on one particular valve. Consequently, one should expect encrustation to be equally distributed between the two valves. Of particular interest is the distribution of borings on *Neospirifer*. Given the thin nature of the shell along the commissure, one would expect fewer signs of boring along the anterior margin compared to the thicker portions of the shell located proximal to the cardinal extremities. This is not the case. A casual view of figure 10 shows an equal to greater number of borings in the anterior quadrants (1-3) relative to the posterior quadrants (4-6) of *Neospirifer*. One could infer that the borers were taking advantage of the respiratory and feeding currents produced by *Neospirifer*. If this is true, it invokes some interesting problems concerning recent views by some paleontologists that brachiopods were passive filterers, and did not use the lophophore to create it's own current. If brachiopods were passive filterers,

then what was the advantage for the borers in positioning themselves immediately along the commissure?

The degree of crushing in *Neospirifer* from both localities were the same as that noted for *Composita*, indicating that the majority of the Lizard float was weathering out of the overlying limestone.

CONCLUSIONS

Clearly the Eudora deposystem represents a more complex paleoenvironmental problem than current cyclothem models imply. Evidence for normal marine conditions during select intervals of Eudora deposition is apparent due to the abundance and diversity of the enclosed brachiopod fauna. This is particularly true if one includes the upper shales at Lizard and McAdams into the Eudora model. This contradicts current thinking that the Pennsylvanian black shales represent anoxic to dysaerobic environments alone, and that these environmental conditions were both constant and continuous throughout Kansas. Evidence for lateral changes from anoxic to aerobic bottom conditions are present (see correlation between the McAdams and Lizard quarries in figure 2), and suggests that Sageman's black shale model may apply to the Eudora.

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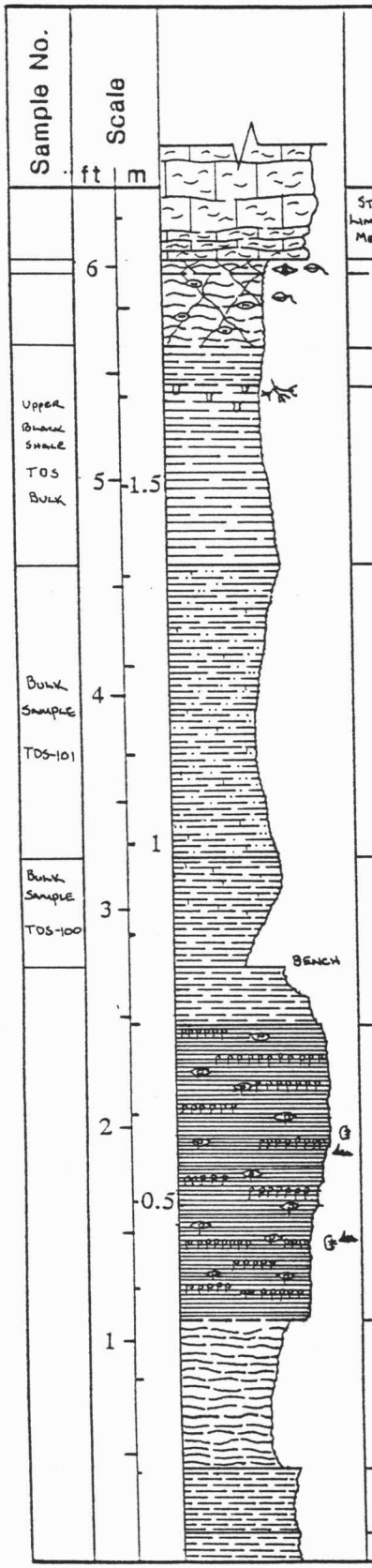
APPENDIX 1

DESCRIPTIONS OF MEASURED SECTIONS



Description: Eudora Shale Member, Stanton Formation

Outcrop Location: East-bound onramp of Edgerton Rd. and K-10, between Eudora and De Soto, Kansas. Center of SE 1/4, Sec. 36, T. 12S., R. 21E., Johnson County, Kansas.

Measured by: Deb. , Sara Marcus, and Tom Stanley, September 5, 1992.

Total Thickness: 1.81 meters. Scale: 1cm = 10cm

Description

Stoner Limestone Mbr.: Thin- to medium-bedded (2-5cm) skeletal to whole fossil wackestone. Becomes thicker bedded (7-10 cm) toward top. Lower contact w/ Eudora Shale sharp

Eudora Shale Mbr: Total Thickness 1.81 meters.

Bed 8c: 3.0cm thick, dark yellowish orange (10YR 6/6), blocky clay shale. Abundant poorly preserved brachiopods (Derbyia, Crurithyris, ?Punctospirifer). Upper contact sharp, lower contact gradational over 1-3 cm. Distinct color probably due to weathering.

Bed 8b: 10cm thick, light olive gray (5Y 5/2), blocky clay shale. Thin (1-2mm), discontinuous black shale partings throughout; poorly preserved Crurithyris (?), orbiculoids(?) occur in top 4-5cm. Lower contact gradational over 2cm.

Bed 8a: 5cm thick, grayish olive (10Y 4/2), laminated shale. Laminae 2-5mm thick. Laminae poorly developed. No fossils evident. Lower contact slightly gradational over 2cm. Signified by a color change, rather than a lithological change.

Bed 7: 25cm thick, black (N1), fissile shale. Laminae vary from 1-5 mm thick (generally becoming thicker toward top). Upper 7cm w/ sparse Chondrites burrows, represented by a single or simple bifurcating horizontal tunnel (2-3 mm diameter); FeOx lining of tunnel common. Shale mod. indurated. Lower contact - type unknown due to trenching. Appears to be sharp.

Bed 6: 42cm thick, dark gray (N3), slightly calcareous, silty shale. Well developed fissility, poorly indurated. Laminae 1-3 mm thick, (thicker toward base). Lower contact - type unknown due to trenching. No macrofossils evident.

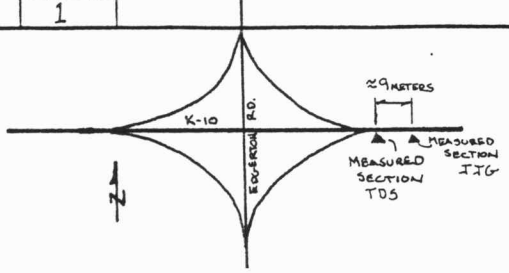
Bed 5: 23cm, medium gray (N5) clayshale. Upper 8cm slightly calcareous; well developed fissility, poorly indurated. Strong FeOx stain on laminae. Laminations 2-3 mm thick. Bed 5 similar to Bed 6 except for lack of silt and color change. Lower contact sharp. Roadcut bench 8 cm above base of unit.

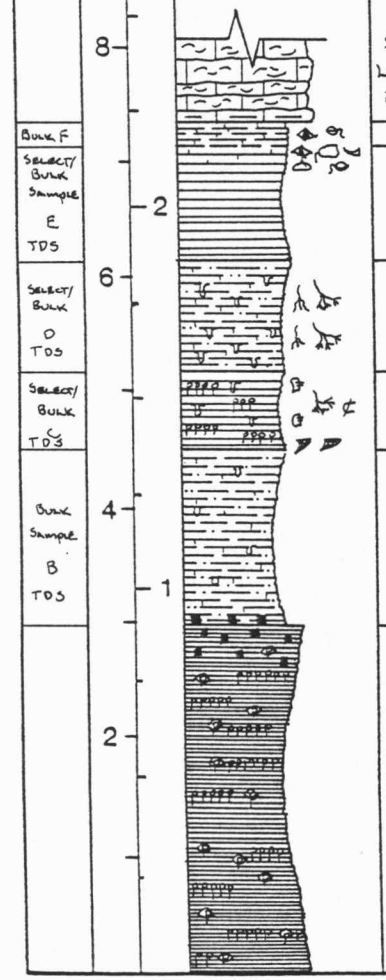
Bed 4: 41 cm, black (N1), well indurated, phosphatic, fissile shale. Phosphate throughout, occurring as 4x10 mm, oblate nodules, or as discontinuous laminations over 5-6 cm (phosphate laminae usually terminating at a nodule). Well developed fissility (1-3 mm). Fish scales and conodonts common throughout. Fissility tends to be better in upper 31cm of unit. Lower contact slightly gradational over 2cm.

Bed 3: 20cm thick, dark gray (N3) to grayish black (N2), blocky laminated to thin-bedded shale. Bedding averages 12 mm, weakly indurated. Slightly wavy. Thin laminated bedding more common in upper 4cm of unit.

Bed 2: 9cm thick, medium (gray (N5) to medium light gray (N6) shale. Bedding laminated (2-3mm), but poorly developed. Lower contact type unknown due to treaching.

Bed 1: 4cm, grades from medium gray (N5) at base to dark gray (N3). Bedding - type unknown due to trenching. Basal contact w/ Captain Creek Member, sharp but wavy.





Description: Eudora Shale Member - Stanton Formation

Measured Section located on middle of North high wall of East Pit, Vogel Quarry (TDS Section II). Central SE 1/4, Sec 12, T. 17S., R. 19E., Franklin County, Kansas.

Measured By: Deb , Sara Marcus, and Tom Stanley. October 11, 1992

Total Thickness: 2.22 meters; Scale: 1cm = 20cm.

Description

Stoner Limestone Member: Basal 3cm light brown (5YR 5/6), to pale yellowish brown (10YR 6/2), argillaceous mudstone. Quickly (grads (over 2-3cm) into a grayish orange pink (5YR 7/2) fossiliferous wackestone. Lower contact with Eudora Shale Member is sharp.

Eudora Shale Member: Total Thickness 2.22 meters.

Bed 6: 6cm thick, light brownish gray (5YR 6/1), calcareous shale. Poorly indurated w/ poorly developed fissility. Bedding ranging from 3-4 mm thick; unit contains poorly preserved fauna (mainly brachiopods) consisting of Punctospirifer, Juresania, Wellerella, and Meekella, w/ minor bryozoan and crinoid columnals. Lower contact is gradational over 2cm w/ unit 5.

Bed 5: 30cm thick, black (N1) shale. Upper 5cm a calcareous blocky shale. Bedding varies from 5-20 mm; shale mod. indurated, tends to fracture conchoidally. Exhibits poorly developed fissility. Upper 5cm contains fairly diverse fauna characterized by low spired gastropods, ? Pectin clams, Orbiculoid and Lingula inarticulate brachiopods. Minor Productid and Neospirifer (?), and Meekella also occur (articulates partially replaced by fine pyrite). No macrofossils evident in lower 25cm of interval. Lower contact sharp.

Bed 4: 30cm thick, medium gray (N5) to medium dark gray (N4), calcareous, silty shale. Poorly indurated, variable fissility (basal 5-10 cm tends to exhibit better fissility, upper parts of interval is blocky). Unit is burrowed throughout by Chondrites (?). Burrows oriented at various angles to bedding, typically lined by olive to olive green coloration (slightly oxidized pyrite ?). Burrows average 3-4 mm in diameter. Some "burrows" taper at ends and have a blueish color, possibly representative root casts (?). Lower contact slightly intercalated (over 2-5cm) to sharp.

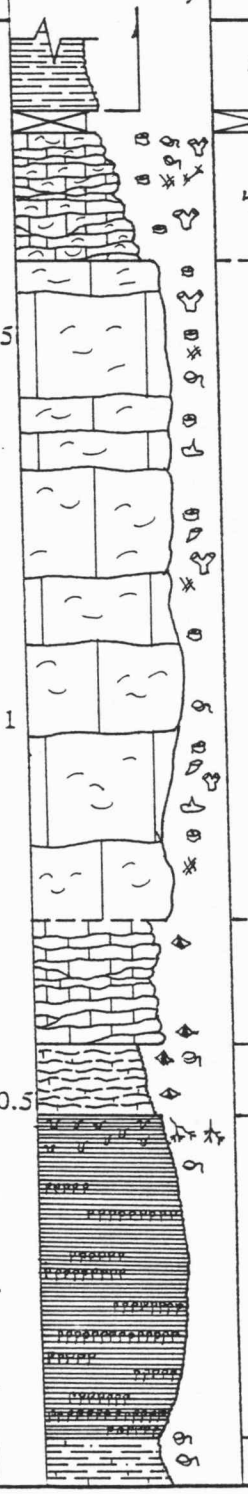
Bed 3: 20cm. Dusky gray (N3) to black (N1). Phosphatic shale. Phosphate occurs as thin, discontinuous laminae (1 mm thick). Nodular phosphate uncommon. Bedding 2-5mm thick w/ poorly developed fissility (similar to Bed 5). Chondrites (?) occur sporadically throughout interval. Burrows typically oriented parallel to bedding; averaging 2-3 mm in diameter. Fish scales and plant fragments common. Conulariids abundant at base of interval. Lower contact sharp.

Bed 2: 46 cm, medium gray (N5), calcareous silty shale. Blocky bedded, poorly indurated. Bedding varies from 5-12 mm thick. Basal 3cm w/ 2 x 3 cm, oblate-shaped pyrite nodules. Minor horizontal burrows throughout; type unknown (Chondrites ?, Planolites ?). Basal contact sharp.

Bed 1: 90 cm thick, black (N1), well indurated, fissile shale. Phosphate abundant, occurring as 1 x 2 cm oblate nodules, or as thin discontinuous laminae. Pyrite nodules common in upper 10 cm of interval (slight FeOx rind on nodules). No macrofossils evident. Lower contact w/ Captain Creek Member sharp, but uneven.

Sample No.

Scale ft | m



Bed No.

A

4a

4b

4c

3

2

1

Description: EUDORA SHALE MEMBER - STANTON FORMATION

MEASURED SECTION LOCATED ON NORTH HIGH WALL OF SOUTHWEST LIZARD QUARRY

MEASURED BY: DEB , SARA MARCUS , AND TOM STANLEY . OCTOBER 4, 1992.

TOTAL THICKNESS:).76 METERS ; SCALE: 1CM=10CM

DESCRIPTION

EUDORA SHALE MEMBER: TOTAL THICKNESS).76 METERS

BED A: NOT PRESENT ALONG NORTH WALL OF QUARRY. SEE TDS MEASURED SECTION FROM NORTHEAST LIZARD QUARRY.

BED 4a: 17CM THICK, PALE BROWN (5YR5/2), WAVY TO IRREGULARLY BEDDED, SKELETAL WACKESTONE. BEDDING CHARACTERISTICALLY THIN (1-2CM THICK), AND WAVY TO IRREGULAR (INDIVIDUAL BEDS PINCH TO 5MM OR LESS, AND SWELL TO 2CM OVER 5-10 CM LATERALLY). UPPER PART OF UNIT TENDS TO BE MORE EVEN AND CONTINUOUS, BUT STILL RETAINS WAVY NATURE. FAUNA FAIRLY DIVERSE, TYPICALLY FRAGMENTED AND ABRADED; CHARACTERIZED BY CRINOID OSSICLES, RAMOSE AND FENESTRATE BRYOZOANS, ALONG W/ SOME ENCRUSTING TYPES. COMPOSITA IS ONLY BRACHIOPOD EVIDENT; GENERALLY CONCENTRATED IN UPPER 5CM OF EXPOSED UNIT. TOP 5CM OF BED MISSING. LOWER CONTACT SHARP AND EVEN.

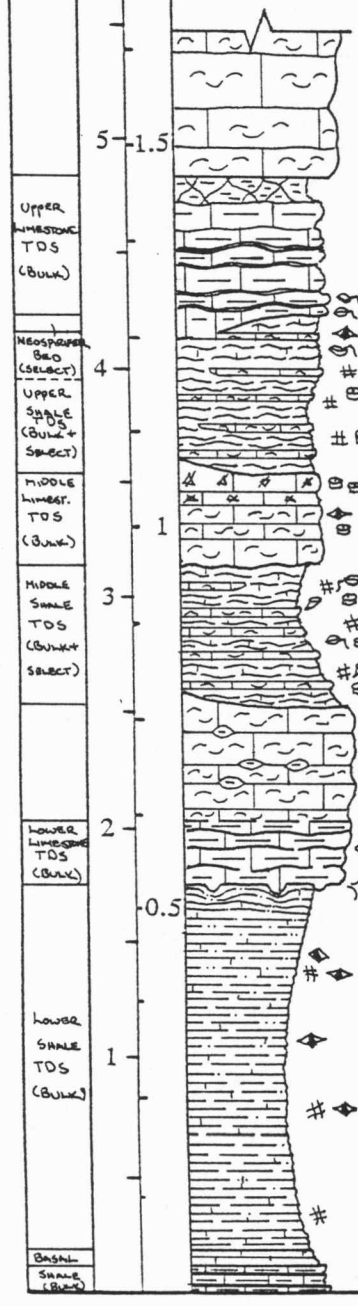
BED 4b: 86CM THICK, PALE BROWN (5YR5/2), CRINOIDAL WACKESTONE. MEDIUM-BEDDED, FAIRLY EVEN, AVERAGING 12CM THICK. FAUNA DOMINATED BY CRINOID COLUMNS (RANGING FROM 2-4 CM LONG) UNIFORM DIAMETER ≈ 5MM). RUGOSE HORN CORALS, BRACHIOPODS, AND HIGH AND LOW-SPIRED GASTROPODS. FENESTRATE AND RAMOSE BRYOZOANS MAKE-UP ≈ 25% OF ENCLOSED FOSSILS. ALL BUT THE RAMOSE BRYOZOANS AND RUGOSA HORN CORALS SHOW A HIGH DEGREE OF FRAGMENTATION. LOWER CONTACT OF UNIT IS SLIGHTLY GRADATIONAL OVER 1-2CM.

BED 4c: 16CM THICK, PALE BROWN (5YR5/2), FOSSILIFEROUS MUDSTONE. BEDDING THIN (3CM), WAVY TO IRREGULAR. TEXTURALLY SIMILAR TO BED 4a. SPARSE, POORLY PRESERVED BRACHIOPODS REPRESENTED BY MOLDS OF *JURESANIA*, AND *PUNCTOSPIRIFER* (?). LOWER CONTACT SHARP AND EVEN.

BED 3: 9CM THICK, BROWNISH GRAY (5YR 4/1), TO LIGHT BROWNISH GRAY (5YR6/1), CALCAREOUS CLAY SHALE, WEAK TO MODERATE DEVELOPED FISSILITY. (1-2MM THICK). POORLY INDURATED. POORLY PRESERVED SHELLY FAUNA OCCURS. PUNCTOSPIRIFER, CRURITHYRIS (?), MEEKELLA (?), ORBICULOIDS. LOWER CONTACT SHARP AND EVEN.

BED 2: 42CM THICK, BLACK (N1), FISSILE, PHOSPHATIC SHALE. WELL DEVELOPED FISSILITY, WELL INDURATED. PHOSPHATE OCCURS AS THIN (<1MM), DISCONTINUOUS LAMINATIONS, OR AS VERY SMALL (2-3MM) NODULES. PHOSPHATE DECREASED IN UPPER 10CM OF UNIT. NUMEROUS CHONDRITES BURROWS IN UPPER 5CM. 4-5 BIFURCATIONS OF TUNNEL COMMON, ALL ≈ 4-5MM IN DIAMETER. POSSIBLE COMPOSITA (?) JUST BELOW CHONDRITES INTERVAL; VERY POORLY PRESERVED. ORBICULOIDS COMMON ALONG LOWER CONTACT. LOWER CONTACT SHARP.

BED 1: 6CM THICK, BROWNISH GRAY (5YR 4/1), SLIGHTLY CALCAREOUS AND SILTY, SHALE. WELL DEVELOPED FISSILITY (1-2 MM). MORE CALCAREOUS AT BASE OF UNIT. VERY POORLY PRESERVED SHELLY FAUNA, PROBABLY ORBICULOIDS, W/ MINOR ARTICULATES. LOWER CONTACT WITH THE CAPTAIN CREEK LIMESTONE MEMBER SHARP BUT WAVY.



Description: EUDORA SHALE MEMBER, STANTON FORMATION
MEASURED SECTION TDSa. FAR SOUTHEAST END OF NORTH PIT, McADAMS QUARRY, SE 1/4, SEC. 12, T. 23S., R. 17E., ANDERSON COUNTY, KANSAS.

SECTION 3 METERS SOUTH OF TDSb, AND ≈ 23 METERS SOUTH OF MEASURED SECTION TSC.

MEASURED BY: DEB , SARA MARCUS, AND TOM STANLEY. SEPTEMBER 12, 1992.

TOTAL THICKNESS: 1.45 METERS. SCALE: 1CM = 10CM.

DESCRIPTION

STONER LIMESTONE MEMBER: MEDIUM-TO THICK-BEDDED WACKESTONE W/ VARIED FAUNA. BRACHIOPODS (ENTELETES, NEOSPIRIFER) + BRYOZOA DOMINATE. LOWER CONTACT W/ EUDORA SHALE MEMBER SHARP BUT WAVY, LOCALLY GRADATIONAL OVER 1-2 CM.

EUDORA SHALE MEMBER: TOTAL THICKNESS 1.45 METERS.*

BED 8: 18-(22)CM THICK, (GRAYISH ORANGE (10YR 7/4)), WAVY BEDDED ARGILLACEOUS MUDSTONE. BEDDING RANGES FROM 2-5CM THICK, SEPARATED BY THIN (1-2 MM) CLAY PARTINGS. WHOLE, UNABRADED FOSSILS OF LINOPRODUCTUS, ENTELETES; MIXED WITH BRYOZOAN AND CRINOID COLUMNS OCCUR. BRACHIOPODS MORE COMMON AT BASE OF UNIT. UPPERMOST 3CM A MODERATE REDDISH BROWN (10 R 4/6), BLOCKY CLAY SHALE. NO BEDDING EVIDENT DUE TO WEATHERING. POORLY PRESERVED SMALL SHELLY FAUNA OCCUR. LOWER CONTACT OF BED 8 SHARP.

BED 7: (8)-20CM THICK, MEDIUM GRAY (N5), HIGHLY FOSSILIFEROUS, CLAY SHALE; INTERBEDDED W/ THIN (2-5MM), ARGILLACEOUS, SKELETAL MUDSTONES TO WACKESTONES BEDS. SHALE SLIGHTY CALCAREOUS UPPER 5CM OF UNIT; POORLY INDURATED, EXIBITING WEAK FISSILITY. LAMINAE RANGE FROM 2-5 MM THICK. FAUNA OF ENCLOSING SHALE VARIABLE, CONSISTING OF NUMEROUS FENESTRATE BRYOZOANS AND CRINOID COLUMNS. (BRYOZOANS PRESERVED AS MOLDS AND CASTS). BRACHIOPODS NEOSPIRIFER, COMPOSITA, PUNCTOSPIRIFER, HEUSTEGIA, AND DARBYA ABUNDANT IN UPPER 5-7 CM; DECREASING IN NUMBERS IN LOWER PARTS OF UNIT. NEOSPIRIFER AND COMPOSITA TYPICALLY W/ PEDICLE VALVE UP, AND ARTICULATED. FAUNA W/IN LIMESTONES SIMILAR TO SHALES, ALTHOUGH FOSSILS SHOW A HIGHER DEGREE OF ABRASION + FRACTMENTATION IN LIMESTONES. DISTINCT NEOSPIRIFER-CRINOID WACKESTONE BED OCCURS 5CM BELOW UPPER CONTACT. THIN LIMESTONE BEDS INTERGRADE LATERALLY WITH UNITS 6 + 8, OR PINCH OUT ALTOGETHER 3M. TO NORTH. LOWER CONTACT OF UNIT SHARP BUT WAVY.

BED 6: 12-(16)CM, GRAYISH ORANGE PINK (5YR 7/2), THIN- TO MEDIUM-BEDDED (4-8CM), WHOLE FOSSIL TO SKELETAL WACKESTONES AND GRAINSTONES (?). LOWER 8CM OF UNIT A THIN-BEDDED, WHOLE FOSSIL WACKESTONE, COMPOSED OF A VARIED FAUNA DOMINATED BY 2-4CM LONG CRINOID COLUMNS AND NEOSPIRIFER. UPPER 4-8CM OF UNIT A CRINOIDAL GRAINSTONE(?) ENCLOSED FOSSILS STRANGELY FRAGMENTARY AND ABRADED. CRINOID OSSICLES CONSTITUTE MAJOR FAUNAL ELEMENT, WITH BRACHIOPOD AND BRYOZOAN FRAGMENTS AS MINOR ELEMENTS. LOWER CONTACT SHARP BUT WAVY.

BED 5: (7)-18 CM, MEDIUM GRAY (N5), INTERBEDDED CALCAREOUS CLAY SHALE AND THIN (2-3 MM) CRINOIDAL WACKSTONE-PACKSTONE. LITHOLOGICALLY + FAUNALLY SIMILAR TO BED 7, ALTHOUGH THERE IS A HIGHER PROPORTION OF OF BRACHIOPODS AND RUGOSE HORN CORALS IN BED 5. WHOLE FENESTRATE BRYOZOANS DOMINATE SHALE, EXIBITING SAME PRESERVATION AS BED 7. CRINOID COLUMNS ALSO ABUNDANT, TYPICALLY 3-5 CM LONG. NEOSPIRIFER AND COMPOSITA REPRESENT MAIN BRACHIOPOD TYPES. LIMESTONE BEDS ARE CRINOID-RICH W/ MINOR BRYOZOAN AND BRACHIOPOD FRAGMENTS. LOWER CONTACT SHARP BUT WAVY DUE TO VARIABLE THICKNESS OF UNIT.

BED 4: 23-(34)CM, DARK YELLOWISH ORANGE (10YR 6/6), THIN- TO MEDIUM-BEDDED (5-8CM) MUDSTONES, WACKESTONE-GRAINSTONES. UPPER 15-26 CM SIMILAR TO BED 6, CONSISTING OF MEDIUM-BEDDED (8CM) WACKESTONES W/ OCCASIONAL (≤ LESS THAN) 1MM THICK) SHALE RIP-UP CLASTS. FAUNA W/IN WACKESTONE DOMINATED BY DISARTICULATED CRINOID COLUMNALS (≥ 2MM DIAMETER), ALONG W/ MINOR FRAGMENTS OF BRACHIOPOD, BRYOZOAN AND CORALS. 3 METERS TO NORTH OF THIS SECTION, WACKESTONE GRADES INTO 8CM THICK CRINOIDAL GRAINSTONE (SAME AS THAT SEEN IN BED 6). BASAL 8CM OF BED 4 CONSISTS OF AN ARGILLACEOUS, WHOLE FOSSIL MUDSTONE. FOSSILS CONSIST OF ARTICULATED CRINOID COLUMNALS (≥ 4-5CM LONG), AND ARTICULATED NEOSPIRIFER. MUDSTONE-WACKESTONE CONTACT GRADATIONAL OVER 5CM. LARGE (5CM IN DIAMETER), HORIZONTAL BURROWS OF THALASSINOIDES OCCUR ALONG CONTACT BETWEEN BEDS 4 AND 3. BURROWS DEFORM SHALE LAMINAE.

* NOTE: THICKNESS OF BEDS RECORDED IN PARENTHESIS REPRESENTS THICKNESS OF BED 3 METER TO THE NORTH OF SECTION TDSa.

Sample No.

Scale ft | m

Bed No.

Description: EUDORA SHALE MEMBER - STANTON FORMATION
MEASURED SECTION TDSb. LOCATED 3 METERS NORTH OF SECTION TDSa, AND ≈ 20 METERS SOUTH OF SECTION TSC. MCADAMS QUARRY, ANDERSON COUNTY, KANSAS.

MEASURED BY: DEB , SARA MARCUS, AND TOM STANLEY. SEPTEMBER 12, 1992.

TOTAL THICKNESS ≈ 1.38 METERS ; SCALE: 1CM = 10CM

CONTINUE DESCRIPTION OF SECTION TDSa:
BENEATH BED 4. LOWER CONTACT SLIGHTLY GRADATIONAL.

BED 3: 47CM, MEDIUM DARK(GRAY (N4), SLIGHTLY SILTY, CALCAREOUS SHALE. SILT CONTENT INCREASES TOWARD TOP OF BED. BEDDING ≈1-2MM TO 5MM THICK. BLOCKY WEATHERING. NUMEROUS FENESTRATE BRYOZOAN MOLDS, W/ OCCASIONAL BRACHIOPOD MOLDS IN UPPER HALF OF UNIT. NO OTHER MACROFOSSILS EVIDENT. LOWER CONTACT SHARP.

STONER LIMESTONE MEMBER

BED 2: 3.5CM, BLACK (N1), BLOCKY BEDDED, SLIGHTLY CALCAREOUS SHALE. BEDDING ≈ 3-5MM THICK, EXHIBITING POOR FISSILITY. SHALE FAIRLY WELL INDURATED, BREAKS CONCHOIDALLY. LOWE CONTACT SHARP.

8

BED 1: 4.5CM, BLACK (N1) TO GRAYISH BLACK (N2), VERY ARGILLACEOUS MUDSTONE W/ SUBMILLIMETER BLACK SHALE PARTINGS. LIMESTONE BEDS AVERAGE 4-5MM THICK, SLIGHTLY WAVY. UNIT MAY REPRESENT GRADATIONAL OR TRANSITIONAL CONTACT BETWEEN EUDORA SHALE AND CAPTAIN CREEK LIMESTONE MEMBER.

DESCRIPTION TDSb: THICKNESS OF EUDORA SHALE ≈ 1.38 METERS. TDSb IS LITHOLOGICALLY AND FAUNALLY SIMILAR TO SECTION TDSa, EXCEPT FOR VARIATIONS OF BED THICKNESSES.

7

BED 8: 22CM THICK; UPPER REDDISH CLAYSHALE THINS TO 2CM. THICK.

6

BED 7: 8CM THICK; DECREASE NUMBER OF LIMESTONE INTERBEDS. ABUNDANT NEOSPIRIFER IN UPPER 3CM OF SHALE.

BED 6: 16CM THICK; CAPPED BY 8CM THICK CRINOIDAL GRAINSTONE(?). ALL COLUMNALS ARE DISARTICULATED.

5

BED 5: 7CM THICK; DECREASE NUMBER OF LIMESTONE INTERBEDS.

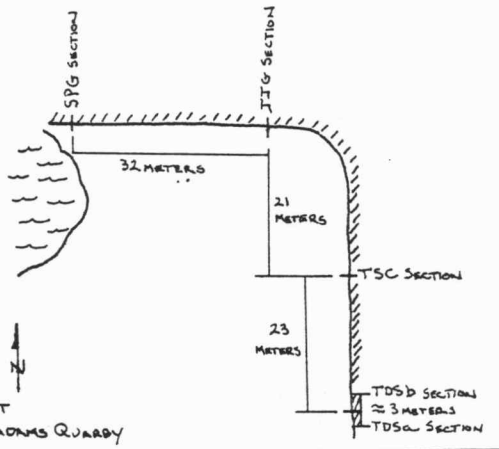
BED 4: 32CM THICK; UPPER 7-8CM OF BED COMPOSED OF A CRINOIDAL GRAINSTONE(?) SIMILAR TO UPPER PART OF UNIT 6.

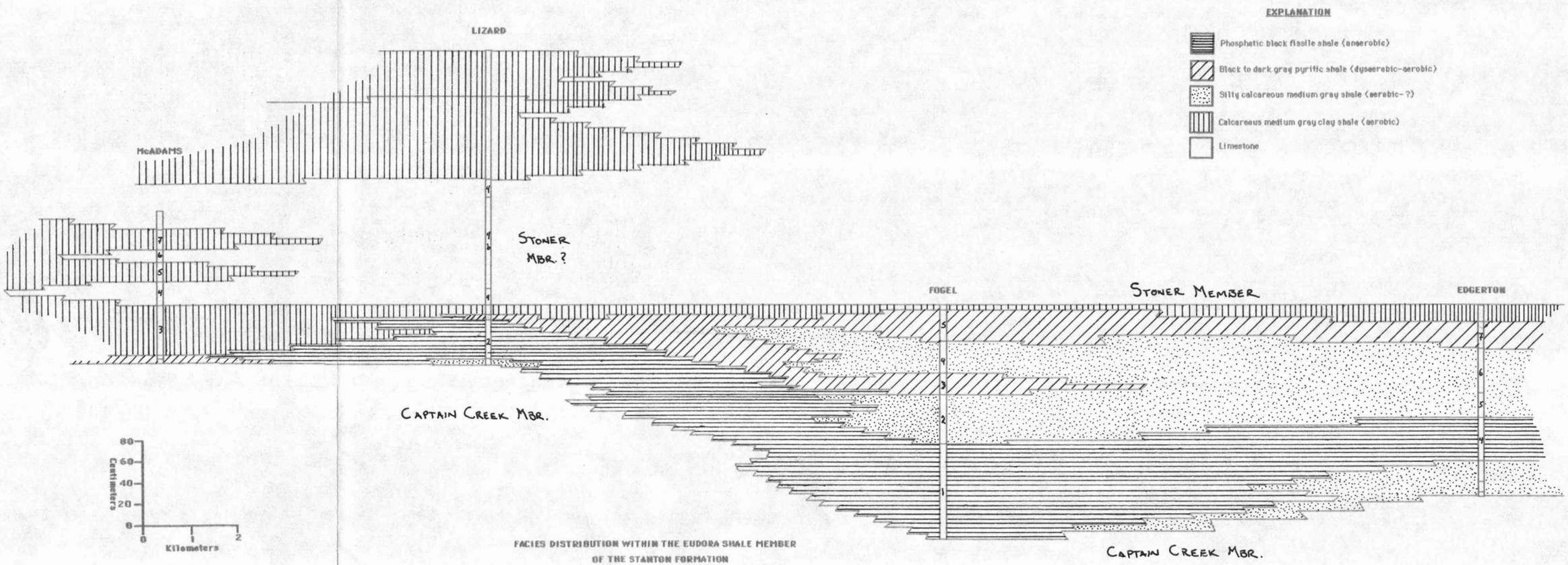
4

BEDS 1-3: ONLY TOP 4CM OF BED 3 EXPOSED. LITHOLOGICALLY THE SAME AS BED 3 IN TDSa SECTION. ≈ 91 CM OF SECTION COVERED BY TALUS.

3

BEDS 3, 2, AND 1 MOSTLY COVERED





FACIES DISTRIBUTION WITHIN THE EUDORA SHALE MEMBER
OF THE STANTON FORMATION

Datum is first significant limestone bed above the Captain Creek

Horizontal Scale: 1cm = 1km
Vertical Scale: 1cm = 20cm
Vertical Exaggeration: x5000

FIGURE 2