FOSSIL ASSEMBLAGES, STRATIGRAPHY, AND DEPOSITIONAL ENVIRONMENTS OF THE CROUSE LIMESTONE (LOWER PERMIAN) IN NORTH CENTRAL KANSAS

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by

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INTRODUCTION

Purpose of Study

This study examines fossil assemblages, stratigraphy, and depositional environments of the Crouse Limestone in north central Kansas, focusing particularly on lateral and vertical changes. The Crouse Limestone was chosen because (1) a previous study (West, et al., 1972) had proposed a depositional model for the Crouse, (2) sections N and O (fig. 1) in the northern part of the area did not fit the proposed model, (3) important new information was available at section Q in the southwest part of the area, and (4) it enabled me to apply my interests in palaeobiology, carbonate petrology, stratigraphy, and field geology. Examination of sections N, O, and Q along with other outcrops in this area was undertaken to refine, expand, and test the proposed depositional model.

Location

Ten measured sections, six roadcuts and four stream exposures, were studied in detail in an area approximately 50 by 20 miles (fig. 1). Three additional sections (E, J, and N) were studied in less detail. Parts of Riley, Geary, Wabaunsee, Pottawatomie, and Marshall Counties make up the area which includes the areas studied by Huber (1965) and West, et al. (1972). In addition to outcrops, I was fortunate to have the opportunity to examine the Crouse Limestone in a core (fig. 1) taken in 1975 by Amoco Production Company.

Previous Investigations

Huber (1965) summarized the nomenclatural history of the Crouse Limestone as follows:

> The Crouse Limestone was named by Heald (1917, p. 21-22) from an exposure at Crouse Hill in the northwest part of the Foraker

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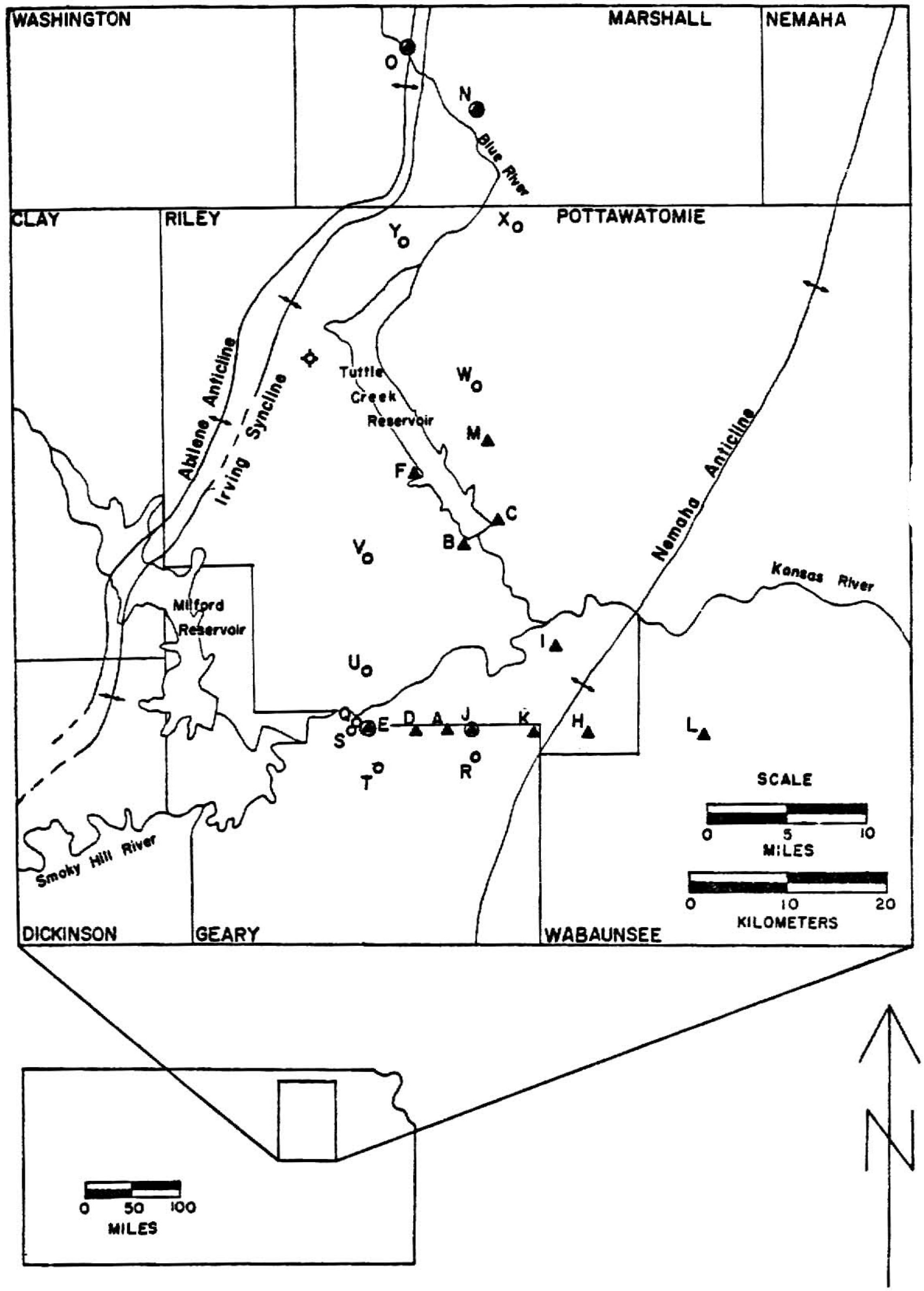

Figure 1. Location of Crouse Limestone Measured Sections.

> quadrangle in Osage County, Oklahoma. The type locality is in the northeast quarter of section 23, T29N, R6E, about 2½ miles west of Frankfort, Oklahoma (Condra and Upp, 1931, p. 21). In 1927 Condra (p. 234) named this limestone the Sabetha Limestone and included it as one of three members in the Bigelow Limestone. The Bigelow consisted, in ascending order, of the Sabetha Limestone, the Blue Rapids Shale, and the Funston Limestone. The Bigelow Limestone was named for the town of Bigelow in Marshall County, Kansas. Later Condra and Upp (1931, p. 21) discarded the name Sabetha when they found that it was correlative with the Crouse Limestone.

In 1941 Jewett (p. 64-65) proposed dropping the Bigelow as a stratigraphic term and recognizing the Crouse Limestone, the Blue Rapids Shale, and the Funston Limestone as three separate formations.

Moore, et al. (1951, p. 46) described the Crouse Limestone in Kansas as follows:

> The formation comprises an upper and lower limestone separated by a few feet of fossiliferous shale. The upper part displays platy structure and weathers tan to brown. The limestone beds locally are flinty. Thickness ranges from about 10 to 18 feet or more.

The three units described by Moore are recognizable in north central Kansas. Throughout this report they will be referred to as "lower limestone," "middle shale," and "upper limestone."

Elias (1937) was among the first workers to deal with depositional environments of the Lower Permian rocks in Kansas. He believed that these rocks represented cyclic deposits and assigned relative distances from shore and absolute water depths to the different biotic and lithologic associations. He suggested that the Crouse Limestone was formed in a sea that was transgressive and later regressive with water depths ranging from 60 to 110 feet.

Mudge and Burton (1959) described the Crouse Limestone in Wabaunsee County, Kansas, adjacent to the study area on the southeast. They recognized three units and noted the abundance of fossils, some of them marine, in the lower limestone.

Huber (1965) studied six Crouse Limestone outcrops in north central Kansas (sections A-F, fig. 1). He believed the lower limestone was deposited in shallow, quiet water with low terrigenous influx and low turbulence. The middle shale and upper limestone were interpreted as deposits of a shallow, low-energy, brackish water environment. Such an interpretation implies that the Crouse is a regressive sequence.

Huber (1965, p. 24-25) described four stratigraphic units in the Crouse Limestone: (1) a lower limestone unit, (2) a middle "shaly" unit, (3) an upper "platy" unit, and (4) an upper "contorted" unit. In this report the upper "platy" unit and the upper "contorted" unit are considered together as the "upper limestone."

West, et al. (1972) examined 14 Crouse Limestone outcrops in the area (sections A, B, C, D, E, F, H, I, J, K, L, M, N, and O, fig. 1). They interpreted the Crouse as a regressive sequence and suggested that the lower limestone was formed in a shallow subtidal to low intertidal environment, the middle shale in a middle to high intertidal environment, and the upper limestone in a high intertidal to supratidal environment. They further interpreted the Crouse Limestone in this area as follows (p. 89):

> ...representing the eastern side of an embayed portion of a shallow open marine shelf. This lagoon was bounded on the east and west by the Nemaha and Abilene Anticlines respectively, and occupies the Irving Syncline. During Crouse deposition this lagoon probably gradually decreased in size. Drying up took place first in the north and northeast and last in the south and southwest. Such conditions would record a regressive sequence in rocks deposited during Crouse time.

Section Q is a roadcut made subsequent to previous investigations. Preliminary study indicated that this section tended to support the depositional model. If drying up did indeed take place as suggested by West, et al., the existence of a swamp (represented by a black shale at section Q) in the southwest part of the area would not be unexpected.

A primary objective of this study was to examine carefully section Q and nearby outcrops to determine if this information supports, negates, or requires refinement of the model.

Marine fossils typical of deeper water were found in the lower limestone at sections N and O and, therefore, these sections did not support the proposed model. Another aim of this study was to use careful stratigraphic correlation and examination of these and other outcrops in the central and northern parts of the area in an attempt to resolve this discrepancy.

METHODS OF INVESTIGATION

Field Procedure

Reconnaissance.--Early in the investigation a reconnaissance was made to locate suitable outcrops. Elevations of previously studied Crouse Limestone outcrops were compared to United States Geological Survey topographic maps to determine areas of possible Crouse Limestone outcrops. Roads and streams in these areas were then checked. Eight exposures located in this way (sections R, S, T, U, V, W, X, and Y) were selected for study along with five previously known exposures (sections E, J, N, O, and Q).

Stratigraphic Description.--Each section was measured and described (Appendix I and West, et al., 1972, p. 46-49). Thicknesses were measured to the nearest one-half inch and later converted to metric units. Color (according to Goddard, et al., 1963), bedding, fracture, weathering characteristics, upper and lower contacts, fossils, and other features, such as bioturbation and sedimentary structures, were noted. Using these characteristics each measured section was divided into homogeneous units and each unit was tentatively assigned a rock name.

Sampling.--An effort was made to collect mappable bedding surfaces from the lower limestone. Such mapping would yield biotic data comparable to that collected by West and McMahon (1972) and facilitate lateral and vertical comparison of the lower limestone. To obtain the desired surfaces I collected slabs on which weathering had exposed and accentuated the fossils making them visible and identifiable. Such slabs were not always available, especially from outcrops where the base of the lower limestone was covered. When they were available they were seldom found in place and, therefore, could not be oriented with respect to compass direction.

Block and/or bag samples were collected, at least one sample from eash described unit. More than one sample was collected from units in which some change in the fossil assemblage and/or lithology was noted.

Stratigraphic Correlation.--Because study of lateral variation in the Crouse Limestone was an objective of this study, careful stratigraphic correlation was essential. The uppermost bed of the lower limestone is a distinctive marker in most parts of the area because it contains abundant gastropods, considerable iron oxide, and makes a prominent outcrop. The platy upper limestone is also distinctive. At sections N and O, however, the Crouse Limestone does not have these characteristics. This has led to erroneous stratigraphic correlation and considerable confusion regarding these two sections. At these localities a one- to three-foot thick limestone bed in the underlying Easly Creek Shale was a useful marker. This bed also makes a prominent outcrop and contains marine fossils, particularly ectoprocts and brachiopods, in the upper part; intraclasts occur locally in the lower part. This limestone bed was previously considered the lower Crouse Limestone, but examination of other outcrops, especially section X, helped determine its proper stratigraphic position.

Laboratory Procedure

General Statement.--Each sample was examined using appropriate palaeontologic and petrologic techniques (fig. 2).

Washed Residue Examination.--Argillaceous (bag) samples were disaggregated and examined for microfossil content. The procedure followed was the standard kerosene method described by Scott (1973, p. 9). This technique worked reasonably well on most samples, but some calcareous samples did not disaggregate well. To facilitate microscopic examination, disaggregated residues were sieved through 10 mesh (-1.0 phi), 18 mesh (0.0 phi), 35 mesh (1.0 phi), and 60 mesh (2.0 phi) sieves. This procedure was used to determine the types of microfossils (Appendix II) and the data were not quantified.

Bedding Surface Study.--Bedding surfaces from the lower limestone (fig. 3) were mapped using a technique similar to one described by Yarrow (1974). A one-eighth inch thick piece of plexiglas was laid on top of the surface and outlines of the fossils traced using grease pencils and rapidograph. Each map was transferred to a sheet of paper for permanence (Appendix III) and the plexiglas wiped clean with soft tissue paper and water. During mapping the following information was recorded for each fossil (Appendix III): (1) type of fossil (to genus if possible), (2) type of preservation, (3) direction of concavity (i.e. concave up or concave down), (4) articulated or disarticulated, (5) if disarticulated, which valve (i.e. right or left), (6) fragmentation, and (7) presence of attached epizoans. Length of *Permophorus* cf. *P. subcuneatus* shells was measured to the nearest millimeter. Size measurements were not made on other taxa because visual inspection of the surfaces indicated that whole specimens

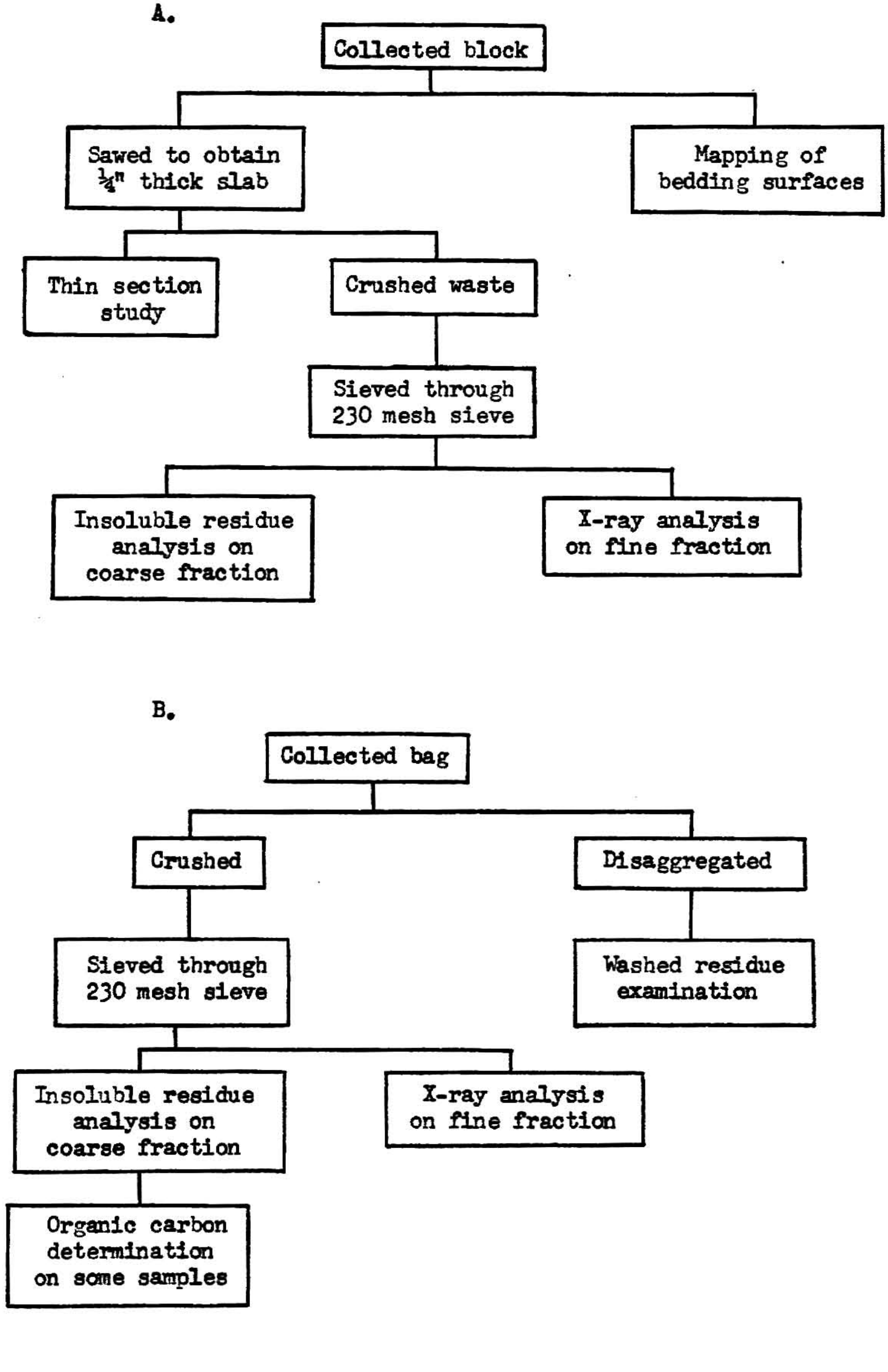

Figure 2. Flow Diagram of General Laboratory Procedure

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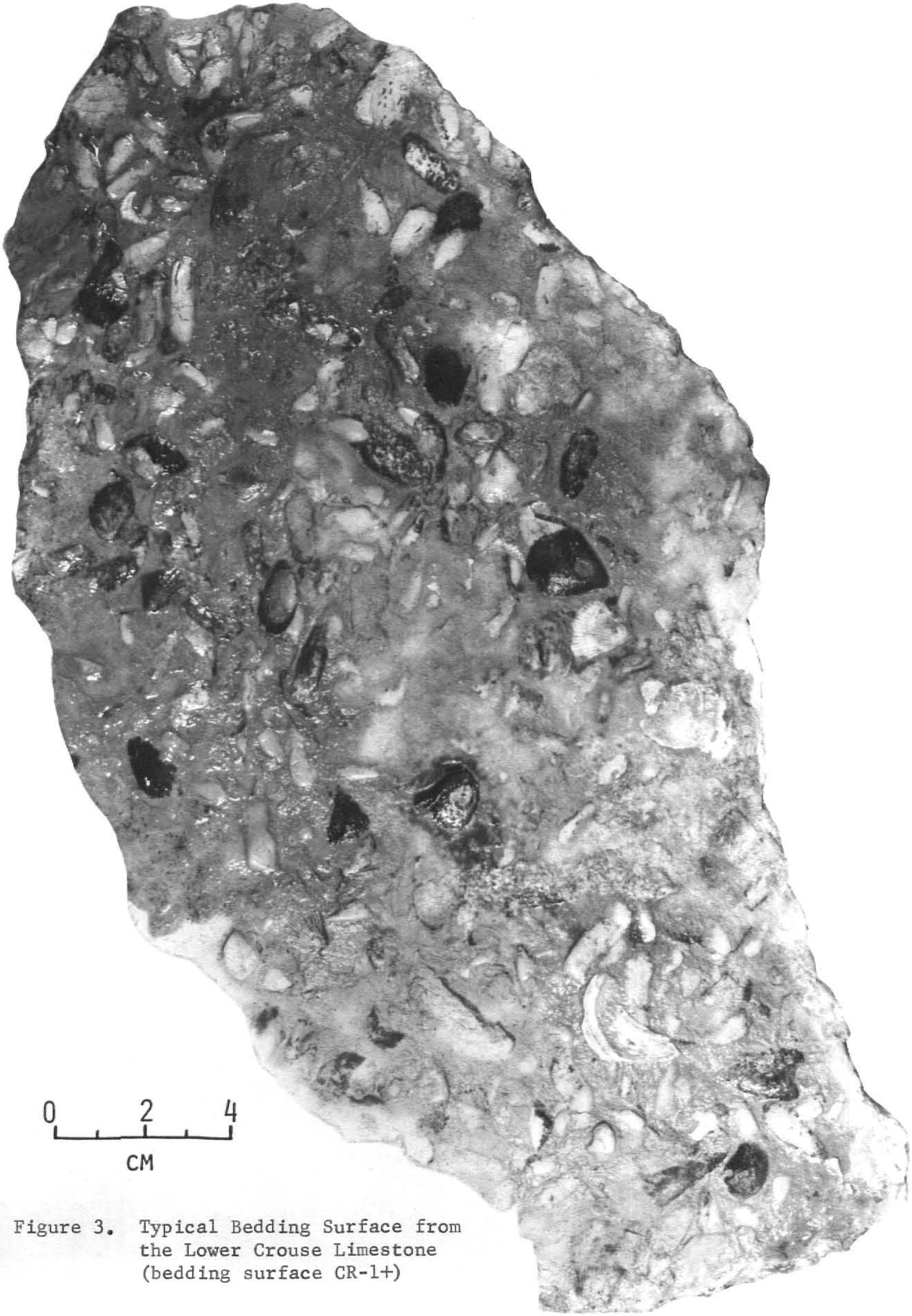

Figure 3. Typical Bedding Surface from the Lower Crouse Limestone (bedding surface CR-1+)

of other taxa were lacking on many surfaces.

Thin Section Study.--Ninety-nine thin sections were made using a Hillquist thin section machine and Petropoxy 154 cement. All thin sections were examined with a petrographic microscope, briefly described, and any noteworthy features recorded. Following the method of Folk (1962), a rock name designating both grain size and composition was assigned to each thin section (e.g. medium calcarenite: immature recrystallized gastropod biomicrite) and is listed in Appendix IV.

Ten thin sections were selected to be point counted. Four were chosen to represent the different rock types and the other six to provide data for lateral and vertical comparison. Using the method described by Chayes (1949) approximately 1400 points were counted in an area 26 mm. by 19 mm. (1" x 3/4") on each slide (Appendix V).

Insoluble Residue Analysis.--Field observations showed that the entire formation was calcareous. Therefore, it was desirable to determine the weight percent insoluble residue.

Approximately one gram of crushed and dried sample was weighed to the nearest 0.0001 gram and placed in a beaker of known weight. Three percent hydrochloric acid was added slowly, allowing effervescence to diminish before adding more acid. After the reaction had ceased more acid was added and the sample was allowed to stand for several hours with periodic stirring. After washing and centrifuging (at least three times) to remove the acid, the residues were dried at 90°C. The residues and beakers were weighed and the weight percent insoluble residue calculated (Appendix VI).

The amount of organic carbon was determined for three samples of black shale and gray mudstone from section Q. The procedure followed is a modification of one described by Yarrow (1974). A known weight (between one and two grams) of insoluble residue was placed in a beaker and covered with distilled water before 30 percent hydrogen peroxide was added. Hydrogen peroxide was added in 10 to 15 milliliter increments and the reaction allowed to diminish before adding more hydrogen peroxide. Beakers were placed in a drying oven at a temperature of 80°C to remove excess water and increase the reaction rate. When the samples were evaporated to dryness the process was repeated until no reaction occurred when hydrogen peroxide was added. The samples were then washed with distilled water until the pH was 6.5 to 7.0, oven dried, weighed, and percent weight loss calculated.

X-ray Diffraction Analysis.--Samples were crushed and dry sieved through a 230 mesh (4.0 phi) sieve. The fine fraction was retained and used for X-ray diffraction analysis. Random powder mounts of each sample were prepared and run from 0 - 62 degrees two theta. The positions and heights of the principal peaks of quartz, calcite, and dolomite were recorded (Appendix VII).

GEOLOGIC SETTING

Structure

The positions of the major structural features in the area (Nemaha Anticline, Abilene Anticline, and Irving Syncline) are in Figure 1 (Shenkel, 1959; Chelikowsky, 1972). All Crouse Limestone sections examined in this study except one (section O) are on the eastern flank of the Irving Syncline with the Nemaha Anticline to the east and the Abilene Anticline to the west. Section O is on the Abilene Anticline. Three sections examined by West, et al. (1972) are either on the Nemaha Anticline (sections H and I) or east of its axis (section L). The Irving

Syncline is asymmetrical and plunges southward along with the Abilene Anticline. Neither feature can be traced south of Abilene.

Stratigraphy

The Crouse Limestone is one of 14 formations in the Council Grove Group, Gearyan Stage, Lower Permian Series, Permian System (fig. 4). It is above the Easly Creek Shale and is overlain by the Blue Rapids Shale. Both formations contain reddish shale representing very shallow, intermittently exposed or emergent environments (Elias, 1937; Russell, 1977). A six- to seven-foot thick bed of gypsum occurs in the Easly Creek Shale near section O.

The Crouse Limestone in Kansas can be divided into three distinct units: an upper and lower limestone separated by a middle shale (Zeller, 1968, p. 47).

The lower limestone is "slabby" at the base to massive near the top. In northern and central Kansas molluscs dominate the fossil assemblage (West and McMahon, 1972), but in southern Kansas the alga Ottonosia is a conspicuous component (Bayne, 1962).

The middle shale in northern Kansas is really an argillaceous limestone because it contains more than fifty percent carbonate (Huber, 1965). In northern Kansas the fossil assemblage consists of ostracodes and foraminifers, but in central Kansas brachiopods, ectoprocts, and echinoderms occur (Mudge and Burton, 1959; O'Conner, 1953). In the southern part of the state the middle "shale" is a dense, locally cherty limestone (Bayne, 1962, p. 46).

The upper limestone is platy across the state. Algae and molluscs are in this unit in central Kansas (O'Conner, 1953). Previous workers in northern Kansas (Huber, 1965; West, et al., 1972) have reported

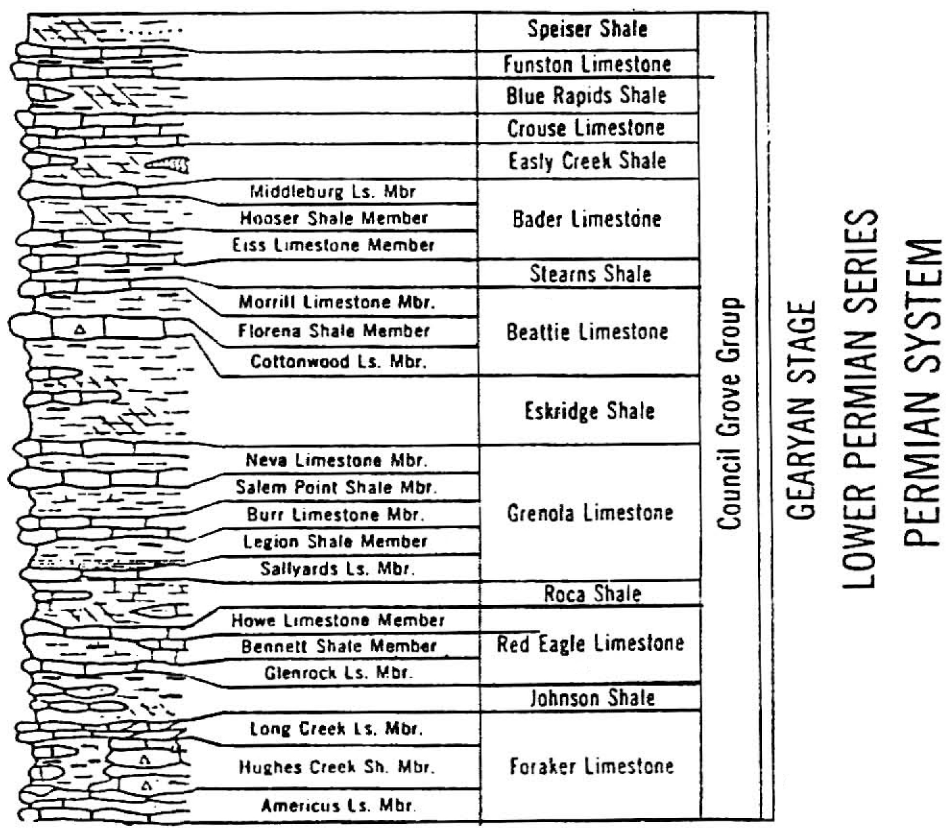

Figure 4. Stratigraphic Section of the Council Grove Group

ostracodes, foraminifers, algae, and bivalves from the upper limestone.

In north central Kansas the Crouse Limestone averages 3.58 meters (11.8 feet) thick. It ranges from 2.22 meters (7.3 feet) at section N to 4.47 meters (14.7 feet) at sections S and T and, in general, thickens southward. The lower limestone averages 0.77 meters (2.5 feet) thick and ranges from 0.23 meters (0.8 feet) at section X to 1.21 meters (4.0 feet) at section S. The middle shale averages 0.92 meters (3.1 feet) thick. It is absent at sections H and I (West, et al., 1972), but ranges up to 1.71 meters (5.6 feet) at section S. The upper limestone averages 1.77 meters (5.8 feet) thick and ranges from 0.52 meters (1.7 feet) at section O to 2.37 meters (7.8 feet) at section C.

BIOTIC DATA

General Statement

Palaeoecologists are constantly concerned with fossil assemblages which may not accurately reflect life assemblages. In addition to the effects of transportation there is the problem of preservability. According to Johnson (1964) less than one organism in three that inhabits the benthic marine environment is preservable. Therefore, a fossil assemblage usually represents no more than one-third of the life assemblage. Often the information is even less representative because of post-mortem effects of physical and biological agents not to mention collecting biases.

The accuracy with which fossil assemblages reflect life assemblages has been discussed considerably. Most investigators agree that fossil assemblages are truly representative of the preservable parts of life assemblages. However, in terms of trophic structure fossil assemblages are not necessarily representative of life assemblages (Stanton, 1976) and meaningful biological interpretation of relative abundance data cannot be made (Johnson, 1965). Consequently, fossil assemblages can be used only for palaeoenvironmental interpretations and, in fact, Warme, et al. (1976) found death assemblages more useful than life assemblages because of the removal of "noise." Care must be taken, however, that such interpretations are not based on the trophic structure of fossil assemblages or relative abundance data, but rather on information such as distribution, sediment relationships, and interspecific associations (Johnson, 1965; Stanton, 1976). In this study distribution and environmental tolerances are emphasized.

The mode of formation of fossil assemblages can be evaluated with criteria proposed by Johnson (1960). These criteria were applied to the bedding surface assemblages of the lower Crouse Limestone. The following evidence indicates similarity of the assemblages to Johnson's Model II: (1) ecologically coherent assemblage, (2) variation in sizes of fossils (from ostracodes less than 1 mm. long to bivalves more than 30 mm. long), (3) varying densities of fossils, (4) moderate proportion of fragmented fossils (average of 20.3 percent for all bedding surfaces), (5) orientation of the long axes of most fossils parallel to bedding, (6) nearly equal proportions of right and left valves (average of 49.3 percent right valves for all bedding surfaces), (7) algal coated shells (average of 8.8 percent for all bedding surfaces), and (8) sedimentary rocks consistent with tolerances of organisms and quiet water (carbonate mudstone). The low proportion of articulated fossils (average of 1.1 percent for all bedding surfaces) and hydrodynamically stable orientation of most specimens (average of 86.5 percent concave down for all bedding surfaces) favor Johnson's Model III. This evidence implies that some post-mortem movement of shells probably took place, but transportation was not a major factor in the formation of the assemblages. Most organisms probably lived very close to the spot where they were buried.

According to Johnson (1960), fossils in either Model II or Model III assemblages may show a preferred orientation in response to a prevailing current direction. Nagle (1967) demonstrated that shells may be oriented either by currents or by waves and he distinguished between the two types of orientation patterns. Pearson (1972) studied shell orientation on some lower Crouse bedding surfaces and concluded that wave action was the dominant factor responsible for the observed orientation.

Washed Residue Examination

Although no quantitative data were obtained from the washed residues, they were examined and microfossils identified. The following were identified in samples from mudstone intervals in the lower limestone: hollinid, bairdiid, and healdiacean ostracodes, pyramidellid snails, holothurian sclerites, and *Earlandia*-like foraminifers.

Fossils in samples from the middle shale include hollinid, bairdiid, and healdiacean ostracodes and the foraminifers *Ammodiscus*? sp. and ammovertellids. Holothurian sclerites were also observed and a single productacean brachiopod spine was found at section Y. In addition, West, *et al.* (1972, p. 86) reported the ostracode *Geisina* sp. and the foraminifers *Bathysiphon* sp., *Globivalvulina* sp., and *Eggerella*-like foraminifers from the middle shale. Huber (1965, p. 34) reported *Tetrataxis* sp. from the same interval.

No washed residues from the upper limestone were examined.

Bedding Surface Study

According to Dennison and Hay (1967), in order to be 95 percent certain of detecting a species of a particular size that occupies two percent or more of the sea floor, an area 160 times as large as the area of that species must be examined. This rule was followed as closely as possible while mapping Crouse Limestone bedding surfaces. The area of the largest individual on the surface was multiplied by 160 and an area approximately that large was mapped. The size of some slabs prevented strict adherence to this rule. Mapped areas ranged from 100 to 565.5 square centimeters. Data obtained from mapped bedding surfaces were used to calculate diversity and equitability and to analyze size distributions of _Permophorus_ cf. _P. subcuneatus_. Unidentifiable specimens and fragments that were less than half of the original specimen were not included in density (number of individual) tabulations. For bivalved taxa the number of individuals was considered to be the same as the greater number of valves. For example, if there were ten right valves and six left valves, the number of individuals would be ten. Some specimens were broken or partly covered and could not be identified with respect to right or left valve. Some or all unidentifiable valves were assumed to match unmatched right or left valves. If there were more unidentifiable valves than unmatched right or left valves, the remaining unidentifiable valves were assumed to be 50 percent right valves and 50 percent left valves. Therefore, the number of remaining unidentifiable valves was divided by two and the quotient added to the number of matched pairs to obtain the total (minimum) number of individuals.

Diversity

Diversity is often considered to be the number of species in a given area. In this study, however, diversity refers to the Brillouin diversity index as modified by Lloyd, _et al_.(1968) and is expressed as:

$$H = \frac{c}{N}(\log_{10}N! - \Sigma \log_{10}n_i!)$$

where H is diversity, N is the total number of individuals with n_i individuals in the ith species, and c is a scale factor for conversion of logarithm bases (for this study c = 3.322). Another commonly used measurement of diversity is the Shannon diversity index. It was not used in this study because the samples are not truly random. Every fossil in the population did not have an equal chance of being included in the sample because some have been eroded and others are not exposed (*i.e.* collecting biases). The diversity that was measured is really the diversity that exists on a very local scale and is in Table 1.

Equitability

Equitability is a measurement of species evenness. The distribution of species is compared to MacArthur's (1957) theoretical distribution which is about as equitable as can be expected in nature. The equitability measurement used (Lloyd and Ghelardi, 1964) is:

$$E = \frac{s'}{s}$$

where E is equitability, s is the number of species observed, and s' is the number of "equitably distributed" species needed to achieve the given diversity according to MacArthur's model. Equitability values are in Table 1.

Size Analysis of *Permophorus*

Length of *Permophorus* cf. *P. subcuneatus* was measured on bedding surfaces from the lower limestone (Table 2). A more harsh environment in which the organism expended more energy to survive and less to grow is one possible cause of smaller size. To determine whether there was any lateral or vertical change in the size of *P.* cf. *P. subcuneatus*, t-tests were used. All possible lateral comparisons between stratigraphically equivalent surfaces were made along with vertical comparisons between surfaces from the same outcrop (Table 3). Lateral comparisons reveal no pattern,

Table 1

Diversity and Equitability
of Bedding Surface Assemblages in the Lower Crouse Limestone

Bedding Surface Number	Diversity	Equitability
CQ-2	2.070	0.857
CQ-3	1.746	0.833
CQ-4	0.843	0.500
CQ-5	0.614	0.500
CR-1	1.461	0.667
CR-1+	1.628	0.571
CT-1	1.481	0.571
*CU-13	0.790	0.333
CW-1	1.124	0.750
*CX-1	1.744	0.714
J-1-1	1.474	0.499

* combines areas #1 and #2 at these horizons; see Appendix III.

Table 2

Length of <u>Permophorus</u> cf. <u>P. subcuneatus</u>
on Lower Limestone Bedding Surfaces

Surface	Number of Individuals	Mean (mm.)	Standard Deviation
CQ-2	45	12.91	4.47
CQ-3	74	10.32	3.32
CQ-4	27	10.44	2.83
CQ-5	18	7.89	1.68
CR-1	150	10.74	4.98
CR-1+	150	11.26	3.54
CT-1	287	11.33	3.30
*CU-13	126	8.72	2.74
CW-1	10	11.60	4.62
*CX-1	79	10.77	4.09
J-1-1	119	10.05	3.36

* combines areas #1 and #2 at these horizons; see Appendix III.

Table 3

Statistical Comparison of Permophorus cf. P. subcuneatus (valve length) between Bedding Surfaces in the Lower Crouse Limestone

Surfaces Compared		t-test	Significant	F-test	Significant
lateral comparisons					
CW-1	CX-1	0.542		1.27	
*#CQ-2	CT-1	2.278	X	1.83	X
*CQ-2	CR-1	2.781	X	1.24	
CT-1	#CR-1	1.306		2.27	X
#CU-13	CQ-5	1.786		2.67	X
#CR-1	J-1-1	1.353		2.19	X
*#CQ-2	J-1-1	3.899	X	1.76	X
*CT-1	J-1-1	3.510	X	1.04	
**vertical comparisons					
*#CQ-2	CQ-3	3.366	X	1.56	X
CQ-3	CQ-4	0.180		1.78	
*#CQ-4	CQ-5	3.789	X	2.19	X
#CR-1	CR-1+	1.040		1.98	X

* sample with larger sized individuals

sample with larger variance

** Surface listed on the left is lower stratigraphically.

Critical t and F values are dependent on sample size. All tests for significance were made at the 0.05 alpha level.

but vertical comparisons indicate an upward decrease in size through the lower limestone. Field observations suggested that this trend exists throughout the area.

F-tests were performed to determine whether the variance of Permophorus cf. P. subcuneatus length changed either laterally or vertically (Table 3). Some lateral comparisons between stratigraphically equivalent surfaces show significant differences, but no definite trend. Vertical comparisons, however, show a decrease of the variance upward through the lower limestone.

Autecology

General Statement.--Autecology is the study of single species, their interaction with and adaptation to their environment (Odum, 1971, p. 6). The purpose of this investigation was not to explore these relationships in detail. Nevertheless, a brief examination of the autecology of the different taxa aids in the interpretation of the fossil assemblages.

Whittaker (1975) listed five trophic levels that make up the links to most food chains: (1) producer, (2) herbivore, (3) first carnivore, (4) second carnivore, and (5) third carnivore. Most food chains are considerably more complex because some organisms occupy several trophic levels. Because energy is lost at each step to a higher trophic level, productivity of each level is much less than that of the level below it. The number of individuals also decreases upward through most food chains (Whittaker, 1975, p. 215).

In the benthic marine environment the relationship of an animal to the substrate (mode of life) is an important part of its autecology. The mode of life categories used here were defined by West (1977) and include (1) epifaunal, animals living on the substrate, (2) epifloral, plants living on the substrate, (3) infaunal, animals living in the substrate, (4) semi-infaunal, animals living with one half or more of their length buried in the substrate, (5) quasi-infaunal, simulating an infaunal habit like some productacean brachiopods, and (6) nektic, swimming.

Among the first workers to recognize the importance of benthic marine detritus eaters was Turpaeva (1957). Her pioneering methods of trophic analysis have been applied, with modifications, to ancient communities by several workers (e.g. Walker, 1972; Rhoads, et al., 1972; and Toomey, 1976).

Walker and Bambach (1974) summarized previous work on feeding in benthic invertebrates and proposed a classification of feeding types. They emphasized (1) the type of food resource, (2) the location of the food resource, (3) the organism's food acquisition mechanisms, and (4) resource selection by the organism. Table 4 lists feeding groups defined by Walker and Bambach that are applicable to this study.

The trophic level, mode of life, and feeding behavior of all organisms encountered on bedding surfaces, in washed residues, and/or in thin section are in Table 5.

Algae.--Phylloid algae and encrusting algae were found in the lower limestone. Recrystallization of the phylloid algae prevented more specific identification. *Osagia* encrusted many fossils, especially bivalves and phylloid algae. *Osagia* consists of encrusting algae intergrown with sedentary tubiform foraminifers, especially *Hedraites* (Henbest, 1963). Blue-green algae are represented by laminar stromatolites in the upper limestone. All algae are epifloral and, of course, primary producers.

Foraminifera.--The encrusting sedentary tubiform foraminifers could have been either high- or low-level suspension feeders depending on their place of attachment. Toomey (1976, p. 11) considered them high-level suspension feeders because he found them attached to phylloid algae which

Table 4

Definition of Feeding Groups
(from Walker and Bambach, 1974)

Feeding Group	Definition
Low-level suspension feeders	Remove food from suspension in the water mass less than 3 mm. above the bottom
High-level suspension feeders	Remove food from suspension in the water mass more than 3 mm. above the bottom
Deposit feeders	Remove food from the sediment either selectively or non-selectively
Browsers	Scrape plant material from environmental surfaces or chew or rasp larger plants
Carnivores	Capture live prey

were in growth position. In the Crouse Limestone these foraminifers commonly encrust bivalve shells, but only after death of the bivalves. Many bivalve shells are encrusted on both the inside and outside. Furthermore, Permophorus cf. P. subcuneatus shells are either encrusted almost entirely or are free of attached epizoans. If they had been encrusted while living, only the part of the shell protruding above the sediment-water interface would have been encrusted. Instead, P. cf. P. subcuneatus and other bivalves are completely encrusted which supports coating as a post-mortem event. Therefore, these foraminifers were attached to the substrate and are considered low level suspension feeders.

Free-living foraminifers are considered epifaunal suspension feeders and primary consumers (West, 1970; Toomey, 1976).

Ectoprocta.--A single ramose ectoproct colony was observed in thin section (sample CQ-4). Ectoproct colonies were epifaunally attached and

Table 5

Autecology of Fossils

Trophic Level	Mode of Life	Feeding Type
PR-Producer	Ep-Epifloral	A-Autotroph
P-Primary Consumer	Ea-Epifaunal	LS-Low-level suspension
S-Secondary Consumer	I-Infaunal	HS-High-level suspension
T-Tertiary Consumer	S-Semi-infaunal	D-Deposit feeder
	Q-Quasi-infaunal	B-Browser
	N-Nektic	C-Carnivore

TAXON	TROPHIC LEVEL	MODE OF LIFE	FEEDING TYPE
Algae			
Phylloid Algae	PR	Ep	A
Osagia	PR	Ep	A
Blue-green Stromatolitic Algae	PR	Ep	A
Protozoa			
Foraminifera			
Tubiform encrusting forms	P	Ea	LS
Free-living mobile forms	P	Ea	HS/LS
Ectoprocta			
Ramose type	P	Ea	HS
Brachiopoda			
Inarticulata			
Lingulid	P	I	LS
Articulata			
Productacean	P	Q	LS
Mollusca			
Bivalvia			
Permophorus cf. P. subcuneatus	P	S	HS
Aviculopecten sp.	P	Ea	HS
Acanthopecten sp.	P	Ea	HS
Septimyalina sp.	P	Ea	HS
Pseudomonotis sp.	P	Ea	LS
Edmondia? sp.	P	I	LS
Gastropoda			
Bellerophon sp.	P	Ea	B/D
Pyramidellids	P	Ea	B/D
Annelida			
Polychaetia			
Spirorbis sp.	P	Ea	HS

Table 5 cont.

TAXON	TROPHIC LEVEL	MODE OF LIFE	FEEDING TYPE
Arthropoda			
Cirripedia			
Acrothoracicans	P	I	LS
Ostracodes	P	Ea/I/N	B/D
Echinodermata			
Crinoid debris	P	Ea	HS
Echinoid debris	S	Ea	C
Holothurian debris	P	I/Ea	B/D
Vertebrata			
Fish debris	S/T	N	C

could not pursue food except to create water movements. Turpaeva (1957) classified ectoprocts as "awaiters," but because they use the same food resources as high level suspension feeders, subsequent workers have included them in that group. The trophic level of ectoprocts is primary consumer.

Brachiopoda.--Brachiopods are represented by two fragmented specimens and are included only for completeness and do not represent a significant part of the assemblage. One is a lingulid from the lower limestone at section Q and the other is a productacean spine from the middle shale at section Y. Recent lingulids are infaunal suspension feeders. Their ancient counterparts are usually considered to have had the same mode of life and feeding type (Walker, 1972; Yarrow, 1974). Productaceans had a quasi-infaunal mode of life with supporting spines allowing them to live in soft substrates. This mode of life afforded them protection with only the commissure protruding above the substrate for food gathering (Rudwick, 1970).

According to Rudwick (1965) brachiopods feed chiefly on diatoms and dinoflagellates. McCammon (1969) has suggested that dissolved or colloidal organic nutrients may be an important food source for articulate brachiopods. Possibly brachiopods utilized both food sources. They are here considered primary consumers.

Bivalvia.--Bivalves are the most diverse group in the Crouse Limestone. They include infaunal, semi-infaunal, and epifaunal forms and both high- and low-level suspension feeders.

Aviculopectinids in the Crouse Limestone (*Aviculopecten* sp. and *Acanthopecten* sp.) possess an elongate anterior auricle and a byssal sinus. These features are indicative of an epifaunal, byssally attached mode of life (Stanley, 1970, p. 32). Some living byssate pectinaceans are able to release the byssus and swim, but they are not especially proficient swimmers (Stanley, 1972, p. 193).

Permophorus cf. *P. subcuneatus* had a semi-infaunal mode of life (Voran, 1977; Stanley, 1972, p. 195). Because it protruded some distance above the bottom, it was probably a high level suspension feeder.

Pseudomonotis sp. is unique among Paleozoic bivalves because of its epifaunal cemented mode of life (Nicol, 1944; Mudge and Yochelson, 1962). Newell (1960) and Newell and Boyd (1970) suggested that *Pseudomonotis* sp. may have given rise to the oysters. Because of its cemented mode of life, *Pseudomonotis* sp. is considered a low-level suspension feeder.

Septimyalina sp. is an epifaunal, byssally attached high-level suspension feeder and *Edmondia*? sp. is an infaunal low-level suspension feeder (Pearce, 1973, p. 21). The trophic level of bivalves is primary consumer (Scott, 1973).

Gastropoda.--Gastropods were considered deposit feeders and/or browsers by West (1970, p. 83) and Toomey (1976, p. 7). Gastropods in the Crouse

Limestone may have obtained food by grazing on algae (primary consumers). West (1970, p. 100-101) inferred that gastropods are epifaunal, however, there are infaunal gastropods.

Polychaetia.--The polychaetes are represented by the genus Spirorbis which has been classified as a suspension feeder (Toomey, 1976). Like encrusting foraminifers, Spirorbis sp. may be either a high- or low-level suspension feeder depending on its place of attachment. High organic carbon content of the rocks in which Spirorbis sp. occurs indicates a reducing environment of deposition. Such a reducing, anaerobic environment would not be favorable for habitation of the bottom. Plant debris is also in these units and although there is no direct evidence, it is inferred that Spirorbis sp. was epiphytic and should be considered a high-level suspension feeder. Spirorbis sp. is a primary consumer (Scott, 1973).

Arthropoda.--Ostracodes are the most common arthropods in the Grouse Limestone. Their modes of life may be epifaunal, infaunal, or nektic and they are considered deposit feeders and/or browsers (West, 1970, p. 101; Toomey, 1976, p. 7). Ostracodes are primary consumers.

Acrothoracican barnacle borings were observed in bivalve shells on several bedding surfaces of the lower limestone (fig. 5). Because they live in borings, acrothoracicans are considered infaunal. They feed by sweeping food, mainly plankton and organic detritus, from the water in the mantle cavity, in the boring, and near the boring (Tomlinson, 1969). Therefore, they are low-level suspension feeders and their trophic level is primary consumer.

Echinodermata.--Echinoderms are represented by crinoid, echinoid, and holothurian debris. Crinoids are epifaunal, high-level suspension feeders (Scott, 1973, p. 46) and their trophic level is primary consumer. Echinoids are considered epifaunal carnivores (West, 1970, p. 84) and are secondary

Figure 5. Acrothoracican Barnacle Borings in a large Osagia-coated Bivalve in the Lower Crouse Limestone (bedding surface CR-1+).

consumers. Holothurian remains included a few sclerites found in washed residues. Holothurians are either infaunal or epifaunal deposit feeders and/or browsers (West, 1970) and their trophic level is primary consumer.

Vertebrata.--Fish bones, teeth, and scales were found at section Q. Fish are nektic and tooth morphology indicates that they were carnivores, either secondary or tertiary consumers.

Trace fossils.--Burrows and/or trails were observed on several bedding surfaces of the lower limestone and on both vertical and horizontal surfaces in the upper limestone (fig. 6A-C). Vertical surfaces of samples from the middle shale and upper limestone displayed disrupted laminations, mottling, and a reworked, homogenized lithology (fig. 7A-C). These features are indicative of bioturbation (Hardie and Ginsburg, 1977; Gebelein, 1971). Worm tubes were identified in the lower limestone by West, et al. (1972)

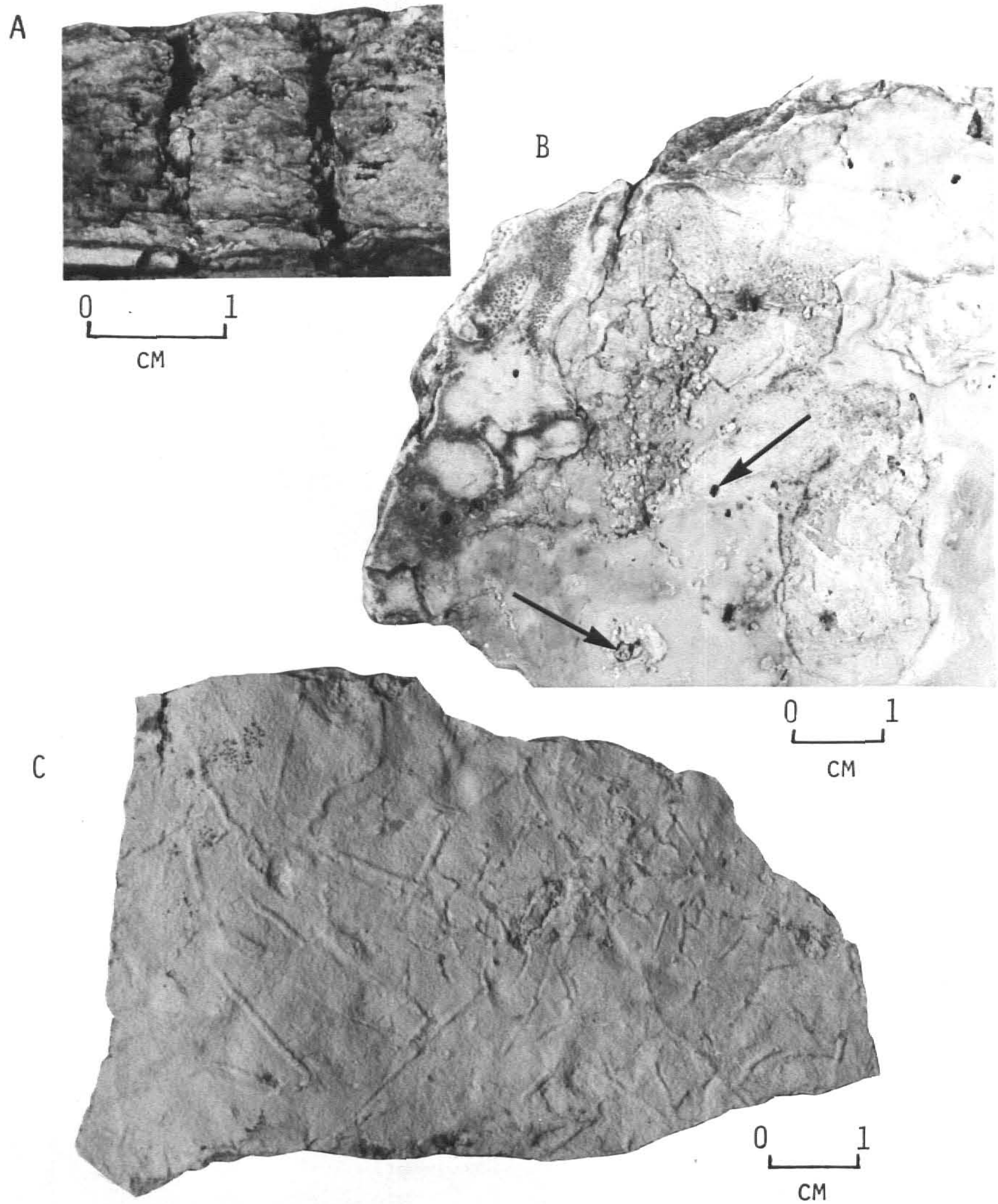

Figure 6. Burrows and Trails in the Upper Crouse Limestone. A. Vertical Burrows, Lateral View, Top is Up (sample CU-8). B. Same as 6A, Top View. C. Trails on Bedding Surface (sample CS-17).

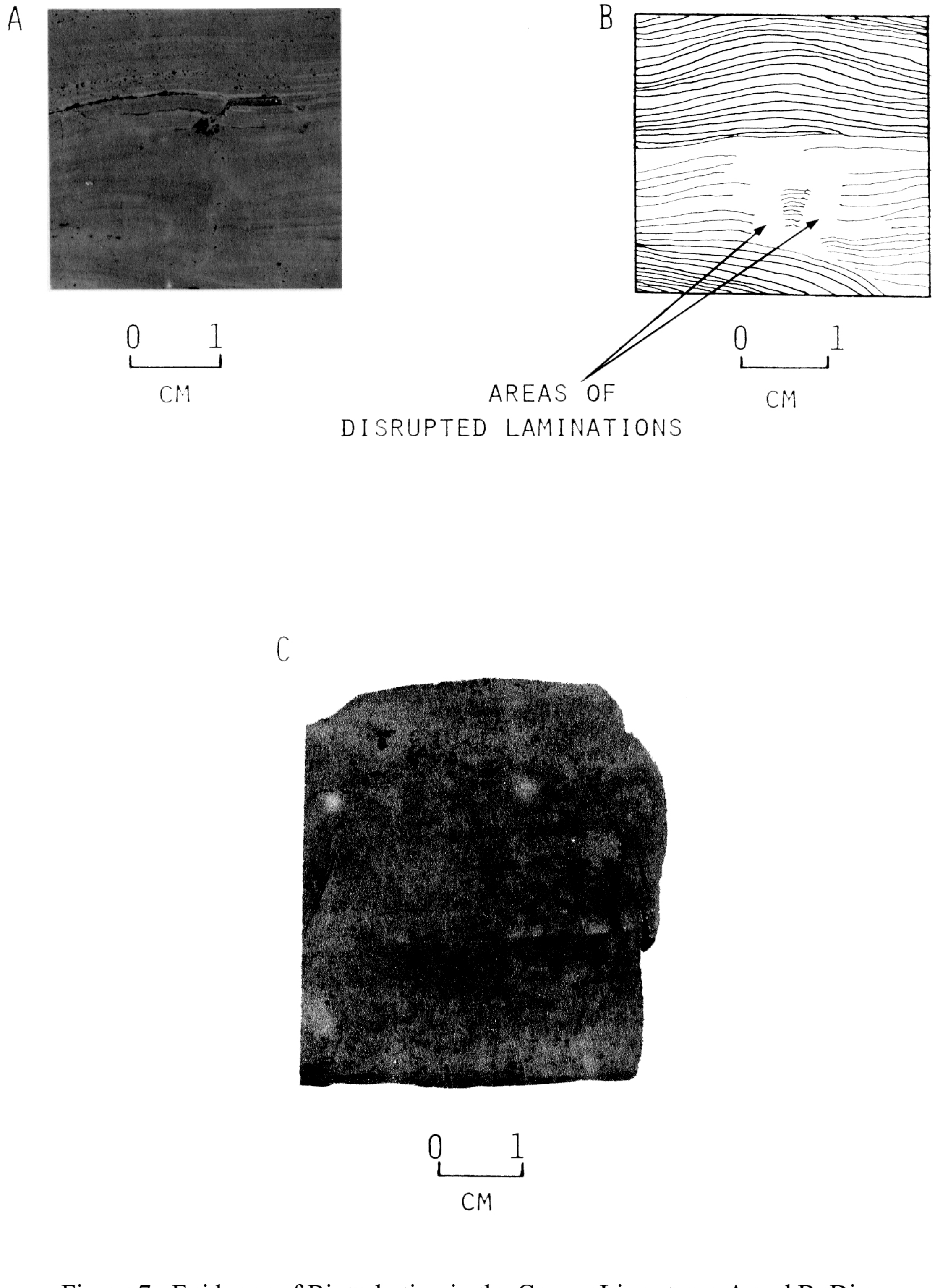

Figure 7. Evidence of Bioturbation in the Crouse Limestone. A and B. Disrupted Laminations, Top is Up (upper limestone, sample (CW-14). C. Mottled Lithology (upper limestone, sample CY-8).

and may represent the organisms responsible for at least part of the bioturbation. Trails (fig. 6C) could have been made by gastropods. Direct evidence of the organisms associated with the trace fossils is lacking.

PETROLOGIC DATA

General Statement

Insoluble residue, X-ray diffraction, and thin section analyses were made to assist in determining the depositional environment of the Crouse Limestone.

Insoluble Residue Analysis

Insoluble residue analysis provided an estimate of the amount of terrigenous detritus. Insoluble residues may be introduced in three ways: (1) as original constituents, (2) diagenetically, by metasomatic fluids, or (3) as a result of weathering. Samples from fresh surfaces were used to minimize the effect of weathering. Iron oxide replacing gastropods was observed in some lower limestone samples, but made up only a small part of the rocks. Therefore, it was assumed that the amount of insoluble residue approximates the amount that was deposited as an original constituent.

The average percents of insoluble residue for the three units are in Table 6 along with the values obtained by Huber (1965) and Twiss and Lee (1972). Agreement is close and the small differences probably result from the use of different outcrops in each study.

These data indicate that the middle shale is a shale only in its weathering characteristics. Most samples from this unit contained between 25 and 40 percent insoluble residue. As Huber (1965, p. 33) pointed out, this unit is really a limestone.

Huber (1965, p. 6) noted that the middle shale grades into the upper

Table 6

Insoluble Residue Percentages
for Crouse Limestone Units

Unit	This Study	Huber (1965)	Twiss and Lee (1972)
Upper Limestone	14.3	12.8	15.1
Middle Shale	29.6	27.5	33.2
Lower Limestone	9.8	6.2	8.1

limestone. Field observations, especially at the less weathered outcrops, confirmed Huber's observations. Examination of the core (fig. 1) also emphasized the arbitrary placement of this boundary. Figure 8 shows the vertical changes in percent of insoluble residue at section Q. There is a sharp increase from the lower limestone to the middle shale and a gradual decrease from the middle shale to the upper limestone. This pattern is typical of the Crouse Limestone at most localities and further confirms the gradational boundary between the middle shale and the upper limestone.

The insoluble residues were not examined to determine their mineralogic composition. However, Huber (1965) examined the silt and coarse fractions from section A. He determined that the major minerals were quartz, chert, and limonite with lesser amounts of chalcedony, orthoclase, volcanic glass, gypsum, hematite, muscovite, and microcline. Twiss and Lee (1972) analyzed samples from sections A, H, and L for clay minerals and found illite, chlorite, and interlayered chlorite and vermiculite.

X-ray Diffraction Analysis

All samples from sections Q, S, and Y and selected samples from all

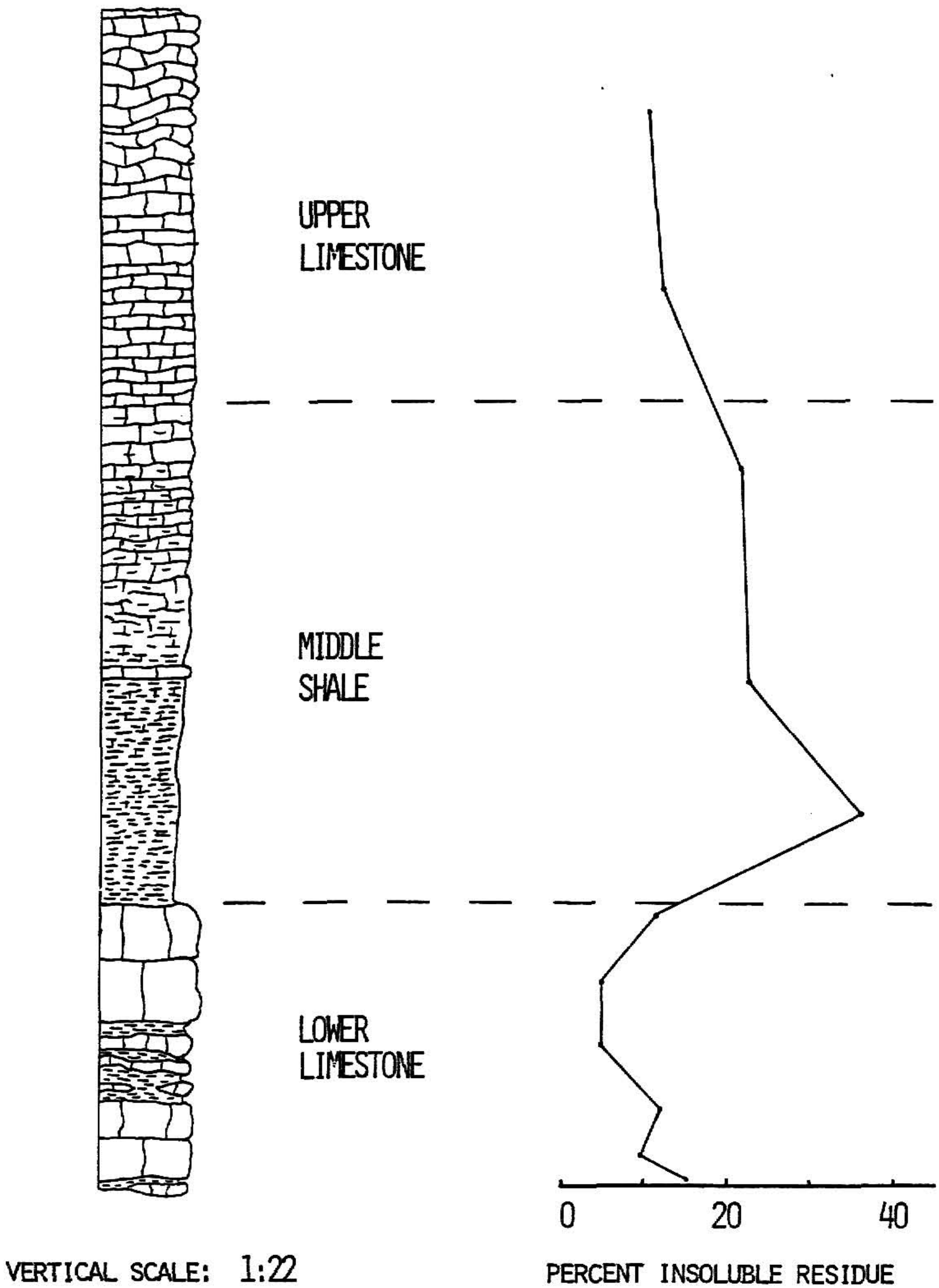

Figure 8. Insoluble Residue Percentages at Section Q

other sections were analyzed by random powder X-ray diffraction. The results indicated three major minerals: quartz, calcite, and dolomite. Calcite/quartz ratios and calcite/dolomite ratios were calculated using X-ray diffraction data (Appendix VII). This was done by comparing the peak heights of the principal peak for each mineral. This method is semi-quantitative at best, yet it provides an approximation of the relative abundances of these minerals.

Abundance of quartz can be roughly correlated with percent insoluble residue. Quartz content is low in the lower limestone, increases sharply in the middle shale, and decreases gradually through the upper limestone.

Dolomite had not previously been found in the Crouse Limestone and its occurrence may be described as erratic. Greatest amounts of dolomite are usually in the upper part of the middle shale. Dolomite occurs in both the middle shale and the upper limestone at sections Q, S, W, and Y. At sections O and E dolomite is only in the middle shale. Section T has dolomite in the upper limestone. No dolomite was found at sections R, U, V, and X.

Changes in dolomite composition may shift the position of the principal (2.88 Å) dolomite peak. The most common variations in composition are the substitution of iron or calcium for magnesium in the dolomite structure. According to Müller (1967, p. 182), if large quantities of iron are present, copper radiation causes iron flourescence during X-ray diffraction. As a result the counts per second of the base line of the X-ray diffraction patterns increase. Thus, ferroan dolomite would cause an increase in the counts per second of the base line and greater amounts of ferroan dolomite would cause a greater increase in the counts per second of the base line. Calcium-enriched dolomite would not affect the base line. Scott (1973) compared the counts per second of the principal dolomite peak with the counts per second of the base line and was able to show that ferroan dolomite was present in the Pennsylvanian Reading Limestone. This method was applied to the Crouse Limestone (fig. 7), but there appears to be no direct relationship between dolomite counts per second and base line counts per second. Therefore, it is assumed that there is no ferroan dolomite in the Crouse Limestone.

Absence of ferroan dolomite implies that any shift in the dolomite peak was due to calcium substitution in the dolomite structure. The mole percent calcium in dolomite can be determined from X-ray diffraction data. As calcium content increases, there is a linear increase in the d-spacing and a resultant shift in the position of the principal dolomite peak (Blatt, et al., 1972, p. 478). Mole percent calcium in dolomite from the Crouse Limestone averages 55.53 mole percent and ranges from 52.10 to 57.05 mole percent (Appendix VII).

Mole percent $MgCO_3$ in skeletal grains is related to three factors: mineralogy, taxonomy, and temperature (Bathurst, 1975, p. 235). Most calcite has either 0 - 5 mole percent $MgCO_3$ (low magnesian calcite) or 10 - 19 mole percent $MgCO_3$ (high magnesian calcite). High magnesian calcite is common in recent sediments, but has recrystallized to low magnesian calcite in most ancient limestones (Bathurst, 1975). $MgCO_3$ content of calcite can be determined from X-ray diffraction data. As $MgCO_3$ content increases there is a linear decrease in the d-spacing. This results in a shift in the position of the principal (3.03 Å) calcite diffraction peak (Goldsmith, et al., 1955). This relationship was used to determine the mole percent $MgCO_3$ in calcite in samples from the Crouse Limestone (Appendix VII). Values ranged from 0.4 to 2.8 mole percent $MgCO_3$--well within the range of low magnesian calcite. This may not have been true of the original sediment. Some skeletal fragments, especially some foraminifers, ostracodes, and

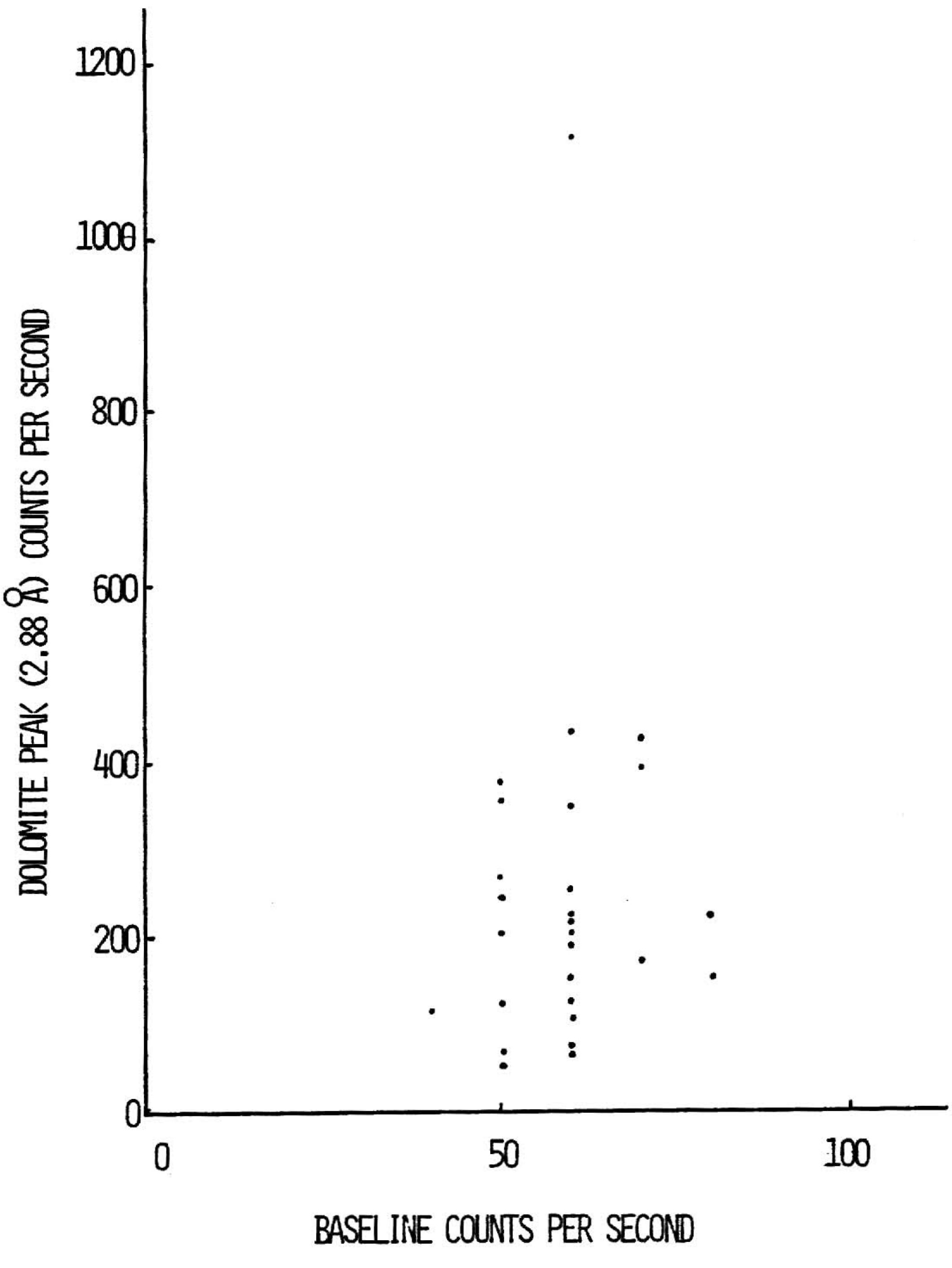

Figure 9. Diffractogram Baseline Counts Per Second Versus Dolomite CPS

calcareous algae are composed of high magnesian calcite. These taxa make up as much as 27.1 percent (sample CS-1, Appendix V) of the rock in the Crouse Limestone. Because of its relative instability, any high magnesian calcite in the Crouse was probably converted to low magnesian calcite during diagenesis.

Thin Section Examination

A rock name was assigned to each thin section based on Folk's (1962) classification of limestones. Four major rock types were recognized: (1) recrystallized bivalve biomicrite, (2) recrystallized gastropod biomicrite, (3) recrystallized micrite, and (4) recrystallized laminated micrite. The lower limestone is a recrystallized biomicrite and belongs to Folk's Type II rocks (microcrystalline allochemical rocks). Most rocks from the middle shale and upper limestone are recrystallized fossiliferous micrites and belong to Folk's Type III rocks (microcrystalline rocks). Rhomb-shaped structures of dolomite and calcite along with rhombohedral pores indicate that many of these rocks were dolomitized and/or dedolomitized. Virtually all slides showed evidence of recrystallization of skeletal fragments and microspar and spar are commonly distributed patchily through the matrix (fig.10). Percentages of orthochemical, allochemical, and terrigenous constituents were determined for the ten thin sections that were point counted (Table 7). Orthochemical constituents are divided into micrite (1 - 4 microns), microspar (4 - 10 microns), and spar (greater than 10 microns) according to Folk (1962). The lower limestone contains more allochems, more spar, and less micrite than the upper limestone. Percentages of microspar are nearly identical. The greater amount of spar in the lower limestone probably represents void fillings between allochems. Absence of voids in the upper limestone may be due to the absence of allochems.

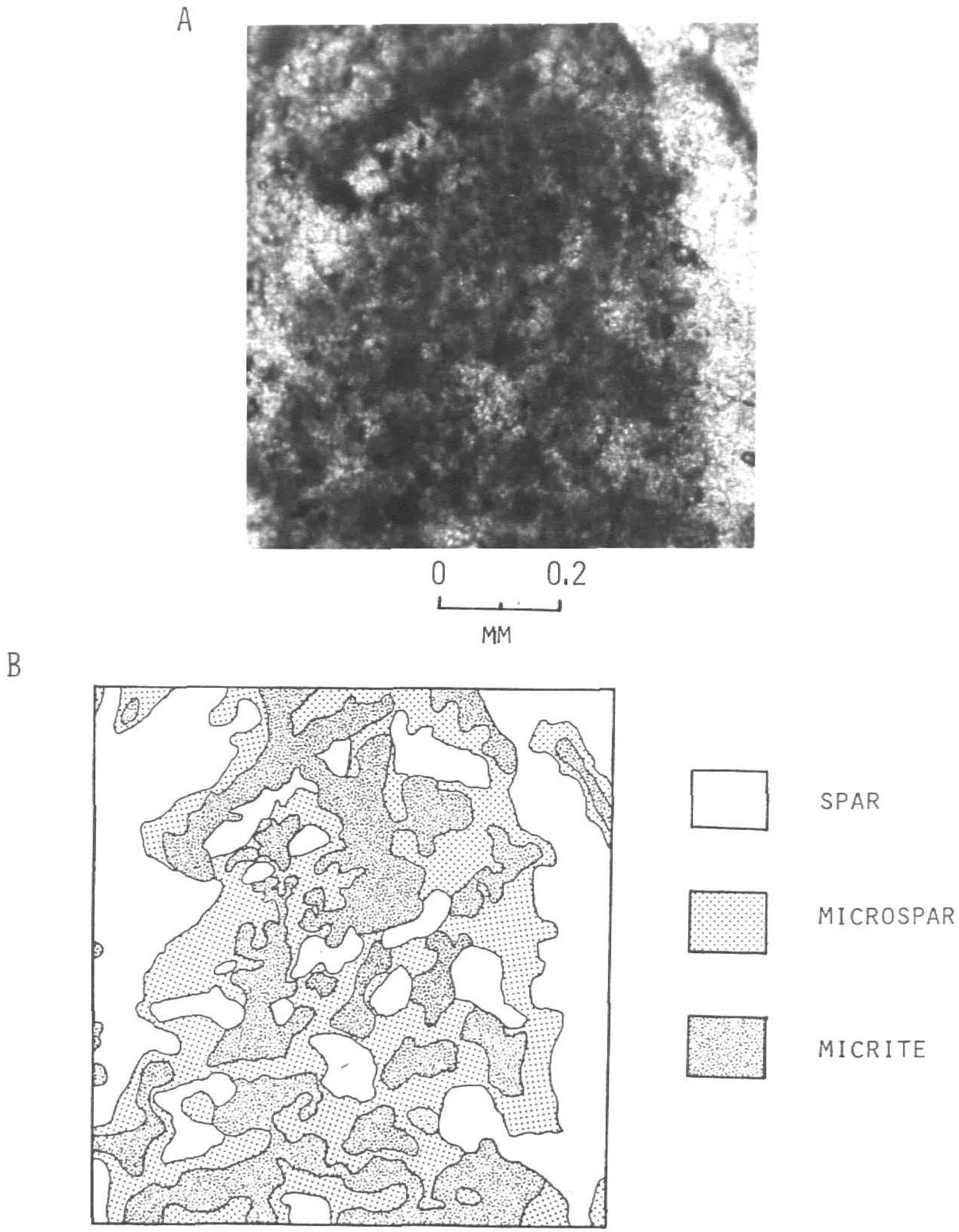

Figure 10. A and B. Patchy Distribution of Microspar and Spar in the Micrite Matrix of the Lower Limestone. Areas of Spar on the Left and Right are Recrystallized Skeletal Fragments (sample CR-2). Top is up.

Table 7

Percentages of Orthochemical, Allochemical, and Terrigenous Constituents in Thin Sections from the Crouse Limestone

Sample	Orthochemical Constituents			Allochemical Constituents	Terrigenous Constituents
	Micrite	Microspar	Spar		
Lower ls.					
CO-1	62.4	8.9	1.8	26.5	0.3
CY-1a	28.3	27.0	6.8	36.4	0.3
CW-2	13.6	19.1	25.1	42.2	---
*CV-1	38.6	3.7	13.0	44.0	0.1
CX-2	35.7	3.7	33.2	27.0	0.4
CS-1	32.3	8.9	5.5	52.3	0.4
*CS-6	16.7	11.0	23.9	44.7	---
Average	32.5	11.8	15.6	39.0	0.2
Upper ls.					
*CS-15	85.3	9.9	1.1	0.9	1.0
*CS-16	79.1	15.5	3.1	1.1	0.9
CX-9	65.5	9.7	14.2	9.8	0.8
Average	76.6	11.7	6.1	4.2	0.9

* the four major rock types

Similar amounts of microspar suggest that the effect of recrystallization was uniform throughout the formation.

Skeletal grains are the most abundant allochemical constituent, but some intraclasts and pelloids were recognized (slides CQ-5, CS-1, CT-5, CT-7, and CY-2; Appendix IV). The most abundant skeletal grains are ostracodes, bivalves, Osagia, and gastropods (Table 8 and fig. 11).

Micrite, microspar, and spar were observed in each thin section. The patchy distribution of the microspar and some of the spar indicate that it is the result of recrystallization. An original micrite matrix suggests deposition in a low energy environment.

Silt-sized angular quartz is the most common terrigenous constituent observed in thin section (Appendix V). Small amounts of mica and clay minerals were also observed. These observations agree with those of Huber (1965) who found that quartz was the most abundant insoluble mineral in the sand and silt size fractions.

Rhomb-shaped structures ranging from 30 to 150 microns were observed in most slides from the middle shale and the upper limestone (fig. 12). Huber (1965, pl. XV) observed similar structures and concluded that they were not dolomite. In thin section some smaller rhombs appeared fuzzy making it difficult and sometimes impossible to determine their composition microscopically. X-ray diffraction indicated dolomite in 27 of 57 samples from the middle shale and upper limestone (Appendix VII), but in the remaining 30 samples calcite was the only carbonate mineral. Based on dedolomitization criteria (Evamy, 1967, fig. 1) these rhombs in the Crouse are interpreted as dedolomite. Three of the five stages of dedolomitization (Evamy, 1967) were observed in Crouse Limestone thin sections--(1) rhombohedral pores, (2) rhombohedral pores partly filled with calcite, and (3) rhomb-shaped areas of equigranular mosaics of anhedral calcite (fig. 12).

Table 8

Allochemical Constituents of Thin Sections that were Point Counted

Type of Allochem	Number	Percent
Bivalves	913	22.3
Ostracodes	1197	29.2
<u>Osagia</u>	508	12.4
Gastropods	454	11.1
Encrusting foraminifers	137	3.3
Free-living foraminifers	118	2.9
Echinoderms	22	0.5
Phylloid algae	6	0.1
Unidentifiable skeletal fragments	672	16.4
Pelloids	15	0.4
Quartz silt	58	1.4
Total	4100	100.0

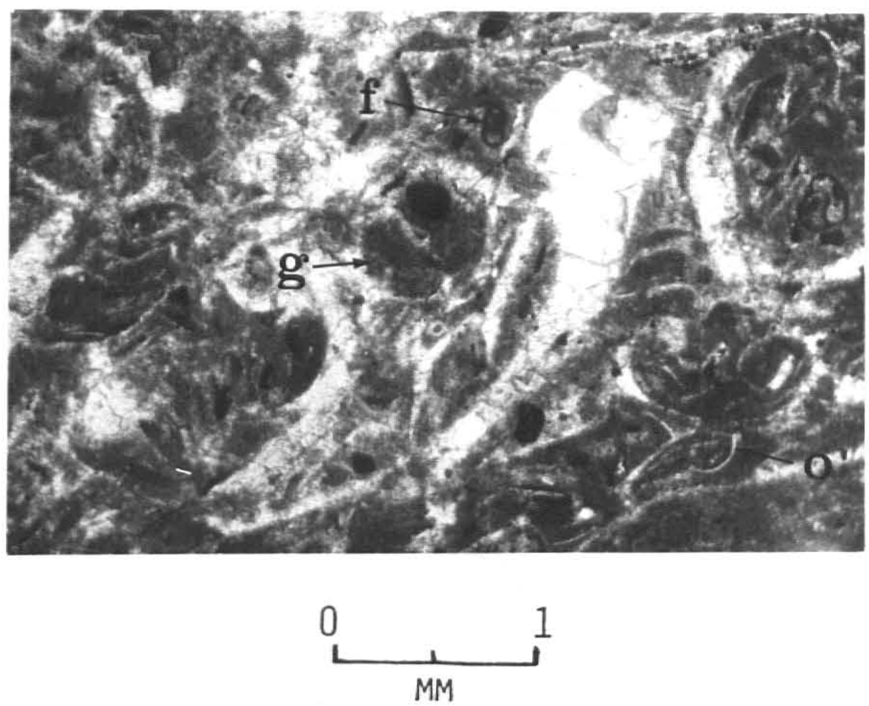

Figure 11. A Typical Thin Section from the Lower Limestone (sample CS-1). Large Areas of Spar are Bivalves. Arrows Indicate Foraminifer (f), Gastropod (g), and Ostracode (o). Top is up.

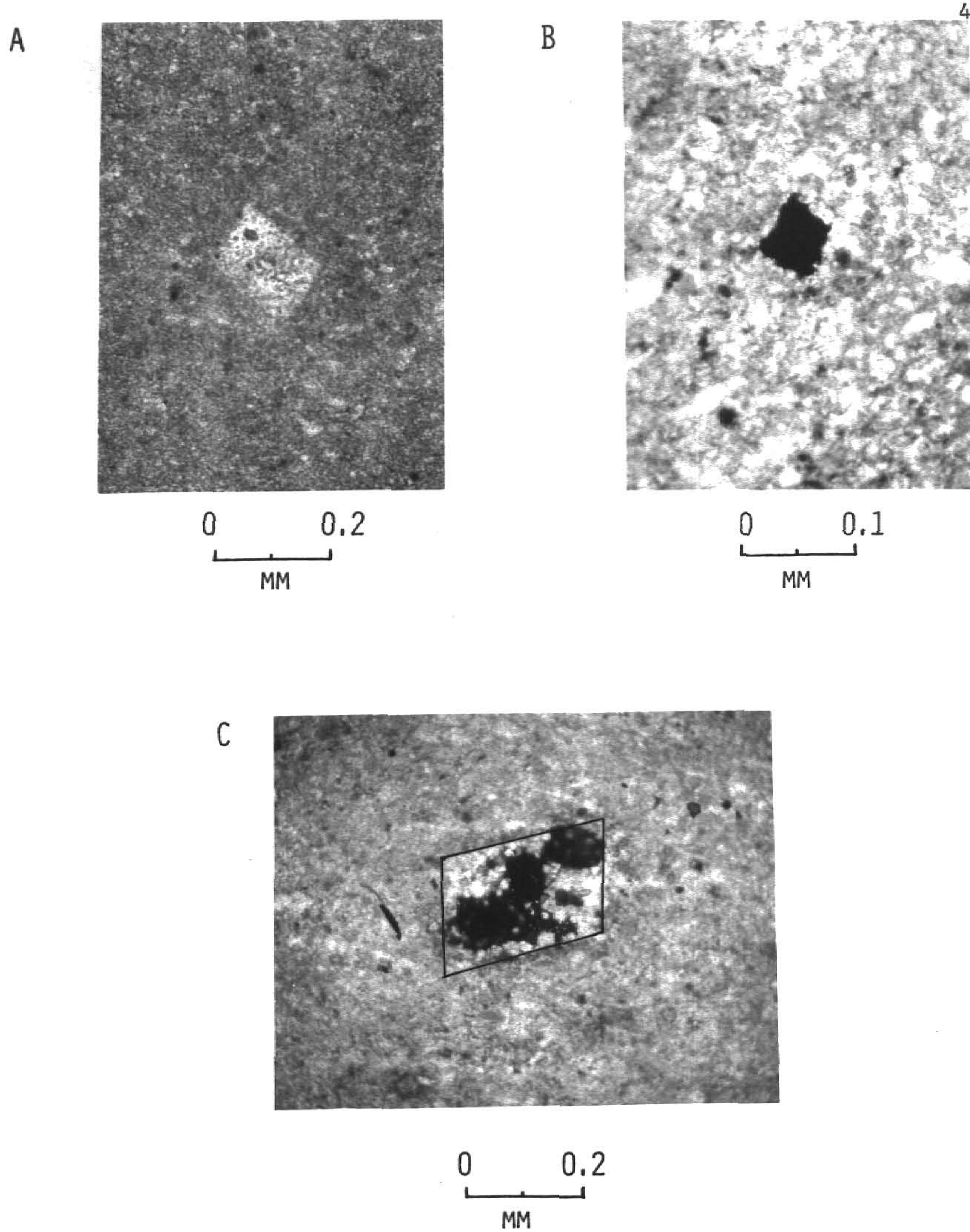

Figure 12. Dedolomitization in the Crouse Limestone. A. Rhomb-shaped Area Filled with an Equigranular Mosaic of Anhedral Calcite (middle shale, sample CV-7). B. Rhombohedral Pore, Crossed Nicols (upper limestone, sample CT-14). C. Rhombohedral Pore Partly Filled with Calcite, Crossed Nicols (upper limestone, sample CQ-11). Top is up on all photos.

Under proper conditions dedolomitization can proceed in the presence of sulfate ions which may be supplied by the dissolution of gypsum (Goldberg, 1967). In the Crouse Limestone gypsum crystal molds indicate that gypsum dissolution has taken place (fig. 13A), but the gypsum molds cannot be correlated stratigraphically with the supposed dedolomitization. Gypsum dissolution and dedolomitization in the Crouse may be related, but direct evidence is lacking.

Calcite also replaced gypsum in the Crouse Limestone. Replacement calcite forms areas of equigranular mosaics of anhedral calcite--a texture identical to that of some dedolomitization (fig. 13B). Some areas of gypsum-replacement calcite were rhomb-shaped in thin section and presented the problem of how to differentiate them from dedolomitization. The gypsum crystals and the pores resulting from their dissolution are elongate and when viewed in thin section they range from perfectly rhombic to elongate (fig. 13C). If in a given thin section replacement calcite was observed only as well-formed rhombs, it was considered dedolomite. If, however, there was considerable variation in the shapes of the areas of replacement calcite, it was assumed that calcite replaced gypsum.

DETAILED ANALYSIS OF SECTION Q

General Statement

As mentioned in the introduction, section Q is a unique exposure. An erosional surface cuts through the upper limestone and part of the middle shale. Above this erosional surface are rocks unlike those exposed elsewhere in the Crouse Limestone. The rocks above the erosional surface at section Q will be considered in detail in this section.

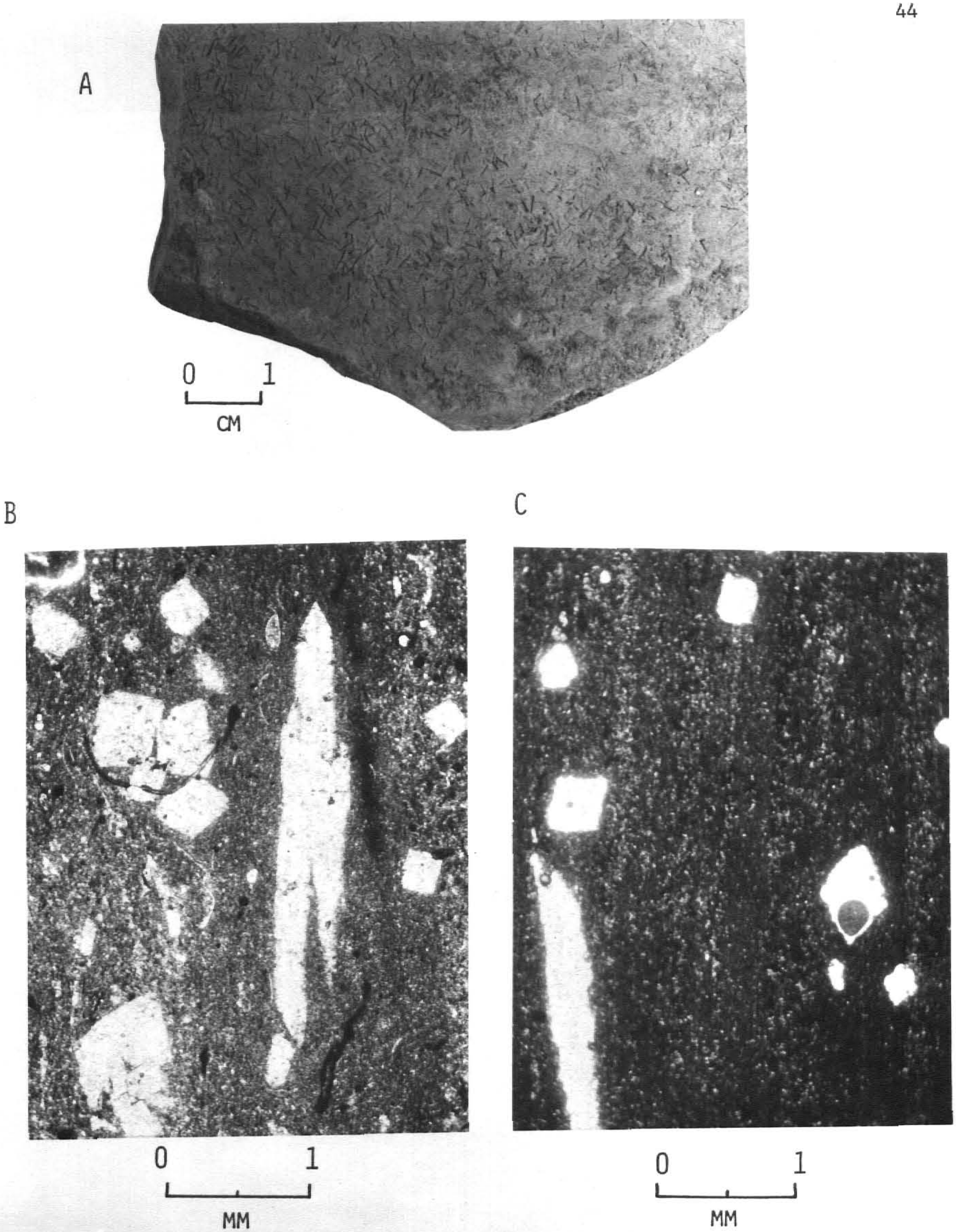

Figure 13. Evidence of Gypsum in the Crouse Limestone. A. Gypsum Crystal Molds from the Middle Shale (sample CW-8). B. Areas Filled with Equigranular Mosaics of Anhedral Calcite Interpreted as Replacement of Gypsum (upper limestone, sample CU-11). C. Pores from Gypsum Dissolution (upper limestone, sample CS-15). Left is up in B and C.

Description

General Statement.--The exposure at section Q and the four rock units between the erosional surface and the Blue Rapids Shale are in Figure 14. In ascending order these rock units are (1) a conglomerate, (2) a black shale, (3) a limestone, and (4) a gray mudstone.

Erosional Surface.--The erosional surface cuts through the upper limestone and part of the middle shale at this locality. Excluding units above the erosional surface, the maximum thickness of the Crouse Limestone is 3.95 meters (13.0 feet) compared to 4.47 meters (14.7 feet) at section S less than a mile away. At its lowest point the erosional surface is 0.41 meters (1.4 feet) below the top of the middle shale. Assuming that the thicknesses of the middle shale and the upper limestone are the same at sections Q and S, between 0.52 and 1.96 meters (1.7 - 6.5 feet) of the Crouse was removed by erosion at section Q. The rocks immediately below the erosional surface have been altered from their typical color of yellowish gray (5Y7/2) to grayish orange (10YR7/4) or pale yellowish orange (10YR8/6).

To determine its configuration, a palaeotopographic map of the erosional surface was constructed (fig. 15). Elevations were determined (plane table and alidade) for 31 points (on both sides of the road) at the erosional surface. The data were adjusted to a datum 1.22 meters (3.9 feet) above the base of the middle shale to eliminate the effect of any post-Crouse deformation.

Conglomerate.--Immediately above the erosional surface is up to 20 centimeters of conglomerate with a greater thickness where the erosional surface is lower (fig. 14). Figure 1 is an isopachous map of this unit made from data obtained while mapping the erosional surface. The conglomerate is composed of lithic clasts and a few pieces of charcoal. Where the unit is thickest the lower part is strongly cemented by sparry calcite, but

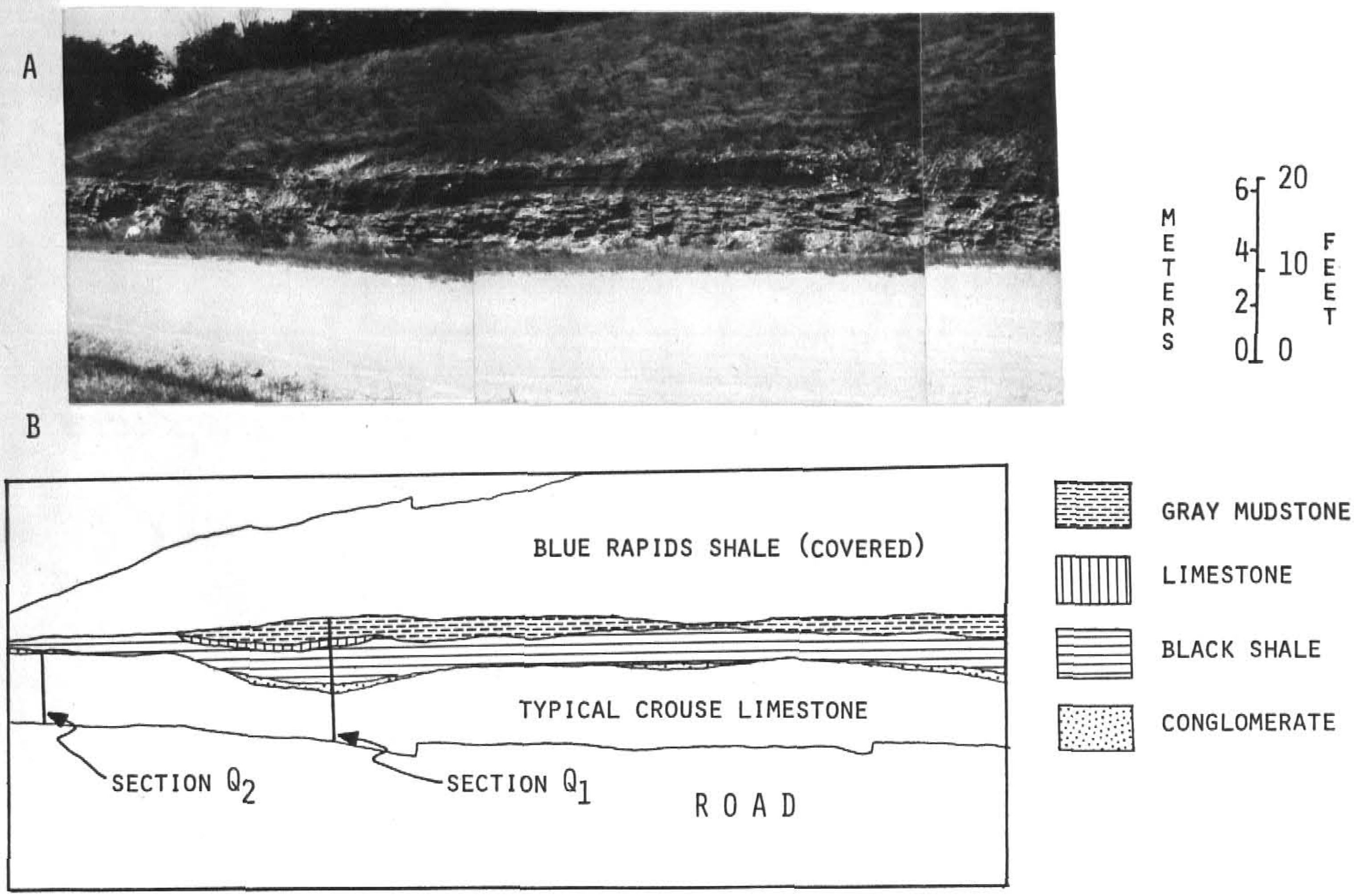

Figure 14. A and B. Crouse Limestone at Section Q (north side of road).

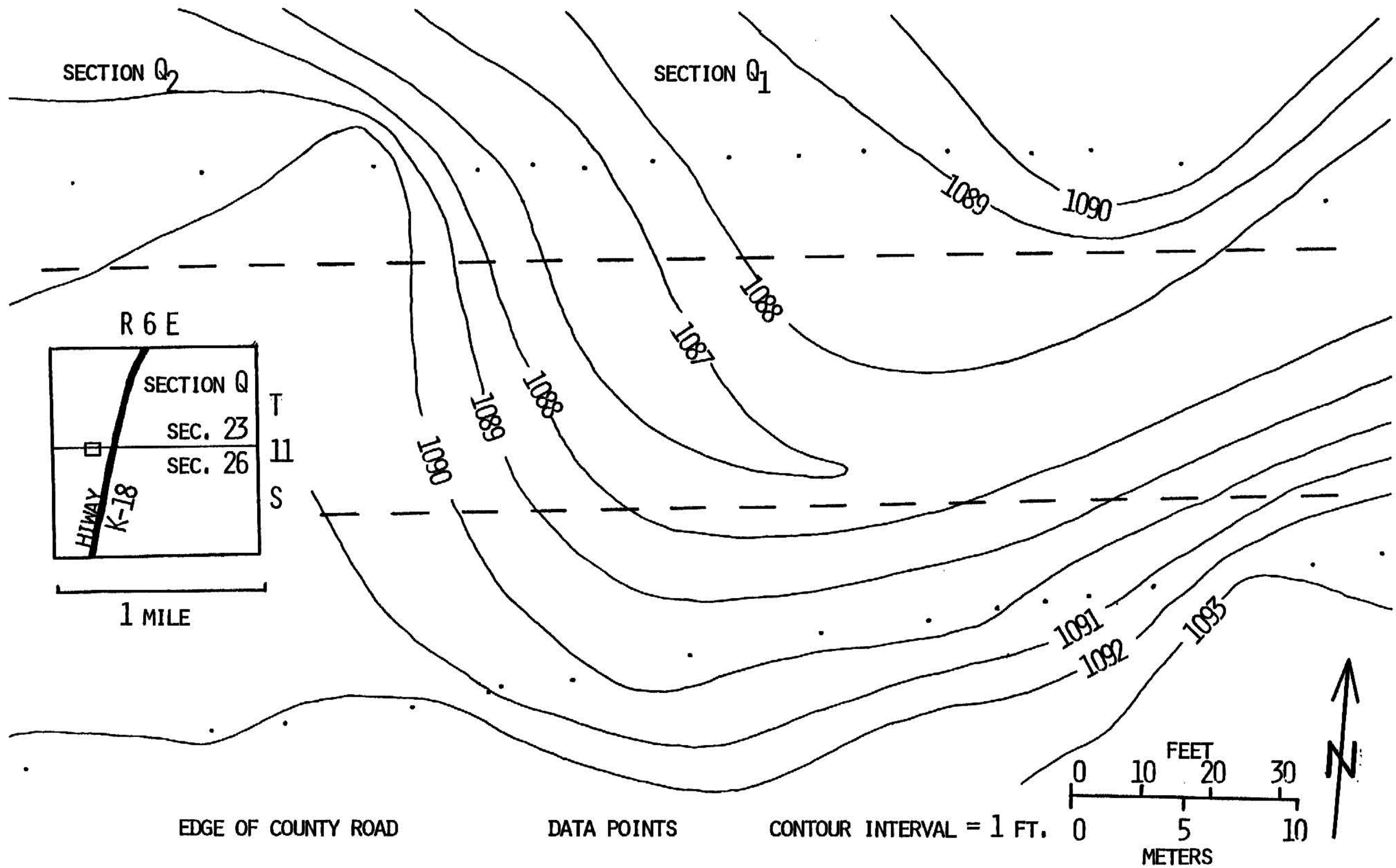

Figure 15. Palaeotopographic Map of the Erosional Surface at Section Q

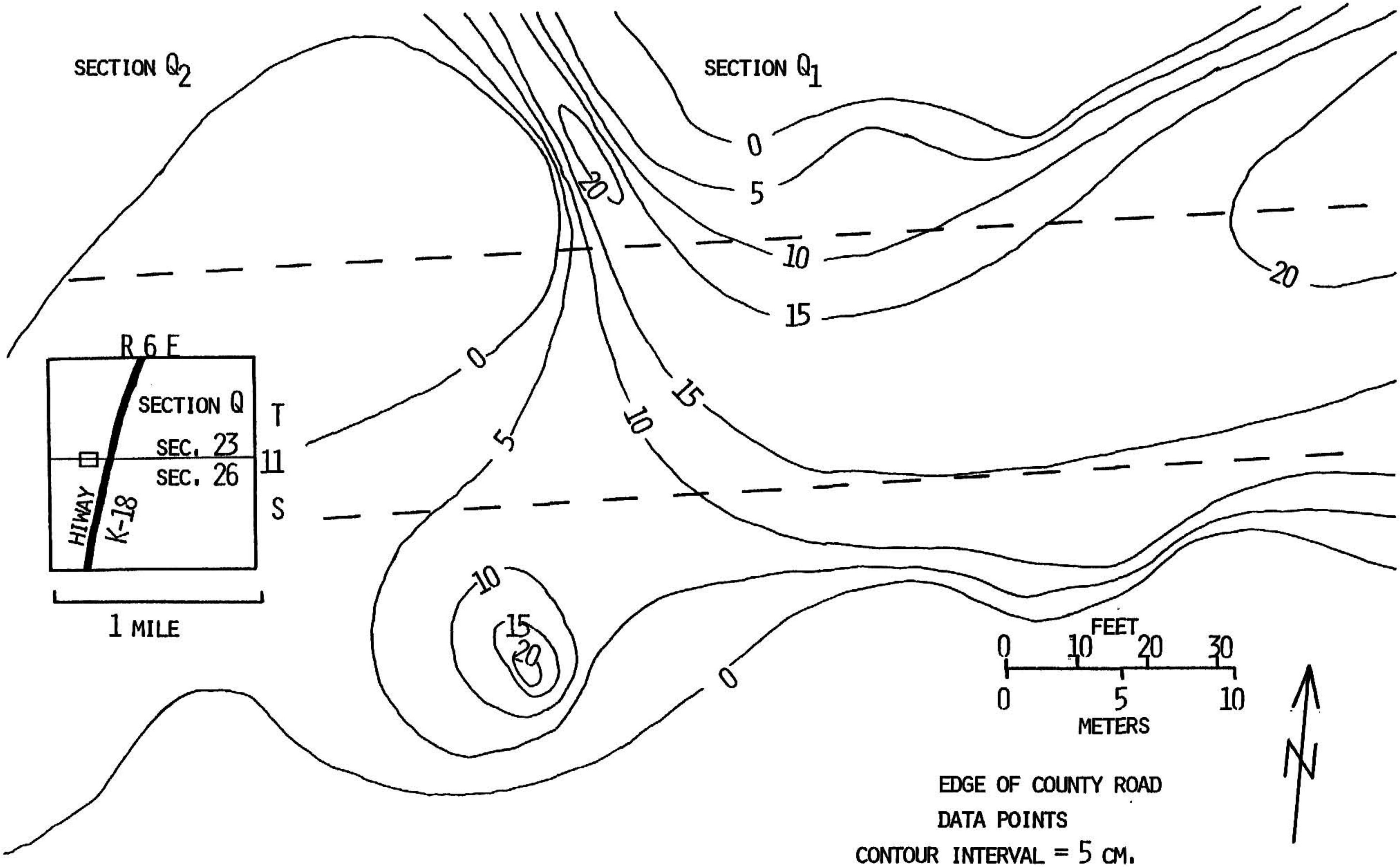

Figure 16. Isopachous Map of the Conglomerate at Section Q

elsewhere it is weakly cemented. The clasts range from 0.2 to 15.0 centimeters and are rounded to subrounded according to Pettijohn's (1975, p. 57) roundness classes. Visual inspection suggests that most of these thinly-laminated recrystallized micrite clasts are oriented with their long axes parallel to bedding. They are dark yellowish orange (10YR6/6) to grayish orange (10YR7/4) compared to the yellowish gray (5Y7/2) typical of the upper limestone. Lithologically the clasts and upper limestone are virtually identical. Based on these similarities it is reasonable to infer that the clasts were derived from this upper limestone (fig. 17). There are only a few examples of embayments of the clasts where they are in contact with each other indicating that most of them were lithified at the time of their deposition.

Black Shale.--Overlying the conglomerate is a black shale that ranges up to 1.37 meters (4.5 feet) thick and the greatest thickness is above the lowest point of the erosional surface (fig. 14). Although the unit is grayish brown (5YT3/2) near the base and the top compared to grayish black (N2) in the center, the contacts with the conglomerate below and the limestone above are sharp. Plant debris is abundant and there are several thin (less than five millimeters) discontinuous coal seams. Ostracodes are conspicuous and Spirorbis sp. and fish debris also occur.

Limestone.--Above the black shale is a discontinuous limestone (fig. 14) that is up to 15 centimeters thick and, like the underlying units, is thickest above the lowest point in the erosional surface. The limestone is subparallel to the erosional surface (fig. 14) and contains rounded clasts of micrite as large as six millimeters (fig. 18). These clasts are recrystallized laminated grayish orange (10YR7/4) micrite--a lithology identical to that of the upper limestone. The top of the unit contains more clasts but is less well cemented. Charcoal, fish debris, and ostracodes occur in this

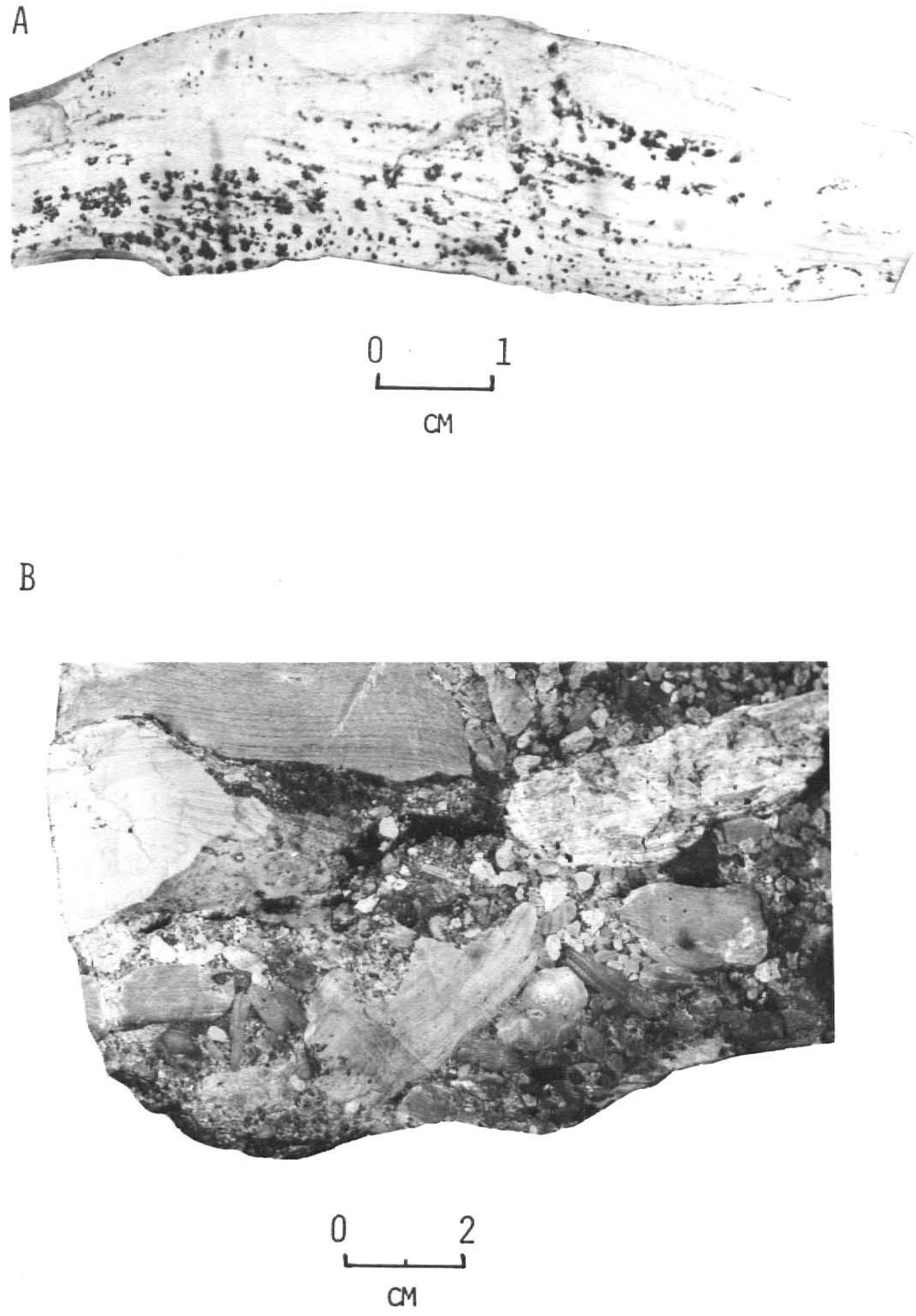

Figure 17. Similarity between Upper Crouse Limestone and Lithic Clasts in the Conglomerate at Section Q. A. Laminated Micrite from the Upper Limestone at Section Q (sample CQ-12). B. Conglomerate Composed of Laminated Micrite Clasts (sample CQ-13). Top is up on both photos.

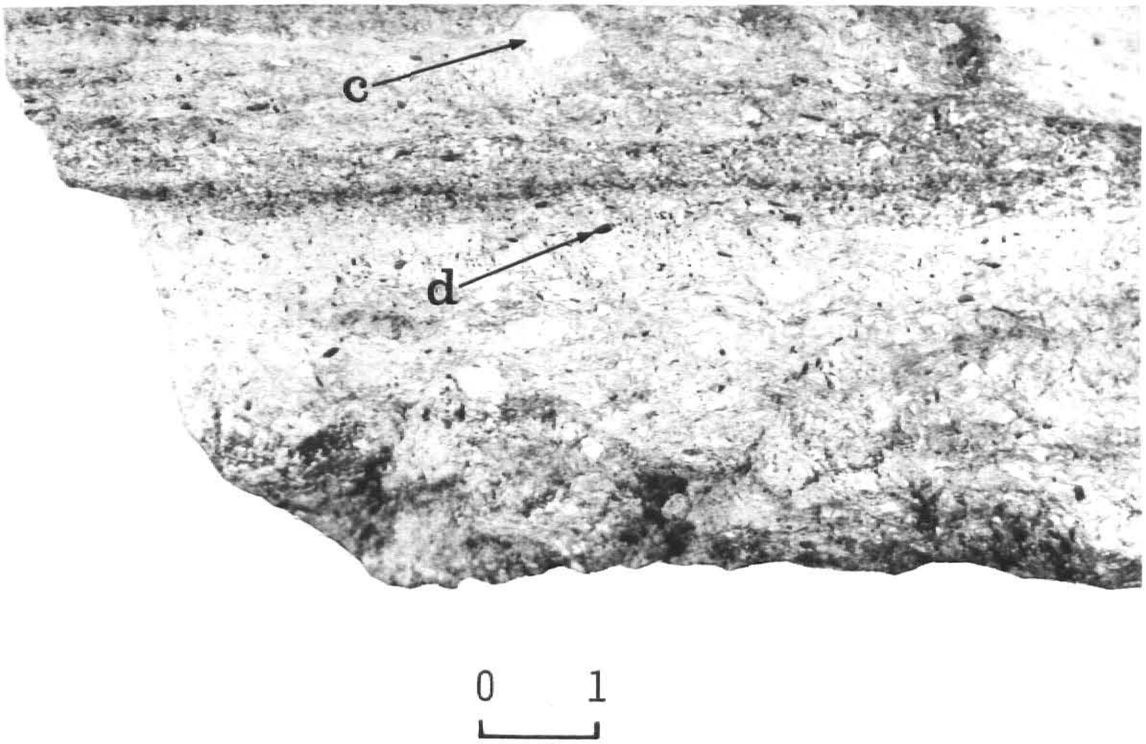

Figure 18. Limestone from above the Erosional Surface at Section Q (sample CQ-19) Arrows indicate Lithic Clast (c) and Fish Debris (d). Top is up.

unit (fig. 17).

Gray Mudstone.--Overlying the limestone is a gray mudstone that grades upward into the Blue Rapids Shale. Again this gray mudstone is thickest above the lowest point in the erosional surface. It appears to fill low areas left after deposition of the underlying units. A few sand-sized grains of rounded micrite which are lithologically similar to the lithic clasts in the limestone and conglomerate units below occur in this mudstone. Fish debris and Spirorbis sp. were the only fossils found.

Data

Biotic Data.--Biotic data were obtained from these units by examining washed residues and thin sections but were not quantified.

Except for a few pieces of charcoal, the conglomerate is devoid of any organic remains. The black shale contains abundant plant debris and smooth-shelled ostracodes along with Spirorbis sp. and some fish debris. Ostracodes could not be identified more specifically because nearly all were broken. The limestone contains abundant ostracodes as well as fish debris and charcoal and the gray mudstone contains Spirorbis sp. and fish debris.

Petrologic Data.--Insoluble residue and X-ray diffraction analyses were made on samples from these four units. Organic carbon content was determined for the black shale and the gray mudstone.

Figure 19 shows the percent of insoluble residue, calcite/quartz ratio, and percent of organic carbon for each sample analyzed. The insoluble residues are low in the conglomerate and the limestone, and the calcite/quartz ratios are high. The mudrocks (shale and mudstone) have high insoluble residue content and low calcite/quartz ratios.

Organic carbon ranges from 16.2 to 18.1 percent of the black shale and the gray mudstone. Mudrocks may have up to 40 percent organic carbon, but less than three percent of all mudrocks contain more than ten percent organic carbon (Blatt, et al., 1972, p. 393). Therefore, the organic carbon content of the black shale and the gray mudstone is unusually high.

Based on thin section examination, the limestone (samples CQ-19 and CQ-19+) is a recrystallized ostracodal biomicrite or biomicrudite.

Interpretation

Erosional Surface.--The erosional surface cuts through the upper limestone and middle shale and, therefore, represents a post-Crouse event. More than two meters of relief is on this surface (fig. 15). In vast, shallow

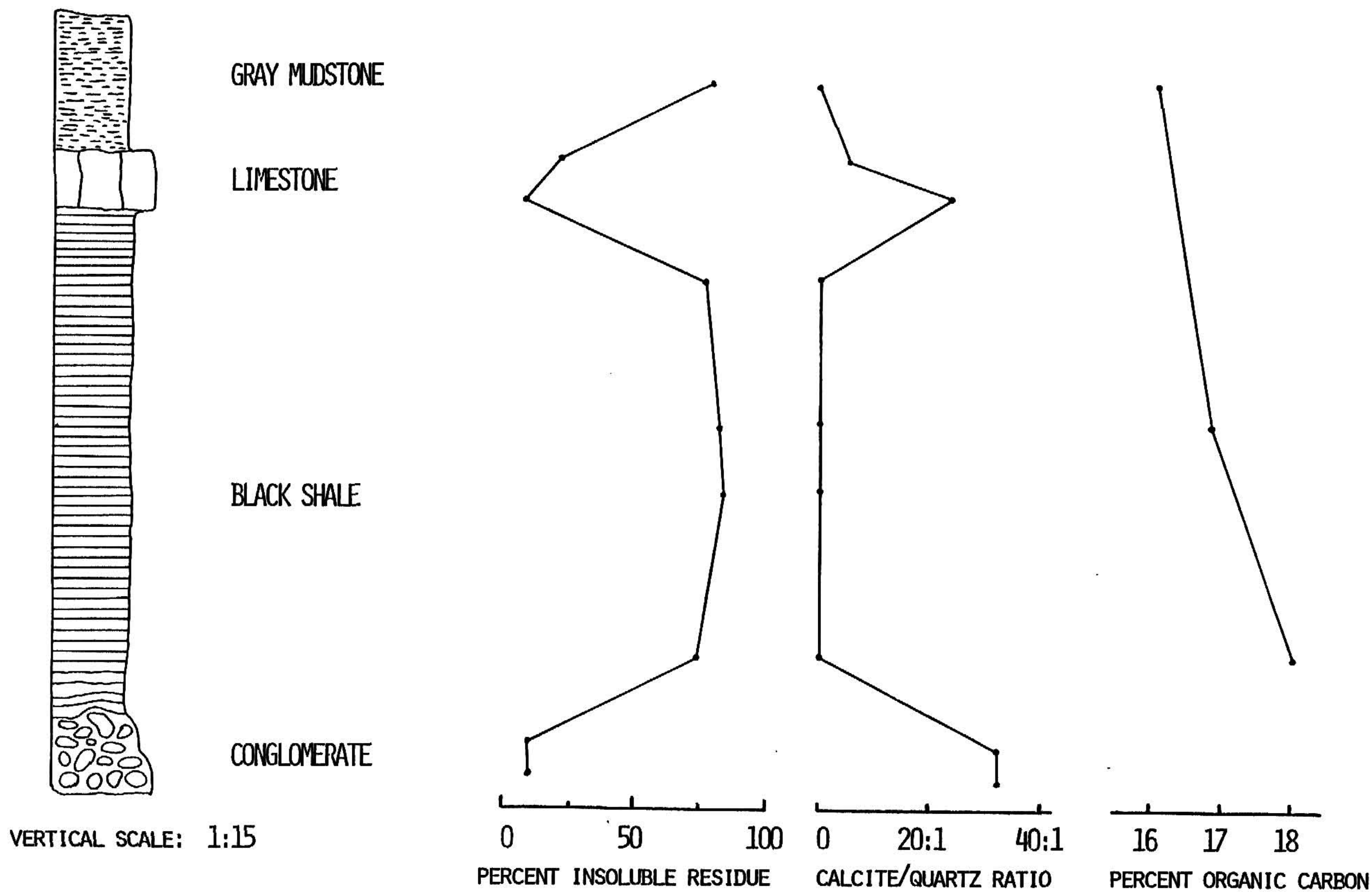

Figure 19. Petrologic Data from the Units Above the Erosional Surface at Section Q

epeiric seas with low energy, submarine erosion of this magnitude seems unlikely. The orange color of the rocks immediately above and below the erosional surface is probably a result of iron oxidation, suggesting that erosion took place in an oxidizing environment (i.e. subaerial).

The shape of the erosional surface (fig. 15) suggests that it may have been the bed of a channel that drained a subaerially exposed area. Its lateral extent could be due to meandering or lateral migration of a tidal channel. The dimensions of this channel (2 meters deep and 25 to 35 meters wide) are similar to those of modern tidal channels on Andros Island, Bahamas (Shinn, et al., 1969). Rapid downcutting during a period of abnormally high energy (i.e. storm) may have deepened the channel.

Conglomerate.--Sub-rounded to rounded lithic clasts with a wide range in size compose the conglomerate. The clasts are lithologically identical to the upper limestone and are believed to have been derived from its erosion. According to Pettijohn (1975, p. 515), limestone pebbles may become well rounded when transported 15 kilometers or less. Erosion of the Crouse Limestone took place soon after deposition of the upper limestone and probably before lithification was complete. Therefore, erosion and rounding of the clasts could have taken place even more easily and quickly. This coupled with poor sorting suggests a nearby source area.

The large size of some clasts and the absence of micrite suggest a high energy environment of deposition which supports the interpretation of the erosional surface as a channel bed. Laminated mud clasts and lithified dolomitic clasts are common in recent tidal channel deposits on Andros Island, Bahamas (Hardie and Ginsburg, 1977; Shinn, et al., 1969). The distribution of the conglomerate (fig. 16) is erratic and suggests deposition by an overloaded stream which supports the idea that maximum downcutting took place during a storm.

Black Shale.--The black shale represents a change to a low energy environment and the fossils in it suggest brackish water. Spirorbis sp. is found in both marine and freshwater deposits (Scott, 1944). According to Lane (1964) smooth-shelled ostracodes occur in both marine and freshwater assemblages and fish debris is typical of a freshwater assemblage.

Organic carbon is an indication of a poorly oxygenated environment. In an oxidizing environment organic carbon is oxidized to carbon dioxide and water. High organic carbon content of the black shale along with coal and abundant plant debris indicate stagnant, anaerobic conditions. According to Zangerl and Richardson (1963) the absence of infaunal and benthic organisms also suggests a toxic bottom. The coal and plant debris indicate close proximity to a terrestrial environment and the characteristics of this black shale are typical of a swamp environment.

Reducing conditions at the bottom do not imply similar conditions in the water above. Spirorbis sp. and fish debris in the black shale suggest that parts of the water were well oxygenated and inhabitable. The stagnant, anaerobic conditions probably extended just a short distance above the bottom (Zangerl and Richardson, 1963).

Limestone.--The limestone unit has a limited lateral extent (fig. 14). Ostracodes, fish debris, and charcoal suggest a freshwater or perhaps brackish environment, but other features common in freshwater limestones such as algal structures and nodular form are absent. The micrite matrix indicates deposition in a low energy environment, but the lithic clasts suggest somewhat higher energy than during deposition of the black shale. The shape of the unit (fig. 14) suggests deposition in a channel or may be due to differential compaction of the underlying shale. A channel deposit is more compatible with the lithic clasts and the unit's limited lateral extent.

Gray Mudstone.--The gray mudstone appears to have filled low areas left after deposition of the underlying units. It consists of over 80 percent insoluble residue and contains 16.2 percent organic carbon. Where the limestone unit is absent the contact between the gray mudstone and the underlying black shale is gradational. The upper contact with the Blue Rapids Shale is also gradational and the gray mudstone could, in fact, be considered part of the Blue Rapids. *Spirorbis* sp. and fish debris suggest a brackish to freshwater environment. Lane (1964) found a similar fossil assemblage in the Blue Rapids Shale. It included charophytes, which he believed represent either fresh or brackish water, the marine foraminifer *Tetrataxis*, the freshwater ostracode *Carbonita*, and fish debris. The high organic carbon content of the gray mudstone indicates reducing conditions of the bottom, unlike the oxidizing conditions during deposition of the reddish shales in the Blue Rapids Shale above. Although water conditions during deposition of the gray mudstone and the Blue Rapids Shale may have been similar, bottom conditions certainly were not. The slight decrease in percent of organic carbon through the black shale and gray mudstone (fig. 18) may be part of the change from reducing to oxidizing conditions.

Placement of the gray mudstone in the Crouse Limestone or the Blue Rapids Shale is not important. It is considered here as part of the depositional sequence and clearly represents a transition between the units above and below. This transitional relationship demonstrates the artificiality of certain stratigraphic boundaries and the need to study a rock unit as part of a depositional sequence.

Summary

A tidal channel at section Q eroded parts of the upper limestone and middle shale. Rounded clasts from these units were deposited as gravel immediately above the erosional surface in a high energy environment.

Subsequently, a black, organic-rich mud was deposited in a swamp-like environment with low energy, fresh or brackish water, and reducing conditions at the bottom. A skeletal carbonate mud containing small (less than six millimeters) rounded lithic clasts was then deposited in a limited area. It formed in fresh or brackish water with more oxidizing conditions and somewhat higher energy than the mud below. Its shape and limited lateral extent suggest that this unit was deposited in a channel. The sequence was capped by a gray mud. It, too, was deposited in a fresh or brackish water, low-energy environment with reducing conditions on the bottom and represents a transition with the overlying Blue Rapids Shale.

The units above the erosional surface at section Q undoubtedly record a very local event. These units are unique in the Crouse Limestone and even nearby outcrops give no indication of a similar situation. The limestone and conglomerate units thin to a zero edge and the other units thin considerably toward the edge of the outcrop. The types of deposits also imply a restricted occurrence. In an area characterized by deposition in shallow epeiric seas, a high-energy environment like that represented by the conglomerate is not likely to be widespread.

INTEGRATION AND INTERPRETATION OF DATA

Vertical Integration and Interpretation

Rocks at each outcrop of Crouse Limestone were formed as a result of a sequence of events and conditions. To best understand these events and conditions it is necessary to study the entire sequence of rocks because each event and each set of conditions did not occur exclusive of those preceding and following it. Furthermore, many factors affect the formation of carbonate rocks. Although it is impossible to consider each factor, the best interpretation is the one that takes into consideration the most evidence.

Figures 20 and 21 are the integration of petrologic and biotic data respectively for all Crouse Limestone sections. Petrologic data (from thin sections and X-ray diffraction) show the following trends (fig. 20): (1) decreasing percent of suspension feeders upward, (2) decreasing grain/matrix ratio upward, and (3) dolomite in the middle shale and upper limestone. Biotic data (from lower limestone bedding surfaces) indicate upward (fig. 21): (1) increase in fragmentation, (2) decrease in diversity, (3) decrease in equitability, (4) decrease in size of Permophorus cf. P. subcuneatus, and (5) increase in deviation of the percent right valves from 50 percent. These trends were not tested for statistical significance.

West and McMahon (1972) examined changes in lower Crouse bedding surface assemblages and found (1) an upward increase in concave downward shells, (2) an upward increase in fragmentation, (3) an upward decrease in relative bivalve abundance, and (4) an upward decrease in percent right valves. They interpreted the assemblages as representative of a regressive sequence with shallow subtidal conditions at the base and low intertidal conditions at the top. The trends noted were considered to be mainly a result of higher energy conditions in the upper part.

Increases in fragmentation and deviation of the percent right valves from 50 percent (fig. 21) agree with the observations of West and McMahon (1972) and suggest an increase in energy (i.e. higher energy).

Trends shown in Figures 20 and 21 suggest an increasingly harsh environment during Crouse Limestone deposition. Such environmental changes would place more and more stress on the organisms and could result in (1) fewer organisms (decrease in grain/matrix ratio because grains are dominantly skeletal), (2) a less diverse assemblage (decrease in diversity)

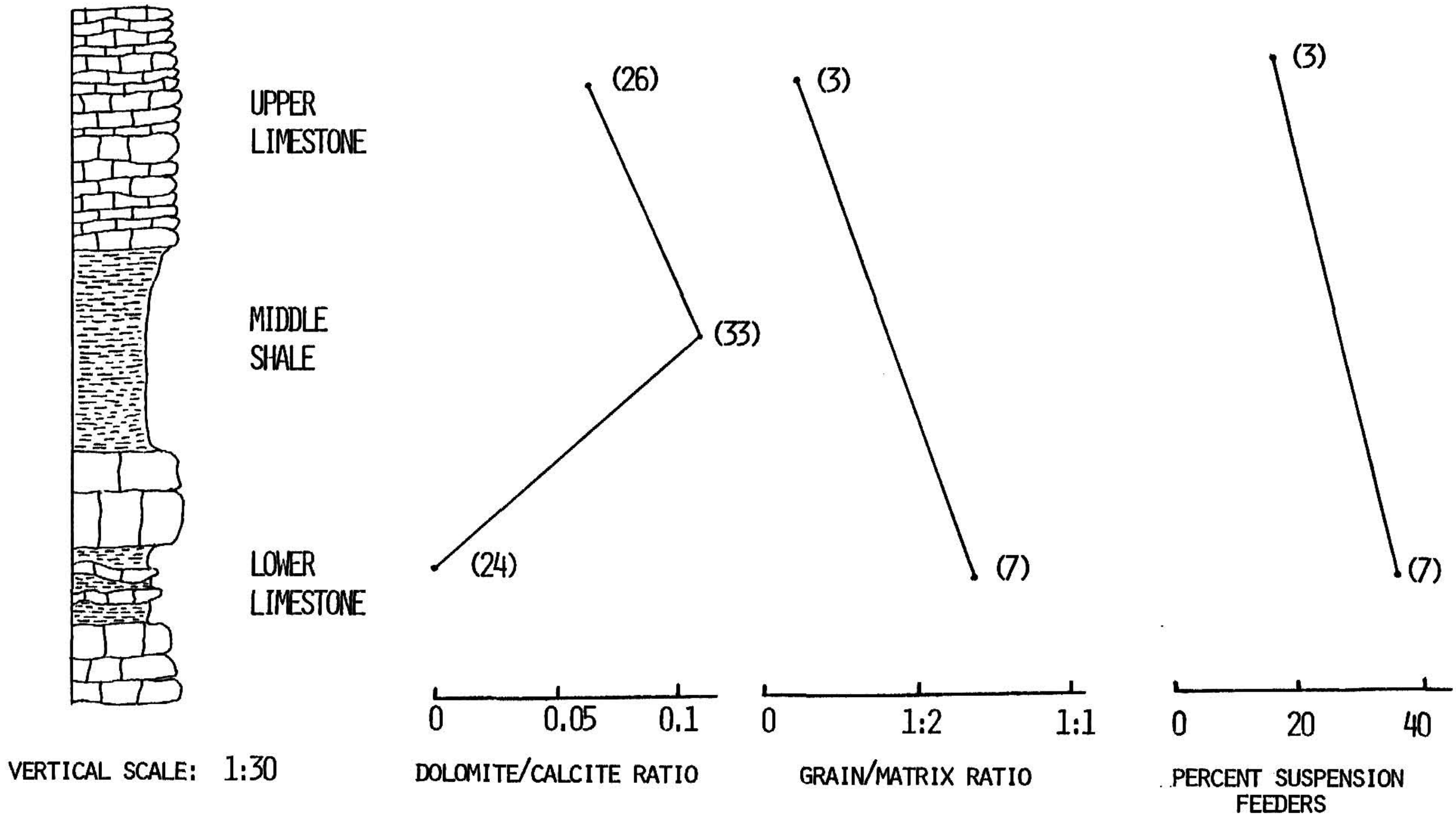

Figure 20. Vertical Integration of Petrologic Data for the Crouse Limestone (composited from all sections). Points plotted are averages for each unit and the number of values averaged are in parentheses.

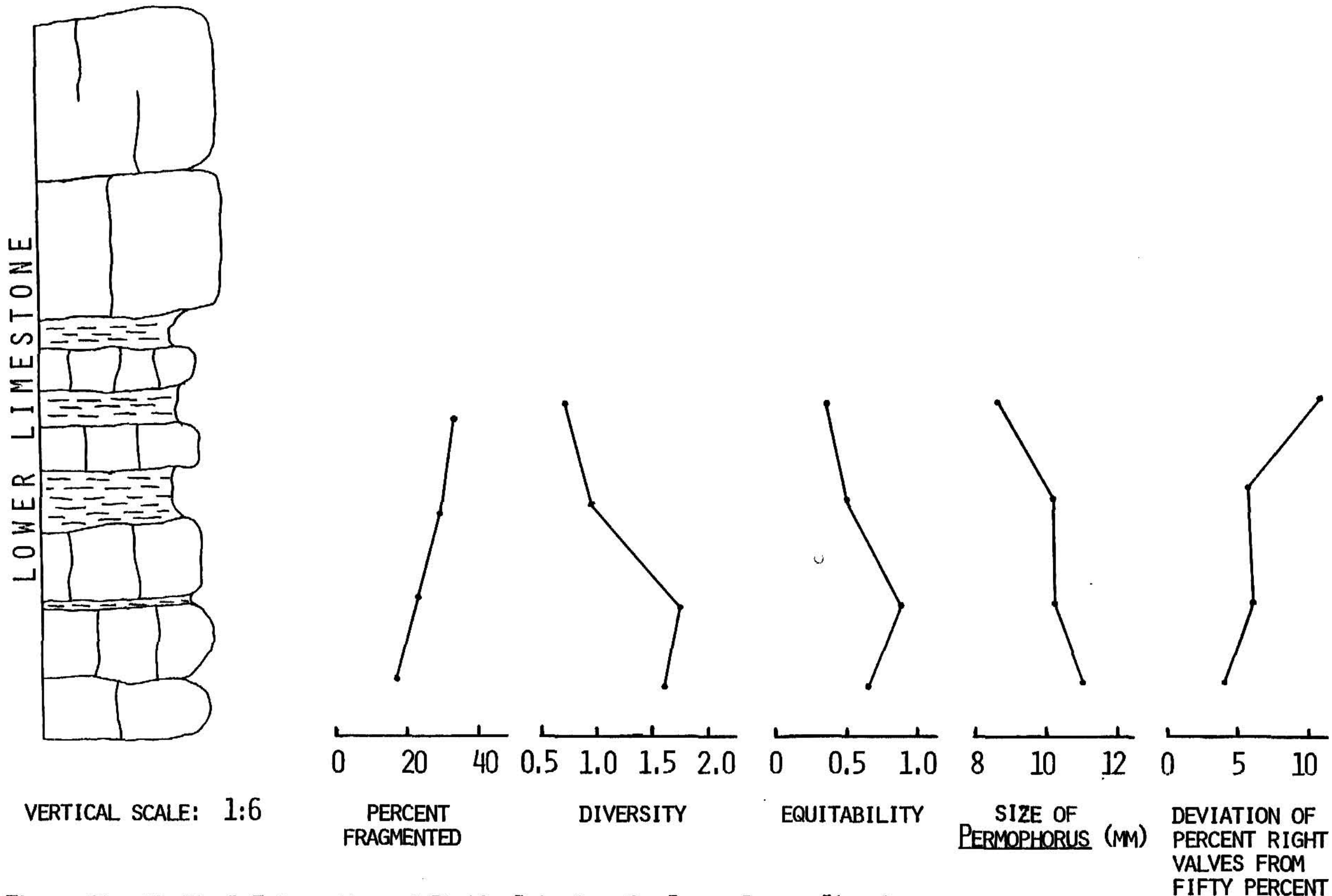

Figure 21. Vertical Integration of Biotic Data for the Lower Crouse Limestone (composited from all mapped bedding surfaces, Appendix III)

(3) dominated by fewer species (decrease in equitability), and (4) smaller sized individuals (decrease in size of Permophorus cf. P. subcuneatus). A shallow regressive sequence like that proposed by West, et al. (1972) would indeed be such an environment. Shallower water and more exposure would place more stress on the organisms. The trend of decreasing suspension feeders also supports a regressive interpretation. Regression would have a particularly adverse effect on shallow subtidal to low intertidal suspension feeders because of greater turbulence and more suspended sediment.

In general, data collected from the lower limestone, the middle shale, and the upper limestone support a regressive interpretation.

Bedding surfaces often mark a change in conditions of sedimentation (Hills, 1972, p. 7). Most bedding surfaces in the lower limestone are irregular and there is usually a thin mudstone between limestone beds. Irregular bedding surfaces represent interruptions in normal sedimentation which were probably caused by periods of increased water movement (i.e. storms). A period of increased agitation would result in an irregular bottom because of submarine erosion and increased wave base. It would also be responsible for an increase in terrigenous sedimentation represented by the thin mudstones. The wave produced orientation of shells (Pearson, 1972) is further evidence of increased turbulence.

The lower surfaces of limestone beds signify a return to normal carbonate sedimentation. Bedding surface data indicate that 88.4 percent of the shells on the upper surfaces of limestone beds are concave downward (hydrodynamically stable). Only 71.8 percent of the shells on lower surfaces are concave downward. Concave up shells are typical of quiet water environments (Johnson, 1965; Clifton, 1971). Although the difference between shell orientations may not be statistically significant, it does suggest that the lower limestone was deposited in a relatively low-energy environment which was periodically interrupted by higher energy conditions.

The conditions described above are typical of a shallow nearshore (subtidal) environment. Horizontal burrows on some bedding surfaces and relatively high diversity of organisms are further evidence favoring subtidal deposition (Walker and Laporte, 1970).

Fossils in the middle shale are a mixture of organisms typical of marine environments and those typical of freshwater environments (Lane, 1964). As pointed out by West, et al. (1972, p. 87) this is evidence in favor of a nearshore environment.

Disrupted laminations, mottled texture, and reworked, homogenized beds--features indicative of bioturbation (Hardie and Ginsburg, 1977, p. 119)--are common in the middle shale. Extensive bioturbation is an indication of intertidal deposition (Gebelein, 1971).

A conspicuous feature of the upper limestone is its fine laminations which are very similar to those caused by high intertidal to supratidal algal mats in recent tidal flat environments (Hardie and Ginsburg, 1977; Logan, 1974; and Hagan and Logan, 1974). The laminated fabric of the upper limestone is similar to typical stromatolitic fabric described by Monty (1976, p. 194). Flat laminated stromatolites such as those in the upper limestone are indicative of high intertidal deposits (Walker and Laporte, 1970). Laminations give the unit its platy character which is also typical of high intertidal and supratidal deposits (Gebelein, 1971).

Hardie and Ginsburg (1977) considered three possible origins for the supratidal laminated sediment on Andros Island. These are (1) chemical precipitation, (2) normal diurnal tidal flooding, particularly high spring tides, and (3) flooding by storms. Chemical precipitation was ruled out because of the well-sorted, open framework fabric of many of the laminae.

Tidal flooding was eliminated as a possibliity because the normal tide-waters carry very little suspended sediment. In fact, clear water is a feature of all recent carbonate environments (Bathurst, 1975, p. 94). Hardie and Ginsburg were able to verify empirically the storm-related origin of the supratidal sediment and they concluded that storm deposition was the exclusive agent responsible for laminated sediment. Black (1933) also emphasized the importance of storms on Andros Island.

At Cape Sable (Florida) 62 percent of the calcareous sediment is deposited by storms. In the supratidal zone all sediment is derived from waters driven over the area during storms (Gebelein, 1971). Storms probably played a role in the deposition of the Crouse Limestone. The irregular bedding surfaces in the lower limestone may well be storm-related and much of the upper limestone sediment was probably storm-derived. As suggested previously, storms may be responsible for the downcutting of the tidal channel at section Q.

Mudcracks, trails, and vertical burrows were observed in the upper part of the upper limestone. Oscillation ripple marks and possible "birdseye" structures were reported from this unit by West, et al. (1972, p. 88). All these features are typical of a high intertidal to supratidal environment (Gebelein, 1971; Walker and Laporte, 1970).

Dolomite in the middle shale and the upper limestone may be further evidence of a high intertidal to supratidal environment of deposition for these units (Pray and Murray, 1965).

The origin of dolomite has long been a mystery to geologists. Its common occurrence in the geologic record and the inability to produce it in the laboratory have compounded the mystery. Among the most widely accepted hypotheses of dolomite formation are that it forms (1) by seepage-refluxion (Adams and Rhodes, 1960), (2) from hypersaline brines in a sabkha environment (Shinn, et al., 1965), or (3) by secondary replacement of calcite.

The seepage-refluxion hypothesis proposes that in restricted waters salinity increases because of evaporation. Gypsum may precipitate raising the Mg/Ca ratio in the brine. The brine becomes heavy and seeps downward displacing lighter connate water. During seepage magnesium-calcium exchange and dolomitization occur.

According to the hypersaline brine hypothesis, pore waters in supratidal sediments become increasingly saline until gypsum precipitates. This raises the Mg/Ca ratio and leads to the replacement of calcium by magnesium and the formation of dolomite.

The secondary replacement hypothesis proposes that dolomitization is accomplished by metasomatic fluids during late diagenesis.

The erratic distribution of dolomite seems to support a secondary origin. However, the occurrence of dedolomite indicates that at one time dolomite was in both the middle shale and upper limestone at virtually every locality (except sections O, R, and T). It is dedolomitization that is erratic.

Recent primary or early diagenetic dolomite has been found in a variety of environments. Several workers have found dolomite forming from hypersaline water (Illing, et al., 1965; Shinn, et al., 1965). Thompson, et al. (1968) reported dolomite from a deep sea environment with normal marine salinity. Freshwater dolomite has also been reported (Müller, 1970; Sherman, et al., 1962).

Folk and Land (1975) related the formation of dolomite to two factors: (1) Mg/Ca ratio of the water and (2) salinity (fig. 22). Dolomite may be produced from calcite by increasing the Mg/Ca ratio or by decreasing salinity. According to Folk and Land, dolomite can form better in less saline waters

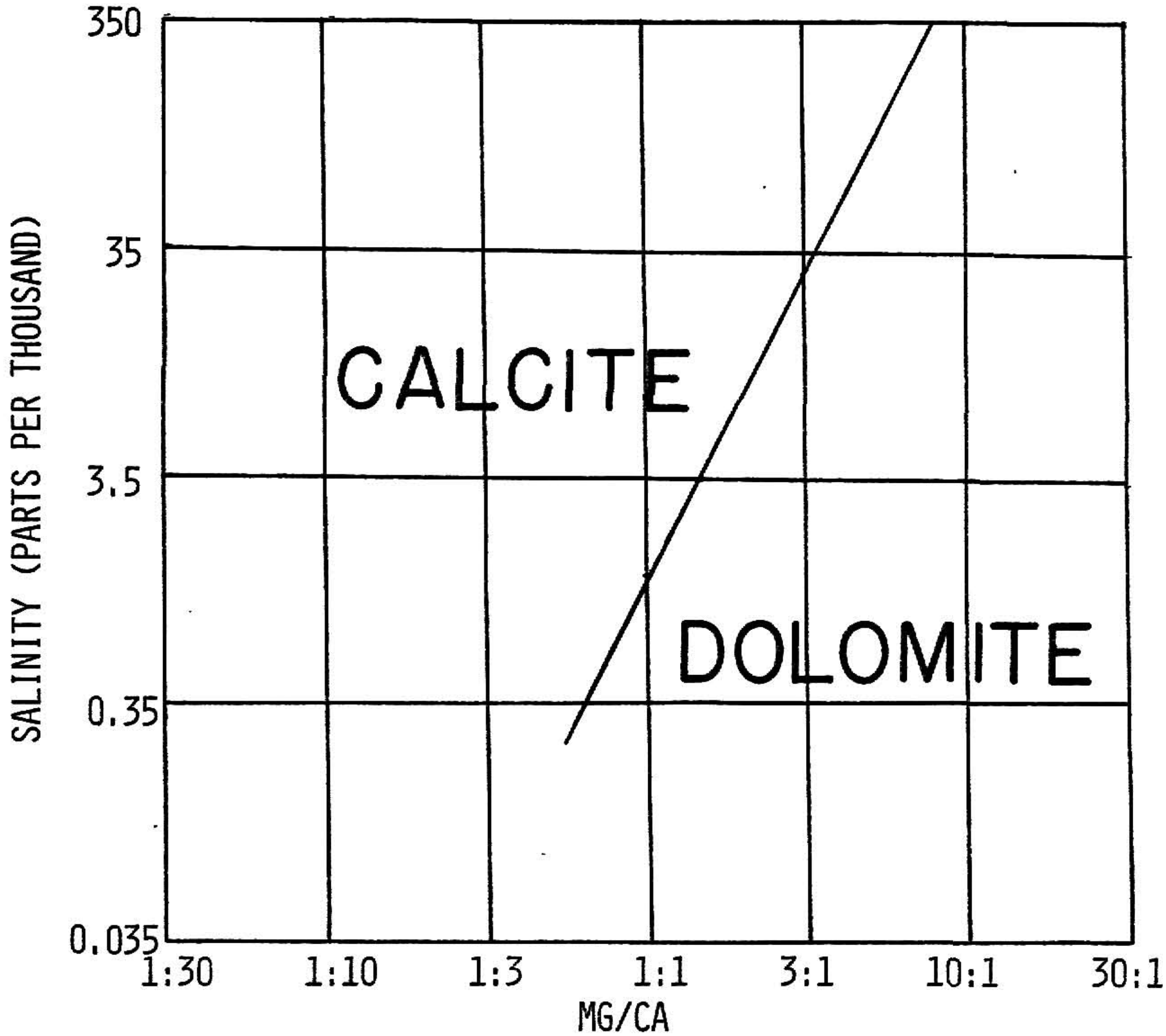

Figure 22. Calcite and Dolomite Stability Fields (after Folk and Land, 1975, p. 61)

because of slower crystallization rates and lower concentrations of competing ions. Perhaps the best way to form dolomite would be to introduce fresh water into marine or hypersaline water. A high Mg/Ca ratio would not be necessary. This does not deny that dolomite may also form in hypersaline environments with high Mg/Ca ratios. In fact, the two processes compliment each other nicely. Hypersaline water with a high Mg/Ca ratio is most likely to be found in a nearshore environment. The effect of freshwater runoff is also greatest there. Therefore, a nearshore environment provides two possible mechanisms for dolomite formation.

The absence of dolomite in section R and in the middle shale at section T could be expected if the dolomite formed in an intertidal or supratidal environment. Sections R and T are the southernmost exposures and occupy the lowest structural positions. Therefore, during regression these sections would be the last to "dry up"--i.e. reflect high intertidal to supratidal conditions favorable for dolomite formation. Section O, which had dolomite in the middle shale only, is on the Abilene Anticline (fig. 1) where different conditions could be expected.

Dolomite commonly occurs with gypsum in recent supratidal flats (Sherman, 1963; Deffeyes, et al., 1965). Gypsum formation may raise the Mg/Ca ratio and lead to dolomitization. In the Crouse Limestone elongate gypsum crystals were observed at sections Q and S. Cavities the size and shape of those crystals were found at all other outcrops, and they are interpreted as molds of gypsum crystals. These molds were found in different beds of the Crouse Limestone, from the base of the lower limestone at sections W and X to the upper limestone at section T. Their greatest abundance is in the middle shale and the upper limestone. Similar cavities have been described by Summerson (1966) from the Silurian of Ohio, Randazzo (1969) from the Devonian of North Carolina, and Hoffman (1967) from the Precambrian of British

Colombia. All have interpreted the cavities as molds of evaporite crystals.

There is no correlation between the stratigraphic occurrences of gypsum and dolomite in the Crouse Limestone. Hence there is no direct evidence that they are related. Nevertheless, these two minerals are not incompatible in a nearshore sedimentary environment. Their occurrence together in the middle shale and upper limestone is evidence in favor of a nearshore hypersaline environment of deposition (embayed lagoon) for these units. Russell (1977) found evidence suggesting an arid climate during deposition of the Council Grove Group. Such a climate would indeed be conducive to formation of both gypsum and dolomite.

In summary, the results of this investigation support the interpretation of the Crouse Limestone as a regressive tidal flat sequence (West, et al., 1972). Depositional environments ranged from subtidal during lower limestone deposition to supratidal during upper limestone formation.

This regression need not have involved any change in sea level. A prograding tidal flat model (Lucia, 1972, p. 160-163) explains such a sequence without any sea level change. Carbonate mud produced on an adjacent carbonate platform migrates shoreward. This sediment is trapped and builds up on the tidal flat. Regression and progradation take place not because sea level is lowered, but because the tidal flat becomes higher through the accretion of sediment (Ginsburg, 1971; Matti and McKee, 1976). The units above the erosional surface at section Q are interpreted as tidal channel and swamp deposits and are not inconsistent with a prograding shore model.

Lateral Integration and Interpretation

North-south and east-west cross sections of the Crouse Limestone are in Figures 23 and 24 respectively. Total thickness of the Crouse increases to the south and west. The lower limestone and the middle shale thicken to

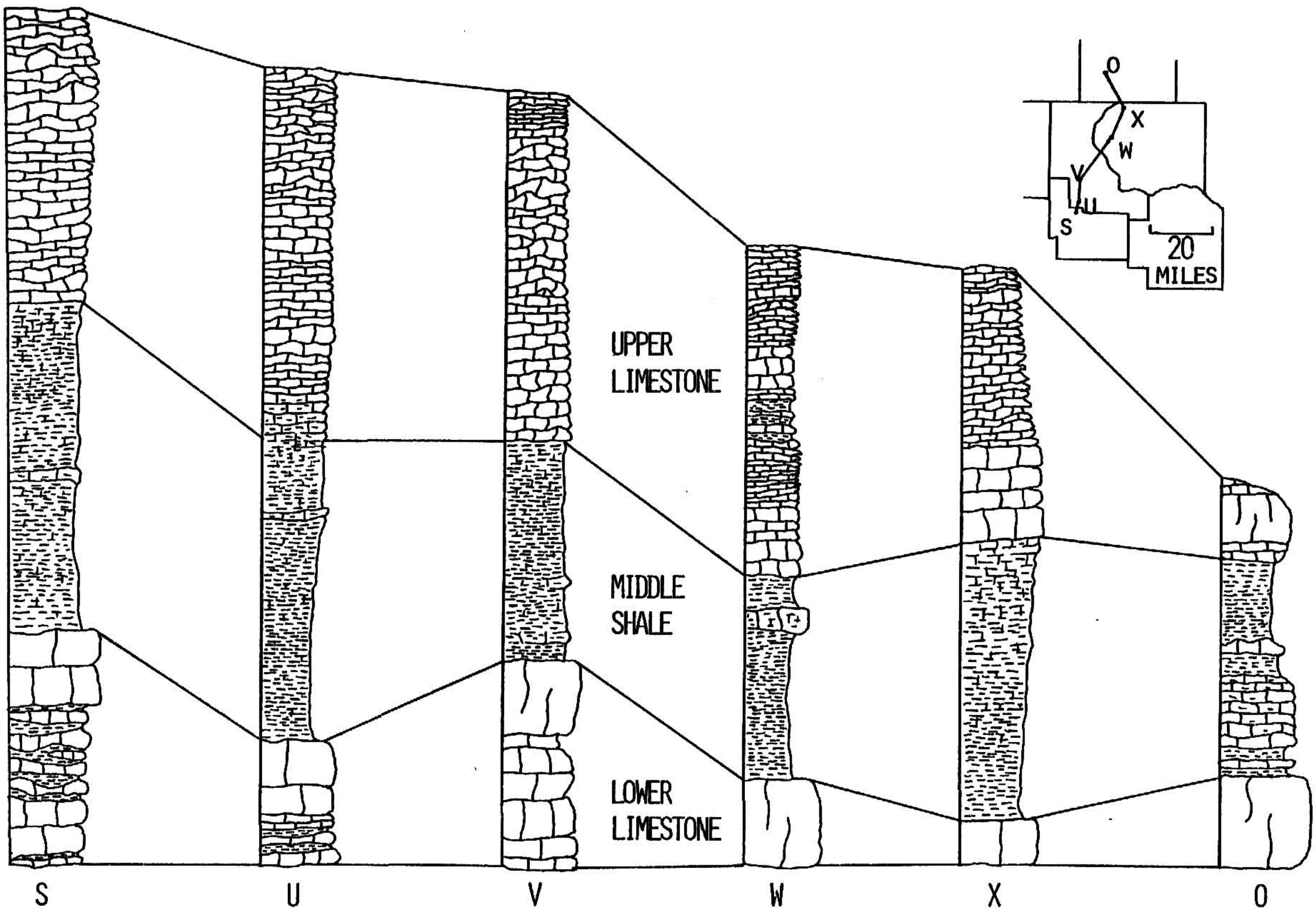

Figure 23. North-South Cross Section of the Crouse Limestone

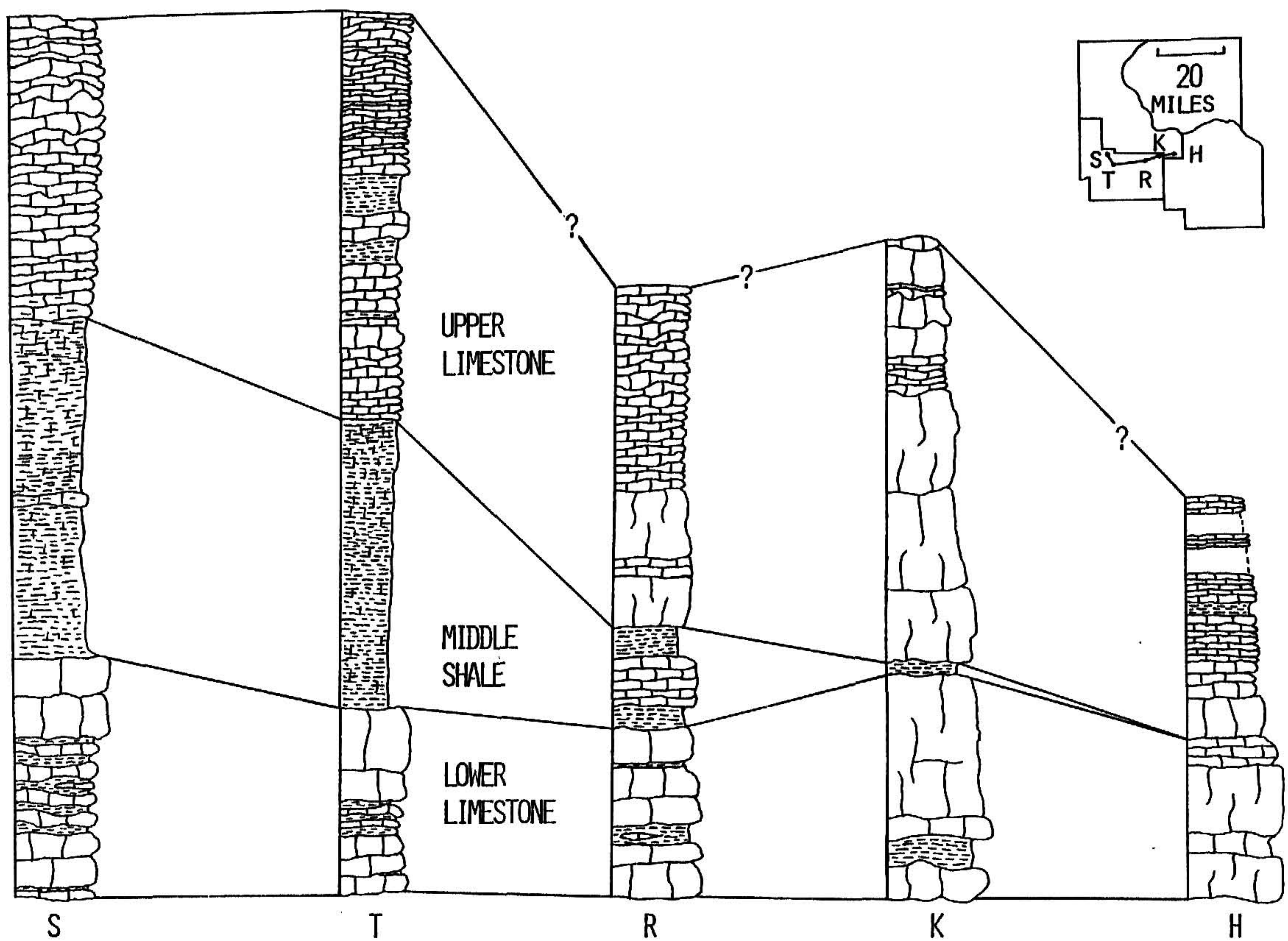

Figure 24. East-West Cross Section of the Crouse Limestone

the west and all three units thicken southward. The area occupies the east flank of the south-plunging Irving Syncline (fig. 1). Therefore, the Crouse Limestone thickens toward structurally low areas.

Figures 25 and 26 are the lateral integration of data in north-south and east-west directions respectively. These data were obtained from stratigraphically equivalent bedding surfaces and thin sections, mostly from the lower limestone. There are northward decreases in (1) the grain/matrix ratio, (2) percent of suspension feeding organisms, (3) size of *Permophorus* cf. *P. subcuneatus* along with eastward decreases in (1) the size of *Permophorus* cf. *P. subcuneatus*, (2) diversity, and (3) equitability. These trends suggest a more harsh environment possibly due to shallower water in the northern and eastern parts of the area. An eastern increase in percent of suspension feeders does not agree with the other trends and may be due to north-south distance between sections.

Although the lateral trends examined by West and McMahon (1972) were different from those used in this study, the conclusions are the same. Bedding surface assemblages in the lower limestone suggest shallow subtidal conditions in the west and south and low intertidal conditions to the east and north. Areas of supposed deeper water coincide with the structurally low areas (fig. 1).

The area was probably protected from the open ocean; the Abilene Anticline to the west may have served this purpose. It need not have been an exposed land area, but could have protected the area equally well as a submarine feature. A protected environment is suggested by several lines of evidence.

Permophorus cf. *P. subcuneatus* is a semi-infaunal, endobyssate bivalve. Endobyssate bivalves are restricted to stable substrates (Stanley, 1972, p. 204). If not protected from the open ocean, the carbonate mud substrate

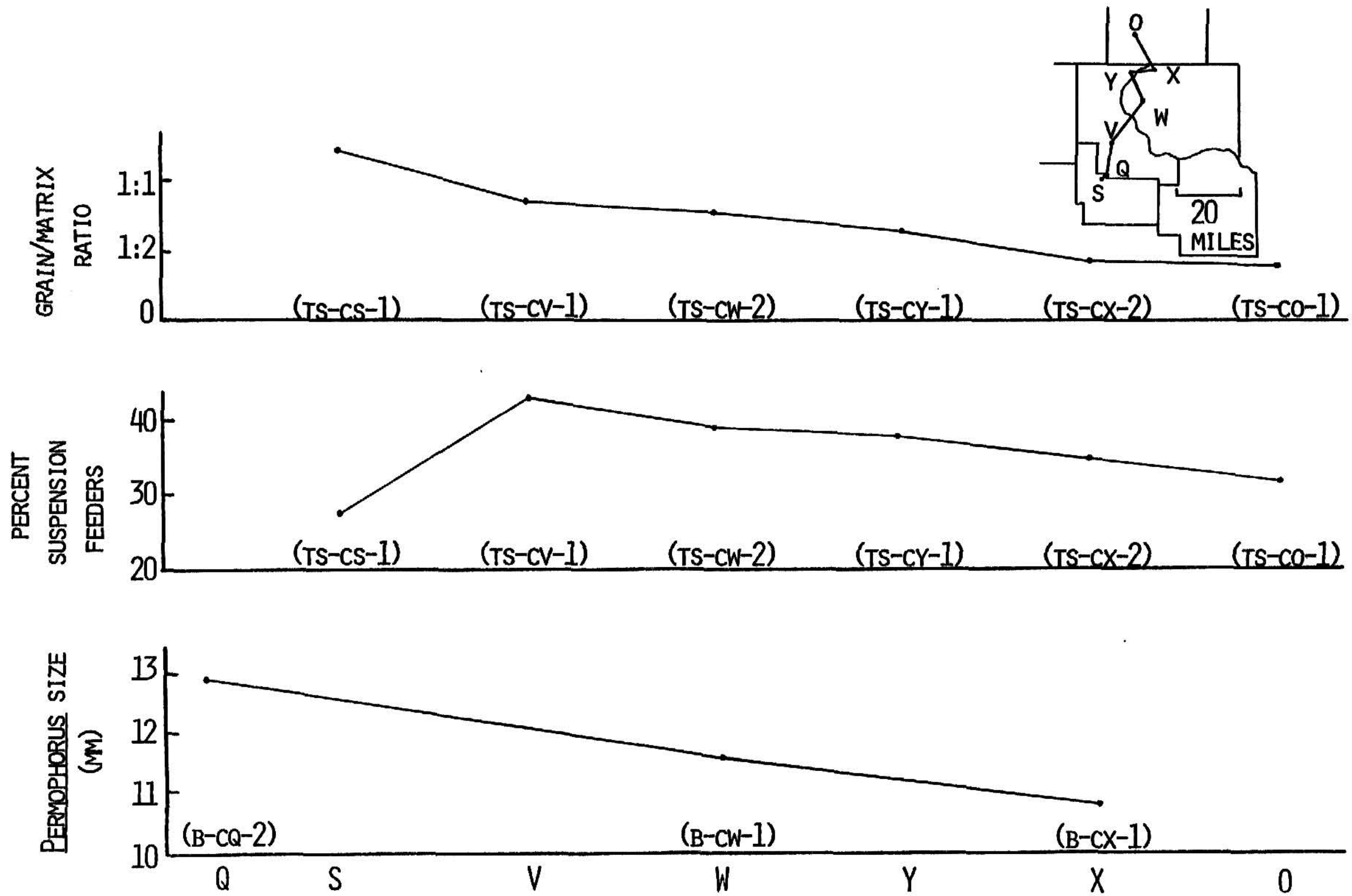

Figure 25. North-South Lateral Integration of Data from the Lower Limestone. Data were derived from the samples indicated in parentheses; "B" indicates a mapped surface, "TS" indicates thin section.

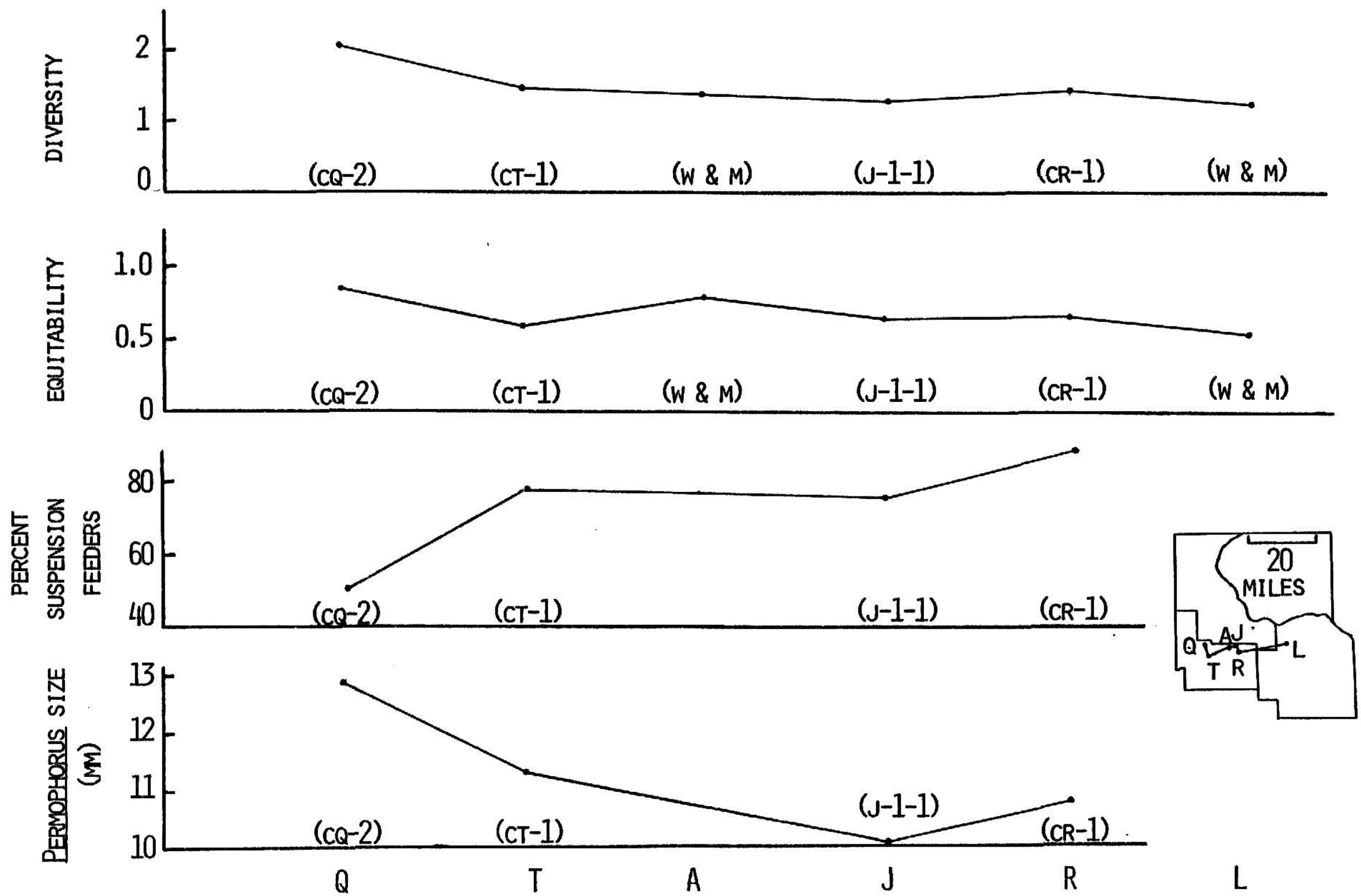

Figure 26. East-West Lateral Integration of Data from the Lower Limestone. Data were derived from the bedding surfaces indicated in parentheses. Data from West and McMahon (1972) are indicated by "W & M."

of the lower limestone would likely undergo frequent periods of instability.

Stability of the substrate is a determining factor in the growth form of stromatolites (Hardie and Ginsburg, 1977, p. 57). An unstable substrate allows stromatolite growth only at isolated spots which results in stromatolite heads similar to those at Shark Bay, Australia (Logan, 1961). Laminar stromatolites like those in the upper Crouse Limestone form on a uniform stable substrate which is more likely if nearby waters are calm and protected.

This is not to imply that the water was completely still and motionless. The Abilene Anticline cannot be detected south of Abilene and could not have caused complete isolation of the area. Connection with the open ocean must have existed and with it some movement of water. Furthermore, some agitation of the water is required by Osagia (Moore, 1964, p. 343).

Clark (1976) in studying populations of Argopecten gibbus in Harrington Sound, Bermuda found a distinct difference in shell convexity between populations from different water depths. Shells from depths greater than ten meters had a lower convexity (flatter shells). Clark considered possible environmental causes of this difference and concluded that turbulence was the factor most likely controlling shell convexity.

Argopecten gibbus and Aviculopecten sp. are similar morphologically (Cox, et al., 1969). Both are members of the Superfamily Pectinacea and their modes of life are the same (epifaunal byssally attached).

Convexity was measured on two specimens of Aviculopecten sp. from bedding surface CQ-2 which were the only specimens not fragmented, distorted, or partly covered. These data are compared to Clark's (1976) measurements (p. 607, fig. 2) in Table 9. The convexity/height ratio of Aviculopecten sp. is very similar to that of the deep water form of Argopecten gibbus.

Several possible interpretations of these results are: (1) The lower Crouse Limestone was deposited in water more than ten meters deep.

Table 9

Shell Convexity in Pectinaceans

Taxon	Height (mm)	Convexity (mm)	Convexity / Height
#*Aviculopecten* sp.	28	6	0.214
#*Aviculopecten* sp.	18	4.5	0.250
**Argopecten gibbus*	56	12	0.214
***Argopecten gibbus*	62	24	0.387

from bedding surface CQ-2

* Clark's (1976) deep water form

** Clark's (1976) shallow water form

(2) The lower Crouse was deposited in non-turbulent water less than ten meters deep. (3) *Aviculopecten* sp. was transported into the area from a deep water and/or non-turbulent environment and has little direct bearing on the interpretation of Crouse Limestone depositional environments in this area. (4) Despite hard part morphological similarities *Argopecten gibbus* and *Aviculopecten* sp. differ biologically and cannot be meaningfully compared. The first two interpretations depend on *Aviculopecten* sp. being buried at or near the spot where it lived. The conclusion was reached earlier in this report that most organisms on lower limestone bedding surfaces probably lived very close to the spot where they were buried. It seems unlikely that a single species could be transported into an area while the remainder of the assemblage was not noticably affected. Nevertheless, high fragmentation of *Aviculopecten* sp. (41.7 percent compared to 20.3 percent for the entire assemblage) may be an indication of transportation (Johnson, 1960).

Orientation data indicate that Aviculopecten sp. along with other taxa was wave-oriented (Pearson, 1972). However, mere shifting of the shell's position may produce orientation without any significant transportation. A shallow water environment with low turbulence is consistent with other lines of evidence and, I believe, is the correct interpretation.

SUMMARY

The Crouse Limestone is interpreted as a regressive carbonate tidal flat sequence. Characteristics of the lower limestone fossil assemblages are (1) high diversity, (2) wide size range of individuals, and (3) many macroscopic invertebrates compared to the overlying parts of the Crouse. All these are typical of subtidal environments. Bioturbation, a mixed marine and freshwater assemblage, and dolomite are evidence for a low to high intertidal environment of deposition for the middle shale. A high intertidal to supratidal environment for the upper limestone is suggested by (1) laminated algal stromatolites, (2) low species diversity, (3) low abundance of individuals, (4) mudcracks, (5) dolomite, and (6) vertical burrows.

This tidal flat environment was probably protected from the open ocean to the west, perhaps by the Abilene Anticline. It was certainly a low energy environment as shown by (1) laminar growth form of stromatolites, (2) the occurrence of Permophorus cf. P. subcuneatus, an endobyssate bivalve, and (3) carbonate mud.

Dolomite rhombs or evidence of dedolomitization and gypsum crystals were found in the middle shale and upper limestone at all localities. Both minerals occur in a high intertidal to supratidal environment of deposition and they may have formed contemporaneously. The processes of dedolomitization

and gypsum dissolution took place during late diagenesis and may be related.

Apparent inconsistencies in the northern part of the area (sections N and O) were found to be due to erroneous stratigraphic correlation. Examination of the outcrops and establishment of the proper stratigraphic relationships revealed that they support a regressive carbonate tidal flat environment.

The units above the erosional surface at section Q are also consistent with a regressive tidal flat sequence. They represent deposition in a tidal channel and tidal pond or swamp environments which are certain to exist on a tidal flat.

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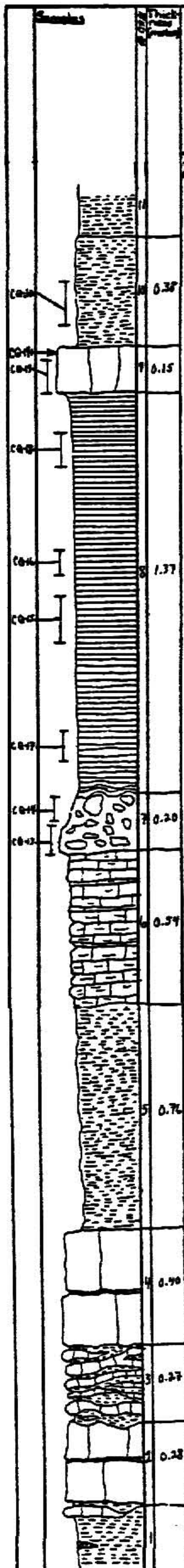
APPENDIX I

This appendix contains measured sections each of which includes (1) descriptions of each unit measured, (2) thickness of each unit, (3) graphic section, and (4) the locations of all samples collected. The location of each sample is indicated on the graphic section by an arrow or bracket. The positions of slabs that were collected for bedding surface mapping are shown by a "B" with the number of the surface shown in parentheses.

Example of numbering system:

CX-3 = Crouse Limestone, Section X, the third sample collected at that exposure.

Some samples were split into an upper and lower part after being collected and the upper was designated by a "+" (e.g. CQ-19+).



Scale: 1:23

SEC. 26 T 11 S R 6 E COUNTY: Geary STATE: Ks. LOC. NO. Q_1

LOC. DESC.: Roadcut on both sides of road

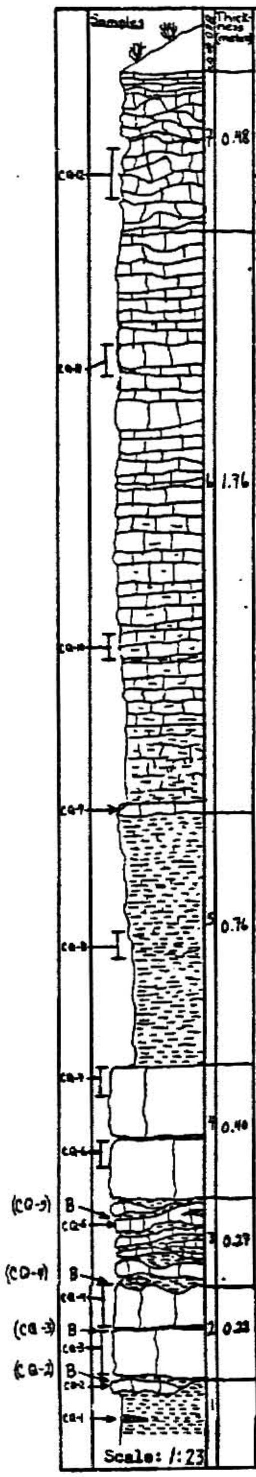
TOPO. QUAD.: Ogden, 7.5' MEASURED BY: R. L. Voran

DATE: 2/2/77 ELEV.: 1080' at base

RMKS.: 74 feet east of section Q_2

BED NO.	DESCRIPTION
11	Blue Rapids Shale above.
10	Calcareous mudstone, fine silty texture, thin and irregular bedding, shaly fracture, greatest thickness is directly above the position of the deepest cut of the erosional surface, medium dark gray (N4) through dusky yellow (5Y6/4) to grayish orange (10YR7/4), weathers yellowish gray (5Y7/2), poor outcrop, upper contact gradational, lower contact distinct, no fossils.
9	Argillaceous carbonate mudstone, uneven bedding, slabby to blocky fracture, greatest thickness is directly above the position of the deepest cut of the erosional surface; contains limestone clasts from 1 mm. to 8 mm. in size and pieces of charcoal of the same size; good outcrop, lower contact distinct, medium gray (N5) to dusky yellow (5Y6/4), weathers to grayish orange (10YR7/4), no fossils.
8	Black shale, fine silt to clay texture, laminated bedding, fissile, grayish black (N2), weathers dark gray (N3), near top grading to grayish brown (5YR3/2) which weathers same, poor outcrop, lower contact distinct one or two thin (~5mm. thick) non-persistent beds of coal may be present near middle of bed; bedding at base may be contorted around clasts protruding from underlying bed, fossils include plant debris and ostracodes, greatest thickness is directly above the position of the deepest cut of the erosional surface.
7	Intraclastic grainstone, coarse sandy to pebbly texture, uneven bedding, blocky to chunky fracture, intraclasts are laminated argillaceous carbonate mudstone, evidently beds #6 and #7; size of intraclasts is from 0.2 cm. to 15.0 cm.; thickness is greatest directly above the deepest cut of the erosional surface; dark yellowish orange (10YR6/6), weathers grayish orange (10YR7/4), poorly cemented except at thickest points where the lower part (~15 cm.) is very well cemented by sparry calcite, outcrop ranges from poor to good depending on degree of cementation, lower contact distinct, no fossils.
6	Argillaceous carbonate mudstone, laminated bedding, becomes wavy near top, platy fracture, mottled, becomes less argillaceous upward, yellowish gray (5Y7/2) to medium gray (N5), weathers same, yellowish gray becomes the dominant color upward, moderately good outcrop, lower contact gradational, no fossils.
5	Calcareous mudstone, fine silty texture, laminated bedding, thin platy fracture, weathers shaly, mottled, medium gray (N5), weathers medium light gray (N6) to yellowish gray (5Y7/2), moderately poor outcrop, lower contact distinct and even, no fossils.
4	Skeletal carbonate mudstone, uneven bedding, blocky fracture, mottled, ferruginous, grayish orange (10YR7/2) to pale grayish orange (10YR7/4), consists of two limestones separated by shale parting, porous, especially lower limestone, good outcrop, lower contact distinct and uneven, fossils include gastropods and some bivalves, many replaced by iron oxide.
3	Skeletal carbonate mudstone, undulatory bedding of four to seven limestone units with shale partings, slabby to chunky fracture, slightly vuggy, ferruginous, yellowish gray (5Y7/2), weathers pale yellowish orange (10YR8/6), poor outcrop, lower contact distinct and uneven, fossils include gastropods and bivalves, especially <u>Permophorus</u> and pyramidellids with gastropods becoming more abundant upward.
2	Skeletal carbonate mudstone, consists of two limestones 12-14 cm thick with a discontinuous limestone (8 cm thick) below, shale partings present in bedding planes, bedding surfaces may contain a 2-4 mm thick layer of gypsum, gypsum is also present in a zone 1 cm thick within 12 cm of the base in the bed below, very uneven bedding, slabby to blocky fracture, yellowish gray (5Y7/2), weathers grayish orange (10YR7/4), moderately good outcrop, lower contact distinct and uneven, fossils are dominantly bivalves and are more abundant upward.
1	Easly Creek Shale below.

TOTAL THICKNESS = 4.35 m (14.3 ft)



SEC. 26 T 11S R 6 E COUNTY: Geary STATE: Ks LOC. NO. Q2

LOC. DESC.: Roadcut on both sides of road

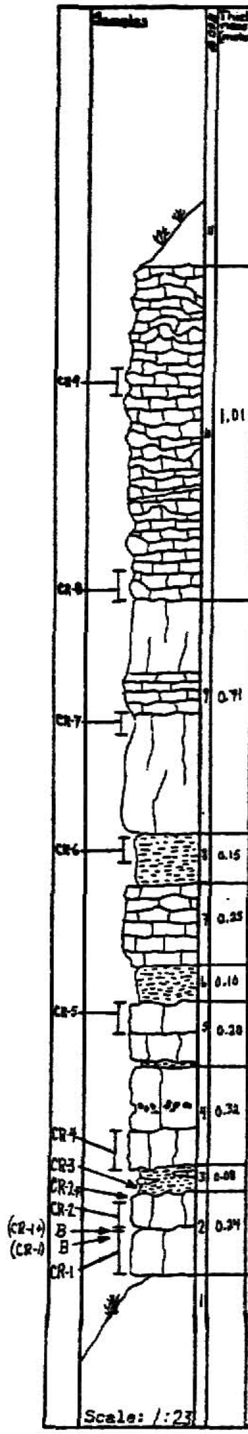
TOPO. QUAD.: Ogden, 7.5' MEASURED BY: R. L. Voran

DATE: 2/2/77 ELEV.: 1080' at base

RMKS.: 74 feet west of section Q1

BED NO.	DESCRIPTION
8	Covered above
7	Argillaceous carbonate mudstone, laminated, wavy bedding, platy fracture, stromatolitic, light olive gray (5Y6/1), weathers yellowish gray (5Y8/1), upper 10-12 cm. grades from yellowish gray (5Y8/1) through grayish yellow (5Y8/4) to pale yellowish orange (10YR8/6), moderate outcrop, lower contact gradational, upper contact erosional, no fossils.
6	Argillaceous carbonate mudstone, laminated bedding, becomes wavy near top, platy fracture, mottled, becomes less argillaceous upward, yellowish gray (5Y7/2) to medium gray (N5), weathers same, yellowish gray becomes the dominant color upward, stromatolitic, moderately good outcrop, lower contact gradational, no fossils.
5	Calcareous mudstone, fine silty texture, laminated bedding, thin platy fracture, weathers shaly, mottled, medium gray (N5), weathers medium light gray (N6) to yellowish gray (5Y7/2), moderately poor outcrop, lower contact distinct and even, no fossils.
4	Skeletal carbonate mudstone, uneven bedding, blocky fracture, mottled, ferruginous, grayish orange (10YR7/4) to pale grayish orange (10YR7/2), weathers pale yellowish brown (10YR6/2) to grayish orange (10YR7/4), consists of two limestones separated by shale parting, porous, especially lower limestone, good outcrop, lower contact distinct and uneven, fossils include gastropods and some bivalves, many replaced by iron oxide.
3	Skeletal carbonate mudstone, undulatory bedding of four to seven limestone units with shale partings, slabby to chunky fracture, slightly vuggy, ferruginous, yellowish gray (5Y7/2) weathers pale yellowish orange (10 YR8/6), poor outcrop, lower contact distinct and uneven, fossils include gastropods and bivalves, especially <u>Permophorus</u> and pyramidellids with gastropods becoming more abundant upward.
2	Skeletal carbonate mudstone, consists of two limestones 12-14 cm thick with a discontinuous limestone (8 cm thick) below, shale partings present in bedding planes, bedding surfaces may contain a 2-4 mm thick layer of gypsum, gypsum is also present in a zone 1 cm thick within 12 cm of the base in the bed below, very uneven bedding, slabby to blocky fracture, yellowish gray (5Y7/2), weathers grayish orange (10YR7/4), moderately good outcrop, lower contact distinct and uneven, fossils are dominantly bivalves and are more abundant upward.
1	Easly Creek Shale below.

TOTAL THICKNESS = 3.95 m. (13.0 ft.)



SEC. 1 **T** 12 S **R** 7 E **COUNTY:** Geary **STATE:** Ks. **LOC. NO.** R

LOC. DESC.: Roadcut on north side of McDowell Cr. Road.

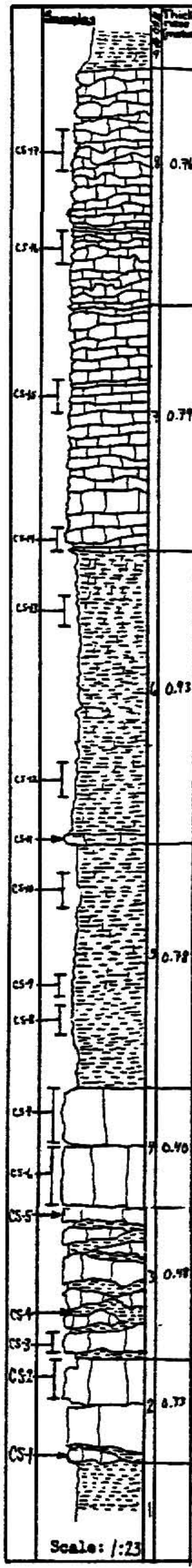
TOPO. QUAD.: Swede Creek, 7.5' **MEASURED BY:** R. L. Voran

DATE: 1/27/77 **ELEV.:** 1190' at base

RMKS.:

BED NO.	DESCRIPTION
11	Covered above
10	Argillaceous carbonate mudstone, laminated, wavy bedding, platy fracture, stromatolitic, dark yellowish gray (5Y6/2), weathers very pale yellowish brown (10YR7/2), moderately poor outcrop, upper contact erosional, lower contact gradational, no fossils.
9	Argillaceous carbonate mudstone, laminated, slightly wavy bedding, fresh surface massive but weathers platy, stromatolitic, very pale orange (10YR8/2) to yellowish gray (5Y7/2), weathers same, good outcrop, lower contact gradational, no fossils.
8	Calcareous mudstone, fine silty texture, laminated, uneven bedding, thin platy fracture, grayish orange (10YR7/4), weathers to very pale orange (10YR8/2), very poor outcrop, lower contact gradational, no fossils.
7	Argillaceous carbonate mudstone, laminated, slightly wavy bedding, platy fracture, olive gray (5Y4/1) to yellowish gray (5Y7/2), weathers light olive gray (5Y6/1), moderately good outcrop, lower contact gradational, no fossils.
6	Calcareous mudstone, fine silty texture, laminated, uneven bedding, shaly fracture, grayish orange (10YR7/4), weathers very pale orange (10YR8/2), lower contact distinct, very poor outcrop, slightly less calcareous than bed #8, no fossils.
5	Skeletal carbonate mudstone, blocky, ferruginous, porous zone near center with iron oxide filling voids, light olive gray (5Y5/2) to pale yellowish orange (10YR8/6), weathers yellowish gray (5Y7/2) to very pale orange (10YR8/2), good outcrop, lower contact distinct and uneven, skeletal fragments include gastropods with some bivalves.
4	Skeletal carbonate mudstone, blocky, lower part dense, upper part vuggy, ferruginous, light olive gray (5Y5/2) to grayish orange (10YR7/4), weathers yellowish gray (5Y7/2) to very pale orange (10YR8/2), moderately good outcrop, lower contact distinct and uneven, skeletal fragments are gastropods and bivalves and are smaller than in beds above and below (<6mm).
3	Calcareous mudstone, fine silty texture, thin and irregular bedding, shaly fracture, yellowish gray (5Y7/2) to grayish orange (10YR7/4), weathers same, poor outcrop, lower contact distinct and and uneven, contains two thin (3/4") and discontinuous limestone beds, limestones contain bivalves and gastropods, no fossils in mudstone.
2	Skeletal carbonate mudstone, blocky, dense, very pale yellowish brown (10YR7/2) to light olive gray (5Y6/1), weathers yellowish gray (5Y7/2), moderately good outcrop, lower contact distinct and uneven, fossils include bivalves, gastropods, ostracodes, algae.
1	Covered below

TOTAL THICKNESS = 3.12 m. (10.2 ft)



SEC. 27 T 11 S R 6 E COUNTY: Geary STATE: Ks LOC. NO. 8

LOC. DESC.: Roadcut on east side of road and adjacent stream cut.

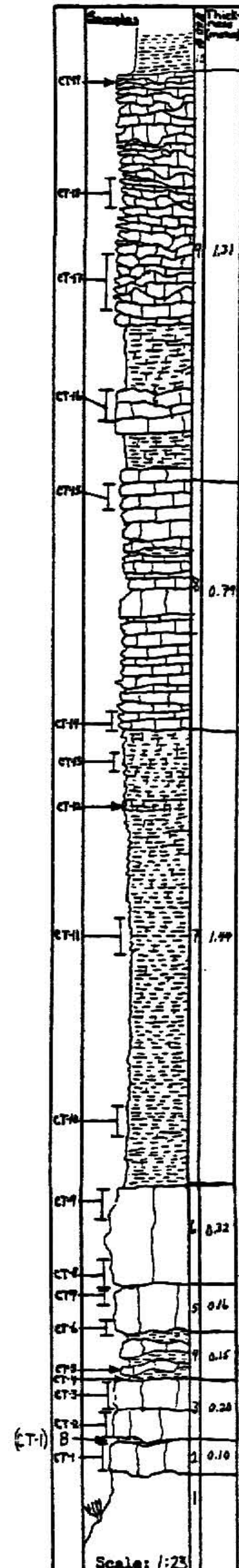
TOPO. QUAD.: Ogden, 7.5' MEASURED BY: R. L. Voran

DATE: 2/15/77 ELEV.: 1070' at base

RMKS.:

BED NO.	DESCRIPTION
9	Blue Rapids Shale above.
8	Argillaceous carbonate mudstone, laminated, wavy bedding, platy fracture, contorted, bioturbated with both horizontal and vertical burrows, yellowish gray (5Y8/1), weathers light olive gray (5Y6/1), poor outcrop, both upper and lower contacts gradational, no fossils
7	Argillaceous carbonate mudstone, laminated, slightly wavy bedding, fresh surface appears massive, but weathered and fractured appearance is platy, vuggy with some vugs containing a few small (1mm.) gypsum crystals, molds of gypsum crystals occur from 25 cm above base upward, light olive gray (5Y5/2) to grayish orange (10YR7/4), weathers very pale orange (10YR8/2) to yellowish gray (5Y7/2), moderately good outcrop, lower contact gradational, no fossils.
6	Calcareous mudstone, fine silty texture, laminated with irregular bedding, thin platy fracture becoming more platy upward, mottled, olive gray (5Y4/2) to yellowish gray (5Y7/2), weathers same, olive gray color dominates lower part with upper part mainly yellowish gray, moderately poor outcrop, lower contact gradational and marked by the base of a 5 cm. thick more calcareous unit (limestone), top of bed is marked by a more calcareous unit with slightly wavy laminations, no fossils.
5	Calcareous mudstone, fine silty texture, thin and irregular bedding, thin platy fracture, olive gray (5Y4/1), weathers light olive gray (5Y6/1), poor outcrop, lower contact distinct but slightly gradational, 8 cm. thick limestone unit is present 30 cm. above base of bed, no fossils.
4	Skeletal carbonate mudstone, two limestones of nearly equal thickness with shale parting between, blocky fracture, ferruginous especially upper part, lower part vuggy, light olive gray (5Y6/1) to grayish orange (10YR7/4), weathers yellowish gray (5Y7/2), good outcrop, lower contact distinct and uneven, fossils include bivalves and gastropods.
3	Skeletal carbonate mudstone, four to eight limestones separated by shale partings up to 3 cm. thick, bedding undulatory, slabby fracture for limestones; mudstones shaly, ferruginous, limestone color light olive gray (5Y6/1), weathers yellowish gray (5Y7/2); color of mudstone medium gray (N5) to yellowish-orange (10YR7/6), weathers same, limestones are not laterally persistent, moderately poor outcrop, lower contact distinct and uneven, fossils include bivalves and gastropods with gastropods becoming more abundant upward.
2	Skeletal carbonate mudstone, bedding uneven with shale partings in bedding planes, slabby below becoming blocky upward, lower part dense becoming porous upward, olive gray (5Y4/1), weathers light olive gray (5Y6/1), good outcrop, lower contact distinct and undulatory, slightly ferruginous, variation in thickness due to discontinuous occurrence of lowermost limestone, fossils include bivalves with a few gastropods.
1	Easly Creek Shale below

TOTAL THICKNESS = 4.47 m (14.7 ft.)



SEC. 12 T 12 S R 6 E COUNTY: Geary STATE: Ks LOC. NO. 7

LOC. DESC.: Stream cut, west bank of Humboldt Creek.

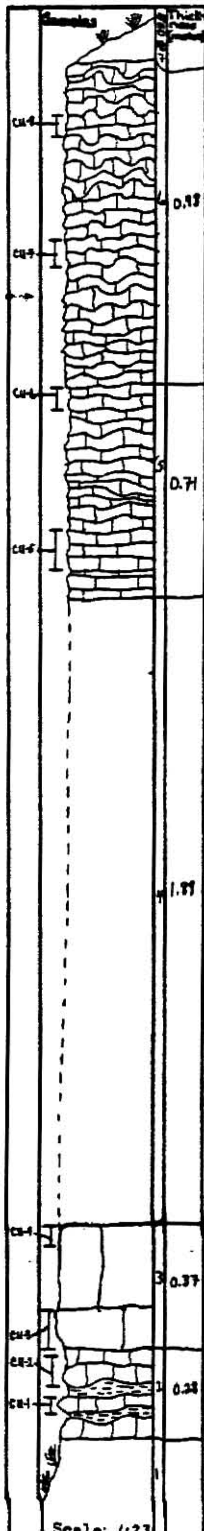
TOPO. QUAD.: Ogden, 7.5' MEASURED BY: R. L. Voran

DATE: 2/17/77 ELEV.: 1120' at base

RMKS.:

BED NO.	DESCRIPTION
10	Blue Rapids Shale above
9	Argillaceous carbonate mudstone, laminated with wavy and contorted bedding, platy to chunky fracture, many shale partings, porous, bioturbated with both vertical and horizontal burrows, greenish gray (5GY6/1) to yellowish gray (5Y8/1), weathers light olive gray (5Y6/1), moderately poor outcrop, both upper and lower contacts gradational, no fossils.
8	Argillaceous carbonate mudstone, laminated with slightly wavy bedding, platy fracture, very pale orange (10YR8/2) to pale yellowish brown (10YR6/2), weathers yellowish gray (5Y7/2), moderately good outcrop, lower contact gradational, gypsum crystal molds present upward from 20 cm. above base, no fossils.
7	Calcareous mudstone, fine silty texture, laminated with thin and irregular bedding, shaly fracture becoming thin platy upward, mottled, medium light gray (N6) to yellowish gray (5Y8/1), weathers same, yellowish gray the dominant color, increasingly calcareous upward, moderately poor outcrop, lower contact distinct but slightly gradational, a 9 cm thick more resistant calcareous unit is present 20 cm above base, no fossils.
6	Skeletal carbonate mudstone, massive to blocky, ferruginous, esp. a zone about 20 cm above base of bed, increasingly argillaceous upward, dark yellowish orange (10YR6/6) through grayish orange (10YR7/4) to yellowish gray (5Y7/2) to olive gray (5Y4/1), weathers light olive gray to grayish orange (10YR7/4), good outcrop, lower contact distinct and uneven, fossils include gastropods with some bivalves, many gastropods replaced by iron oxide.
5	Skeletal carbonate mudstone, bedding uneven, blocky to slabby fracture, shale parting 10 cm above base, pale yellowish orange (10YR8/6) through yellowish gray (5Y7/2) to light olive gray (5Y6/1), weathers very pale orange(10YR8/2) to grayish orange (10YR7/4), ferruginous, moderate outcrop, lower contact distinct and undulatory, fossils include bivalves and gastropods and are patchily distributed.
4	Calcareous mudstone, consists of three mudstones with two intervening limestones, thicknesses of individual units varies considerably, but units are laterally persistent, bedding undulatory, mudstone has shaly fracture and is thin bedded, limestones slabby, color of mudstone olive gray (5Y4/1) to light olive gray (5Y5/2), weathers yellowish gray (5Y7/2) to light olive gray (5Y5/2), limestone color light olive gray (5Y6/1) to pale yellowish brown (10YR6/2), weathers very pale orange (10YR8/2) to grayish orange (10YR7/4), moderately poor outcrop, lower contact distinct and uneven, mudstone texture fine silty, limestones argillaceous, fossils in limestones include bivalves and gastropods and are less abundant than in underlying beds.
3	Skeletal carbonate mudstone, uneven bedding, blocky fracture, vuggy, increasingly so upward, light olive gray (5Y6/1) to very pale orange (10YR7/4), weathers grayish orange (10YR7/4) to yellowish gray (5Y7/2), moderately good outcrop, lower contact distinct and uneven, fossils include bivalves with some gastropods.
2	Skeletal carbonate mudstone, uneven bedding, slabby fracture, ferruginous, shale parting at top of unit, light olive gray (5Y6/1) to grayish orange (10YR7/4), weathers light olive gray (5Y6/1) to very pale orange (10YR8/2), moderately good outcrop, lower contact undulatory, fossils are mainly bivalves.
1	Covered below.

TOTAL THICKNESS = 4.47 m. (14.7 ft.)



SEC. T 11 S R 6 E **COUNTY:** Riley **STATE:** Ks. **LOC. NO.** U-1

LOC. DESC.: Trail cut in side of hill, west side of trail.

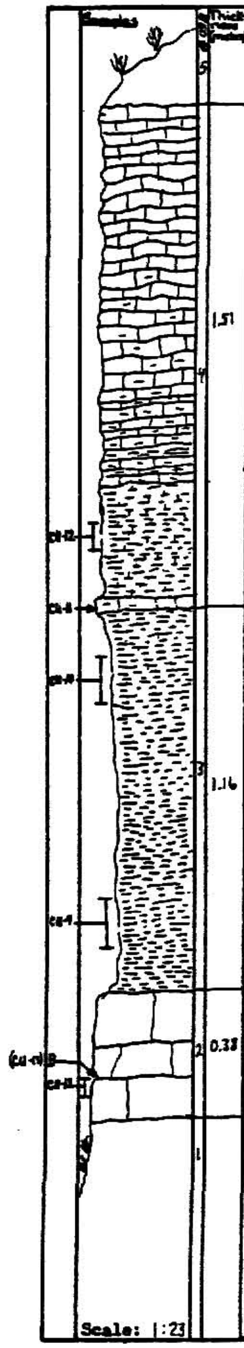
TOPO. QUAD.: Ogden, 7.5' **MEASURED BY:** R. L. Voran

DATE: 3/5/77 **ELEV.:** 1080' at base

RMKS.: 2700' due south and 150' due west of the southwest corner of Sec. 1, R6E, T11S, Riley Co., Ks.

BED NO.	DESCRIPTION
7	Covered above.
6	Argillaceous carbonate mudstone, bedding wavy, uneven, and contorted platy fracture, bioturbated with both vertical and horizontal burrows, very light gray (N8) to yellowish gray (5Y8/1) with spots of light greenish gray (5GY8/1) and grayish yellow (5Y8/4), moderately poor outcrop, lower contact gradational, upper contact distinct, some solution cavities present along bedding, no fossils.
5	Argillaceous carbonate mudstone, laminated with slightly wavy bedding, platy fracture, dense, yellowish gray (5Y7/2) to light olive gray (5Y5/2), weathers same, good outcrop, lower contact gradational, gypsum crystal molds occur from 15 cm. above base upward, no fossils.
4	Covered, mudstone (?)
3	Skeletal carbonate mudstone, massive with uneven bedding, large blocky fracture, ferruginous, especially upper part, middle zone vuggy, dark yellowish gray (10YR6/6) to light olive gray (5Y5/2), weathers grayish orange (10YR7/4) to very pale orange (10YR8/2), good outcrop, lower contact uncertain, bedding plane 10 cm. above base with many small (≤ 5-6 mm.) gypsum crystal molds, fossils include bivalves and gastropods and become more abundant upward.
2	Skeletal carbonate mudstone, undulatory bedding, slabby to chunky fracture, somewhat porous, slightly ferruginous, grayish yellow (5Y8/4) to olive gray (5Y7/2), weathers yellowish gray (5Y7/2), consists of a sequence of beds 2-5 cm thick with shale partings, poor outcrop, lower contact uneven and indistinct, fossils include bivalves and gastropods.
1	Covered below

TOTAL THICKNESS = 4.23 m (13.9 ft.)



SEC. T 11 S R 6 E **COUNTY:** Riley **STATE:** Ks **LOC. NO.** U-2

LOC. DESC.: Roadcut on the east side of Engineer Road

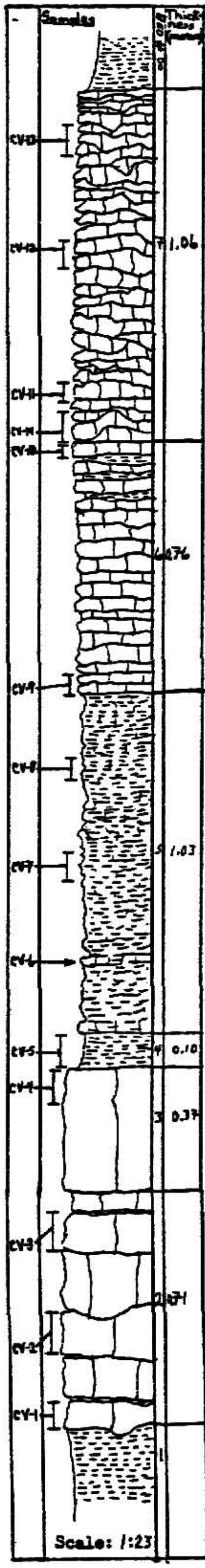
TOPO. QUAD.: Ogden, 7.5' **MEASURED BY:** R. L. Voran

DATE: 3/5/77 **ELEV.:** 1080' at base

RMKS.: 2050' due east and 1120' due south of southwest corner of Sec. 1, T11S, R6E, Riley Co., Ks.

BED NO.	DESCRIPTION
5	Covered above
4	Argillaceous carbonate mudstone, thin, even bedding, platy fracture, yellowish gray (5Y7/2) to light olive gray (5Y5/2), weathers same, moderate outcrop, upper contact erosional, lower contact gradational, base is marked by a 2-3 cm thick more calcareous, resistant bed and 28 cm above that is a more argillaceous bed, thus contact could be placed higher, no fossils.
3	Calcareous mudstone, laminated, thin bedded, shaly fracture, fine silty texture, light grayish orange (10YR8/4) to olive gray (5Y4/1), weathers yellowish gray (5Y7/2) to light olive gray (5Y5/2), poor outcrop, lower contact distinct but slightly gradational, no fossils.
2	Skeletal carbonate mudstone, uneven bedding, blocky fracture, ferruginous, dark yellowish gray (10YR6/6) to light olive gray (5Y5/2), weathers grayish orange (10YR7/4), good outcrop, lower contact not exposed, fossils include <u>Permophorus</u>, pyramidellids, and <u>Aviculopecten</u>.
1	Covered below.

TOTAL THICKNESS = 3.05 m. (10.0 ft.)



SEC. 1 T 10 S R 6 E COUNTY: Riley STATE: Ks LOC. NO. V

LOC. DESC.: Stream cut, south bank of Wildcat Creek.

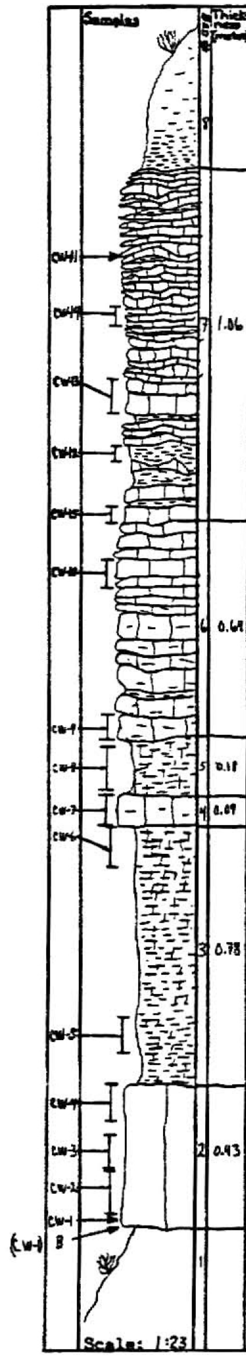
TOPO. QUAD.: Keats, 7.5' MEASURED BY: R. L. Voran

DATE: 3/24/77 ELEV.: 1105' at base

RMKS.:

BED NO.	DESCRIPTION
8	Blue Rapids Shale above.
7	Argillaceous carbonate mudstone, laminated, wavy, contorted bedding, platy to thin platy fracture, stromatolitic, vuggy, light gray (N7) to light greenish gray (5GY8/1), weathers yellowish gray (5Y8/1), moderately good outcrop, some porosity developed along bedding, lower and upper contacts gradational, a few small (<8 mm) *Permophorus*? on some bedding surfaces.
6	Argillaceous carbonate mudstone, laminated, even bedding, several shale partings near top, platy fracture, mottled, olive gray (5Y4/1) and yellowish gray (5Y7/2), weathers yellowish gray (5Y7/2), moderately good outcrop, becomes more blocky near top, dense, lower contact gradational, stromatolitic, bedding becomes slightly wavy near top, no fossils.
5	Calcareous mudstone, thin (<2 cm) bedding, laminated, thin platy fracture, becomes platy near top, mottled, olive gray (5Y4/1) and yellowish gray (5Y7/2), weathers, olive gray dominates lower part and upper part is mainly yellowish gray, moderately poor outcrop, lower contact sharp, no fossils.
4	Calcareous mudstone, more argillaceous than overlying bed, very thin bedded, shaly fracture, yellowish gray (5Y7/2), weathers same, fine silty texture, poor outcrop, lower contact sharp and undulatory, no fossils.
3	Skeletal carbonate mudstone, a single bed, blocky fracture, vuggy, ferruginous, especially vugs many of which are filled with iron oxide, grayish orange (10YR7/4) to light olive gray (5Y6/1), weathers yellowish gray (5Y7/2), good outcrop, lower contact distinct and undulatory, becomes more argillaceous upward, fossils are mainly gastropods with some bivalves, some fossils replaced by iron oxide.
2	Skeletal carbonate mudstone, bedding uneven and undulatory, slabby fracture, ferruginous, beds of limestone separated by shale partings, limestones become thinner upward, vuggy with many vugs partly filled by iron oxide, olive gray (5Y4/1) to pale yellowish orange (10YR8/6), weathers grayish orange (10YR7/4) to yellowish gray (5Y7/2), moderately good outcrop, lower contact distinct and undulatory, fossils include bivalves, gastropods, and ?phylloid algae, bivalves most abundant in lower part and gastropods more abundant near top, fossils patchily distributed near top.
1	Easly Creek Shale below.

TOTAL THICKNESS = 4.03 m. (13.2 ft.)



SEC. 1 T 8 S R 7 E COUNTY: Pott. STATE: Ks. LOC. NO. V

LOC. DESC.: East bank of Carnahan Cr. just above fork

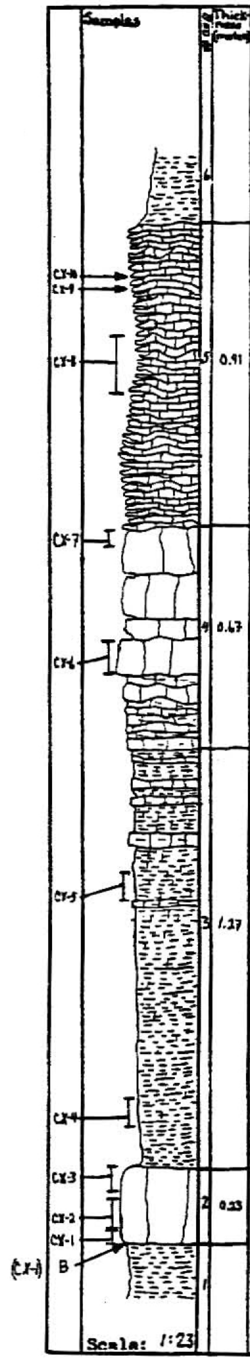
TOPO. QUAD.: Olsburg, 7.5' MEASURED BY: R. L. Voran

DATE: 4/1/77 ELEV.: 1186' at base

RMKS.:

BED NO.	DESCRIPTION
8	Blue Rapids Shale above.
7	Argillaceous carbonate mudstone, laminated, wavy, contorted bedding, platy fracture to thin platy near top, grayish orange (10YR7/4) to grayish yellow green (5GY7/2), weathers yellowish gray (5Y7/2) to very pale orange (10YR8/2), moderately poor outcrop, both upper and lower contacts uneven and gradational, slightly ferruginous, bioturbated, no fossils.
6	Argillaceous carbonate mudstone, laminated, smooth, even bedding, slightly wavy near top, platy fracture, yellowish gray (5Y7/2), weathers same, lower contact gradational, moderately good outcrop, slightly ferruginous, stromatolitic, no fossils.
5	Calcareous mudstone, uneven and irregular bedding, platy to chunky fracture, this unit cannot be distinguished in less weathered parts of the outcrop, yellowish gray (5Y7/2), weathers same, moderately poor outcrop, lower contact gradational, fine silty texture, gypsum crystal molds present in lower 5 cm., no fossils.
4	Argillaceous carbonate mudstone, laminated, smooth, even bedding, platy fracture, yellowish gray (5Y7/2), weathers same, moderate outcrop, lower contact gradational, no fossils.
3	Calcareous mudstone, thin, irregular bedding, irregular, conchoidal to shaly fracture, fine silty texture, mottled olive gray (5Y4/1) and yellowish gray (5Y7/2), weathers yellowish gray (5Y7/2), lower part dominantly olive gray and upper part mainly yellowish gray, poor outcrop, lower contact distinct, no fossils.
2	Skeletal carbonate mudstone, a single bed of limestone, large blocky fracture, ferruginous near top, medium light gray (N6) through pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6) near top, weathers pale yellowish brown (10YR6/2) to yellowish gray (5Y7/2), good outcrop, lower contact distinct, gypsum crystal molds present within 2 cm of base, very discontinuous argillaceous patches (lens-shaped) with no visible fossils are present scattered throughout unit—mainly the middle 70%, they are up to 4 cm thick, a few small (2 cm) solution cavities in upper half of unit, fossils include gastropods (pyramidellids and others) and bivalves (*Aviculopecten*, *Permophorus*, and others).
1	Covered below.

TOTAL THICKNESS = 3.18 m. (10.4 ft.)



SEC. 9 T 6 S R 8 E COUNTY: Pott. STATE: Ks. LOC. NO. X

LOC. DESC.: Roadcut on both sides of road just west of creek.

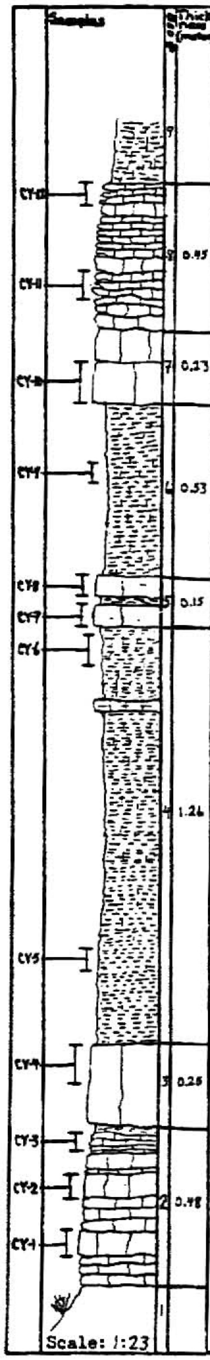
TOPO. QUAD.: Blue Rapids SE, 7.5' MEASURED BY: R.L. Voran

DATE: 4/7/77 ELEV.: 1220' at base

RMKS.:

BED NO.	DESCRIPTION
6	Blue Rapids Shale above.
5	Argillaceous carbonate mudstone, laminated, wavy bedding, platy to thin-platy fracture, stromatolitic, yellowish-gray (5Y8/1) to light gray (N7), weathers yellowish gray (5Y7/2) to very pale orange (10YR8/2), poor outcrop, both upper and lower contacts gradational, bioturbated with horizontal and a few vertical burrows, small (≤7mm) *Permophorus* occur as molds on some surfaces, mudcracks.
4	Argillaceous carbonate mudstone, laminated, wavy, irregular bedding, platy to slabby fracture, stromatolitic, ferruginous, grayish yellow (5Y8/4) to light olive gray (5Y6/1), weathers yellowish gray (5Y7/2) to medium light gray (N6), moderately good outcrop, lower contact gradational, vuggy, gypsum crystal molds scattered throughout unit, no fossils.
3	Calcareous mudstone, thin, irregular bedding, shaly to thin-platy fracture, becomes more calcareous upward with a few limestone beds present near top, yellowish gray (5Y7/2), weathers same, poor outcrop, lower contact distinct, gypsum crystal molds present throughout, no fossils.
2	Skeletal carbonate mudstone, a single bed, blocky fracture, ferruginous, especially upper half of unit, moderate yellowish brown (10YR5/4) through pale yellowish brown (10YR6/2) to light olive gray (5Y6/1), weathers dusky yellow (5Y6/4) to grayish orange (10YR7/4), good outcrop, lower contact distinct and even, gypsum crystals present at base of unit, fossils include gastropods and bivalves in lower third of unit and gastropods only in upper part, lower part of unit is more argillaceous with patches of skeletal remains, upper part has argillaceous areas within the dominant pyramidellid grainstone, fossils on the lower surface include *Aviculopecten*, *Septimyalina*, *Permophorus*, and others.
1	Easly Creek Shale below.

TOTAL THICKNESS = 3.08 m. (10.1 ft.)



SEC. 21 T 6 S R 7 E COUNTY: Riley STATE: Ks. LOC. NO. 7

LOC. DESC.: Roadcut on west side of unimproved road.

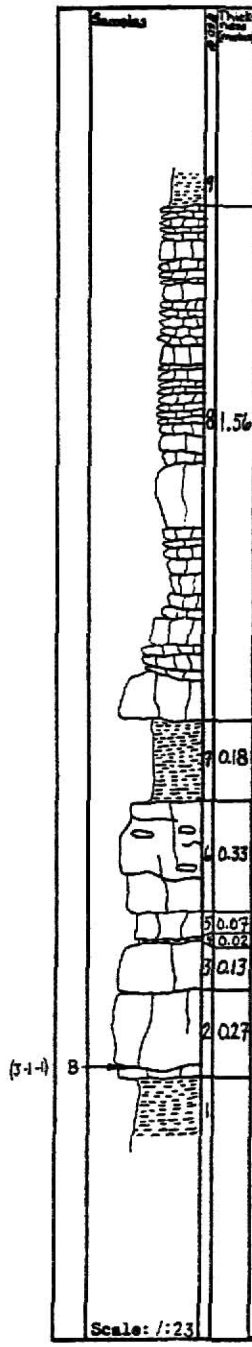
TOPO. QUAD.: Blue Rapids SW, 7.5' MEASURED BY: R.L. Voran

DATE: 4/8/77 ELEV.: 1126' at base.

RMKS.:

BED NO.	DESCRIPTION
9	Blue Rapids Shale above.
8	Argillaceous carbonate mudstone, laminated, wavy bedding, platy to slabby fracture, light olive gray (5Y6/1) to pale greenish yellow (10YR8/2), weathers same, moderate outcrop, both upper and lower contacts gradational with lower contact more gradational than upper, upper surface has pyramidellids and crinoids.
7	Argillaceous carbonate mudstone, uneven bedding, blocky fracture, vuggy, slightly ferruginous, wavy laminations, medium gray (N5) to dusky yellow (5Y6/4), weathers yellowish gray (5Y8/1), moderately good outcrop, lower contact distinct and undulatory, argillaceous patches scattered throughout unit, gypsum crystal molds present, no fossils.
6	Calcareous mudstone, irregular bedding, crumbly to shaly fracture, fine silty texture, yellowish gray (5Y8/1), weathers same, poor outcrop, lower contact distinct, no fossils.
5	Argillaceous carbonate mudstone, consists of two limestones with a shale parting about 2 cm thick, unit is not evident in less weathered parts of outcrop, smooth, even bedding, platy fracture, very pale orange (10YR8/2) to yellowish gray (5Y7/2), weathers same, moderate outcrop, lower contact distinct, no fossils.
4	Calcareous mudstone, thin, irregular bedding, conchoidal fracture, shaly when weathered, fine silty texture, yellowish gray (5Y7/2) to olive gray (5Y4/1), weathers yellowish gray (5Y7/2), moderately poor outcrop, lower contact distinct, more calcareous, resistant zone present with base 103 cm above base of unit, no fossils.
3	Skeletal carbonate mudstone, a single unit, blocky fracture, ferruginous, especially upper half of unit, upper 2 cm extremely argillaceous, dark yellowish orange (10YR6/6) to light olive gray (5Y5/2), weathers very pale orange (10YR8/2) to grayish orange (10YR7/4), good outcrop, lower contact gradational, argillaceous patches scattered throughout unit, especially lower 7 cm. and a 5 cm zone 12 to 17 cmabove base, gypsum crystal molds present 2 to 5 cm. below top of unit, fossils include bivalves and pyramidellids, many replaced with iron oxide.
2	Skeletal carbonate mudstone, slightly wavy bedding, slabby to platy fracture, pale yellowish brown (10YR6/2) to yellowish gray (5Y7/2), weathers yellowish gray (5Y7/2), moderate outcrop, lower contact distinct, ferruginous, skeletal grains are mainly bivalves and many are replaced by iron oxide, Aviculopecten near top of unit.
1	Covered below

TOTAL THICKNESS = 3.35 m. (11.0 ft.)



SEC. **T 11 S** **R 7 E** **COUNTY**: Geary **STATE**: Ks **LOC. NO.** J

LOC. DESC.: Roadcut on I-70, north side of road

TOPO. QUAD.: Swede Creek, 7.5' **MEASURED BY**: Jeppesen, Pearce, West

DATE: 1972 **ELEV.**: 1226' at base

RMKS.:

BED NO.	DESCRIPTION
9	Blue Rapids Shale above.
8	Thin to medium bedded laminated limestone; possible selenite molds, pelecypod shell fragments in upper part.
7	Blocky calcareous claystone.
6	Vuggy limestone.
5	Thin bed of limestone.
4	Shale parting.
3	Thin bed of limestone.
2	Gastropodal limestone, medium to thick bedded, bellerophontid.
1	Easly Creek Shale below.

TOTAL THICKNESS = 2.56 m. (8.4 ft)

Samples	Thickness
No Samples	

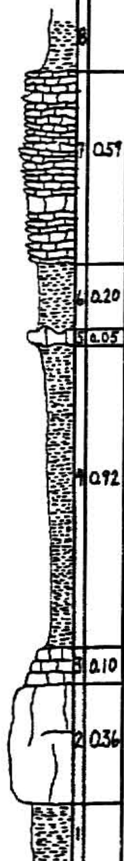
SEC. 6 T 5 S R 8 E COUNTY: Marshall STATE: Ks | LOC. NO. N

LOC. DESC.: Roadcut on east side of road

TOPO. QUAD.: Blue Rapids NE, 7.5' MEASURED BY: R. L. Voran

DATE: 6/14/77 ELEV.: 1145' at base

RMKS.:



BED NO.	DESCRIPTION
8	Blue Rapids Shale above.
7	Thin to medium bedded platy carbonate mudstone.
6	Medium gray calcareous mudstone.
5	Fine grained nodular carbonate mudstone.
4	Like Unit 6.
3	Thin, wavy bedded, platy gray argillaceous carbonate mudstone.
2	Medium to thick, dense crystalline skeletal carbonate mudstone.
1	Easly Creek Shale below.

Scale: 1:23

TOTAL THICKNESS = 2.22 m. (7.3 ft.)

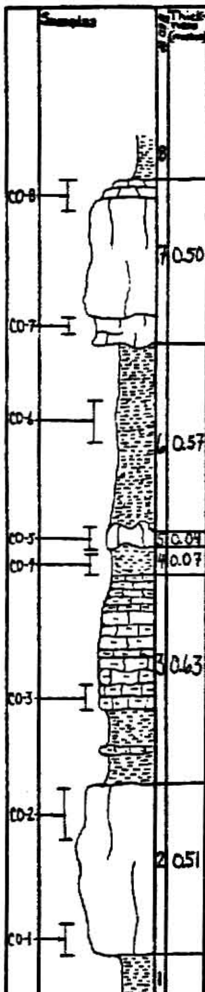
SEC. 21 T 4 S R 7 E COUNTY: Marshall STATE: Ks LOC. NO. 0

LOC. DESC.: Roadcut on west side of U.S. 77 north of Blue Rapids, Ks

TOPO. QUAD.: Blue Rapids, 7.5' MEASURED BY: Jeppesen, Lee, Pearce, West

DATE: 5/25/71 ELEV.: 1170 at base

RMKS.: Just northeast of the bridge over the Big Blue River



BED NO.	DESCRIPTION
8	Blue Rapids Shale above.
7	Light gray to whitish medium grained, algal coated grained, calcarenite at base grading upward to a fine grained algal coated grain calcarenite at top; thin to medium and thick wavy beds.
6	Medium to dark gray calcareous claystone.
5	Fine grained nodular carbonate mudstone.
4	Same as Unit 6.
3	Interbedded gray to brown (tan) calcareous platy shale and platy to thin wavy bedded argillaceous carbonate mudstone.
2	Brown, medium to thick bedded, dense crystalline foraminiferal (opthalmid) calcisiltite with stromatolitic-like (laminar) weathered surface.
1	Easly Creek Shale below.

Scale: 1:23

TOTAL THICKNESS = 2.32 m. (7.6 ft.)

APPENDIX II

Argillaceous (bag) samples were disaggregated and the residues examined for microfossils. The following pages contain lists of the microfossils identified in the washed residues. Locations of the samples are shown in Appendix I.

Sample	Taxa
Section O	
CO-4	healdiaceans, bairdiids
CO-6	healdiaceans
Section Q_1	
CQ-15	smooth-shelled ostracodes, plant debris, coal
CQ-16	smooth-shelled ostracodes, plant debris
CQ-17	*Spirorbis* sp., plant debris, charcoal, fish debris
CQ-18	smooth-shelled ostracodes, plant debris
CQ-20	fish debris, *Spirorbis* sp.
Section Q_2	
CQ-8	None
Section R	
CR-3	hollinids, healdiaceans, bairdiids, pyramidellids, *Earlandia*-like foraminifers, holothurian sclerites
CR-6	healdiaceans, hollinids, bairdiids?
Section S	
CS-4	hollinids, healdiaceans, bairdiids?, pyramidellids, holothurian sclerites, *Earlandia*-like foraminifers
CS-8	hollinids
CS-10	None
CS-12	None
CS-13	healdiaceans
Section T	
CT-4	pyramidellids, hollinids, healdiaceans, bairdiids, holothurian sclerites, *Earlandia*-like foraminifers
CT-10	healdiaceans
CT-11	None
CT-13	healdiaceans
Section U-2	
CU-9	hollinids, bairdiids?, healdiaceans, ammovertellids
CU-10	bairdiids?
CU-12	None
Section V	
CV-5	hollinids, healdiaceans, bairdiids?
Section W	
CW-6	hollinids, healdiaceans
CW-13	None
Section X	
CX-4	bairdiids, hollinids, healdiaceans
CX-5	healdiaceans

Sample	Taxa
Section Y	
CY-5	healdiaceans, bairdiids?
CY-6	None
CY-9	productacean spine

APPENDIX III

This appendix contains data from mapped bedding surfaces from the lower Crouse Limestone. It consists of (1) descriptions of fossils observed on these surfaces and (2) maps of the bedding surfaces showing the relative positions of fossils. The stratigraphic positions from which the slabs were collected are designated by a "B" and the number of the surface is given in parentheses on the measured sections (Appendix I). Two separate areas were mapped on surfaces CU-13 and CX-1 to obtain sufficient data. They are designated areas #1 and #2 (e.g. CX-1 Area #1). Some data from surface J-1-1 were lost and not all specimens could be identified by number. Some are identified only by a letter.

Fossil names are abbreviated and are listed below:

Abbreviation
Brachiopoda ling = Lingulid
Bivalvia Per = Permophorus cf. P. subcuneatus Avic = Aviculopecten sp. Acan = Acanthopecten sp. Pseu = Pseudomonotis sp. Sept = Septimyalina sp. Edm = Edmondia? sp.
Gastropoda Bell = Bellerophon sp. pyra = Pyramidellid
Echinodermata crin = Crinoid debris
Arthropoda ost = Ostracodes
alfr = Algal-coated fragment burr = Burrow unid = Unidentifiable

Fossil Size

The number in this column is the length in millimeters of *Permophorus* cf. *P. subcuneatus*. Size of other taxa was not measured.

Articulation = art

An x in this column indicates that the specimen was articulated.

Valve = val

The letter in this column indicates which valve of the organism was observed.

r = right valve
l = left valve
? = valve indeterminate

Preservation = pres

The following abbreviations are used for type of preservation:

o = original or altered shell
i = internal mold
e = external mold

Orientation = orient

Orientation of single valves was recorded. The following abbreviations are used to indicate orientation:

cu = concave up
cd = concave down
i = inclined to bedding

Fragmentation = frag

An x in this column indicates that the fossil was fragmented.

Epizoans = epiz

An x in this column indicates that epizoans were attached to the shell. The only epizoans observed were tubiform sedentary foraminifers and encrusting algae, usually intergrown in *Osagia* colonies.

THIS BOOK CONTAINS NUMEROUS PAGES THAT WERE BOUND WITHOUT PAGE NUMBERS.

THIS IS AS RECEIVED FROM CUSTOMER.

CQ-2

#	name	size	art	val	pres	orient	frag	epiz
1	Avic			?	o	cd	x	x
2	Avic			?	o	cd	x	
3	unid				o		x	
4	Per	--		r	i	cd	x	
5	ost			r	o	cu		
6	pyra				i		x	
7	Per	10.0		?	i	cd		
8	unid				o		x	x
9	Avic			l	o	cd		x
10	Per	--		?	i	cd	x	
11	Per	14.0		r	i	cd		
12	pyra				i			
13	Per	8.0		r	i	cd		
14	unid				o		x	
15	Per	18.0		l	i	cd		
16	ost			l	o	cu		
17	Per	18.0		l	i	cd		
18	pyra				i		x	
19	Avic			r	o	cd	x	x
20	pyra				i			
21	Avic			r	o	cd		x
22	Avic			r	o	cd		x
23	Not a fossil							
24	unid				o		x	
25	unid				o		x	x
26	unid				o		x	
27	Per	--		?	i	cd		
28	Acan			?	o	cd		
29	Avic			l	o	cd		x
30	Per	8.0		r	i	cd		
31	Per	10.0		?	i	cd		
32	Per	13.0		r	i	cd		
33	pyra				i			
34	Per	18.0		r	i	cd		
35	Per	10.0		r	i	cd		
36	pyra				i			
37	pyra				i		x	
38	pyra				i			
39	pyra				i			
40	Per	15.0		r	i	cd		
41	ost			l	o	cu		
42	ost			l	o	cu		
43	ost			r	o	cu		
44	Per	--		?	o	cd		
45	ost			r	o	cu		
46	ost			l	o	cu		
47	Sept			l	o	cd		
48	ost			l	o	cu		
49	ost			l	o	cu		
50	Sept			r	o	cd		
51	Per	--		?	i	cd		

CQ-2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Per	14.0		r	i	cd		
53	Avic			r	o	cd		x
54	unid				o		x	
55	Per	18.0		r	i	cd		
56	unid				o		x	
57	pyra				i			
58	Per	14.0		l	i	cd		
59	pyra				i			
60	unid				o		x	
61	Avic			l	o	cd		
62	Per	15.0		l	i	cd		
63	ost			r	o	cu		
64	ost			r	o	cu		
65	ost			l	o	cd		
66	ost			?	o	cd		
67	ost			l	o	cu		
68	Avic			l	o	cd		x
69	Avic			l	o	cd		
70	ost			r	o	cu		
71	Per	--		r	o	cd	x	
72	Avic			?	o	cd	x	x
73	pyra				i			
74	unid				o		x	
75	pyra				i			
76	unid				i	cd		
77	Per	11.0		l	i	cd		
78	Per	17.0		r	i	cd		x
79	Per	9.0		l	i	cd		
80	Per	8.0		l	i	cd		
81	unid				o		x	
82	Per	13.0		l	i	cd		
83	Avic			l	o	cd	x	
84	Per	15.0		l	i	cd		
85	unid				o		x	x
86	Avic			?	o	cd		x
87	pyra				i			
88	Avic			l	o	cd	x	
89	Per	9.0		r	i	cd		
90	pyra				i			
91	unid				o		x	
92	Sept			l	o	cd	x	
93	pyra				i			
94	Per	15.0		r	i	cd		
95	unid				o		x	
96	Per	15.0		l	i	cd		
97	pyra				i			
98	Avic			?	o	cd	x	x
99	Avic			?	o	cd	x	
100	Per	18.0		r	i	cd		x
101	Per	9.0		r	i	cd		
102	ost			r	o	cu		

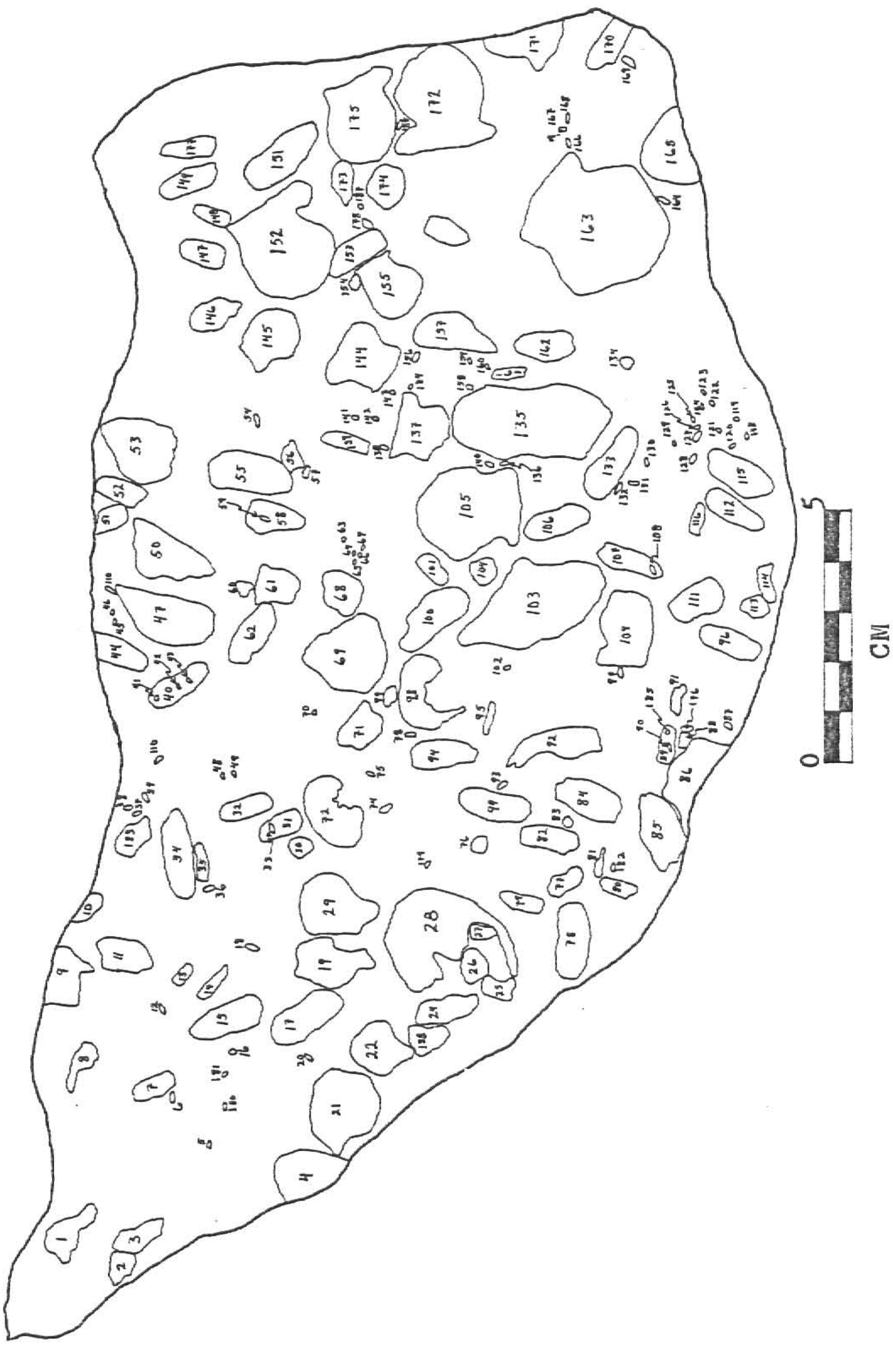
CQ-2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Sept			l	o	cd		
104	unid				o		x	
105	Avic			l	o	cd		x
106	Sept			l	o	cd	x	
107	Per	14.0		l	i	cd		
108	pyra				i			
109	Avic			l	o	cd		x
110	pyra				i			
111	Per	16.0		r	i	cd		
112	Per	13.0		l	i	cd		
113	unid				o		x	x
114	unid				o		x	x
115	Per	14.0	x		i	cd		
116	Per	6.0		?	i	cd		
117	Not a fossil							
118	ost			r	o	cd		
119	ost			l	o	cd		
120	ost			l	o	cu		
121	ost			l	o	cu		
122	ost			l	o	cu		
123	ost			r	o	cu		
124	ost			?	o	cd		
125	crin				o			
126	ost			r	o	cd		
127	pyra				i		x	
128	pyra				i			
129	ost			l	o	cu		
130	pyra				i			
131	pyra				i			
132	pyra				i			
133	Per	16.0		r	i	cd		x
134	Avic			?	o	cu	x	
135	Per	31.0		l	i	cd		x
136	pyra				i			
137	Avic			l	o	cd	x	x
138	ost			l	o	cd		
139	Per	9.0		r	i	cd		
140	pyra				i			
141	ost			l	o	cu		
142	ost			l	o	cu		
143	ost			l	o	cd		
144	Avic			l	o	cd		x
145	Avic			r	o	cd		x
146	Per	9.0		r	i	cd		x
147	Per	11.0		?	i	cd		x
148	Per	8.0		r	i	cd		
149	Per	12.0	x		i	cd		x
150	Not a fossil							
151	Per	18.0		r	i	cd		x
152	Avic			r	o	cd		
153	Per	14.0		r	i	cd		

CQ-2 Cont

#	name	size	art	val	pres	orient	frag	epiz
154	unid				o		x	
155	Avic			l	o	cd		x
156	pyra				i			
157	Sept			l	o	cd		
158	ost			l	o	cu		
159	ost			r	o	cu		
160	ost			l	o	cu		
161	Per	9.0		r	i	cd		
162	Per	12.0		r	i	cd		
163	Avic			l	o	cd		
164	pyra				i			
165	Per	--		r	i	cd		x
166	pyra				i			
167	ost			r	o	cu		
168	pyra				i			
169	unid				o		x	
170	unid				o		x	
171	Avic			?	o	cd		x
172	Avic			r	o	cd		x
173	Per	11.0		l	i	cd		
174	unid				o	cd		x
175	Avic			?	o	cd	x	
176	unid				o		x	
177	Per	10.0		l	i	cd		
178	Avic			r	o	cd		x
179	pyra				i			
180	ost			l	o	cu		
181	ost			l	o	cu		
182	pyra				i			
183	Per	6.0		l	i	cd		
184	pyra				i			
185	pyra				i			
186	unid				o		x	
187	pyra				i			

CQ-2



CQ-3

#	name	size	art	val	pres	orient	frag	epiz
1	Avic			?	o	cd		
2	unid				o		x	
3	unid						x	x
4	unid				o		x	
5	Per	--		?	i	cd		
6	pyra				i		x	
7	pyra				i			
8	Per	11.0		r	i	cd		
9	pyra				i			
10	Per	--		?	i	cd		
11	unid						x	x
12	pyra				i			
13	Per	--		?	o	cd		
14	unid				i		x	
15	pyra				i			
16	pyra				i			
17	Per	--		?	i	cd		
18	Avic			?	o	cu	x	
19	ost			l	o	cu		
20	ost			l	o	cd		
21	unid				o		x	
22	pyra				i			
23	Per	7.0		r	i	cd		
24	pyra				i			
25	pyra				i			
26	Per	—		?	i	cd		
27	ling			?	o	cd	x	
28	unid				o		x	x
29	Per	17.0		l	o	cu		
30	Avic			r	o	cd		
31	unid				o		x	
32	Per	--		?	i	cd		
33	unid				o			x
34	Per	8.0		l	i	cd		
35	Avic			?	o	cd		
36	Avic			r	o	cd		x
37	pyra				i			
38	pyra				i		x	
39	Per	13.0		l	i	cd		
40	Avic			?	o	cd	x	x
41	Avic			?	o	cd		x
42	Avic			l	o	cd		
43	Avic			?	o	cd		x
44	unid				o		x	x
45	pyra				i			
46	Per	11.0	x		i	cd		
47	Avic			?	o	cd	x	
48	Per	7.0		r	i	cd		
49	pyra				i			
50	ost			l	o	cu		
51	pyra				i			

#	name	size	art	val	pres	orient	frag	epiz
52	Per	6.0		l	i	cd		
53	Per	16.0		l	i	cd		x
54	ost			l	o	cu		
55	Per	9.0		l	i	cd		
56	Per	8.0		l	i	cd		
57	pyra				i		x	
58	pyra				i			
59	pyra				i			
60	pyra				i			
61	Per	12.0		r	i	cd		x
62	Per	12.0		l	i	cd		
63	pyra				i			
64	Per	11.0		r	i	cd		
65	pyra				i			
66	pyra				i			
67	Per	--		?	i	cd		
68	Avic			?	o	cd	x	
69	Avic			?	o	cd	x	
70	Per	12.0		l	i	cd		
71	Per	9.0		r	i	cd		
72	pyra				i			
73	pyra				i			
74	Per	12.0		r	i	cd		
75	pyra				i		x	
76	Avic			r	o	cu		x
77	Per	6.0		l	i	cd		
78	pyra				i		x	
79	Per	13.0		r	i	cd		
80	pyra				i		x	
81	pyra				i			
82	Per	17.0		l	i	cd		x
83	pyra				i		x	
84	unid				o		x	
85	Per	12.0		l	i	cd		
86	pyra				i			
87	Avic			?	o	cd	x	
88	pyra				i		x	
89	pyra				i			
90	Per	--		?	i	cd	x	
91	Per	12.0		l	i	cd		
92	pyra				i			
93	Sept			?	o	cd	x	
94	pyra				i			
95	pyra				i		x	
96	Per	--		r	i	cd	x	
97	unid				o		x	
98	Avic			r	o	cd		
99	unid				o			x
100	unid				i			
101	Avic			?	o	cd	x	
102	pyra				i			

CQ-3 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Per	10.0	x		i	i		
104	ost			r	o	cu		
105	Avic			?	o	cd	x	
106	pyra				i		x	
107	unid				o		x	
108	ost			r	o	cu		
109	Per	13.0		?	o	cu		
110	unid				o		x	
111	unid						x	x
112	Per	10.0		r	o	cu		
113	pyra				i		x	
114	Per	--		?	i	cd		
115	pyra				i			
116	ost			l	o	cd		
117	Avic			?	o	cd		
118	Per	--		?	o	cu		
119	unid				o		x	
120	ost			r	o	cu		
121	ost			r	o	cu		
122	ost			r	o	cu		
123	unid				o	cd	x	x
124	Per	13.0		r	i	cd		
125	pyra				i			
126	ost			l	o	cd		
127	pyra				i			
128	Per	--		?	o	cd		
129	pyra				i			
130	ost			l	o	cu		
131	Avic			?	o	cu	x	
132	Per	6.0		l	i	cd		
133	ost			l	o	cu		
134	Avic			?	o	cd	x	
135	ost			l	o	cd		
136	ost			r	o	cd		
137	unid				o			
138	pyra				i			
139	ost			r	o	cu		
140	pyra				i			
141	pyra				i			
142	pyra				i			
143	ost			r	o	cd		
144	ost			r	o	cu		
145	pyra				i			
146	unid				i		x	
147	pyra				i		x	
148	Per	6.0		I	i	cd		
149	Per	10.0		r	i	cd		
150	Avic			?	o	cu	x	
151	Avic			?	o	cd	x	
152	Per	8.0		?	i	cd		
153	Per	10.0		?	i	cd		

CQ-3 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	Per	--		?	o	cu		
155	Per	--		?	o	cd		
156	Per	--		?	o	cd		
157	ost			r	o	cd		
158	ost			r	o	cu		
159	Per	5.0		l	i	cd		
160	Per	--		?	i	cd		
161	Per	--		?	i	cd		
162	Per	10.0		r	i	cd		
163	Per	--		?	i	cd		
164	Avic			?	o	cd		
165	Per	12.0		r	i	cd		
166	Per			l	o	cu	x	x
167	Per	21.0		l	i	cd		x
168	unid				o			x
169	pyra				i		x	
170	unid				o		x	x
171	Per	12.0		l	i	cd		
172	pyra				i			
173	pyra				i			
174	Per	11.0		r	i	cd		
175	Per	6.0		r	i	cd		
176	Per	13.0		r	i	cd		
177	Per	8.0		l	i	cd		
178	pyra				i			
179	pyra				i			
180	pyra				i			
181	Per	14.0		r	i	cd		
182	Per	8.0		l	i	cd		
183	unid				o		x	x
184	pyra				i			
185	Per	10.0		r	i	cd		
186	Per	--		?	i	cd		
187	pyra				i			
188	Per	12.0		l	i	cd		
189	Per	--		l	i	cd		
190	Per	8.0		r	i	cd		
191	Per	7.0		l	i	cd		
192	unid				i			
193	pyra				i			
194	pyra				i			
195	pyra				i			
196	pyra				i			
197	ost			l	o	cu		
198	Avic			?	o	cd		
199	ost			l	o	cd		
200	pyra				i			
201	Per	--		?	i	cd		
202	Per	9.0		?	i	cd		
203	Per	10.0		l	i	cd		
204	unid				o		x	x

CQ-3 Cont.

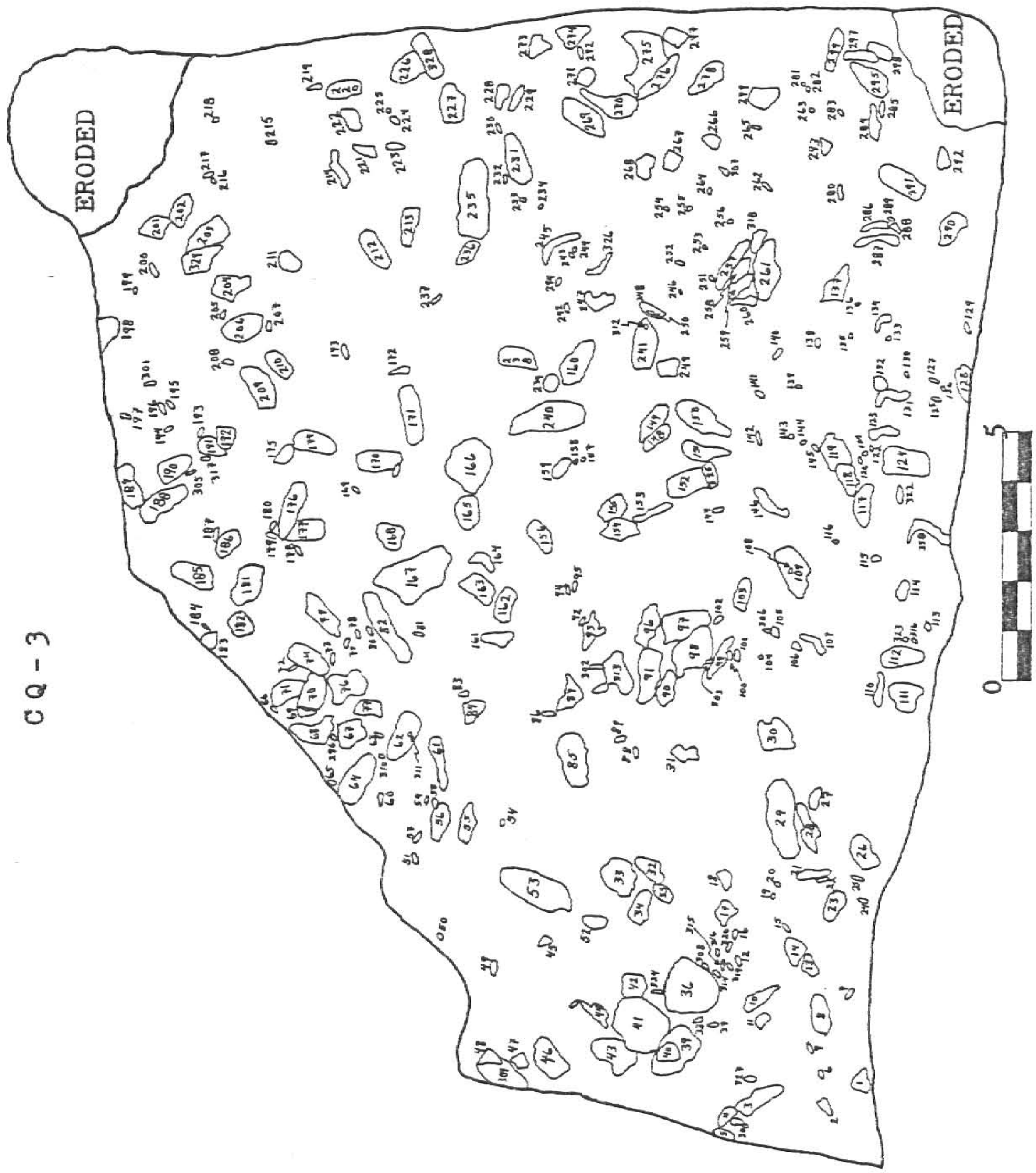
#	name	size	art	val	pres	orient	frag	epiz
205	pyra				i			
206	Per	--		l	i	cd		
207	pyra				i		x	
208	pyra				i		x	
209	Per	11.0		l	i	cd		
210	Per	8.0		r	i	cd		
211	unid				i		x	
212	Per	8.0		l	i	cd		
213	Per	8.0		l	i	cd		
214	Avic			?	o	cd	x	
215	pyra				i			
216	ost			r	o	cd		
217	pyra				i		x	
218	ost			r	o	cd		
219	pyra				i			
220	Per	9.0		l	i	cd		
221	Avic			?	o	cu	x	
222	Sept			l	o	cd	x	
223	Per	--	x		i	i		
224	unid				o		x	x
225	ost			l	o	cu		
226	Per	9.0		l	i	cd		
227	unid				o		x	x
228	Per	6.0		l	i	cd		
229	Avic			?	o	cd	x	
230	pyra				i			
231	Per	10.0		l	i	cd		
232	pyra				i			
233	ost			l	o	cu		
234	ost			r	o	cd		
235	Per	18.0		r	i	cd		
236	Per	7.0		r	i	cd		
237	pyra				i			
238	unid				o		x	
239	Avic			r	o	cd		
240	Per	17.0		r	i	cd		x
241	Per	11.0		l	i	cd		
242	pyra				i			
243	ost			l	o	cu		
244	ost			l	o	cu		
245	Per	12.0		?	o	cu		
246	ost			r	o	cu		
247	Per	11.0		l	i	cd		
248	unid				o			
249	unid				o		x	
250	pyra				i			
251	ost			r	o	cd		
252	pyra				i		x	
253	ost			r	o	cu		
254	ost			r	o	cu		
255	ost			l	o	cd		

CQ-3 Cont.

#	name	size	art	val	pres	orient	frag	epiz
256	ost			l	o	cu		
257	Per	11.0		r	o	cu		
258	Per	--		?	o	cd	x	
259	Per	--		?	o	cd	x	
260	Per	--		?	o	cd	x	
261	Per	15.0		l	o	cu	x	
262	pyra				i			
263	ost			r	o	cu		
264	ost			l	o	cu		
265	pyra				i			
266	unid				o		x	
267	unid				o		x	
268	Per	--		?	i	cd		
269	Per	12.0		r	i	cd		
270	Per	12.0		l	i	cd		
271	Per	4.0		l	i	cd		
272	pyra				i			
273	unid				o		x	x
274	unid				o		x	x
275	unid				o		x	x
276	Per	14.0		?	i	cd		
277	Per	--		?	i	cd		
278	unid				o		x	
279	Per	--		?	o	cu		
280	pyra				i			
281	ost			l	o	cd		
282	ost			l	o	cd		
283	ost			l	o	cd		
284	unid				o		x	x
285	pyra				i			
286	Avic			?	o	cu	x	
287	Avic			?	o	cu	x	
288	Avic			?	o	cd	x	
289	ost			l	o	cu		
290	Per	8.0		l	i	cd		
291	Per	12.0		r	e	cu		
292	Per	5.0		l	i	cd		
293	unid				o		x	x
294	pyra				i			
295	Per	--		?	i	cd	x	
296	ost			r	o	cu		
297	Per	7.0		l	i	cd		
298	Per	9.0		l	i	cd		
299	Per	7.0		l	i	cd		
300	unid				o		x	
301	pyra				i			
302	pyra				i			
303	pyra				i			
304	pyra				i			
305	pyra				i			
306	pyra				i			

CQ-3 Cont.

#	name	size	art	val	pres	orient	frag	epiz
307	pyra				i			
308	pyra				i			
309	unid				o		x	x
310	ost			r	o	cu		
311	ost			r	o	cd		
312	ost			l	o	cd		
313	Sept			?	o	cd	x	
314	pyra				i		x	
315	pyra				i			
316	ost			r	o	cd		
317	ost			l	o	cu		
318	Avic			?	o	cd	x	
319	pyra				i			
320	pyra				i			
321	pyra				i			
322	pyra				i			
323	ost			l	o	cu		
324	pyra				i			
325	Per	--		r	i	cd		
326	Per	--		?	i	cd		
327	pyra				i			
328	Per	--		?	o	cu		
329	Per	--		?	o	cu		
330	Avic			?	o	cd	x	


CQ - 3
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CQ-4

#	name	size	art	val	pres	orient	frag	epiz
1	pyra				i			
2	unid				o	cu	x	
3	Per	--		?	i	cd		
4	Per	12.0		l	i	cd		
5	pyra				i			
6	pyra				i		x	
7	Avic			?	o	cd	x	
8	Per	10.0		?	i	cd		
9	pyra				i			
10	Per	12.0		l	o	cd		x
11	pyra				i		x	
12	Per	7.0		l	i	cd		
13	pyra				i		x	
14	Per	8.0		?	i	cd		
15	pyra				i			
16	pyra				i		x	
17	pyra				i			
18	Per	10.0		r	i	cd		
19	pyra				i			
20	pyra				i			
21	pyra				i			
22	Per	16.0		r	i	cd		
23	pyra				i			
24	Per	9.0		l	i	cd		
25	Per	5.0		r	i	cd		
26	pyra				i		x	
27	pyra				i		x	
28	pyra				i			
29	pyra				i			
30	pyra				i			
31	pyra				i		x	
32	pyra				i			
33	Per	8.0		r	i	cd		
34	Per	11.0		l	i	cd		
35	Per	--		?	i	cd		
36	Per	9.0		r	i	cd		
37	Per	16.0		l	i	cd		
38	Per	9.0		r	i	cd		
39	ost			r	o	cu		
40	pyra				i			
41	pyra				i		x	
42	Per	10.0		l	i	cd		
43	pyra				i		x	
44	Per	12.0		?	i	cd		
45	Per	11.0		?	i	cd		
46	Per	--		?	i	cd		
47	pyra				i			
48	pyra				i		x	
49	Per	--		?	i	cd		
50	Per	--		?	i	cd		
51	pyra				i			

CQ-4 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	pyra				i		x	
53	Per	--		?	i	cd		
54	pyra				i			
55	pyra				i		x	
56	pyra				i		x	
57	pyra				i			
58	pyra				i			
59	pyra				i			
60	pyra				i		x	
61	pyra				i		x	
62	pyra				i			
63	pyra				i			
64	pyra				i		x	
65	pyra				i		x	
66	pyra				i			
67	ost			l	o	cd		
68	ost			l	o	cu		
69	ost			l	o	cd		
70	ost			l	o	cu		
71	pyra				i		x	
72	ost			r	o	cu		
73	ost			r	o	cd		
74	pyra				i			
75	pyra				i		x	
76	Per	--		r	o	cu	x	
77	pyra				i		x	
78	ost			r	o	cu		
79	pyra				i			
80	pyra				i			
81	Per	11.0		l	i	cd		
82	Per	--		r	i	cd		
83	pyra				i			
84	pyra				i			
85	unid				o		x	
86	pyra				i			
87	pyra				i			
88	pyra				i		x	
89	pyra				i		x	
90	pyra				i		x	
91	pyra				i			
92	pyra				i			
93	pyra				i			
94	pyra				i			
95	pyra				i		x	
96	pyra				i		x	
97	pyra				i		x	
98	pyra				i			
99	pyra				i		x	
100	pyra				i			
101	pyra				i		x	
102	pyra				i			

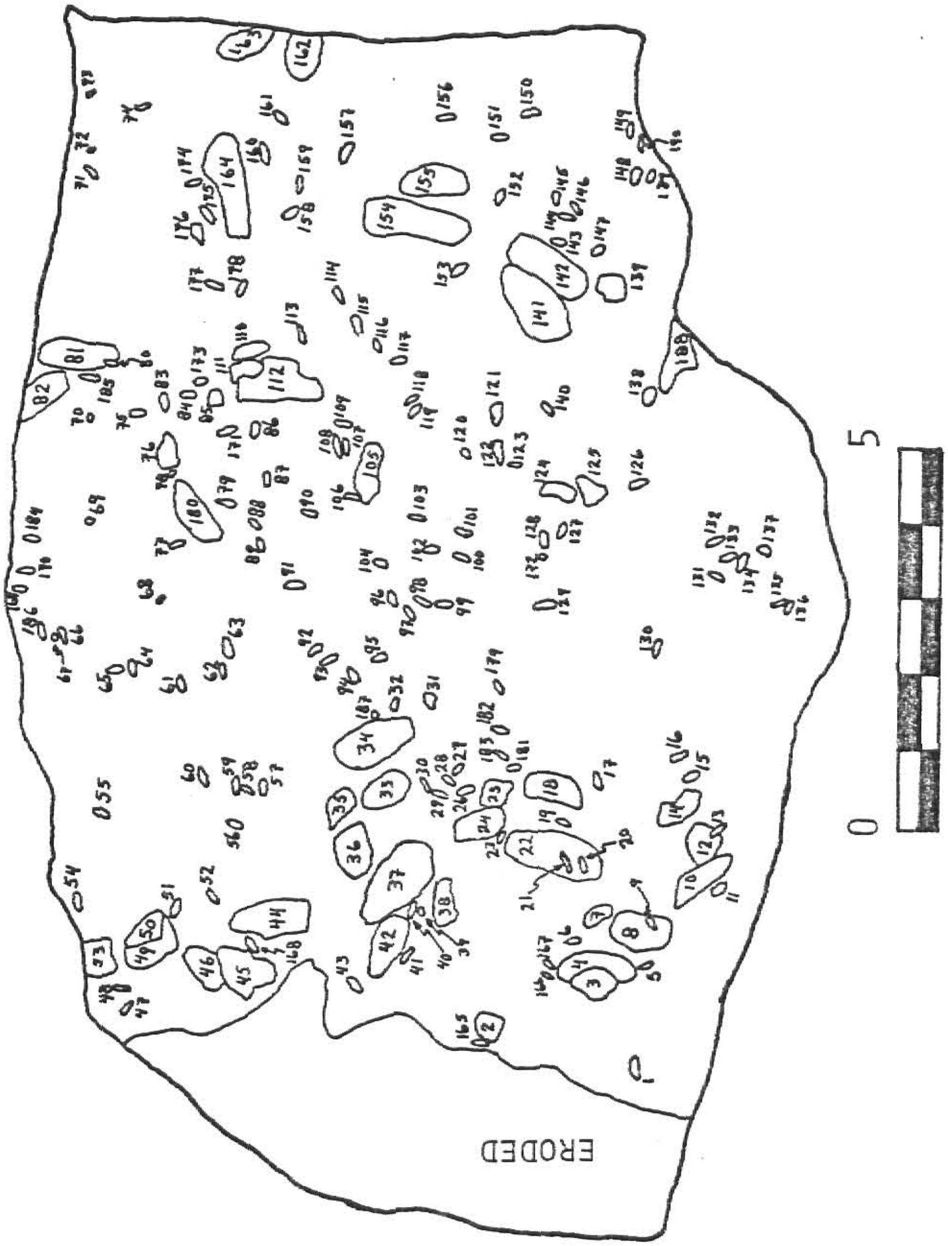
CQ-4 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	pyra				i		x	
104	pyra				i			
105	Per	9.0		l	i	cd		
106	pyra				i			
107	pyra				i			
108	pyra				i			
109	pyra				i		x	
110	Per	--		?	i	cd		
111	Avic			r	o	cd		
112	Per	5.0		r	i	cd		
113	pyra				i			
114	pyra				i			
115	pyra				i			
116	pyra				i			
117	pyra				i		x	
118	pyra				i			
119	pyra				i			
120	pyra				i		x	
121	pyra				i			
122	pyra				i		x	
123	pyra				i			
124	unid				o	cu	x	
125	Avic			?	o	cd	x	
126	pyra				i		x	
127	pyra				i			
128	pyra				i		x	
129	pyra				i		x	
130	pyra				i			
131	pyra				i			
132	pyra				i			
133	pyra				i		x	
134	pyra				i			
135	pyra				i			
136	pyra				i		x	
137	pyra				i			
138	pyra				i		x	
139	unid				o		x	
140	pyra				i		x	
141	Per	14.0		l	i	cd		
142	Per	12.0		r	i	cd		
143	pyra				i			
144	pyra				i			
145	pyra				i		x	
146	pyra				i			
147	pyra				i			
148	pyra				i			
149	pyra				i			
150	pyra				i		x	
151	pyra				i			
152	pyra				i			
153	pyra				i		x	

CQ-4 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	Per	14.0		r	i	cd		
155	Per	10.0		l	i	cd		
156	pyra				i			
157	pyra				i			
158	pyra				i		x	
159	pyra				i			
160	pyra				i			
161	pyra				i		x	
162	Per	--		?	i	cd		
163	Per	8.0		l	i	cd		
164	Per	14.0		r	o	cd		x
165	pyra				i			
166	pyra				i		x	
167	pyra				i			
168	pyra				i			
169	pyra				i			
170	pyra				i			
171	pyra				i			
172	ost			l	o	cd		
173	ost			r	o	cu		
174	pyra				i		x	
175	pyra				i		x	
176	pyra				i			
177	pyra				i		x	
178	pyra				i		x	
179	pyra				i			
180	Per	10.0		?	i	cd		
181	ost			r	o	cd		
182	pyra				i			
183	pyra				i			
184	pyra				i			
185	pyra				i		x	
186	ost			r	o	cu		
187	ost			r	o	cu		
188	unid				o	cu	x	x
189	pyra				i		x	
190	pyra				i			

CQ-4



CQ-5

#	name	size	art	val	pres	orient	frag	epiz
1	pyra				i		x	
2	pyra				i		x	
3	ost			r	o	cd		
4	pyra				i		x	
5	pyra				i			
6	ost			l	o	cu		
7	ost			?	o	cd		
8	pyra				i			
9	ost			l	o	cd		
10	pyra				i			
11	pyra				i			
12	pyra				i		x	
13	Per	9.0		r	i	cd		
14	Per	10.0		r	i	cd		
15	pyra				i			
16	pyra				i			
17	pyra				i			
18	Per	7.0		l	i	cd		
19	pyra				i			
20	pyra				i		x	
21	Per	5.0		l	i	cd		
22	ost			r	o	cu		
23	pyra				i		x	
24	Per	6.0		l	i	cu		
25	pyra				i			
26	pyra				i			
27	pyra				i		x	
28	pyra				i		x	
29	pyra				i		x	
30	Per	6.0		r	i	cd		
31	ost			l	o	cu		
32	pyra				i		x	
33	pyra				i		x	
34	pyra				i			
35	pyra				i			
36	ost			?	o	cu		
37	Avic			?	o	cd		
38	pyra				i			
39	Per	8.0		l	i	cd		
40	pyra				i		x	
41	pyra				i			
42	pyra				i		x	
43	pyra				i			
44	pyra				i		x	
45	pyra				i		x	
46	pyra				i			
47	pyra				i			
48	pyra				i		x	
49	pyra				i		x	
50	pyra				i		x	
51	pyra				i		x	

CQ-5

#	name	size	art	val	pres	orient	frag	epiz
1	pyra				i		x	
2	pyra				i		x	
3	ost			r	o	cd		
4	pyra				i		x	
5	pyra				i			
6	ost			l	o	cu		
7	ost			?	o	cd		
8	pyra				i			
9	ost			l	o	cd		
10	pyra				i			
11	pyra				i			
12	pyra				i		x	
13	Per	9.0		r	i	cd		
14	Per	10.0		r	i	cd		
15	pyra				i			
16	pyra				i			
17	pyra				i			
18	Per	7.0		l	i	cd		
19	pyra				i			
20	pyra				i		x	
21	Per	5.0		l	i	cd		
22	ost			r	o	cu		
23	pyra				i		x	
24	Per	6.0		l	i	cu		
25	pyra				i			
26	pyra				i			
27	pyra				i		x	
28	pyra				i		x	
29	pyra				i		x	
30	Per	6.0		r	i	cd		
31	ost			l	o	cu		
32	pyra				i		x	
33	pyra				i		x	
34	pyra				i			
35	pyra				i			
36	ost			?	o	cu		
37	Avic			?	o	cd		
38	pyra				i			
39	Per	8.0		l	i	cd		
40	pyra				i		x	
41	pyra				i			
42	pyra				i		x	
43	pyra				i			
44	pyra				i		x	
45	pyra				i		x	
46	pyra				i			
47	pyra				i			
48	pyra				i		x	
49	pyra				i		x	
50	pyra				i		x	
51	pyra				i		x	

CQ-5 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Per	--		?	i	cd		
53	Per	8.0		r	i	cd		
54	pyra				i			
55	pyra				i		x	
56	Per	10.0		l	i	cd		
57	pyra				i			
58	pyra				i		x	
59	pyra				i		x	
60	pyra				i		x	
61	pyra				i		x	
62	pyra				i		x	
63	pyra				i		x	
64	pyra				i		x	
65	pyra				i			
66	pyra				i			
67	pyra				i		x	
68	Per	7.0		l	i	cd		
69	pyra				i			
70	pyra				i		x	
71	pyra				i		x	
72	pyra				i		x	
73	pyra				i			
74	pyra				i		x	
75	ost			l	o	cu		
76	pyra				i		x	
77	pyra				i			
78	pyra				i		x	
79	Per	8.0		l	i	cd		
80	pyra				i			
81	pyra				i		x	
82	pyra				i		x	
83	pyra				i		x	
84	pyra				i			
85	pyra				i		x	
86	pyra				i		x	
87	pyra				i		x	
88	pyra				i		x	
89	pyra				i		x	
90	Per	8.0		l	i	cd		
91	pyra				i			
92	pyra				i		x	
93	pyra				i		x	
94	Per	7.0		l	o	cd		
95	pyra				i		x	
96	pyra				i		x	
97	pyra				i		x	
98	pyra				i			
99	pyra				i			
100	pyra				i			
101	pyra				i		x	
102	pyra				i		x	

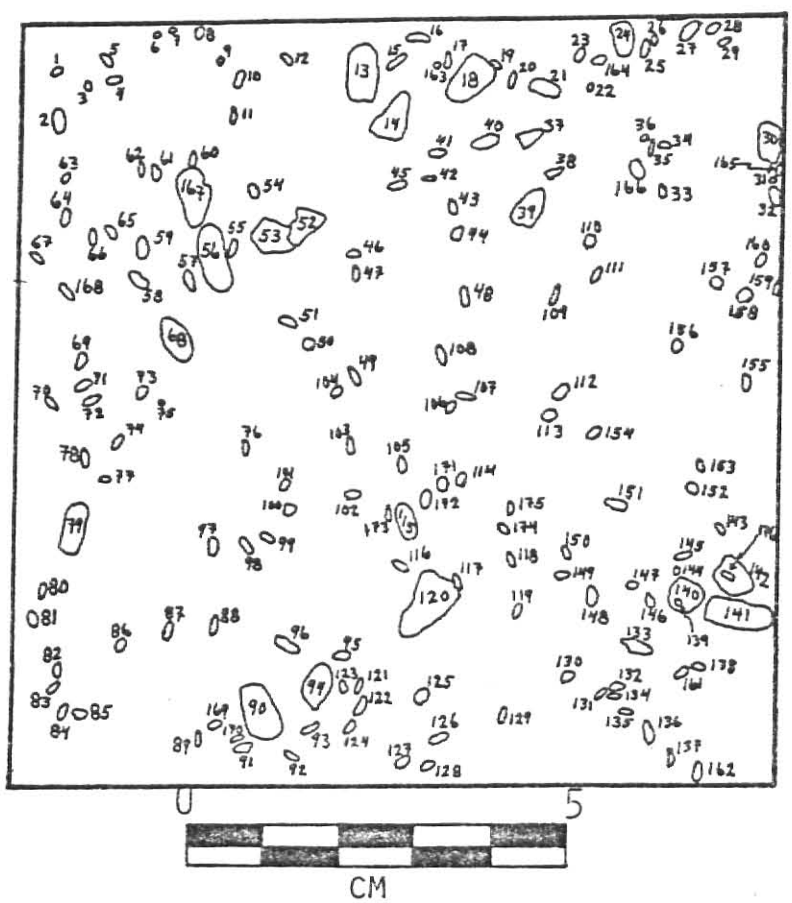
CQ-5 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	pyra				i		x	
104	pyra				i		x	
105	pyra				i			
106	pyra				i		x	
107	pyra				i		x	
108	pyra				i		x	
109	pyra				i			
110	pyra				i		x	
111	pyra				i		x	
112	pyra				i		x	
113	pyra				i		x	
114	pyra				i			
115	Per	6.0		l	i	cd		
116	pyra				i		x	
117	pyra				i		x	
118	pyra				i		x	
119	pyra				i		x	
120	Per	11.0		l	i	cd		
121	pyra				i			
122	pyra				i		x	
123	pyra				i		x	
124	pyra				i			
125	pyra				i		x	
126	pyra				i			
127	pyra				i		x	
128	pyra				i		x	
129	pyra				i		x	
130	pyra				i		x	
131	pyra				i		x	
132	pyra				i			
133	unid				o	cu		
134	pyra				i		x	
135	pyra				i		x	
136	pyra				i		x	
137	pyra				i		x	
138	pyra				i		x	
139	ost			l	o	cu		
140	Per	--		r	i	cd		
141	Per	9.0		r	i	cd		
142	Per	7.0		r	i	cd		
143	pyra				i			
144	ost			l	o	cd.		
145	pyra				i		x	
146	pyra				i		x	
147	pyra				i		x	
148	pyra				i		x	
149	pyra				i		x	
150	pyra				i			
151	pyra				i			
152	pyra				i		x	
153	pyra				i			

CQ-5 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	pyra				i		x	
155	pyra				i		x	
156	pyra				i		x	
157	pyra				i		x	
158	pyra				i			
159	pyra				i		x	
160	pyra				i		x	
161	pyra				i		x	
162	pyra				i		x	
163	ost			?	o	cd		
164	pyra				i		x	
165	pyra				i			
166	pyra				i		x	
167	Per	10.0		1	i	cd		
168	pyra				i		x	
169	pyra				i			
170	pyra				i			
171	pyra				i			
172	pyra				i			
173	pyra				i		x	
174	pyra				i			
175	pyra				i			
176	pyra				i		x	

CQ-5



#	name	size	art	val	pres	orient	frag	epiz
1	unid				i			
2	unid				o		x	x
3	Per	13.0		r	i	cd		x
4	Per	12.0		r	i	cd		x
5	Per	17.0		l	i	cd		
6	unid				o			x
7	Per	--		l	i	cd		
8	Per	14.0		r	o	cd		
9	Per	18.0		r	i	cd		x
10	Per	--		l	i	cd		
11	Per	8.0		r	i	cd		
12	unid				o		x	
13	unid				o			x
14	Avic			?	o	cd		
15	Per	10.0		l	i	cd		
16	Per	--		?	o	cd		
17	Per	10.0		r	i	cd		
18	alfr							
19	Per	16.0		r	o	cd		
20	Sept			l	o	cd		
21	Per	11.0		l	i	cd		x
22	Per	11.0		l	i	cd		
23	unid				o			x
24	Avic			r	o	cd		
25	Per	13.0		r	o	cd		
26	alfr							
27	Per	17.0		r	i	cd		
28	Avic			?	o	cd		
29	Per	11.0		l	o	cd		
30	Per	11.0		r	i	cd		
31	unid				o	i		
32	Per	--		?	o	i		
33	Per	12.0		l	i	cd		
34	Per	9.0		?	i	cd		
35	unid				o		x	
36	unid				o		x	
37	Avic			?	o	i		
38	Avic			l	o	cd		
39	Per	12.0		r	o	cu		
40	unid				o		x	
41	Avic			r	o	cd		x
42	Per	6.0		r	i	cd		
43	Per	10.0		r	i	cd		
44	Avic			r	o	cd		
45	Avic			?	o	cd		x
46	Per	19.0		r	i	cd		x
47	unid				o			x
48	Per	7.0		r	i	cd		
49	unid				o		x	
50	Per	8.0		r	i	cd		
51	Avic			?	o	cd	x	

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	unid				o	cu	x	
53	Per	6.0		l	i	cd		
54	unid				o			
55	Per	10.0		l	i	cd		
56	unid				o			
57	Per	12.0		l	i	cd		
58	Per	16.0		?	o	cd		x
59	Per	10.0		l	i	cd		
60	Sept			l	o	cd		
61	Avic			r	o	cd		
62	Per	7.0		r	i	cd		
63	unid				o	cu		
64	Per	--		r	i	cd		
65	unid				e			
66	unid				o		x	x
67	unid				o			
68	Avic			?	o	cd	x	
69	ost			r	o	cd		
70	Per	12.0		l	i	cd		x
71	Per	15.0		r	i	cd		
72	Per	10.0		r	i	cd		
73	Avic			?	o	cd	x	
74	Per	9.0		l	i	cd		
75	Per	9.0		r	i	cd		
76	Per	9.0		l	i	cd		
77	Per	17.0		l	o	cd		
78	Per	6.0		?	i	cd		
79	Per	5.0		?	i	cd		
80	Per	10.0		l	i	cd		
81	Avic			r	o	cd		
82	Per	10.0		r	i	cd		
83	alfr							
84	unid				o			x
85	unid				o		x	
86	Per	--		l	i	cd		
87	Per	13.0		r	i	cd		
88	Per	13.0		r	i	cd		
89	Avic			l	o	cd	x	
90	Avic			l	o	cd	x	
91	Per	13.0		l	o	cd		
92	Per	--		r	i	cd		
93	Avic			?	o	cd		
94	Avic			?	o	cd	x	
95	unid				o		x	
96	Avic			l	o	cd		
97	Per	12.0		r	i	cd		x
98	Per	--		?	i	cd		
99	Avic			?	o	cd		
100	Per	10.0		l	i	cd		
101	Per	13.0		l	i	cd		x
102	Avic			?	o	cd		x

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Per	7.0		r	i	cd		
104	Per	18.0		l	o	cd		x
105	Avic			l	o	cd		x
106	Avic			?	o	cd		
107	unid				o		x	x
108	Per	--		?	o	cd		x
109	Per	18.0		?	i	cd		
110	Per	7.0		r	i	cd		
111	Per	9.0		?	i	cd		
112	Per	19.0		r	i	cd		
113	Per	35.0		r	i	cd		x
114	unid				o			
115	unid				o			
116	Per	10.0		r	i	cd		
117	Per	6.0	x		o			
118	Not a fossil							
119	Avic			?	o	cd		x
120	Per	20.0		?	i	cd		
121	Avic			?	o	cd	x	
122	unid				o			
123	unid				o		x	x
124	unid				o	i	x	x
125	unid				o		x	x
126	unid				o			
127	Per	22.0		r	i	cd		x
128	Avic			?	o	cd	x	
129	alfr							
130	Avic			r	o	cd		
131	Per	10.0		?	i	cd		
132	Per	11.0		l	i	cd		
133	unid				o			
134	Per	11.0		l	o	cd		
135	Per	--		?	i	cd		
136	pyra				i			
137	Avic			?	o	cd	x	
138	unid				o			
139	unid				o			
140	Avic			?	o	cd		x
141	Per	12.0		l	i	cd		
142	alfr							
143	alfr							
144	Per	27.0		r	i	cd		x
145	Per	--		r	i	cd	x	x
146	Per	8.0		?	i	cd		
147	Per	8.0		?	i	cd		
148	Per	5.0		l	i	cd		
149	Avic			r	o	cd		
150	unid				o			
151	Per	8.0		r	i	cd		
152	unid				o		x	x
153	Per	7.0		l	i	cd		

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	unid				o			x
155	Per	7.0		r	i	cd		
156	Per	12.0		r	i	cd		
157	Per	14.0		l	i	cd		x
158	Per	9.0		r	i	cd		
159	Per	10.0		r	i	cd		x
160	Per	--		?	i	cd	x	
161	Per	7.0		l	i	cd		
162	Per	--		?	i	cd		
163	Per	12.0		l	i	cd		
164	pyra				i			
165	pyra				i			
166	Per	7.0		r	i	cd		
167	pyra				i			
168	Per	6.0		r	i	cd		
169	Per	12.0		l	o	cd		
170	Per	11.0		?	i	cd		
171	unid				o			
172	unid				o			x
173	Avic			?	o			x
174	Per	6.0		r	i	cd		
175	Sept			r	i	cd		
176	unid				o	cu	x	
177	Per	11.0		r	i	cd		
178	Per	9.0		l	i	cd		
179	unid				o			
180	Per	7.0		r	i	cd		x
181	Avic			?	o	i		
182	Per	--		?	i	cd		
183	Per	14.0		r	o	cu		
184	Not a fossil							
185	Avic			?	o	cd	x	
186	Per	9.0		l	o	cd		
187	unid				o		x	
188	Avic			l	o	cd		x
189	unid				o			
190	unid				o	i		
191	unid				o		x	
192	unid				o			
193	Sept			r	i	cd		
194	Avic			r	o	cd		x
195	unid				o		x	
196	unid				o		x	
197	Avic			?	o	cd	x	
198	Per	9.0		r	i	cd		
199	Avic			?	o	cd		x
200	Per	10.0		l	o	cu		
201	Per	7.0		l	i	cd		
202	Per	6.0		r	i	cd		
203	Per	11.0		l	i	cd		
204	Per	7.0		l	o	cd		

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
205	Per	6.0		l	i	cd		
206	Per	6.0		?	i	cd		
207	Avic			?	o	cd		x
208	Avic			r	o	cd		
209	unid				o		x	x
210	unid				o			x
211	pyra				i			
212	unid				o			x
213	Per	12.0		l	i	cd		
214	Avic			l	o	cd		
215	Per	13.0		l	o	cu		
216	Per	7.0		l	i	cd		
217	Pseu			r	o	cd		
218	Per	--		?	i	cd		x
219	Per	18.0		l	o	cu		
220	Per	10.0		r	i	cd		
221	Per	9.0		?	i	cd		
222	Per	10.0		r	i	cd		
223	Per	--	x		i	i		
224	unid				o	i		
225	unid				o	i		
226	Per	8.0		r	i	cd		
227	Per	10.0		l	o	cu		
228	Per	11.0		r	i	cd		
229	Per	--		r	i	cd		
230	Per	7.0		r	i	cd		
231	Per	7.0		r	o	cd		
232	unid				o			
233	Per	10.0		l	i	cd		
234	Per	--		?	o	i		
235	Per	7.0		r	i	cd		
236	Per	6.0		?	i	cd		
237	pyra				i			
238	Per	7.0		r	i	cd		
239	Per	38.0		r	i	cd		x
240	pyra				i			
241	ost			l	o	cd		
242	pyra				i			
243	ost			l	o	cd		
244	ost			r	o	cd		
245	pyra				i		x	
246	Per	12.0		r	i	cd		
247	Per	9.0		r	o	cu		
248	ost			r	o	cd		
249	burr							
250	ost		x		o			
251	Per	9.0		r	i	cd		
252	ost			l	o	cd		
253	ost			l	o	cu		
254	Avic			l	o	cd		x
255	Per	7.0		?	i	cd		

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
256	Avic			r	o	cd		
257	Per	11.0		l	i	cd		
258	Per	10.0		l	i	cd		
259	Per	13.0		r	i	cd		
260	Per	5.0		r	i	cd		
261	Per	26.0		r	i	cd		x
262	ost			l	o	cu		
263	ost			r	o	cu		
264	ost			r	o	cd		
265	Per	6.0		?	i	cd		
266	Per	7.0		r	i	cd		
267	Per	--		?	i	cd		x
268	ost			r	o	cd		
269	Per	13.0		?	o	cu		
270	ost			r	o	cd		
271	Per	10.0		l	i	cd		
272	Per	--	x		o	i		
273	Per	9.0		r	i	cd		
274	Per	8.0		r	i	cd		
275	Per	13.0		r	i	cd		
276	Per	16.0		l	o	cu		
277	Per	15.0		l	i	cd		
278	Per	11.0		r	i	cd		
279	unid				o	cu		
280	Per	14.0		r	o	cd		x
281	Per	12.0		l	i	cd		
282	Per	4.0		l	i	cd		
283	unid				o			
284	unid				o			
285	Per	10.0		r	i	cd		
286	Per	8.0		?	i	cd		
287	Avic			r	o	cd		
288	pyra				i			
289	Per	12.0		r	i	cd		
290	Per	10.0		r	i	cd		
291	Per	12.0		l	i	cd		
292	Per	9.0		l	i	cd		
293	Per	7.0		?	i	cd		
294	Per	7.0		l	i	cd		
295	Per	11.0		r	i	cd		
296	unid				o			x
297	Avic			r	o	cd		x
298	pyra				i			
299	pyra				i			
300	Per	8.0		l	i	cd		
301	Per	7.0		l	i	cd		x
302	Per	7.0		l	i	cd		
303	Per	--		r	i	cd		
304	Per	--		?	i	cd		
305	Per	9.0		l	i	cd		x
306	Per	8.0		?	i	cd		

CR-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
307	Avic			r	o	cd		x
308	Per	6.0		l	i	cd		
309	unid				o	i		
310	Per	4.0		r	i	cd		
311	Avic			r	o	cd		
312	Avic			?	o	cd	x	
313	unid				o			
314	Per	10.0		l	i	cd		
315	unid				o		x	
316	Per	5.0		r	i	cd		
317	Per	--		?	o	cu		
318	unid				o	i		
319	Per	--		?	i	cd		
320	Per	--		?	i	cd		
321	Per	--		l	o	cu		
322	Per	--	x		i	i		
323	Per	6.0		l	i	cd		
324	pyra				i			

CR - 1

CR-1+

#	name	size	art	val	pres	orient	frag	epiz
1	Avic			?	o	cd		
2	Per	--		l	i	cd		
3	Per	14.0		r	i	cd		x
4	Per	11.0		l	i	cd		
5	Per	--		l	i	cd	x	
6	unid				o		x	x
7	Per	--		l	o	cd		x
8	Avic			?	o	cd		
9	Per	10.0		l	i	cd		x
10	Per	10.0		l	i	cd		x
11	Per	7.0		r	i	cd		
12	Per	--		?	i	cd	x	
13	Per	--		?	i	cd	x	
14	Per	12.0		?	i	cd		
15	Per	10.0		l	i	cd		
16	unid				o		x	x
17	Per	9.0		r	i	cd		
18	Per	14.0		l	i	cd		x
19	Per	8.0		l	i	cd		
20	Per	--		?	i	cd	x	
21	Per	13.0		l	i	cd		
22	Per	12.0		r	i	cd		
23	Per	15.0		l	i	cd		
24	Per	12.0		?	i	cd		
25	Per	--		?	i	cd	x	
26	unid				o	cu	x	x
27	Avic			?	o	cd	x	
28	Avic			l	i	cd		x
29	Per	--		l	i	cd		
30	Avic			r	o	cd		
31	Per	12.0		?	i	cd		
32	Per	11.0		l	o	cu		x
33	Avic			?	o	cd	x	x
34	Per	14.0		r	i	cd		
35	Per	9.0		l	i	cd		
36	pyra				i		x	
37	pyra				i			
38	ost			l	o	cd		
39	Avic			?	o	cd	x	
40	Per	16.0		r	o	cd	x	
41	Avic			?	o	cd		x
42	Sept			r	o	cd		
43	Per	13.0		?	o	cd	x	
44	Per	8.0		r	i	cd		
45	Per	--		?	i	cd	x	
46	Avic			r	o	cd		x
47	Per	14.0		r	o	cd		x
48	Avic			r	o	cd		
49	Avic			?	o	cd		x
50	ost			r	o	cd		
51	ost			l	o	cd		

CR-1+ Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	pyra				i			
53	Avic			l	o	cu	x	
54	Avic			r	o	cd		
55	Per	10.0		l	i	cd		
56	Per	7.0		l	i	cd		
57	Per	17.0		r	i	cd		x
58	Per	20.0		r	i	cd		
59	Per	12.0		l	i	cd		
60	Avic			?	o	cd	x	
61	Per	8.0		r	i	cd		
62	Per	9.0		l	i	cd		
63	Per	11.0		r	i	cd		
64	Sept			r	o	cd		
65	Per	14.0		r	o	cu		
66	Avic			?	o	cd	x	
67	unid				o		x	
68	Per	8.0		l	i	cd		
69	Per	--		?	i	cd	x	
70	unid				o		x	x
71	Per	10.0		r	i	cd		
72	Per	20.0		l	i	cd		x
73	ost			r	o	cd		
74	Per	11.0		l	i	cd		
75	Per	9.0		l	i	cd		
76	Per	18.0		r	i	cd		x
77	Per	14.0		?	o	cu		
78	Per	15.0		r	i	cd		x
79	Per	14.0		r	i	cd		
80	unid				o		x	x
81	Per	12.0		r	i	cd		
82	Avic			?	o	cd	x	x
83	Per	10.0		r	o	cd		
84	Per	7.0		l	i	cd		
85	Per	3.0		?	i	cd		
86	Per	17.0		r	o	cd		
87	Avic			r	o	cd		x
88	Per	16.0		l	i	cd		
89	Per	14.0		r	i	cd		
90	Per	--		?	i	cd	x	
91	Per	10.0		r	i	cd		x
92	Per	13.0		r	i	cd		
93	pyra				i		x	
94	Per	13.0		l	i	cd		
95	Per	--		?	i	cd	x	
96	ost			l	o	cu		
97	Per	7.0		?	i	cd		
98	Avic			r	o	cd		
99	Per	16.0		r	i	cd		x
100	Per	8.0		l	i	cd		
101	Per	13.0		l	i	cd		
102	Avic			l	o	cd		

CR-1+ Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Per	16.0		l	o	cd		
104	Per	--		?	i	cd		
105	Per	22.0		r	i	cd		x
106	Per	10.0		r	i	cd		
107	Per	13.0		?	i	cd		x
108	Per	14.0		r	i	cd		x
109	Avic			?	o	cd	x	
110	Avic			?	o	cu	x	
111	unid				o		x	
112	Per	--		?	i	cd		
113	Avic			r	o	cd		
114	Per	9.0		l	i	cd		
115	ost			r	o	cu		
116	ost			r	o	cu		
117	Avic			l	o	cd		x
118	Per	13.0		l	o	cd		x
119	Per	6.0		l	i	cd		
120	Per	17.0		l	o	cu		
121	Avic			r	o	cd	x	
122	Per	13.0		r	i	cd		
123	Per	--		?	i	cd	x	
124	Per	--		?	i	cd	x	
125	Per	6.0		l	i	cd		
126	Sept			l	o	cd		
127	unid				o	cu	x	
128	unid				o	cu	x	x
129	Per	10.0		l	o	cu		
130	Per	8.0		?	i	cd		
131	Avic			?	o	cd	x	
132	Per	--		?	i	cd	x	
133	unid				o		x	
134	Per	--		?	i	cd	x	
135	unid				o		x	
136	Avic			l	o	cd		x
137	unid				o		x	
138	Per	11.0		r	i	cd		
139	Per	--		?	i	cd	x	
140	Avic			?	o	cd	x	
141	Per	13.0		l	i	cd		
142	Per	12.0		r	o	cd	x	
143	Per	6.0		r	i	cd		
144	Per	9.0		r	i	cd		
145	Avic			l	o	cd		
146	Per	16.0		r	o	cu		
147	Per	13.0		l	o	cd		
148	Per	8.0		l	o	cd		
149	Per	12.0		r	i	cd		
150	Per	6.0		?	i	cd		
151	Per	5.0		r	i	cd		
152	Avic			?	o	cu	x	
153	Per	9.0		?	i	cd		

#	name	size	art	val	pres	orient	frag	epiz
154	Per	18.0		r	o	cu	x	
155	Per	12.0		l	o	cu	x	
156	Per	9.0		l	i	cd		
157	Avic			?	o	cd	x	
158	Per	10.0		l	i	cd		
159	Per	18.0		r	o	cu		x
160	Per	8.0		l	i	cd		
161	Per	8.0		r	i	cd		
162	Per	8.0		l	i	cd		
163	Per	--		?	i	cd	x	
164	unid				o		x	
165	Per	18.0		r	o	cd		x
166	unid				o	cu	x	
167	Per	8.0		?	i	cd		
168	Per	11.0		l	i	cd		
169	pyra				i			
170	Per	11.0		l	i	cd		x
171	Per	14.0		l	o	cu		
172	Per	9.0		l	i	cd		
173	Per	16.0		l	i	cd		x
174	Per	--		?	i	cd	x	
175	Per	12.0		l	i	cd		
176	Per	--		?	i	cd	x	
177	Bell				i			
178	Per	--		?	i	cd	x	
179	Per	10.0		l	i	cd		
180	Avic			l	o	cu		
181	Per	18.0		l	i	cd		
182	Per	9.0		r	i	cd		
183	Per	15.0		l	i	cd		
184	Per	9.0		l	i	cd		
185	Avic			?	o	cd	x	x
186	Per	--		?	i	cd		
187	Per	11.0		r	i	cd		
188	Sept			r	i	cd		
189	Avic			l	o	cd		
190	Per	11.0		l	i	cd		
191	Avic			l	o	cd		
192	Avic			?	o	cd		
193	Per	13.0		l	i	cd		x
194	Per	8.0		r	i	cd		x
195	unid				o		x	x
196	unid				o		x	
197	unid				o		x	x
198	Per	11.0		?	i	cd		x
199	ost			r	o	cu		
200	ost			l	o	cd		
201	ost			r	o	cd		
202	ost			r	o	cu		
203	ost			l	o	cu		
204	ost			l	o	cu		

CR-1+ Cont.

#	name	size	art	val	pres	orient	frag	epiz
205	ost			l	o	cu		
206	ost			?	o	cd		
207	ost			r	o	cu		
208	Per	15.0		l	o	cu		
209	unid				o	cu	x	
210	ost			l	o	cd		
211	ost			l	o	cu		
212	Per	12.0		r	i	cd		
213	Per	6.0		?	o	cu		
214	Per	10.0		r	i	cd		
215	Avic			r	o	cd		x
216	unid				o		x	
217	Per	--		?	i	cd		
218	ost			l	o	cu		
219	ost			l	o	cd		
220	Per	11.0		l	i	cd		
221	ost			r	o	cd		
222	ost			r	o	cu		
223	ost			l	o	cd		
224	ost			l	o	cd		
225	ost			l	o	cu		
226	Per	12.0		l	i	cd		
227	Per	--		?	i	cd		
228	unid				o	cu	x	
229	Per	9.0		?	i	cd		
230	Avic			?	o	cd		
231	Avic			r	o	cd		x
232	ost			l	o	cd		
233	Per	11.0		l	i	cd		x
234	Per	9.0		r	i	cd		
235	Per	9.0		r	i	cd		
236	unid				o		x	x
237	Per	--		l	i	cd		
238	Avic			l	o	cd		
239	Per	8.0		r	i	cd		
240	Per	7.0		l	i	cd		
241	Per	9.0		r	i	cd		
242	Per	7.0		l	i	cd		
243	Per	10.0		l	i	cd		
244	Per	18.0		l	i	cd		
245	Psue			r	o	cd		
246	Per	8.0		l	i	cd		
247	Per	5.0		r	i	cd		
248	Per	5.0		l	i	cd		
249	unid				o		x	
250	Per	12.0		l	i	cd		
251	Per	13.0		l	o	cu		
252	unid				o			x
253	Per	7.0		l	i	cd		
254	Per	7.0		l	i	cd		
255	ost			l	o	cd		

CR-1+ Cont.

#	name	size	art	val	pres	orient	frag	epiz
256	unid				o		x	x
257	Avic			?	o	cu	x	
258	Per	18.0		r	i	cd		x
259	Avic			?	o	cu	x	
260	Avic			?	o	cd		
261	Per	13.0		r	i	cd		
262	Pseu			r	o	cd		
263	Per	--		r	o	cu	x	x
264	unid				o			x
265	Per	6.0		r	i	cd		
266	ost			l	o	cu		
267	unid				i			
268	ost			r	o	cu		
269	unid				o	cu		
270	Per	9.0		l	i	cd		x
271	Per	15.0		r	o	cd		
272	Per	8.0		r	i	cd		
273	Per	8.0		r	i	cd		x
274	Bell				i			
275	Avic			?	o	cd	x	
276	Per	--		?	i	cd		
277	Per	13.0		l	i	cd		
278	Per	--		?	i	cd		
279	Per	--		?	i	cd		
280	Sept			l	o	cd		
281	Per	15.0		r	i	cd		
282	Per	9.0		r	i	cd		
283	unid				o			x
284	Avic			?	o	cd	x	
285	Per	11.0		l	i	cd		
286	Per	--		l	i	cd		
287	Per	8.0		l	i	cd		
288	Per	12.0		r	i	cd		
289	Avic			?	o	cu		
290	Per	12.0		r	o	cd		
291	Avic			?	o	cd		
292	Avic			?	o	cu		
293	Per	--		?	o	cu		
294	Avic			?	o	cd		
295	Avic			?	o	cd		
296	unid				o		x	x
297	unid				o		x	x
298	unid				o		x	x
299	Per	9.0		r	i	cd		
300	Per	10.0		l	i	cd		x
301	Per	--		?	o	cu		
302	Per	10.0		r	o	cu		
303	unid				o	cu	x	
304	Avic			?	o	cd	x	
305	Per	16.0		l	o	cu		
306	Per	14.0		l	i	cd		

CR-1+ Cont.

#	name	size	art	val	pres	orient	frag	epiz
307	Per	8.0		1	i	cd		
308	Per	13.0		?	o	cu		
309	Avic			?	o	cu		
310	pyra				i			
311	pyra				i			
312	pyra				i		x	
313	Per	10.0		r	i	cd		
314	burr							

CR - 1+

#	name	size	art	val	pres	orient	frag	epiz
1	Per	13.0		r	i	cd		
2	Per	--		?	i	cd		
3	Per	5.0	x		i	cd		
4	Not a fossil							
5	Per	5.0		r	i	cd		
6	Per	7.0		r	i	cd		
7	Per	11.0		l	i	cd		
8	Per	7.0		r	i	cd		
9	Per	--		?	i	cd		
10	Per	11.0		?	i	cd	x	
11	Per	6.0		r	i	cd		
12	Per	15.0		l	i	cd		
13	Per	10.0		l	i	cd		
14	pyra				i			
15	Per	13.0		l	i	cd		
16	Per	10.0		l	i	cd		
17	pyra				i			
18	Per	11.0		l	i	cd		
19	Per	12.0		r	i	cd		
20	Per	17.0		r	o	cd		x
21	unid				o	cu	x	
22	Per	9.0		r	i	cd		
23	Per	11.0		r	i	cd		
24	Per	12.0		l	o	cd		x
25	Per	12.0		r	i	cd		
26	Per	8.0		r	i	cd		
27	Per	9.0		?	i	cd		
28	Per	--		?	i	cd		
29	Per	--		l	o	cu		x
30	Acan			?	o	cu		
31	Avic			?	o	cd		
32	Per	5.0		l	i	cd		
33	Sept			?	o	cd	x	
34	Acan			l	o	cd	x	
35	Per	11.0		r	i	cd		
36	Per	8.0		r	i	cd		
37	Per	13.0		l	i	cd		x
38	unid				o		x	x
39	Avic			r	o	cd		
40	Per	14.0		l	i	cd		
41	Per	10.0		l	i	cd		
42	Per	15.0		r	i	cd		
43	Avic			r	o	cd		
44	Per	4.0		r	i	cd		
45	Per	12.0		r	i	cd		
46	Per	13.0		l	o	cu		
47	Per	13.0		r	i	cd		x
48	Per	16.0		l	i	cd		
49	Per	15.0		l	i	cd		
50	Per	13.0		r	i	cd		
51	Per	11.0		l	i	cd		

CT-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Per	16.0		l	i	cd		
53	pyra				i			
54	Per	13.0		r	i	cd		
55	Avic			?	o	cd	x	
56	Per	10.0		l	i	cd		
57	Per	8.0		r	i	cd		
58	Per	--		?	i	cd		
59	Per	16.0		l	i	cd		
60	Per	13.0		l	i	cd		
61	Per	15.0		?	i	cd		
62	Per	12.0		r	i	cd		
63	pyra				i			
64	Per	--		?	i	cd		
65	pyra				i		x	
66	Per	12.0		l	i	cd		
67	Per	12.0		r	i	cd		
68	Per	11.0		l	i	cd		
69	pyra				i			
70	Per	15.0		l	i	cd		
71	Per	7.0		r	i	cd		
72	Per	8.0		r	i	cd		
73	Avic			l	o	cd		
74	Per	8.0		l	i	cd		
75	Per	18.0		r	o	cd		
76	unid				i			
77	Per	13.0		r	o	cd		
78	Per	11.0		r	i	cd		
79	Avic			l	o	cd		
80	Avic			l	o	cd		
81	Sept			?	o	cd	x	
82	Per	13.0		r	i	cd		
83	unid				o			
84	Per	10.0		?	i	cd		
85	unid				o			
86	Per	12.0		r	i	cd		
87	Per	11.0		l	i	cd		
88	Per	6.0		l	i	cd		
89	Per	--		l	o	cu		
90	Per	15.0		r	i	cd		
91	Per	5.0	x		i	cd		
92	Not a fossil							
93	Per	13.0		r	i	cd		
94	Per	11.0		l	i	cd		
95	Per	13.0		l	i	cd		
96	Acan			?	o	cu	x	
97	Per	14.0		l	i	cd		
98	Per	14.0		r	i	cd		
99	Per	15.0		l	i	cd		
100	Avic			l	o	cd		
101	Per	11.0		r	i	cd		
102	Per	10.0		l	i	cd		

CT-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Per	13.0		r	i	cd		
104	Per	9.0		r	i	cd		
105	Per	16.0		r	i	cd		
106	Avic			?	o	cu	x	
107	Avic			?	o	cu	x	
108	Avic			?	o	cd		x
109	Per	12.0		r	i	cd		x
110	Per	11.0		r	i	cd		x
111	Avic			r	o	cd		
112	Per	9.0		r	i	cd		
113	pyra				i			
114	Bell				i			
115	Avic			?	o	cd		
116	pyra				i			
117	Per	17.0		r	i	cd		
118	Per	12.0		r	i	cd		
119	Per	8.0		l	i	cd		
120	Per	12.0		l	i	cd		
121	Sept			l	o	cd		
122	Avic			?	o	cd		x
123	pyra				i			
124	pyra				i		x	
125	pyra				i		x	
126	unid				i			
127	Per	8.0		l	i	cd		
128	Per	7.0		l	i	cd		
129	Per	14.0		r	i	cd		x
130	Per	11.0		l	i	cd		
131	Per	13.0		r	i	cd		
132	Avic			?	o	cu	x	
133	unid				o		x	x
134	pyra				i			
135	unid				o		x	
136	Per	7.0		?	i	cd		
137	Per	--		?	i	cd		
138	Per	16.0		r	i	cd		
139	unid				o	cu		
140	unid				o		x	
141	pyra				i			
142	Per	6.0		r	i	cd		
143	Per	8.0		l	i	cd		
144	Avic			r	o	cd		x
145	Avic			?	o	cd	x	
146	Per	12.0		r	i	cd		
147	Per	8.0		l	i	cd		
148	Per	12.0		l	i	cd		
149	Per	14.0		l	e	cu		
150	unid				o		x	x
151	unid				o	cu	x	
152	Per	10.0		?	i	cd		
153	Per	13.0		r	i	cd		

CT-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	Per	8.0		r	i	cd		
155	Per	--		?	i	cd		
156	Per	--		?	i	cd		
157	Per	11.0		l	i	cd		
158	Per	11.0		r	i	cd		
159	Per	10.0		l	i	cd		
160	Per	4.0		l	i	cd		
161	Per	14.0		r	i	cd		x
162	Per	14.0		r	i	cd		x
163	Per	12.0		l	i	cd		
164	Per	6.0	x		i	cd		
165	Not a fossil							
166	Per	16.0		l	i	cd		
167	Per	10.0		l	i	cd		
168	unid				o		x	x
169	Per	7.0		r	i	cd		
170	Avic			r	o	cd		
171	Per	7.0		l	i	cd		
172	Per	13.0		r	i	cd		
173	Bell				i			
174	Per	12.0		r	i	cd		
175	Per	7.0		l	i	cd		
176	Per	5.0		?	i	cd		
177	Per	17.0		r	o	cd		x
178	pyra				i			
179	Per	6.0		r	i	cd		
180	Per	11.0		l	i	cd		
181	pyra				i			
182	Avic			r	o	cd		
183	Per	9.0		r	i	cd		
184	Not a fossil							
185	Avic			l	o	cd		x
186	Per	12.0		l	i	cd		
187	Per	14.0		r	o	cu		
188	Per	15.0		r	i	cd		
189	Avic			?	o	cd	x	
190	Per	6.0		r	i	cd		
191	Per	10.0		r	i	cd		
192	Per	15.0		r	i	cd		
193	Per	15.0		l	i	cd		
194	Avic			r	o	cd		
195	unid				o			
196	Per	10.0		r	i	cd		
197	Per	20.0		r	i	cd		
198	Per	11.0		r	i	cd		
199	Per	14.0		r	i	cd		
200	Per	16.0		r	i	cd		
201	pyra				i			
202	pyra				i		x	
203	Per	13.0		l	o	cd		
204	Bell				i			

#	name	size	art	val	pres	orient	frag	epiz
205	Per	10.0		?	i	cd		
206	unid				o	cu	x	
207	Per	16.0		r	i	cd		
208	Avic			?	o	cd	x	x
209	Bell				i			
210	Per	10.0		r	i	cd		
211	Avic			r	o	cd		
212	Per	8.0		l	i	cd		
213	Pseu			r	o	cd		
214	Per	13.0		?	i	cd		
215	Per	9.0		r	i	cd		
216	Per	12.0		l	i	cd		
217	Per	13.0		r	i	cd		
218	Per	10.0		r	i	cd		
219	Bell				i			x
220	Per	10.0		l	i	cd		
221	Per	9.0		r	i	cd		
222	Per	12.0		r	i	cd		
223	Per	13.0		l	i	cd		
224	Per	20.0		l	i	cd		x
225	Per	11.0	x		i	i		
226	Per	17.0		l	i	cd		
227	Per	14.0	x		i	cd		
228	Per	14.0		r	i	cd		
229	Per	12.0		r	i	cd		
230	Per	4.0		?	i	cd		
231	Per	16.0		r	i	cd		
232	Per	9.0		l	i	cd		
233	Per	19.0		l	i	cd		
234	Avic			?	o	cu	x	
235	Avic			l	o	cd		x
236	Per	14.0		?	i	cd		
237	Per	11.0		r	i	cd		
238	Avic			l	o	cd		
239	pyra				i			
240	unid				o		x	
241	Per	6.0		l	i	cd		
242	Avic			?	o	cd	x	
243	unid				o		x	x
244	Per	6.0		r	i	cd		
245	Per	15.0		l	i	cd		
246	Per	16.0		l	i	cd		x
247	Per	10.0		l	o	cd		
248	Per	18.0		l	i	cd		x
249	Per	9.0		l	i	cd		x
250	Per	8.0		l	i	cd		
251	Per	10.0		r	o	cd		x
252	Per	11.0		l	i	cd		
253	Per	13.0		?	i	cd		
254	Per	12.0		l	o	cu		
255	Per	16.0		r	i	cd		x

#	name	size	art	val	pres	orient	frag	epiz
256	Per	9.0		l	i	cd		
257	pyra				i			
258	Per	9.0		l	i	cd		
259	Avic			?	o	cd	x	
260	Per	10.0		l	i	cd		
261	Bell				i			
262	Per	8.0		?	i	cd		
263	Per	14.0		r	i	cd		
264	Per	11.0		l	i	cd		
265	Sept			r	o	cd		
266	Per	13.0		r	i	cd		
267	Per	8.0		r	i	cd		
268	unid				o			x
269	Per	11.0	x		i	cd		
270	Per	9.0		r	i	cd		
271	Per	16.0		r	i	cd		
272	Per	13.0		r	i	cd		
273	unid				i			
274	Avic			r	o	cd		x
275	Per	12.0		r	i	cd		
276	Per	12.0		r	i	cd		
277	Avic			l	o	cd		x
278	Avic			?	o	cd		x
279	Per	13.0		l	i	cd		x
280	Per	11.0		r	i	cd		
281	Per	10.0		l	i	cd		
282	Per	10.0		r	i	cd		
283	Per	10.0		?	i	i		
284	Per	8.0		?	i	cd		
285	Avic			l	o	cd		x
286	Per	13.0		l	i	cd		
287	Per	19.0		l	i	cd		
288	unid				o			
289	Per	15.0		l	i	cd		
290	Per	16.0		l	i	cd		x
291	Per	--		?	i	cd		
292	Per	10.0		l	i	cd		
293	Per	7.0		l	i	cd		
294	Per	11.0		l	i	cd		
295	pyra				i		x	
296	Per	9.0		l	i	cd		
297	Per	13.0		?	o	cd		x
298	Avic			r	o	cd		x
299	Per	10.0		l	i	cd		
300	Per	9.0		r	i	cd		
301	Per	8.0		?	i	cd		
302	Avic			?	o	cu	x	
303	Per	11.0		r	i	cd		
304	pyra				i			
305	pyra				i			
306	Per	12.0		r	i	cd		

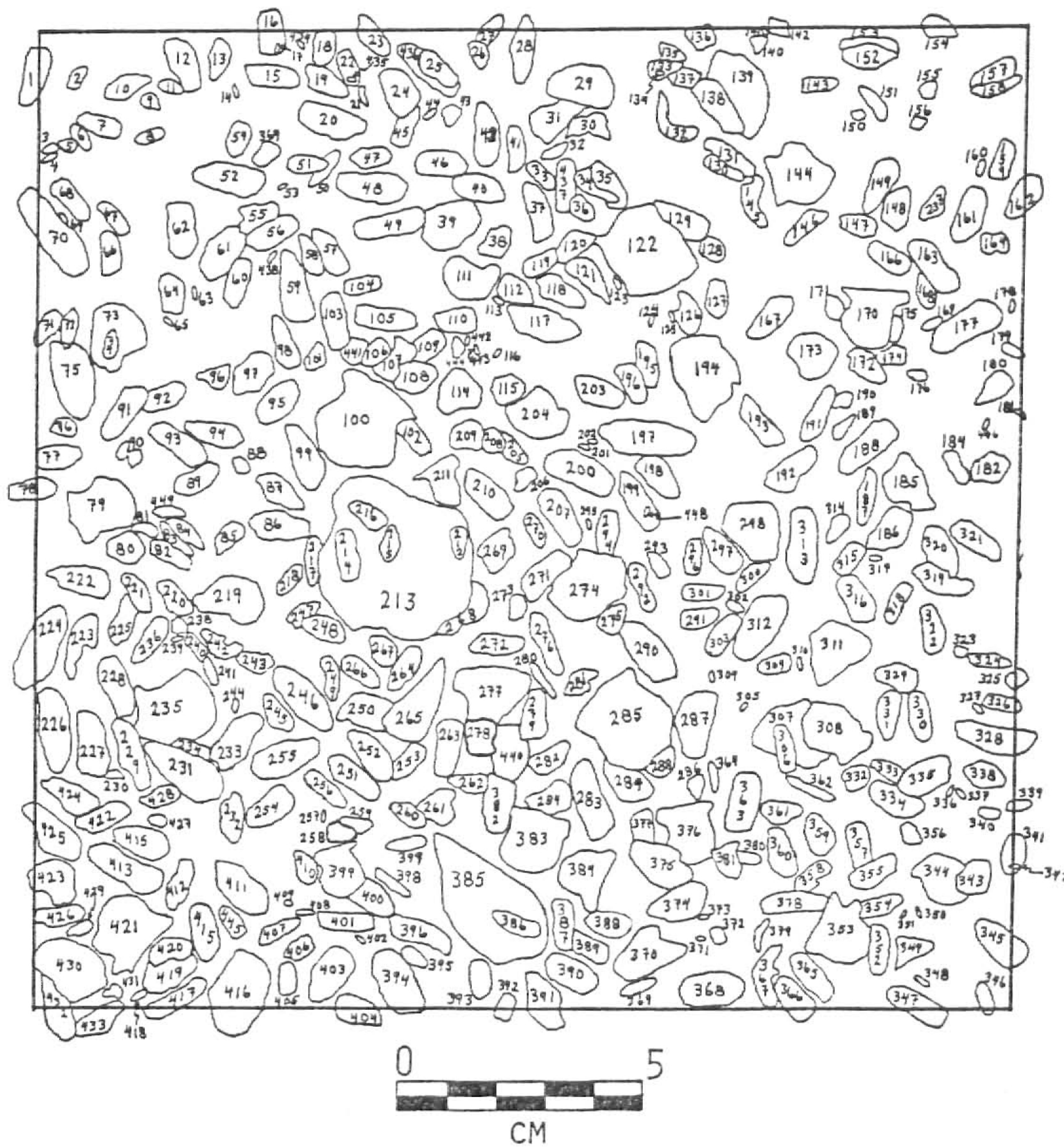
#	name	size	art	val	pres	orient	frag	epiz
307	Avic			?	o	cu		x
308	Avic			l	o	cd		x
309	Per	8.0		?	i	cd		
310	pyra				i			
311	unid				o			
312	Per	16.0		l	o	cd		x
313	Per	19.0		r	i	cd		
314	Per	7.0		r	i	cd		
315	Per	8.0		l	i	cd		
316	Per	13.0		l	i	cd		
317	pyra				i		x	
318	Per	9.0		l	i	cd		
319	Per	12.0		l	i	cd		x
320	Per	12.0		r	i	cd		
321	Per	12.0		r	i	cd		
322	Per	9.0		l	i	cd		
323	unid				o	cu	x	
324	Per	8.0		r	i	cd		
325	Per	--		r	o	cu		
326	Per	9.0		r	i	cd		
327	pyra				i			
328	Per	17.0		l	o	cd		
329	Per	12.0		r	i	cd		
330	Per	11.0		?	i	cd		
331	Per	11.0		l	i	cd		
332	unid				o	cu		
333	Per	7.0		r	i	cd		
334	Per	12.0		l	i	cd		
335	Per	13.0		r	i	cd		
336	pyra				i		x	
337	pyra				i			
338	Avic			?	o	cd		x
339	Per	5.0		?	i	cd		
340	Per	5.0		l	i	cd		
341	Per	11.0		l	i	cd		
342	pyra				i			
343	unid				i			
344	Avic			?	o	cd		x
345	Per	15.0		l	o	cd		
346	Per	8.0		r	i	cd		
347	Per	14.0		r	i	cd		
348	unid				o		x	
349	Avic			?	o	cd	x	x
350	pyra				i			
351	pyra				i			
352	Per	12.0		r	i	cd		
353	Avic			l	o	cd		x
354	Per	11.0		?	i	cd		
355	Per	11.0		r	i	cd		
356	Avic			?	o	cd	x	
357	Per	12.0		r	o	cu		

CT-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
358	Per	11.0		l	i	cd		
359	Per	9.0		r	i	cd		
360	Per	11.0		l	i	cd		
361	Per	11.0		l	i	cd		
362	Per	9.0		r	i	cd		
363	Per	13.0		l	i	cd		
364	unid				o	cu		
365	Per	13.0		r	i	cd		
366	Per	13.0		r	i	cd		
367	Avic			?	o	cu	x	
368	Per	13.0		?	i	cd		
369	Per	9.0		l	o	cd		x
370	Per	17.0		l	i	cd		
371	pyra				i		x	
372	Avic			?	o	cd	x	
373	pyra				i			
374	Per	14.0		r	o	cu		
375	Avic			l	o	cd		
376	Avic			l	o	cu	x	
377	Per	7.0		r	i	cd		
378	Per	17.0		r	i	cd		
379	unid				o			
380	Per	6.0		l	i	cd		
381	Avic			l	o	cd		
382	Per	9.0		r	i	cd		
383	Avic			r	o	cd		
384	Avic			l	o	cd		x
385	Sept			l	o	cd		
386	Per	12.0		r	i	cd		
387	Per	11.0		l	i	cd		
388	Per	9.0		r	i	cd		
389	Per	9.0		r	i	cd		
390	Per	12.0		r	i	cd		
391	Per	8.0		l	i	cd		
392	Per	7.0		l	i	cd		x
393	Per	11.0		r	i	cd		
394	Per	14.0		l	i	cd		
395	Per	8.0		?	i	cd		
396	Per	13.0		l	i	cd		
397	Per	10.0		?	i	i		
398	Per	9.0		l	i	cd		
399	Avic			l	o	cd		x
400	Per	9.0		r	i	cd		
401	Per	14.0		l	i	cd		
402	pyra				i			
403	Per	14.0		l	i	cd		
404	Per	12.0		l	i	cd		
405	Per	9.0		?	i	cd		
406	Per	9.0		r	i	cd		
407	Per	11.0		l	i	cd		
408	pyra				i			

#	name	size	art	val	pres	orient	frag	epiz
409	pyra				i		x	
410	unid				o		x	
411	Per	13.0		r	i	cd		
412	Per	14.0		r	i	cd		
413	Per	17.0		r	i	cd		
414	Per	8.0		l	i	cd		
415	Per	15.0		r	i	cd		x
416	Per	19.0		r	o	cd		x
417	Per	14.0		?	i	cd		
418	Per	5.0		l	i	cd		
419	unid				o			x
420	Avic			?	o	cd	x	
421	Avic			r	o	cd		
422	Per	12.0		r	i	cd		
423	Avic			?	o	cd	x	
424	Per	13.0		l	i	cd		
425	Per	18.0		l	i	cd		
426	Per	15.0		l	i	cd		
427	Avic			?	o	cd		
428	Per	8.0		?	i	cd		x
429	Per	6.0		l	i	cd		
430	Avic			r	o	cd		x
431	unid				o		x	
432	Per	14.0		l	i	cd		
433	Per	13.0		l	i	cd		
434	pyra				i			
435	pyra				i			
436	Per	17.0		?	o	cu		
437	Per	13.0		r	o	cd		
438	pyra				i			
439	Per	--		?	i	cd		
440	unid				o		x	x
441	Avic			?	l	cu	x	
442	pyra				i			
443	pyra				i			
444	Per	6.0		l	i	cd		
445	Per	6.0		l	i	cd		
446	pyra				i		x	
447	Per	15.0		r	i	cd		x
448	pyra				i			
449	unid				o			x

CT-1



CU-13 Area #1

#	name	size	art	val	pres	orient	frag	epiz
1	Per	6.0		l	i	cd		
2	Per	12.0		l	i	cd		
3	pyra				i			
4	pyra				i		x	
5	pyra				i		x	
6	Per	15.0		r	i	cd		
7	pyra				i			
8	Per	7.0		l	i	cd		
9	pyra				i		x	
10	pyra				i			
11	Per	7.0		r	i	cd		
12	Per	12.0		?	i	cd		
13	pyra				i			
14	pyra				i			
15	pyra				i			
16	pyra				i			
17	pyra				i			
18	Per	14.0		r	i	cd		
19	pyra				i		x	
20	Per	11.0		r	i	cd		
21	pyra				i			
22	pyra				i			
23	Per	8.0		?	i	cd		
24	pyra				i			
25	pyra				i			
26	pyra				i			
27	pyra				i			
28	Per	7.0		?	i	cd		
29	pyra				i			
30	pyra				i			
31	pyra				i			
32	Per	15.0		?	i	cd		
33	Avic			r	o	cd		
34	Per	14.0		r	i	cd		
35	Per	13.0		l	i	cd		
36	pyra				i		x	
37	pyra				i		x	
38	pyra				i			
39	pyra				i			
40	pyra				i			
41	pyra				i			
42	pyra				i		x	
43	pyra				i			
44	pyra				i			
45	Per	12.0		l	i	cd		
46	pyra				i			
47	Per	10.0		r	i	cd		
48	pyra				i			
49	pyra				i			
50	pyra				i			
51	pyra				i			

CU-13 Area #1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Per	6.0		l	i	cd		
53	Per	4.0		r	i	cd		
54	pyra				i		x	
55	pyra				i			
56	pyra				i		x	
57	pyra				i			
58	pyra				i		x	
59	Per	--		?	i	cd	x	
60	pyra				i			
61	pyra				i		x	
62	pyra				i			
63	pyra				i			
64	pyra				i			
65	pyra				i			
66	pyra				i		x	
67	Per	13.0		r	i	cd		
68	pyra				i			
69	pyra				i			
70	pyra				i			
71	pyra				i		x	
72	Per	14.0		r	i	cd		
73	Per	--		?	i	cd	x	
74	Per	6.0		l	i	cd		
75	unid				o		x	
76	Per	5.0		?	i	cd		
77	pyra				i			
78	pyra				i			
79	Per	13.0		?	i	cd		
80	Per	11.0		r	i	cd		
81	pyra				i		x	
82	unid				o		x	
83	unid				o		x	
84	pyra				i		x	
85	Per	6.0		?	i	cd		
86	Per	5.0		r	i	cd		
87	ost			r	o	cd		
88	pyra				i		x	
89	pyra				i		x	
90	pyra				i			
91	Per	7.0		l	i	cd		
92	Per	12.0		r	i	cd		
93	Per	11.0		r	i	cd		
94	pyra				i			
95	pyra				i			
96	pyra				i			
97	pyra				i		x	
98	pyra				i			
99	pyra				i			
100	pyra				i			
101	pyra				i		x	
102	pyra				i			

CU-13 Area #1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	pyra				i			
104	pyra				i			
105	pyra				i			
106	pyra				i		x	
107	pyra				i			
108	pyra				i			
109	unid				o		x	
110	pyra				e			
111	pyra				i			
112	pyra				i		x	
113	pyra				i			
114	pyra				i			
115	pyra				i			
116	pyra				i			
117	pyra				i		x	
118	Per	7.0		r	i	cd		
119	Per	8.0		r	i	cd		
120	pyra				i		x	
121	unid				o		x	
122	Per	14.0		l	i	cd		
123	pyra				i			
124	Per	13.0		r	i	cd		
125	pyra				i		x	
126	pyra				i		x	
127	pyra				i			
128	pyra				i			
129	pyra				i		x	
130	pyra				i			
131	pyra				i			
132	pyra				i			
133	Per	10.0		?	i	cd		
134	pyra				i			
135	Per	14.0		?	i	cd		
136	pyra				i			
137	pyra				i		x	
138	pyra				i			
139	pyra				i			
140	Per	10.0		r	i	cd		
141	pyra				i			
142	pyra				i			
143	pyra				i			
144	pyra				i		x	
145	pyra				i			
146	Per	9.0		r	i	cd		
147	pyra				i			
148	pyra				i			
149	pyra				i			
150	pyra				i			
151	pyra				i			
152	pyra				i		x	
153	pyra				i			

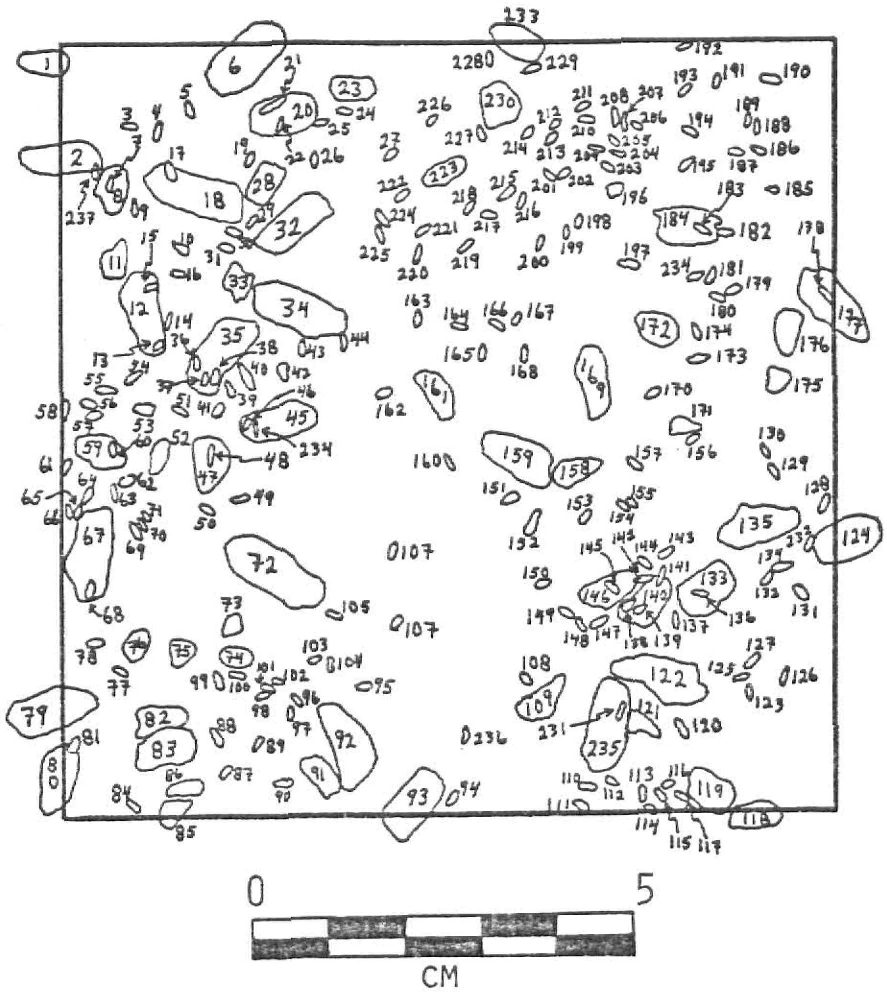
CU-13 Area #1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	pyra				i			
155	pyra				i		x	
156	pyra				i		x	
157	pyra				i			
158	unid				o		x	
159	Per	14.0		r	i	cd		
160	pyra				i			
161	Per	8.0		r	i	cd		
162	pyra				i		x	
163	pyra				i			
164	pyra				i			
165	pyra				i			
166	pyra				i			
167	pyra				i			
168	pyra				i			
169	Per	10.0		l	i	cd		
170	pyra				i		x	
171	unid				o		x	
172	Per	6.0		r	i	cd		
173	pyra				i			
174	pyra				i			
175	Per	6.0		l	e	cu		
176	Per	7.0		r	i	cd		
177	Per	12.0		l	i	cd		
178	pyra				i			
179	pyra				i		x	
180	pyra				i		x	
181	pyra				i		x	
182	pyra				i			
183	pyra				i			
184	Per	9.0	x		i	cd		
185	pyra				i			
186	pyra				i			
187	pyra				i			
188	pyra				i			
189	pyra				i		x	
190	pyra				i			
191	pyra				i			
192	pyra				i			
193	pyra				i			
194	pyra				i			
195	pyra				i			
196	pyra				i			
197	pyra				i			
198	pyra				i		x	
199	pyra				i		x	
200	pyra				i			
201	pyra				i			
202	pyra				i			
203	pyra				i			
204	pyra				i		x	

CU-13 Area #1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
205	pyra				i			
206	pyra				i		x	
207	pyra				i		x	
208	pyra				i		x	
209	pyra				i			
210	pyra				i			
211	pyra				i			
212	pyra				i		x	
213	pyra				i			
214	pyra				i			
215	pyra				i			
216	pyra				i			
217	pyra				i			
218	pyra				i			
219	pyra				i		x	
220	pyra				i			
221	pyra				i			
222	pyra				i		x	
223	Per	7.0		r	i	cd		
224	pyra				i		x	
225	pyra				i		x	
226	pyra				i		x	
227	pyra				i		x	
228	pyra				i			
229	pyra				i			
230	Per	8.0		r	i	cd		
231	pyra				i			
232	pyra				i			
233	Per	8.0		r	i	cd		
234	pyra				i			
235	Per	9.0		l	i	cd		
236	pyra				i		x	
237	pyra				i			

CU-13 AREA #1



CU-13 Area #2

#	name	size	art	val	pres	orient	frag	epiz
1	Per	8.0		r	i	cd	x	
2	pyra				i			
3	pyra				i			
4	Per	7.0		?	i	cd		
5	Per	13.0		l	i	cd		
6	Per	--		?	i	cd	x	
7	Per	9.0		l	i	cd		
8	pyra				i			
9	pyra				i			
10	pyra				i			
11	unid				o		x	
12	pyra				i			
13	pyra				i			
14	pyra				i			
15	pyra				i		x	
16	pyra				i			
17	pyra				i			
18	Per	7.0		r	i	cd		
19	Per	10.0		l	i	cd		
20	pyra				i			
21	Per	5.0		r	i	cd		
22	pyra				i			
23	pyra				i			
24	Per	6.0		?	i	cd		
25	pyra				i			
26	pyra				i			
27	Per	7.0		?	i	cd		
28	Per	7.0		r	i	cd		
29	Per	6.0		l	i	cd		
30	Per	6.0		?	i	cd		
31	pyra				i			
32	pyra				i			
33	pyra				i		x	
34	pyra				i			
35	Per	--		?	i	cd	x	
36	pyra				i		x	
37	pyra				i		x	
38	pyra				i			
39	pyra				i			
40	pyra				i			
41	pyra				i			
42	pyra				i			
43	pyra				i			
44	pyra				i			
45	pyra				i		x	
46	pyra				i			
47	pyra				i		x	
48	pyra				i			
49	pyra				i			
50	pyra				i			
51	pyra				i			

CU-13 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	pyra				i			
53	pyra				i			
54	pyra				i			
55	Per	8.0		r	i	cd		
56	pyra				i			
57	ost			r	o	cd		
58	Per	13.0		l	i	cd		
59	Per	5.0		l	i	cd		
60	Per	5.0		l	i	cd		
61	unid				o	cu	x	
62	Per	8.0		l	i	cd		
63	Sept			r	o	cd		
64	Pseu			r	o	cd		
65	Per	9.0		r	i	cd		
66	Per	8.0		r	i	cd		
67	Per	8.0		r	i	cd		
68	Per	13.0		r	i	cd		
69	unid				o		x	
70	Per	7.0		r	i	cd		
71	pyra				i		x	
72	Sept			l	o	cd	x	
73	Per	--		r	e	cu	x	
74	unid				o		x	x
75	Per	12.0		l	i	cd		
76	Per	6.0		r	i	cd		
77	Per	8.0		l	i	cd		
78	unid				o		x	
79	Per	7.0		r	i	cd		
80	pyra				i			
81	pyra				i			
82	Per	9.0		r	i	cd		
83	Per	9.0		l	i	cd		
84	unid				o		x	
85	pyra				i			
86	Per	8.0		r	i	cd		
87	Per	9.0		l	i	cd		
88	Per	7.0		r	i	cd		
89	pyra				i			
90	Per	--		?	i	cd	x	
91	Avic			?	o	cd	x	
92	Per	12.0		l	i	cd		x
93	Per	7.0		l	i	cd		
94	Per	7.0		l	i	cd		
95	Per	--		?	i	cd	x	
96	Per	7.0		l	i	cd		
97	Per	11.0		r	i	cd		
98	Per	8.0		?	i	cd		
99	Per	9.0		l	i	cd		
100	pyra				i			
101	pyra				i			
102	pyra				i		x	

CU-13 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Per	--		?	i	cd	x	
104	pyra				i			
105	pyra				i		x	
106	unid				o	cu	x	
107	Per	9.0		l	i	cd		
108	pyra				i			
109	pyra				i			
110	pyra				i			
111	Per	7.0		r	i	cd		
112	Per	4.0		r	i	cd		
113	Per	11.0		l	i	cd		
114	Per	--		?	i	cd	x	
115	Per	12.0		r	i	cd		
116	Per	--		l	i	cd	x	
117	pyra				i			
118	unid				o		x	
119	Per	5.0		?	i	cd		
120	Per	7.0		l	i	cd		
121	Per	8.0		l	i	cd		
122	pyra				i			
123	Per	13.0		l	i	cd		
124	Per	11.0		l	i	cd		
125	Per	12.0		r	i	cd		
126	Per	--		?	i	cd		
127	Per	9.0		r	i	cd		
128	pyra				i			
129	unid				o		x	
130	pyra				i			
131	Per	6.0		r	i	cd		
132	pyra				i			
133	pyra				i			
134	Per	11.0		l	i	cd		
135	pyra				i			
136	pyra				i			
137	Per	6.0		l	i	cd		
138	pyra				i			
139	unid				o		x	
140	pyra				i			
141	Per	10.0		r	i	cd		
142	Per	--		?	i	cd	x	
143	Per	7.0		?	i	cd		
144	Per	9.0	x		i	cd		
145	pyra				i			
146	pyra				i		x	
147	pyra				i			
148	pyra				i			
149	pyra				i			
150	Per	9.0		l	i	cd		
151	pyra				i			
152	Per	7.0		l	i	cd		
153	Per	7.0		r	i	cd		

CU-13 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
154	pyra				i			
155	pyra				i			
156	pyra				i		x	
157	pyra				i			
158	pyra				i			
159	pyra				i			
160	Per	5.0		r	i	cd		
161	pyra				i			
162	pyra				i			
163	pyra				i			
164	pyra				i			
165	Per	4.0		l	i	cd		
166	Per	8.0		r	i	cd		
167	pyra				i		x	
168	Per	--		?	i	cd		
169	Per	12.0		l	i	cd		
170	pyra				i			
171	pyra				i			
172	pyra				i			
173	pyra				i			
174	pyra				i		x	
175	pyra				i			
176	pyra				i			
177	Per	5.0		r	i	cd		
178	pyra				i			
179	Per	7.0		l	i	cd		
180	Per	10.0		r	i	cd		
181	pyra				i		x	
182	Per	--		l	i	cd	x	
183	pyra				i			
184	pyra				i			
185	Per	8.0		r	i	cd		
186	Per	9.0		l	i	cd		
187	pyra				i			
188	pyra				i			
189	pyra				i			
190	pyra				i			
191	pyra				i			
192	pyra				i			
193	Per	8.0		l	i	cd		
194	pyra				i			
195	Per	4.0		l	i	cd		
196	Per	9.0		r	i	cd		
197	unid				o		x	
198	pyra				i			
199	pyra				i			
200	Per	--		?	i	cd	x	
201	Per	7.0		?	i	cd		
202	pyra				i			
203	Per	8.0		r	i	cd		
204	Per	11.0		r	i	cd		

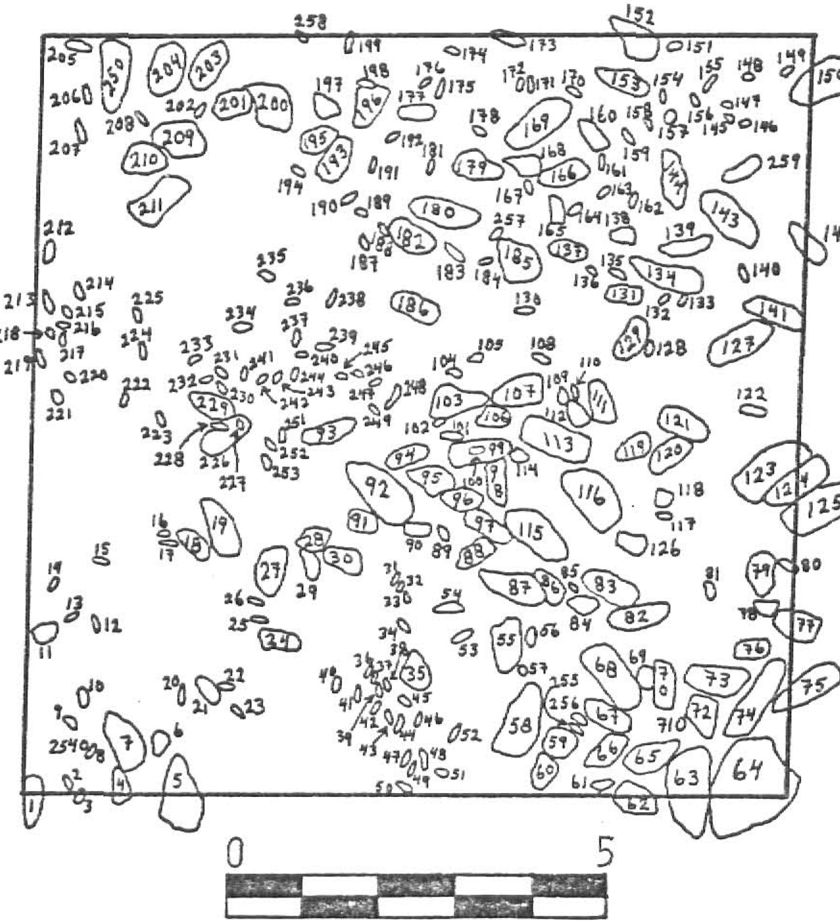
CU-13 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
205	pyra				i			
206	pyra				i			
207	pyra				i			
208	pyra				i			
209	Per	--		?	i	cd	x	
210	Per	--		?	i	cd	x	
211	Per	8.0		?	i	cd		
212	pyra				i			
213	pyra				i			
214	pyra				i			
215	pyra				i			
216	pyra				i			
217	pyra				i			
218	pyra				i			
219	pyra				i			
220	pyra				i			
221	pyra				i			
222	pyra				i			
223	pyra				i			
224	pyra				i			
225	pyra				i			
226	Per	6.0		r	i	cd		
227	pyra				i			
228	pyra				i			
229	Per	7.0		r	i	cd		
230	pyra				i			
231	pyra				i			
232	pyra				i			
233	pyra				i			
234	pyra				i			
235	pyra				i			
236	pyra				i			
237	pyra				i			
238	pyra				i			
239	pyra				i			
240	pyra				i			
241	pyra				i			
242	pyra				i			
243	pyra				i			
244	pyra				i			
245	pyra				i			
246	pyra				i			
247	pyra				i			
248	Avic			?	o	cd	x	
249	pyra				i			
250	Per	7.0		l	o	cu		
251	pyra				i			
252	pyra				i			
253	pyra				i			
254	ost			l	o	cd		
255	pyra				i		x	

CU-13 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
256	pyra				i		x	
257	pyra				i			
258	pyra				i			
259	Per	--		?	i	cd		

CU-13 AREA #2



CM

CW-1

#	name	size	art	val	pres	orient	frag	epiz
1	unid				o			
2	Avic			?	o	cd	x	
3	Avic			?	o	cd	x	
4	Avic			l	o	cd		
5	unid				o			
6	unid				o	cu		
7	Avic			?	o	cd	x	
8	unid				o		x	
9	unid				o		x	
10	Avic			l	o	cu		
11	Avic			?	o	cu	x	
12	Avic			?	o	cu		
13	Sept			?	o	cu		
14	unid				o			x
15	Per	11.0		l	o	cu		x
16	Sept			?	o	cd		
17	unid				o	cu		
18	unid				o		x	
19	unid				o		x	
20	unid				o		x	
21	Avic			?	o	cd	x	
22	Sept			l	o	cd		
23	unid				o		x	
24	Per	8.0		r	i	cu		
25	unid				o		x	
26	unid				o		x	
27	Avic			?	o	cd	x	
28	Avic			?	o	cd		
29	unid				o		x	
30	Per	12.0		?	o	cd		
31	Avic			l	o	cd		
32	Avic			l	o	cd		
33	unid				o		x	
34	unid				o		x	
35	Avic			?	o	cd	x	
36	unid				o		x	
37	Per	13.0		l	o	cu		
38	Avic			r	o	cd		
39	unid				o		x	
40	unid				o			
41	unid				o			
42	unid				o			
43	Avic			?	o	cd		
44	Avic			?	o	cd		
45	unid				o		x	
46	Avic			?	o	cd	x	
47	Sept			l	i	cu		
48	unid				o			
49	Avic			l	o	cd		
50	Sept			l	o	cd		
51	Avic			?	o	cd	x	

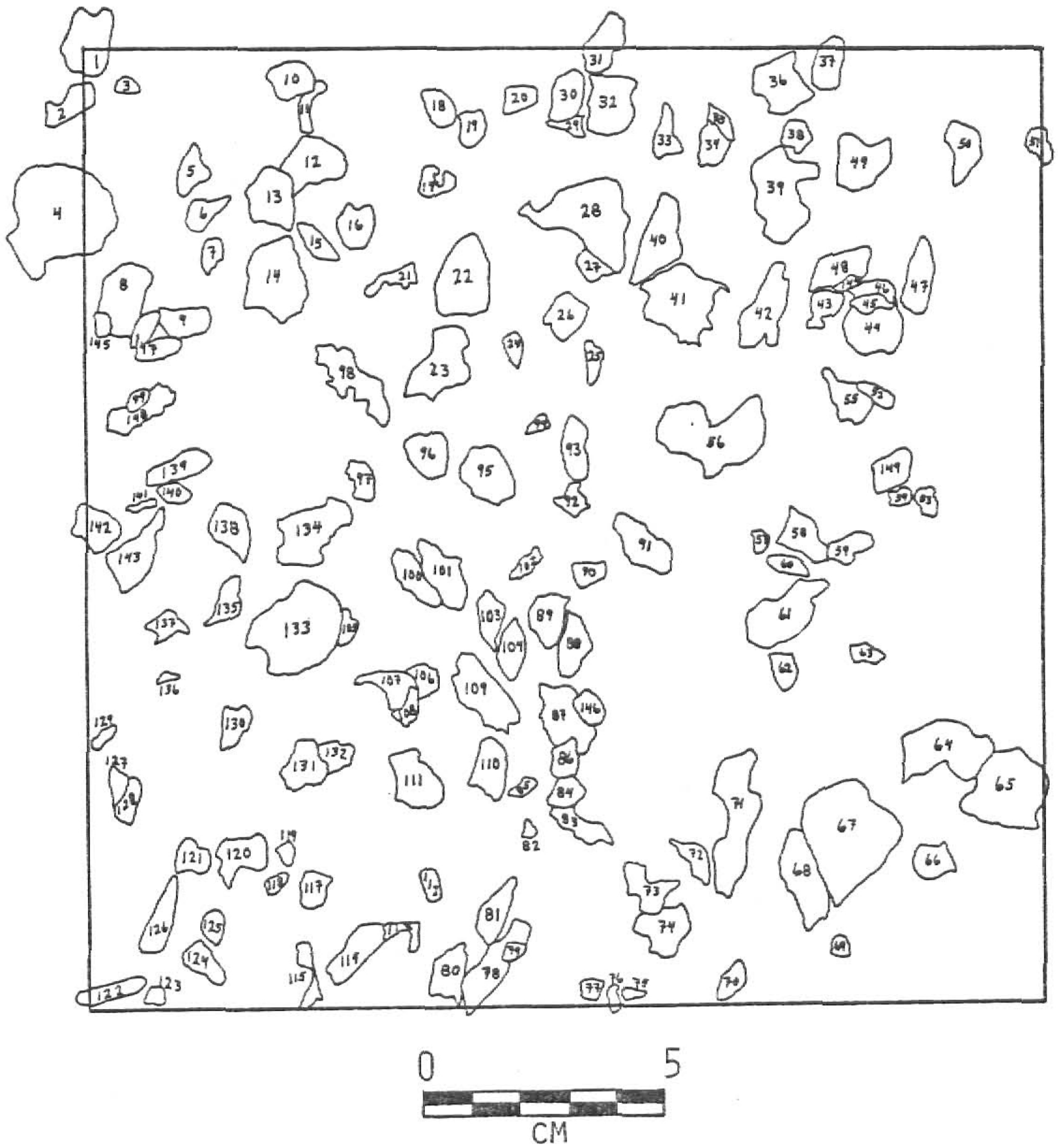
CW-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Avic			?	o	cd	x	
53	Avic			?	o	cd	x	
54	Avic			?	o	cd	x	
55	unid				o		x	
56	unid				o		x	
57	Avic			?	o	cu		
58	unid				o			
59	unid				o			x
60	Per	11.0		?	i	cu		
61	Sept			?	o	cd		
62	Per	9.0		r	i	cu		
63	Avic			?	o	cd	x	
64	unid				o			
65	Avic			l	o	cd		
66	Avic			l	o	cd		
67	Sept			r	o	cd		
68	Per	22.0		?	o	cd		
69	Avic			?	o	cd	x	
70	unid				o			
71	unid				o		x	
72	Avic			?	o	cd	x	
73	Avic			?	o	cd	x	
74	unid				o			
75	Avic			?	o	cd	x	
76	unid				o		x	
77	Avic			?	o	cd	x	
78	Sept			r	o	cd		
79	Avic			?				
80	Sept			r	o	cd		
81	Sept			r	i	cd		
82	Sept			?	o	cd	x	
83	Avic			?	o	cd	x	
84	Avic			?	o	cd	x	
85	Avic			?	o	cd	x	
86	Avic			l	o	cd		
87	Avic			?	o	cd	x	
88	Sept			?	o	cd		
89	unid				o			
90	Avic			?	o	cd	x	
91	Avic			?	o	cd	x	
92	Avic			?	o	cd	x	
93	unid				o			
94	Avic			?	o	cd	x	
95	Avic			?	o	cd		
96	Avic			?	o	cd		
97	unid				o		x	
98	unid				o		x	
99	Avic			r	o	cd		
100	Sept			?	o	cd		
101	unid				o			
102	Avic			?	o	cd	x	

CW-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
103	Avic			?	o	cd	x	
104	unid				o		x	
105	Avic			?	o	cd	x	
106	unid				o		x	
107	unid				o		x	
108	Avic			?	o	cd	x	
109	Avic			1	o	cd		
110	unid				o			
111	Avic			?	o	cd	x	
112	unid				o			
113	Avic			1	o	cu		
114	unid				o			
115	Avic			r	o	cd		
116	Not a fossil							
117	unid				o		x	
118	Avic			?	o	cd	x	
119	Avic			?	o	cd	x	
120	Avic			1	o	cu		
121	unid				o			
122	Sept			r	o	cu		
123	unid				o		x	
124	unid				o			
125	unid				o		x	
126	Sept			?	o	cd		
127	Sept			?	o	cd		
128	unid				o			
129	unid				o			
130	Sept			?				
131	Avic			?	o	cd		
132	unid				o			
133	Pseu			r	o	cd		
134	Avic			?	o	cd	x	
135	Sept			?	o	cd		
136	unid				o		x	
137	unid				o			
138	unid				o			
139	unid				o	cu		
140	unid				o			
141	unid				o		x	
142	Avic			?	o	cd	x	
143	unid				o	cu		
144	Per	6.0		1	o	cu		
145	Avic			?	o	cd	x	
146	Avic			?	o	cd	x	
147	Per	10.0	x		i	cu		
148	Per	16.0		1	i	cu		
149	Sept			1	o	cd		
150	unid				o			

CW-1



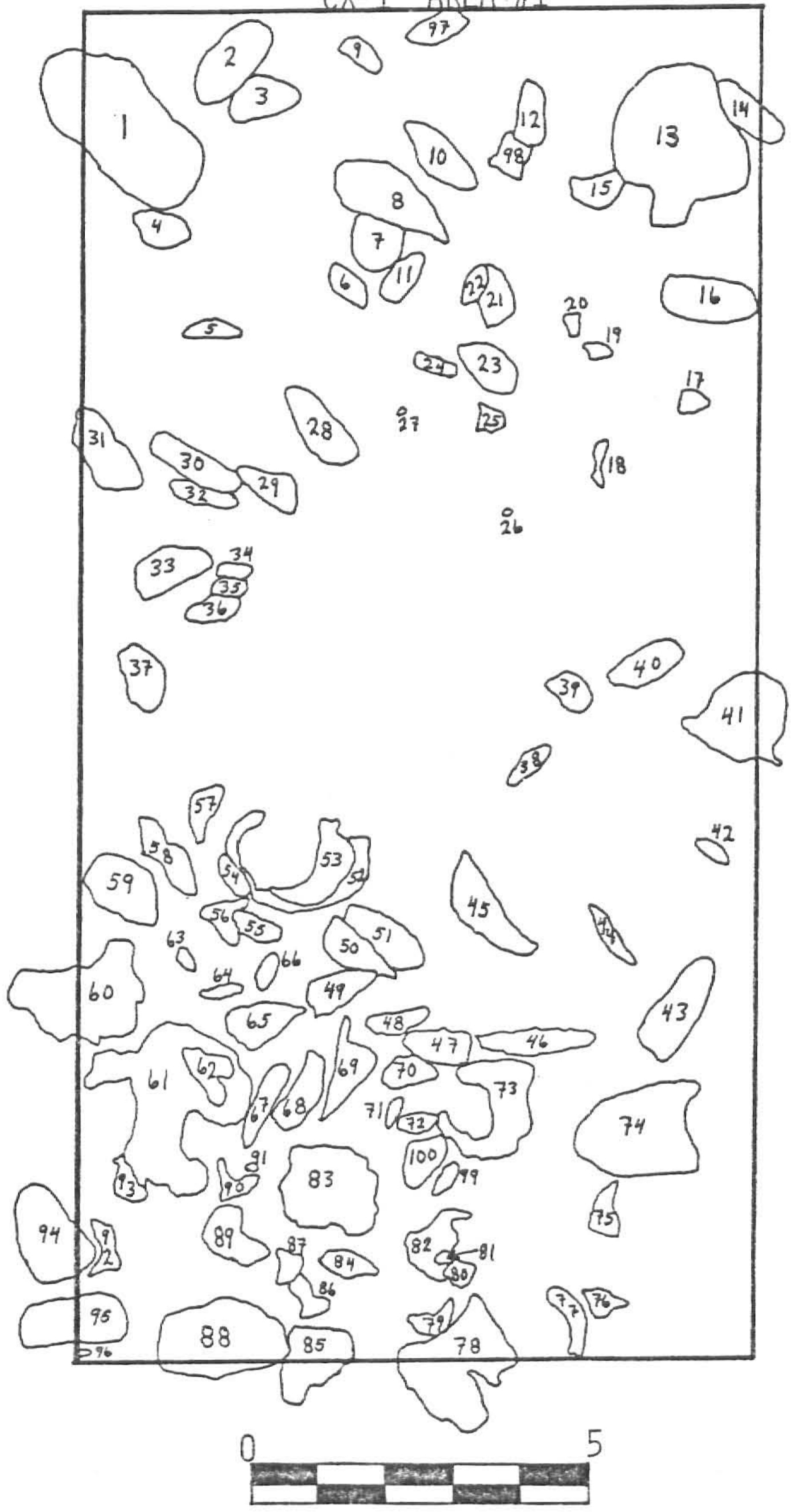
CX-1 Area #1

#	name	size	art	val	pres	orient	frag	epiz
1	Per	30.0		r	e	cd		
2	Per	15.0		l	i	cu		
3	Edm			?	e			
4	Avic			l	o	cd		
5	Sept			l	o	cu		
6	unid				i	cu		
7	Bell				i			
8	Sept			l	o	cd		
9	Per	9.0		l	i	cu		
10	Per	13.0		r	e	cd		
11	Sept			r	o	cu		
12	Sept			r	o	cu		
13	Avic			l	o	cd		
14	Per	12.0		l	e	cd		
15	Avic			?	o	cd		
16	Per	18.0		r	e	cd		
17	Avic			?	o	cd	x	
18	Avic			?	o	cu	x	
19	unid				o		x	
20	Avic			?	o	cd	x	
21	Per	10.0		r	i	cu		
22	Per	7.0		r	i	cu		
23	Per	10.0		?	e	cd		
24	Per	11.0		?	e	cd		
25	Avic			l	o	cd		
26	ost			r	o	cd		
27	ost			r	o	cd		
28	Per	17.0		l	e	cd		x
29	Sept			r	o	cu		
30	Per	15.0		?	e	cd		
31	Sept			?	o	cd	x	
32	Per	12.0		?	e	cd		
33	Per	16.0		l	e	cd		
34	Per	6.0		l	i	cu		
35	Per	7.0		r	i	cu		
36	Per	9.0		l	i	cu		
37	Sept			?	o	cd	x	
38	Per	10.0		?	i	cu		
39	Per	8.0		r	e	cd		
40	Per	13.0		l	e	cd		
41	Avic			?	o	cd		
42	unid				o		x	
43	Per	17.0		?	o	cd		
44	Per	15.0		?	o	i		
45	unid				o			
46	Per	18.0		l	i	cu		
47	Sept			r	o	cu		
48	Sept			r	o	cu		
49	Sept			l	o	cu		
50	Sept			r	o	cu		
51	Per	13.0		r	e	cd		

CX-1 Area #1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Avic			?	o	cd		
53	Avic			?	o	cd		
54	Per	6.0		?	i	cu		
55	Sept			?	o	cd		
56	Avic			?	o	cd		
57	Per	14.0		r	i	cu		
58	Avic			?	o	cd	x	x
59	Per	--		l	o	cd		
60	Avic			?	o	cd		
61	Avic			?	o	cd		
62	alfr							
63	Per	4.0		r	i	cu		
64	unid				o	cu		
65	Sept			r	o	cu		
66	unid				o	cu		
67	Per	17.0		l	i	cu		
68	Avic			?	o	cd		
69	Avic			?	o	cd		
70	Sept			r	o	cu		
71	unid				o		x	
72	Sept			?	o	cd	x	
73	Avic			l	o	cd		
74	unid				o			
75	unid				o			
76	unid				o		x	
77	Avic			?	o	cd		
78	unid				o			
79	Avic			?	o	cd	x	
80	Avic			?	o	cd	x	
81	Avic			?	o	cd	x	
82	unid				o		x	
83	Avic			?	o	cd		
84	Sept			l	o	cu		
85	Avic			r	o	cd		x
86	Avic			?	o	cd	x	
87	Avic			?	o	cd	x	
88	Avic			?	o	cd		
89	Avic			?	o	cd		
90	Sept			r	o	cu		
91	unid				o		x	
92	Avic			l	o	cd		
93	unid				o		x	
94	Per	--		r	i	cu		
95	Per	16.0		r	e	cd		
96	pyra				i			
97	Per	9.0		l	i	cu		
98	Avic			l	o	cd		
99	unid				o	cu		
100	Sept			l	o	cu		

CX-1 AREA #1



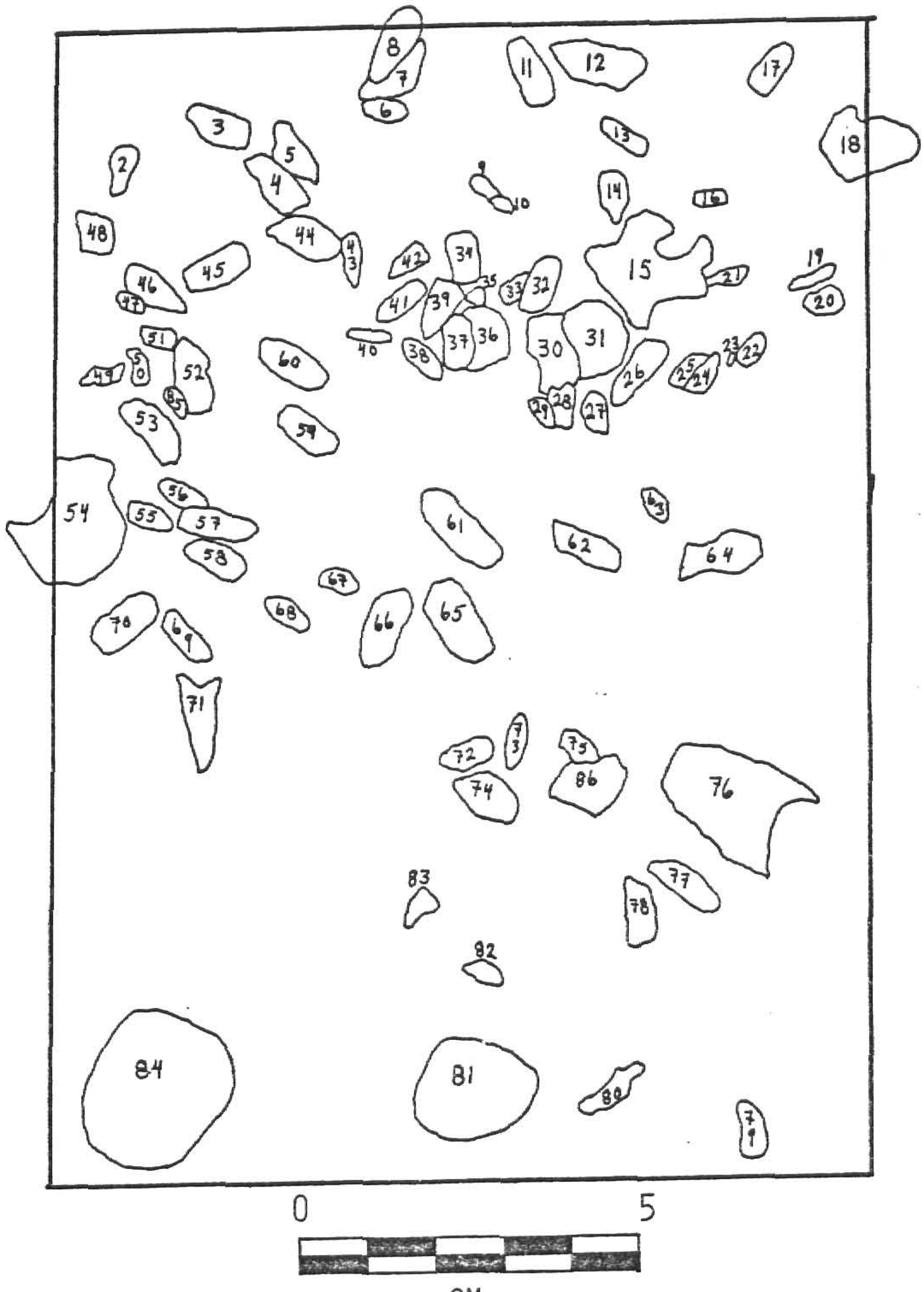
CX-1 Area #2

#	name	size	art	val	pres	orient	frag	epiz
1	Not a fossil							
2	unid				o			
3	Per	13.0		r	i	cu		
4	Per	10.0		l	i	cu		
5	Per	10.0		r	i	cu		
6	unid				o		x	
7	Avic			?	o	cd	x	
8	Per	11.0		l	i	cu		
9	Per	5.0		?	i	cu		
10	Per	5.0		?	i	cu		
11	Per	12.0		r	i	cu		
12	Per	14.0		l	i	cu		
13	unid				o		x	
14	Per	9.0		l	i	cu		
15	Avic			l	o	cd		
16	Per	6.0		r	i	cu		
17	Per	9.0		l	i	cu		
18	Avic			?	o	cd		
19	unid				i	cu		
20	Per	8.0		?	i	cu		
21	Sept			?	o	cu		
22	Per	6.0		l	i	cu		
23	pyra				i			
24	Per	8.0		?	i	cu		
25	Per	8.0		?	i	cu		
26	Per	13.0		r	o	cd		
27	Per	9.0		l	i	cu		
28	Per	7.0		?	i	cu		x
29	Per	7.0		?	i	cu		x
30	unid				o			
31	Edm			?	e	cd		
32	Per	10.0		r	i	cu		
33	Per	5.0		l	i	cu		
34	Per	10.0		l	i	cu		
35	unid				o		x	
36	Per	8.0		l	i	cu		
37	Sept			r	o	cu		
38	Per	8.0		l	i	cu		
39	Per	11.0		l	i	cu		
40	Sept			?	o	cu		
41	Per	9.0		?	i	cu		
42	Per	9.0		l	i	cu		
43	Sept			r	o	cu		
44	unid				o			
45	Per	11.0		r	i	cu		
46	Sept			l	e	cd		
47	Per	6.0		r	i	cu		
48	Per	--		?	i	cu		
49	Avic			?	o	cd	x	
50	Avic			?	o	cd	x	
51	Per	6.0		l	i	cu		

CX-1 Area #2 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Sept			?	o	cu		
53	Per	13.0		l	e	cd		
54	Avic			l	o	cd		
55	Per	8.0		l	e	cd		
56	Sept			l	e	cd		
57	Per	11.0		r	e	cd		
58	Per	9.0		r	e	cd		
59	Per	8.0		r	e	cd		
60	Per	11.0		l	e	cd		
61	Per	16.0		r	e	cd		
62	Sept			r	o	cd		
63	Sept			?	o	cu		
64	Avic			?	o	cd		
65	Per	17.0		l	o	cd		
66	Per	14.0		l	e	cd		
67	Per	7.0		?	e	cd		
68	Per	8.0		?	e	cd		
69	Per	10.0		l	e	cd		
70	Per	14.0		r	e	cd		
71	Avic			r	o	cd		
72	Per	9.0		l	o	cd		
73	Per	10.0		r	o	cd		
74	Per	11.0		r	o	cd		
75	unid				o		x	
76	unid				o			
77	Per	13.0		r	e	cd		
78	Per	11.0		r	i	cu		
79	Per	11.0		l	i	cu		
80	unid				o		x	
81	Edm			l	e	cd		
82	Sept			?	o	cd		
83	unid				o		x	
84	Edm			l	i	cd		
85	Sept			r	o	cd		
86	Avic			?	o	cd	x	

CX-1 AREA #2



#	name	size	art	val	pres	orient	frag	epiz
1	pyra				i			
2	pyra				i			
3	pyra				i			
4	pyra				i			
5	pyra				i			
6	pyra				i			
7	pyra				i			
8	pyra				i			
9	Per	6.5		r	i	cd		
10	Avic			l	o	cd	x	
11	Per	7.5		r	i	cd		
12	Per	6.5		l	i	cd		
13	Per	9.5		l	o	cu		
14	pyra				i			
15	Avic			l	o	cd	x	
16	Per	14.0		r	i	cd		
17	Per	9.0		r	i	cd		
18	Per	9.5		r	i	cd		
19	Per	5.5		r	i	cd		
20	pyra				i			
21	Avic			l	o	cd	x	
22	Avic			l	o	cd	x	x
23	Per	9.0		l	i	cd		
24	Per	11.0		l	i	cd		
25	Per	11.0		r	i	cd		
26	Per	6.5		r	i	cd		
27	pyra				i			
28	Avic			l	o	cd	x	
29	Per	13.0		r	i	cd		
30	pyra				i			
31	Avic			?	o	cd		
32	unid				o		x	x
33	Per	8.0		r	i	cd		
34	pyra				i			
35	Per	9.5		r	i	cd		
36	Pseu			r	o	cd		
37	Per	7.5		l	i	cd		
38	Per	31.0		r	i	cd		
39	Per	9.0		l	i	cd		
40	Avic			l	i	cd		x
41	Per	12.5		l	i	cd		
42	Per	6.5		r	i	cd		
43	Avic			?	o	cd		
44	Per	8.0		l	i	cd		
45	pyra				i			
46	Per	8.0		r	i	cd		
47	Per	11.5		l	i	cd		
48	Per	11.0		r	i	cd		
49	Per	9.0		l	i	cd		
50	Per	13.5		l	i	cd		
51	pyra				i			

J-1-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
52	Per	8.5		1	i	cd		
53	Per	10.0		1	i	cd		
54	Per	6.5		r	i	cd		
55	Per	10.5		r	i	cd		
56	Per	10.0		r	i	cd		
57	Per	8.0		1	i	cd		
58	Per	6.0		1	i	cd		
59	Per	4.5		r	i	cd		
60	Per	6.0		r	i	cd		
61	Per	3.5		1	i	cd		
62	Per	5.0		r	i	cd		
63	pyra				i			
64	Per	5.0		1	i	cd		
65	alfr							
66	alfr							
67	alfr							
73	unid				o			
114	Sept			1	o	cu	x	
P	Per	11.0		r	i	cd		
P	Per	12.0		1	i	cd		
P	Per	9.5		r	i	cd		
P	Per	12.5		1	i	cd		
A	Avic			1	o	cd		
P	Per	14.0		1	i	cd		
P	Per	8.5		1	i	cd		
S	pyra				i			
S	pyra				i			
P	Per	6.0		1	i	cd		
C	alfr							
C	alfr							
S	pyra				i			
S	pyra				i			
P	Per	9.0		1	i	cd		
S	pyra				i			
S	pyra				i			
S	pyra				i			
S	pyra				i			
P	Per	13.0		1	e	cu		
P	Per	6.0		1	i	cd		
P	Per	8.5		1	i	cd		
S	pyra				i			
P	Per	12.0		r	i	cd		
P	Per	11.0		1	i	cd		
S	pyra				i			
P	Per	7.5		r	i	cd		
P	Per	14.0		1	i	cd		
P	Per	8.5		r	i	cd		
P	Per	14.5		r	i	cd		
P	Per	7.5		1	i	cd		x
P	Per	10.5		1	i	cd		
P	Per	9.0		r	i	cd		

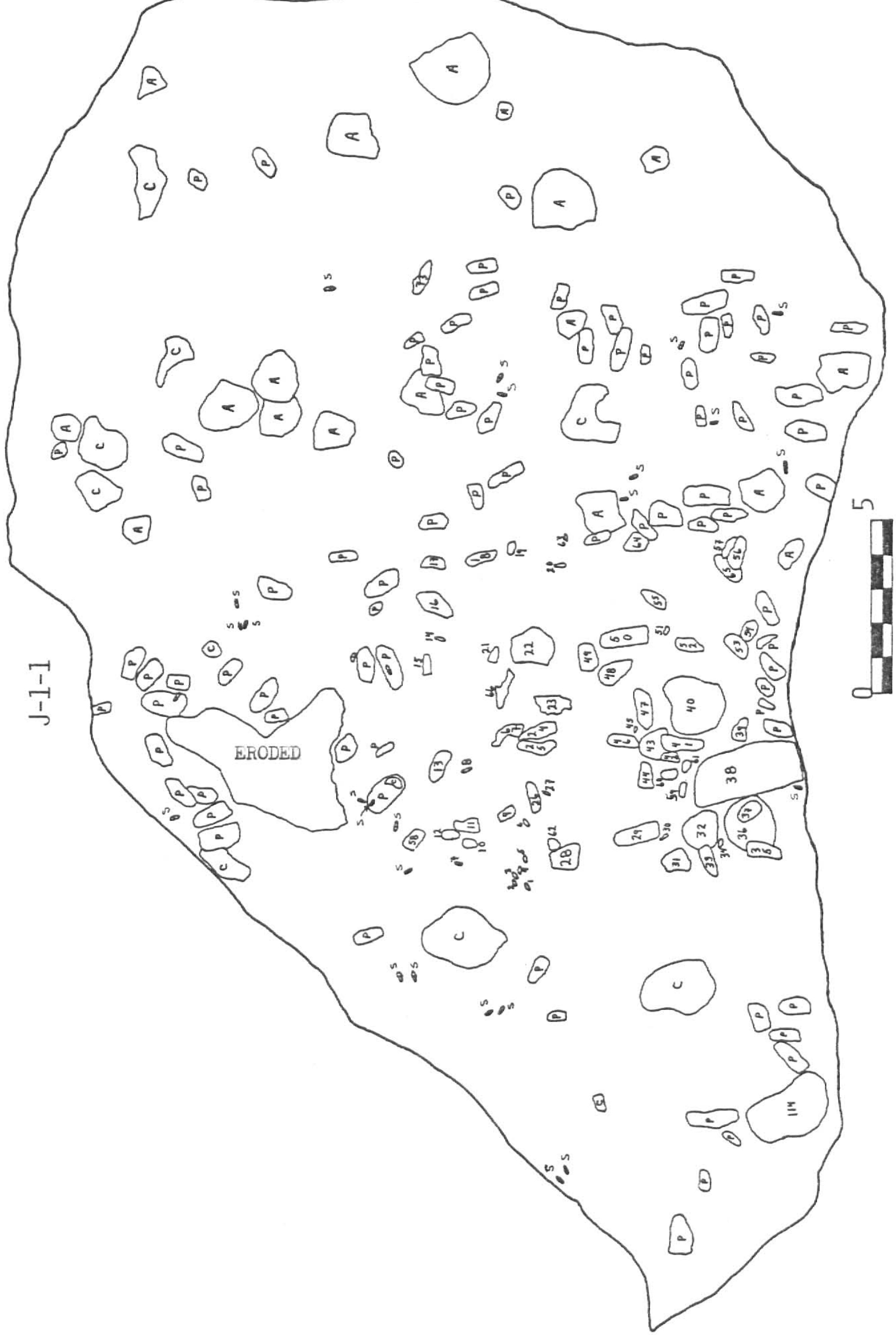
J-1-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
C	alfr							
P	Per	15.5		l	i	cd		
P	Per	12.5		r	i	cd		
P	Per	10.0		l	i	cd		
P	Per	13.0		l	i	cd		
P	Per	13.5		l	i	cd		
P	Per	7.5		r	i	cd		x
P	Per	10.5		l	i	cd		
P	Per	8.5		r	i	cd		
S	pyra				i			
S	pyra				i			
S	pyra				i			
P	Per	10.0		r	i	cd		
P	Per	11.0		l	i	cd		
P	Per	10.5		l	i	cd		
S	pyra				i			
S	pyra				i			
C	alfr							
C	alfr							
C	alfr							
S	pyra				i			
P	Per	14.0		r	i	cd		
P	Per	10.0		l	i	cd		
S	pyra				i			
P	Per	12.5		r	i	cd		
P	Per	5.5		l	i	cd	x	
P	Per	8.5		r	i	cd		
P	Per	13.0		r	i	cd		
P	Per	8.0		r	i	cd		
P	Per	12.0		l	i	cd		
A	Avic			l	o	cu		
P	Per	14.0		l	i	cd	x	
P	Per	12.0		r	i	cd		
P	Per	13.0		r	i	cd		
S	pyra				i			
S	pyra				i			
P	Per	10.0		l	i	cd		
P	Per	11.0		l	i	cd		
P	Per	17.0		r	i	cd		
P	Per	9.5		r	i	cd		
P	Per	12.5		l	i	cd		
P	Per	11.5	x		i			
S	pyra				i			
A	Avic			l	o	cd		
S	pyra				i			
C	alfr							
P	Per	15.0		r	i	cd		
P	Per	11.0		l	i	cd		
P	Per	10.5		r	i	cd		
P	Per	5.0		r	i	cd		
P	Per	11.5		l	i	cd		

#	name	size	art	val	pres	orient	frag	epiz
P	Per	10.5		r	i	cd		
P	Per	10.0		l	i	cd		
P	Per	10.0		l	i	cd		
S	pyra				i			
S	pyra				i			
P	Per	10.0		l	i	cd		
P	Per	14.0		r	i	cd		
P	Per	9.0		r	i	cd		
P	Per	12.0		r	i	cd		
P	Per	14.5		l	i	cd		
P	Per	7.0		r	i	cd		
P	Per	11.0		r	i	cd		
P	Per	13.5		r	i	cd		
P	Per	11.5		r	i	cd		
P	Per	14.5		l	i	cd		
P	Per	8.0		l	i	cd		
P	Per	6.5		l	i	cd		
P	Per	9.5		r	i	cd		
P	Per	11.0		l	i	cd		
A	Avic			l	o	cd		
S	pyra				i			
P	Per	12.0		r	i	cd		
A	Avic			l	o	cd		
S	pyra				i			
P	Per	9.5		r	i	cd		
S	pyra				i			
A	Avic			?	o	cd	x	x
P	Per	6.5		l	i	cd		
A	Avic			r	o	cd		
P	Per	8.0		l	i	cd		
P	Per	5.5		r	i	cd		
S	pyra				i			
P	Per	7.5		r	i	cd		
A	Avic			l	o	cd		
C	alfr							
C	alfr							
A	Avic			l	o	cd		x
A	Avic			?	o	cd		
C	alfr							
A	Avic			r	o	cd		
A	Avic			?	o	cd	x	
A	Avic			r	o	cd		
C	alfr							
S	pyra				i			
P	Per	11.5		l	i	cd		
A	Avic			r	o	cd		
A	Avic			r	o	cd		
A	Avic			r	o	cd		
P	Per	9.5		l	i	cd		
P	Per	8.5		r	i	cd		
A	Avic			r	o	cd		

J-1-1 Cont.

#	name	size	art	val	pres	orient	frag	epiz
A	Avic			r	o	cd		
P	Per	6.5		r	i	cd		
P	Per	8.0		1	i	cd		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APPENDIX IV

Thin sections from 99 samples were examined. Rock names were assigned according to Folk's (1962) classification of limestones and grain size scale for carbonate rocks. The stratigraphic positions from which the samples were collected are shown in Appendix I. Sample numbers with an "a" or "b" at the end (*e.g.* CQ-7a, CQ-7b) designate a slide made from the bottom or top parts respectively, of a sample.

* indicates thin sections point counted as representative of the four major rock types

** indicates other thin sections point counted

Sample	Rock Name
**CO-1	Medium calcarenite: immature, recrystallized bivalve, ostracode, gastropod, foraminifer silty Biomicrite
CO-2	Fine calcarenite: immature, recrystallized ostracode, foraminifer, silty, ferruginous Biomicrite
CO-3	Fine calcarenite: immature ostracode, foraminifer, Osagia, ferruginous Biomicrite
CO-5	Ferruginous Dismicrite
CO-7	Medium calcarenite: immature recrystallized ostracode, foraminifer, bivalve, gastropod, echinoderm, pelloid-bearing Biomicrite
CO-8	Medium calcarenite: immature recrystallized bivalve, foraminifer, gastropod, ostracode, algal, echinoderm Biomicrite
CQ-2	Fine calcirudite: immature recrystallized bivalve, gastropod, ostracode, foraminifer, echinoderm, Osagia Biomicrudite
CQ-3	Coarse calcarenite: immature recrystallized bivalve, gastropod, ostracode, Osagia Biomicrite
CQ-4	Coarse calcarenite: immature recrystallized gastropod, bivalve, ostracode, foraminifer, bryozoan, Osagia Biomicrite
CQ-5	Coarse calcarenite: immature recrystallized gastropod, ostracode, bivalve, pelloid-bearing Biomicrite
CQ-6	Medium calcarenite: immature recrystallized gastropod, ostracode, foraminifer, bivalve, ferruginous Biomicrite
CQ-7a	Fine calcarenite: immature recrystallized ostracode, foraminifer, gastropod, bivalve, ferruginous Biomicrite
CQ-7b	Medium calcarenite: immature recrystallized ostracode, gastropod, foraminifer, bivalve, Osagia, ferruginous Biomicrite
CQ-9	Dolomitized silty Micrite

Sample	Rock Name
CQ-10	Dolomitized ostracode, foraminifer, silty Micrite
CQ-11	Dedolomitized ostracode, foraminifer, silty Micrite
CQ-12	Recrystallized ostracode, bivalve, foraminifer, laminated silty Micrite
CQ-19	Fine calcirudite: immature recrystallized clast-bearing, ostracode, vertebrate, charcoal-bearing Biomicrudite
CQ-19+	Fine calcirudite: immature recrystallized clast-bearing, ostracode, vertebrate, charcoal-bearing ferruginous Biomicrudite
CR-1	Coarse calcarenite: immature recrystallized bivalve, gastropod, foraminifer, ostracode, echinoderm, Osagia Biomicrite
CR-2	Medium calcarenite: immature recrystallized bivalve, gastropod, foraminifer, ostracode, Osagia, ferruginous Biomicrite
CR-2+	Medium calcarenite: immature recrystallized ostracode, gastropod, bivalve, foraminifer, Osagia, silty Biomicrite
CR-4	Fine calcirudite: immature recrystallized gastropod, bivalve, ostracode, foraminifer, Osagia Biomicrudite
CR-5	Fine calcirudite: immature recrystallized gastropod, bivalve, foraminifer, ostracode, ferruginous Biomicrudite
CR-7	Fine calcarenite: immature recrystallized ostracode, silty Biomicrite
CR-8	Fine calcarenite: immature recrystallized ostracode, foraminifer Biomicrite
CR-9	Medium calcarenite: immature recrystallized ostracode, foraminifer, ferruginous Biomicrite
**CS-1	Fine calcirudite: immature recrystallized bivalve, gastropod, algal, ostracode, Osagia, pelloid-bearing Biomicrudite
CS-5	Fine calcirudite: immature recrystallized gastropod, bivalve, foraminifer, ostracode, pelloid-bearing Biomicrudite

Sample	Rock Name
*CS-6	Coarse calcarenite: immature recrystallized gastropod, bivalve, foraminifer, ostracode, ferruginous Biomicrite
CS-7	Fine calcarenite: immature recrystallized ostracode, foraminifer Biomicrite
CS-11	Dolomitized ostracode Micrite
CS-14	Dedolomitized laminated silty Micrite
*CS-15	Dolomitized ostracode, foraminifer silty Micrite
*CS-16	Dedolomitized ostracode laminated silty Micrite
CT-2	Fine calcirudite: immature recrystallized bivalve, gastropod, ostracode, algal, echinoderm, <u>Osagia</u>, silty Biomicrudite
CT-5	Coarse calcarenite: immature recrystallized gastropod, bivalve, ostracode, foarminifer, pelloid-bearing Biomicrite
CT-6	Fine calcirudite: immature recrystallized bivalve, gastropod, ostracode, foraminifer Biomicrite
CT-7	Medium calcarenite: immature recrystallized ostracode, foraminifer, gastropod, bivalve, pelloid-bearing Biomicrite
CT-8	Fine calcirudite: immature recrystallized gastropod, bivalve, foraminifer, ostracode, <u>Osagia</u>, ferruginous Biomicrudite
CT-9	Medium calcarenite: immature recrystallized ostracode, gastropod, foraminifer, ferruginous, silty Biomicrite
CT-12	Recrystallized ostracode, foraminifer, silty Micrite
CT-14	Dedolomitized ostracode, silty Micrite
CT-15	Dolomitized ostracode, silty Micrite
CT-16	Dolomitized ostracode, laminated, ferruginous, silty Micrite
CT-17	Dedolomitized ostracode, silty Micrite

Sample	Rock Name
CU-1	Coarse calcarenite: immature recrystallized bivalve, gastropod, ostracode, foraminifer, silty Biomicrite
CU-2	Coarse calcarenite: immature recrystallized bivalve, ostracode, foraminifer, silty Biomicrite
CU-3	Coarse calcarenite: immature recrystallized gastropod, ostracode, bivalve, foraminifer, silty Biomicrite
CU-4	Fine calcirudite: immature recrystallized gastropod, bivalve, foraminifer, ostracode, echinoderm, ferruginous Biomicrudite
CU-5	Dedolomitized ostracode, silty Micrite
CU-6	Fine calcarenite: immature dedolomitized ostracode, foraminifer, ferruginous, silty, Biomicrite
CU-7	Dedolomitized ostracode, silty Micrite
CU-8	Dedolomitized ostracode, laminated, silty Micrite
CU-11	Recrystallized ostracode, foraminifer, gastropod, silty Micrite
CU-13	Coarse calcarenite: immature recrystallized gastropod, bivalve, algal, ostracode, foraminifer, *Osagia*, ferruginous Biomicrite
*CV-1	Coarse calcarenite: immature recrystallized gastropod, bivalve, ostracode, foraminifer, algal, *Osagia*, ferruginous Biomicrite
CV-2	Medium calcarenite: immature recrystallized bivalve, ostracode, foraminifer, *Osagia* Biomicrite
CV-3	Medium calcarenite: immature recrystallized ostracode, bivalve, foraminifer, *Osagia*, ferruginous, silty Biomicrite
CV-4	Fine calcirudite: immature recrystallized bivalve, gastropod, ostracode, foraminifer, *Osagia*, ferruginous Biomicrudite
CV-6	Silty, argillaceous Micrite

Sample	Rock Name
CV-7	Dedolomitized ostracode, foraminifer, silty Micrite
CV-8	Dedolomitized ostracode, foraminifer, silty Micrite
CV-9	Recrystallized ostracode, silty Micrite
CV-10	Recrystallized ostracode, foraminifer, silty Micrite
CV-11	Medium calcarenite: immature recrystallized ostracode, foraminifer, bivalve, silty Biomicrite
CV-13	Dedolomitized recrystallized ostracode laminated Micrite
CV-14	Recrystallized ostracode, ferruginous, silty Micrite
**CW-2	Coarse calcarenite: immature recrystallized bivalve, gastropod, ostracode, algal, foraminifer, Osagia, ferruginous Biomicrite
CW-3	Coarse calcarenite: immature recrystallized bivalve, gastropod, ostracode, algal, foraminifer, Osagia, ferruginous Biomicrite
CW-4	Medium calcarenite: immature recrystallized gastropod, foraminifer, ostracode, bivalve, algal, Osagia, ferruginous, Biomicrite
CW-5	Silty, argillaceous Micrite
CW-7	Dolomitized silty, argillaceous Micrite
CW-8	Dolomitized silty Micrite
CW-9	Recrystallized ostracode, foraminifer, silty, Micrite
CW-10	Dedolomitized foraminifer, ostracode, silty Micrite
CW-11	Dolomitized recrystallized ostracode, laminated, silty Micrite
CW-12	Fine calcarenite: immature recrystallized ostracode, foraminifer, ferruginous, silty Micrite

Sample	Rock Name
CW-14a	Recrystallized ostracode, laminated, bioturbated, silty Micrite
CW-14b	Dolomitized, recrystallized ostracode, laminated, silty Micrite
CW-15	Fine calcarenite: immature dedolomitized, recrystallized ostracode, foraminifer, echinoderm Biomicrite
CX-1	Fine calcirudite: immature recrystallized gastropod, ostracode, foraminifer, bivalve, algal, Osagia, ferruginous Biomicrite
**CX-2	Medium calcarenite: immature recrystallized foraminifer, ostracode, gastropod, algal, bivalve, Osagia Biomicrite
CX-3	Coarse calcarenite: immature recrystallized gastropod, ostracode, bivalve, algal, foraminifer, echinoderm, Osagia, ferruginous Biomicrite
CX-6	Fine calcarenite: immature recrystallized ostracode, foraminifer, silty Biomicrite
CX-7	Medium calcarenite: immature dedolomitized recrystallized ostracode, foraminifer, ferruginous, silty Biomicrite
CX-8	Dedolomitized, recrystallized ostracode, foraminifer, laminated, silty Dismicrite
**CX-9	Recrystallized ostracode, foraminifer, laminated Micrite
**CY-1a	Coarse calcarenite: immature recrystallized bivalve, ostracode, gastropod, echinoderm, foraminifer, Osagia, pelloid-bearing, ferruginous, silty Biomicrite
CY-1b	Coarse calcarenite: immature recrystallized gastropod, bivalve, ostracode, echinoderm, foraminifer, algal, Osagia, ferruginous, silty Biomicrite
CY-2	Fine calcarenite: immature recrystallized foraminifer, ostracode, echinoderm, bivalve, pelloid-bearing, intraclast-bearing Biomicrite

Sample	Rock Name
CY-3	Fine calcarenite: immature recrystallized ostracode, foraminifer, echinoderm, bivalve, silty Biomicrite
CY-4	Coarse calcarenite: immature recrystallized gastropod, bivalve, ostracode, foraminifer, algal, *Osagia*, ferruginous Biomicrite
CY-7	Dolomitized silty Micrite
CY-8	Dolomitized, recrystallized ostracode, silty Micrite
CY-10	Dolomitized ostracode, echinoderm, foraminifer, silty Micrite
CY-11	Fine calcarenite: immature dolomitized, dedolomitized ostracode, foraminifer, bivalve, *Osagia*, silty Biomicrite
CY-12a	Fine calcarenite: immature recrystallized ostracode, foraminifer, bivalve, *Osagia* Biomicrite
CY-12b	Medium calcarenite: immature recrystallized gastropod, foraminifer, ostracode, bivalve, echinoderm, *Osagia* Biomicrite

APPENDIX V

Approximately 1400 points were counted on each of ten thin sections according to the methos described by Chayes (1949). These data are summarized on the following pages. The stratigraphic positions of the samples from which these thin sections were made are shown in Appendix I.

* indicates thin sections point counted as representative of the four major rock types

** indicates other thin sections point counted

**Slide CO-1

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	860	62.4	--
Microspar	123	8.9	--
Spar	25	1.8	--
Allochems (Grains)			
Bivalves	55	4.0	15.0
Ostracodes	140	10.2	38.3
Osagia	6	0.4	1.6
Gastropods	48	3.5	13.1
Encrusting Foraminifers	10	0.7	2.7
Free-living Foraminifers	18	1.3	4.9
Phylloid Algae	1	0.1	0.3
Unidentifiable Skeletal Fragments	88	6.4	24.0
Terrigenous (Grains)			
Quartz Silt	5	0.3	--
Total	1379	100.0	99.9

Grain/Matrix Ratio = 0.368

**Slide CS-1

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	455	32.3	--
Microspar	126	8.9	--
Spar	78	5.5	--
Limonite	7	0.5	--
Allochems (Grains)			
Bivalves	169	12.0	23.1
Ostracodes	343	24.4	46.8
Osagia	69	4.9	9.4
Gastropods	47	3.3	6.4
Echinoderms	2	0.1	0.3
Encrusting Foraminifers	11	0.8	1.5
Free-living Foraminifers	21	1.5	2.9
Phylloid Algae	5	0.2	0.7
Pelloids	3	0.2	--
Unidentifiable Skeletal Fragments	66	4.7	9.0
Terrigenous (Grains)			
Quartz Silt	6	0.4	--
Total	1408	99.9	100.1

Grain/Matrix Ratio = 1.131

*Slide CS-6

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	227	16.7	--
Microspar	149	11.0	--
Spar	325	23.9	--
Limonite	1	0.1	--
Allochems (Grains)			
Bivalves	114	8.4	18.8
Ostracodes	90	6.6	14.8
<u>Osagia</u>	6	0.4	1.0
Gastropods	266	19.6	43.8
Echinoderms	7	0.5	1.2
Encrusting Foraminifers	8	0.6	1.3
Free-living Foraminifers	5	0.4	0.8
Unidentifiable Skeletal Fragments	111	8.2	18.3
Porosity	49	3.6	--
Total	1358	100.0	100.0

Grain/Matrix Ratio = 0.866

*Slide CS-15

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	1203	85.3	--
Microspar	139	9.9	--
Spar	15	1.1	--
Allochems (Grains)			
Ostracodes	11	0.8	91.7
Free-living Foraminifers	1	0.1	8.3
Terrigenous (Grains)			
Quartz Silt	14	1.0	--
Porosity	28	2.0	--
Total	1411	100.2	100.0

Grain/Matrix Ratio = 0.019

*Slide CS-16

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	1116	79.1	--
Microspar	219	15.5	--
Spar	44	3.1	--
Allochems (Grains)			
Ostracodes	10	0.7	66.7
Bivalves	2	0.1	13.3
Free-living Foraminifers	3	0.2	20.0
Terrigenous (Grains)			
Quartz Silt	12	0.9	--
Porosity	4	0.3	--
Total	1410	99.9	100.0

Grain/Matrix Ratio = 0.011

*Slide CV-1

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	526	38.6	--
Microspar	50	3.7	--
Spar	178	13.0	--
Allochems (Grains)			
Bivalves	239	17.5	39.8
Ostracodes	197	14.4	32.8
<u>Osagia</u>	21	1.5	3.5
Gastropods	25	1.8	4.2
Echinoderms	2	0.1	0.3
Encrusting Foraminifers	9	0.7	1.5
Free-living Foraminifers	9	0.7	1.5
Unidentifiable Skeletal Fragments	98	7.2	16.3
Terrigenous (Grains)			
Quartz Silt	2	0.1	--
Porosity	8	0.6	--
Total	1364	99.9	99.9

Grain/Matrix Ratio = 0.798

**Slide CW-2

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	182	13.6	--
Microspar	255	19.1	--
Spar	336	25.1	--
Allochems (Grains)			
Bivalves	194	14.5	34.4
Ostracodes	42	3.1	7.4
Osagia	134	10.0	23.8
Gastropods	51	3.8	9.0
Echinoderms	3	0.2	0.5
Encrusting Foraminifers	11	0.8	2.0
Free-living Foraminifers	7	0.5	1.2
Unidentifiable Skeletal Fragments	122	9.1	21.6
Total	1337	99.8	99.9

Grain/Matrix Ratio = 0.730

**Slide CX-2

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	492	35.7	--
Microspar	51	3.7	--
Spar	458	33.2	--
Allochems (Grains)			
Bivalves	4	0.3	1.1
Ostracodes	152	11.0	40.9
Osagia	1	0.1	0.3
Gastropods	11	0.8	3.0
Encrusting Foraminifers	64	4.6	17.2
Free-living Foraminifers	41	3.0	11.0
Unidentifiable Skeletal Fragments	99	7.2	26.6
Terrigenous (Grains)			
Quartz Silt	5	0.4	--
Total	1378	100.0	100.1

Grain/Matrix Ratio = 0.377

**Slide CX-9

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	837	65.5	--
Microspar	124	9.7	--
Spar	182	14.2	--
Allochems (Grains)			
Bivalves	2	0.2	1.5
Ostracodes	73	5.7	54.1
Encrusting Foraminifers	5	0.4	3.7
Free-living Foraminifers	4	0.3	3.0
Unidentifiable Skeletal Fragments	41	3.2	37.8
Terrigenous (Grains)			
Quartz Silt	10	0.8	--
Total	1278	100.0	100.1

Grain/Matrix Ratio = 0.118

**Slide CY-1a

Type of Particle	Number of Points	Percent of Rock	Percent of Skel. Grains
Orthochems (Matrix)			
Micrite	384	28.3	--
Microspar	366	27.0	--
Spar	92	6.8	--
Allochems (Grains)			
Bivalves	134	9.9	27.8
Ostracodes	139	10.2	28.8
<u>Osagia</u>	120	8.8	24.9
Gastropods	6	0.4	1.2
Echinoderms	8	0.6	1.7
Encrusting Foraminifers	19	1.4	3.9
Free-living Foraminifers	9	0.7	1.9
Pelloids	12	0.9	--
Unidentifiable Skeletal Fragments	47	3.5	9.8
Terrigenous			
Quartz Silt	4	0.3	--
Porosity	18	1.3	--
Total	1358	100.1	100.0

Grain/Matrix Ratio = 0.587

APPENDIX VI

Weight percent insoluble residue was determined and these data are listed in this appendix. The stratigraphic position from which the samples were collected is shown in Appendix I.

Sample	Weight Percent Insoluble Residue
CO-1	14.42
CO-2	13.13
CO-3	16.11
CO-4	30.83
CO-5	10.82
CO-6	28.60
CO-7	8.34
CO-8	6.16
CQ-1	38.28
CQ-2	14.28
CQ-3	8.82
CQ-4	10.87
CQ-5	4.12
CQ-6	4.30
CQ-7	10.22
CQ-8	35.47
CQ-9	22.28
CQ-10	21.99
CQ-11	12.21
CQ-12	10.78
CQ-13	10.10
CQ-14	11.01
CQ-17	76.83
CQ-15	84.58
CQ-16	83.47
CQ-18	78.28
CQ-19	9.50
CQ-19+	23.54
CQ-20	80.46
CR-1	11.41
CR-2	10.16
CR-2+	24.98
CR-3	56.89
CR-4	8.18
CR-5	8.65
CR-6	37.97
CR-7	11.97
CR-8	7.95
CR-9	9.89
CS-1	11.88
CS-2	7.69
CS-3	13.56
CS-4	59.59
CS-5	7.89
CS-6	13.38
CS-7	10.33
CS-8	35.30
CS-9	26.93
CS-10	38.05

Sample	Weight Percent Insoluble Residue
CS-11	18.68
CS-12	26.80
CS-13	28.47
CS-14	22.82
CS-15	18.39
CS-16	12.14
CS-17	15.88
CT-1	7.84
CT-2	5.16
CT-3	17.30
CT-4	64.66
CT-5	13.00
CT-6	9.45
CT-7	6.14
CT-8	5.53
CT-9	14.86
CT-10	38.47
CT-11	34.87
CT-12	23.61
CT-13	26.81
CT-14	23.78
CT-15	12.24
CT-16	12.46
CT-17	19.19
CT-18	20.48
CT-19	30.58
CU-1	12.26
CU-3	6.44
CU-13	3.83
CU-4	5.43
CU-9	34.74
CU-10	31.90
CU-11	13.94
CU-12	25.69
CU-5	10.28
CU-6	7.65
CU-7	10.75
CU-8	11.58
CV-1	12.43
CV-2	9.66
CV-3	9.95
CV-4	5.77
CV-5	44.34
CV-6	38.40
CV-7	29.76
CV-8	27.37
CV-9	28.95
CV-10	9.88
CV-14	10.94

Sample	Weight Percent Insoluble Residue
CV-11	8.15
CV-12	15.65
CV-13	12.60
CW-2	3.09
CW-3	2.73
CW-4	3.40
CW-5	37.73
CW-6	32.14
CW-7	27.20
CW-8	33.26
CW-9	26.27
CW-10	10.23
CW-15	9.53
CW-12	16.87
CW-13	23.08
CW-14	18.53
CW-11	18.85
CX-1	6.93
CX-2	4.84
CX-3	7.98
CX-4	35.39
CX-5	24.49
CX-6	9.59
CX-7	9.26
CX-8	14.24
CX-9	12.25
CX-10	17.93
CY-1	9.53
CY-2	13.41
CY-3	16.51
CY-4	11.17
CY-5	38.59
CY-6	38.91
CY-7	22.49
CY-8	19.86
CY-9	21.83
CY-10	11.02
CY-11	11.71
CY-12	7.76

APPENDIX VII

This appendix contains data obtained from X-ray diffraction analyses. The stratigraphic positions from which the samples were collected are in Appendix I and (section E) in West, et al. (1972, p. 46-49).

Sample	Calcite / Dolomite	Calcite / Quartz	Mole % $MgCO_3$ in calcite	Mole % Ca in dolomite
CO-2	--	11.5	2.25	--
CO-4	--	3.5	1.35	--
CO-5	--	32.3	1.05	--
*CO-6	0.0	--	--	53.10
CO-7	--	24.0	2.55	--
CQ-2	--	9.0	2.25	--
CQ-3	--	24.0	2.55	--
CQ-4	--	11.5	1.62	--
CQ-5	--	24.0	0.80	--
CQ-6	--	99.0	1.95	--
CQ-7	--	11.5	1.62	--
CQ-8	9.6	2.6	1.95	56.85
CQ-9	3.6	5.2	1.95	56.15
CQ-10	16.4	6.3	2.20	56.77
CQ-11	--	11.5	2.55	--
CQ-12	--	24.0	1.62	--
CQ-13	--	32.3	2.80	--
CQ-14	--	32.3	1.62	--
CQ-15	--	0.2	0.40	--
CQ-16	--	0.2	1.35	--
CQ-17	--	0.1	1.05	--
CQ-18	--	0.6	0.60	--
CQ-19	--	24.0	1.95	--
CQ-19+	--	5.7	1.95	--
CQ-20	--	0.3	1.05	--
CR-4	--	24.0	1.95	--
CR-6	--	2.6	1.95	--
CR-7	--	11.5	1.62	--
CR-9	--	49.0	1.95	--
CS-1	--	11.5	1.95	--
CS-2	--	32.3	1.95	--
CS-3	--	11.5	1.00	--
CS-4	--	1.2	1.62	--
CS-5	--	13.3	2.50	--
CS-6	--	6.7	1.95	--
CS-7	--	13.3	1.95	--
CS-8	4.8	2.5	1.62	55.55
CS-9	3.6	3.6	1.95	56.48
CS-10	16.5	2.2	1.62	56.17
CS-11	2.1	6.1	2.50	56.48
CS-12	15.0	3.8	1.35	56.17
CS-13	6.8	3.1	1.95	57.05
CS-14	38.5	3.7	1.95	54.32
CS-15	10.4	3.7	1.95	56.18
CS-16	44.0	8.8	1.62	55.25
CS-17	--	6.1	1.62	--
CT-7	--	24.0	1.05	--
CT-11	--	2.6	1.95	--

Sample	Calcite / Dolomite	Calcite / Quartz	Mole % $MgCO_3$ in calcite	Mole % Ca in dolomite
CT-13	--	4.0	1.95	--
CT-14	--	6.7	1.95	--
CT-15	2.7	9.7	2.55	56.48
CT-18	3.9	3.9	1.95	53.43
CU-1	--	11.5	1.95	--
CU-6	--	11.5	1.62	--
CU-10	--	4.3	1.62	--
CU-11	--	15.7	1.62	--
CU-12	--	6.1	1.95	--
CU-13	--	49.0	1.35	--
CV-3	--	8.1	2.20	--
CV-6	--	3.8	1.62	--
CV-8	--	7.3	1.95	--
CV-9	--	5.7	2.20	--
CV-12	--	4.6	1.35	--
CV-14	--	13.3	1.35	--
CW-3	--	49.0	1.95	--
CW-6	7.5	5.0	2.25	55.55
CW-7	4.7	4.7	1.95	56.17
CW-8	18.8	3.6	1.62	55.55
CW-10	--	24.0	1.95	--
CW-11	5.4	4.1	1.62	54.62
CW-12	--	5.7	2.25	--
CW-13	4.3	3.3	1.95	54.32
CW-14	2.8	5.4	1.62	54.32
CW-15	--	11.5	1.35	--
CX-2	--	19.0	2.55	--
CX-4	--	3.2	1.95	---
CX-5	--	4.3	1.00	--
CX-6	--	24.0	1.35	--
CX-8	--	7.3	1.95	--
CY-1	--	11.5	2.20	--
CY-2	--	7.3	1.62	--
CY-3	--	4.3	2.20	--
CY-4	45.0	11.3	1.35	55.25
CY-5	9.6	2.6	1.80	56.18
CY-6	4.9	2.0	2.20	54.90
CY-7	2.0	3.8	1.35	55.87
CY-8	2.2	3.6	0.70	56.17
CY-9	2.0	3.2	0.70	54.95
CY-10	2.0	6.0	1.05	55.87
CY-11	5.7	5.7	1.62	54.95
CY-12a	--	13.3	2.55	--
E-6	--	2.2	1.35	--
E-7	6.0	2.9	2.25	55.55
E-8	--	5.7	1.95	--

* no calcite in this sample

FOSSIL ASSEMBLAGES, STRATIGRAPHY, AND DEPOSITIONAL ENVIRONMENTS OF THE CROUSE LIMESTONE (LOWER PERMIAN) IN NORTH CENTRAL KANSAS

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

A study of the fossil assemblages and stratigraphy of the Crouse Limestone in north central Kansas was undertaken to (1) test a previously proposed depositional model which suggested that the Crouse Limestone represents a regressive tidal flat sequence deposited in a lagoonal environment and (2) expand the area previously studied to include outcrops to the north where evidence suggested open marine conditions and the southwest where evidence favoring subaerial exposure was observed.

Careful stratigraphic correlation indicated that the rocks previously examined at sections in southern Marshall County were not the Crouse Limestone. Study of the proper stratigraphic interval at those outcrops revealed that they also support a regressive carbonate tidal flat environment of deposition.

Detailed study of a unique exposure in northern Geary County showed that an erosional surface and rock units above it--conglomerate, black shale, limestone, and gray mudstone--are consistent with the regressive interpretation. These units are interpreted as tidal channel and swamp deposits which are to be expected in a tidal flat environment.

Biotic data obtained from bedding surfaces, washed residues, and thin sections support the interpretation of the Crouse Limestone as a regressive carbonate tidal flat sequence. Fossil assemblages decrease upward in (1) density, (2) diversity, (3) mean size of individuals, and (4) size range of individuals. Petrologic data from the study of thin sections, insoluble residues, and X-ray diffraction also support the regressive interpretation. Dolomite and gypsum found in the middle shale and upper limestone occur in intertidal to supratidal deposits.

The area represents a protected lagoon and/or tidal flat. This tidal

flat and/or lagoon occupied the Irving Syncline, bounded on the west by the Abilene Anticline and on the east by the Nemaha Anticline.