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Quantitative Taphonomic Analysis, Classification and Correlation of Kope Formation Limestones (Cincinnatian Series, Upper Ordovician), Cincinnati Arch Region

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Ann Catherine Purdy

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QUANTITATIVE TAPHONOMIC ANALYSIS, CLASSIFICATION AND CORRELATION OF KOPE FORMATION LIMESTONES (CINCINNATIAN SERIES, UPPER ORDOVICIAN), CINCINNATI ARCH REGION

By

Ann Catherine Purdy

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ABSTRACT

QUANTITATIVE TAPHONOMIC ANALYSIS, CLASSIFICATION AND CORRELATION OF KOPE FORMATION LIMESTONES (CINCINNATIAN SERIES, UPPER ORDOVICIAN), CINCINNATI ARCH REGION

By

Ann Catherine Purdy

The interbedded limestones and mudstones of the Upper Ordovician Kope Formation represent mixed carbonate-clastic deposition on a storm-dominated, intracratonic ramp. Despite the structural simplicity of the strata and the abundance of diverse, well preserved fossil material, the Kope limestone beds and the faunal assemblages they contain have a complex taphonomic and sedimentologic history. Superficially similar deposits can be produced in any of the high-energy environments in storm-dominated systems. The similarity of texture and bedding style produced by high-energy deposition or reworking can obscure depth-related facies associations. Classification of the limestones on both taphonomic and sedimentological criteria facilitates the interpretation of beds that exhibit a range of characteristics, yet are still associated with similar facies. Taphonomic analysis is also sensitive to subtle variation within texturally similar beds, that may actually reflect different facies associations.

The Kope Formation contains a range of limestone types that may be categorized into eleven taphonomically distinct groups. The taphonomic variation between the groups reflects a range of depth/energy-intensity conditions that existed within the Kope

environment. In this study, comparasions between taxonomic groups indicates that differences in skeletal composition, complexity, density, size and shape-related hydrodynamic properties results in different susceptibilities to biostratinomic processes. Comparative taphonomic analysis of all taxonomic components within a polytaxic assemblage provides greater insight into the history of the fossil assemblage and conditions of the depositional environment.

Quantitative taphonomic analysis allows for the genetic classification of limestone beds, providing insight into the biostratinomic history of the fossil assemblages, as well as the environmental factors that contributed to the variation between the beds. Dispite limited exposure and lateral discontinuity of the beds, quantitative taphonomic analysis and genetic classification of the Kope limestones facilitates stratigraphic correlation across the study area.

To Joshua Boice Nielsen

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INTRODUCTION

Previous Work

The interlayered limestones and shales of the Upper Ordovician Cincinnatian Series have received the attention of geologists for more than a century (for historical review see Weiss and Norman, 1960). While the early work was generally descriptive in nature (e.g. Nickles, 1902; Cumings, 1908), the mixed carbonate / clastic units and the well preserved fauna within them have continued to be the focus of many studies.

The original subdivision of the relatively repetitive limestone and shale layers within the type Cincinnatian was based on distinctive faunal differences within the limestones. The acceptance of the Code of Stratigraphic Nomenclature in 1961 required that stratigraphic units be defined on lithologic, rather than paleontologic criteria. Interest in the Cincinnatian Series was renewed as the traditional formation boundaries were redefined according to lithologic parameters (e.g. Weiss and Sweet, 1964; Brown and Lineback, 1966; Peck, 1966). At this same period of time, developments in the field of carbonate petrography brought about by the work of Folk (1959 and 1962) and Dunham (1962), encouraged petrographic reevaluation of the Cincinnatian limestones (Weiss and Norman, 1960b; Wetzel, 1968; Farber, 1968; Martin, 1975; Hay et. al., 1981; Wier et al., 1984).

As the field of paleoecology developed in the 1970's, several studies attempted to describe the distribution, structure and succession of paleocommunities preserved within the fossiliferous units of the Cincinnatian (e.g. Lorenz, 1973; MacDaniel, 1976; Harris and Martin, 1979). While much of this work initially appeared fruitful, advances in the and taphonomy (e.g. Schindel, 1980; Kidwell et al., 1986; Brandt, 1989) have resulted in the reevaluation of the original conclusions of these early studies.

The highly disturbed nature of Cincinnatian limestones has been widely recognized (Anstey and Fowler, 1969; Meyer et al., 1981; Harrison, 1984; Tobin and Pryor, 1985). A significant proportion, if not the majority of the limestone beds may be interpreted as event beds. Despite the abundant, well-preserved fossil material they contain, the taphonomic complexity of the limestone beds has made paleoecological analysis of these units extremely difficult.

Over the past two decades, paleontologic studies conducted within the Cincinnatian Series have focused on a wide range of subjects that include the autecology (e.g. Anstey and Perry, 1973; Alexander, 1975; Frey, 1980) and biostratinomy (e.g. Brandt, 1980; Meyer et al., 1981) of the predominant faunal groups within these rocks.

Various aspects of the sedimentology of Cincinnatian strata have been examined. Lithologies associated with sedimentary environments that range from deep water to supratidal have been described within the Cincinnatian. The complexity and number of the event beds preserved in the Cincinnatian (Anstey and Fowler, 1969; Meyer et al., 1981; Tobin, 1982;) are attributable to storm processes (eg. Kreisa and Bambach, 1982; Aigner, 1985) and multiple episodes of reworking.

The cyclic nature of the lithologies in the Cincinnatian Series has been the focus of investigation. Several studies have offered interpretations of the causes and mechanisms that produced the shoaling cycles and depositional sequences found within the Cincinnatian; and to the stratigraphic correlation of those sequences (eg. Tobin, 1982; Jennette and Pryor, 1993; Holland, 1993).

Purpose

Although the structural simplicity of the flat lying strata and the abundance of diverse, well-preserved fossil material initially made the Cincinnatian limestones appealing targets for paleoecological study, the recognition of the complex taphonomic history of these limestone beds has made interpretation of the faunal assemblages extremely difficult. Over the past decade, developments in the field of taphonomy have resulted in a reevaluation of the nature and range of paleoecological and biostratinomic information that may be preserved within fossiliferous assemblages (Springer and Bambach, 1985; Kidwell and Aigner, 1985; Kidwell 1982; 1986; Brandt, 1989; Meldahl and Flessa, 1989). The limestones of the Kope Formation, like the majority of Cincinnatian limestones, have strong hydrodynamic and taphonomic overprints, making paleoecological interpretation, without taphonomic analysis, impossible.

Taphonomy

Simply defined, taphonomy is the study of all of the processes, biological, sedimentological and diagenetic, that are involved in the accumulation, preservation and alteration of biogenetic material. Taphonomic processes may be separated into two broad categories. The first is the field of biostratinomy, which involves all of the processes in the sedimentary environment that may affect biogenetic material between the death of an organism and its final burial. The second group of taphonomic processes are those that affect biogenetic material after burial. These processes include fossilization and diagenetic alteration.

This study focuses on the biostratinomic process that contributed to the accumulation of the biogenetic material preserved within the limestones of the Kope Formation. Biostratinomic processes are primarily physical, or mechanical processes that generally occur in the following sequential order; 1) *in situ* reorientation of skeletal material followed by disarticulation through decay of connective tissue; 2) subsequent breakage and corrosion resulting from bioerosion and/or dissolution during preburial exposure on the sea floor; 3) further fragmentation and abrasion brought about through winnowing and transport by waves and currents prior to final deposition and burial.

Any preserved accumulation of biogenetic material will show evidence of the biostratinomic processes that acted on that material prior to and during final burial. The effects of these processes will vary along environmental gradients. The duration of preburial exposure, as well as the amount and intensity of reworking and transport, are dependent on conditions within the environment in which the material accumulates. Therefore, the condition of the bioclasts and the final orientation and fabric of the skeletal material preserved in a fossil assemblage will depend on chemical conditions at the sediment / water interface, water depth, and the nature and intensity of bottom energy, as well as the background sedimentation rate (Johnson, 1960; Brett and Baird; 1986; Kidwell et al., 1986; Kidwell, 1986; Speyer and Brett, 1987; Brandt, 1989).

The interbedded limestones and shales of the Kope Formation span the entirety of the first progradational cycle (discussed below) within the Cincinnatian Series. These deposits formed during the highest stand of the Cincinnatian Sea and represent deposition in the deepest-water environment preserved within the five sequences (Holland, 1993). The amount of bottom energy, frequency of reworking and degree of amalgamation of beds corresponds to water depth (Norris, 1986; Speyer and Brett, 1988). Particularly in a storm-dominated ramp environment, the deeper the water, the greater is the likelihood that a bed will be preserved. Therefore, the greatest variety and maximum number of discrete event, as well as fair weather, beds preserved within the Cincinnatian Series, should be contained within the Kope Formation. Previous studies, as well as field observation of overlying Cincinnatian strata support this premise (Tobin, 1982; Rabbio, 1988; Jennette and Pryor, 1993).

Although this study focuses on the limestones of the Kope Formation, the object of the study is to develop a systematic method for quantitative taphonomic analysis that may be applied to a broad range of fossil assemblages, but is sensitive enough to differentiate subtle difference between assemblages of the same taphonomic grade (*sensu* Brandt, 1989). The goal of this analysis will be (1) to determine the nature and relative intensity of the forces that acted on the skeletal material in the sedimentary environment, and to assess the degree in which the variation evidenced in the fossilized assemblages reflects those forces; (2) to determine how taphonomic processes affected the primary components of the biota; (3) to identify key features that may be useful indicators of the taphonomic history of an assemblage; and (4) to develop a genetic classification approach that reflects the taphonomic history of a limestone bed. Once the taphonomic history of a fossil assemblage is understood, it is possible to assess the nature and range of paleontological, paleoecological and sedimentological information that may be retrieved from the assemblage or limestone bed.

The purpose of this study is to develop a quantitative approach for the analysis and genetic classification of taphonomically complex fossil assemblages. This approach entails viewing skeletal material as authigenic sedimentary particles (*sensu* Meldahl and Flessa, 1990). In this study, the sedimentologic characteristics of the Kope limestone beds and the taphonomic attributes of the fossil assemblages contained within them (Table 1) were analyzed. An attempt was then made to determine the environmental factors that contributed to the variation of the taphonomic properties reflected in the beds. The vertical distribution of limestones of differing taphonomic type was also examined, and used as the basis for a paleoenvironmental facies model, that is compared

Feature	Taphonomic Inferrence	Selected References
Taxonomic Composition	Reflects original composition of community; Hydrodynamic properties ; preferrential preservation reworking; ecological succession	Anstey & Fowler, 1969; Kidwell, 1986; Kidwell & Aigner, 1985; Fursich, 1978 Driscoll, 1970; Johnson, 1960;
Bioclast Shape	Hydrodynamic properties are dependent on morphologic characteristics.	Kidwell, 1986; Maiklem, 1968 Driscoll, 1970; Johnson, 1960
Sorting	Reflect "mechanical" vs. biological accumulations Selective winnowing, transport and redeposition	Kidwell, 1986; Hallam, 1967 Speyer & Brett, 1988; Johnson, 1960
Reorientation	Nature of burial, wave and current reworking, prolonged exposure, hydrodynamic bottom conditions	Speyer & Brett, 1988; Alexander, 1986 Futterer,1982; Kreisa & Bambach, 1982
Fabric	Indicates current or wave transport or reworking; bioturbation; compaction and amalgamation of beds. nature of bed deposition	Futterer, 1982; Norris, 1986 Kidwell, 1986; Speyer & Brett, 1988 Brandt, 1989
Breakage	Reflects nature of burial; rate of bioerosion; bottom energy conditions; individual bioclast susceptibility depends on skeletal type and composition	Brandt, 1989; Speyer & Brett, 1988 Brett & Baird, 1986
Abrasion	Reflects length of exposure time; energy conditions; wave reworking and transport	Driscoll, 1970; Driscoll & Weltin, 1973 Brandt, 1989
Percent Matrix	Background sedimentation rate; degree of winnowing	Brandt, 1989; Kidwell, 1986 Johnson, 1960

TABLE 1: Taphonomic characteristics considered in this study

to other taphofacies and sedimentary facies models proposed for the Kope Formation and other Cincinnatian and shallow shelf / ramp environments.

Methods

To generate the data used in this study, samples of 232 limestone beds collected *in situ* from five measured sections within the Kope Formation were examined. The geographic locations of the measured sections are shown on Figure 1. Petrographic and taphonomic information was obtained from 172 polished slabs and 325 acetate peels. Observations were made, and information recorded pertaining to thirteen taphonomically significant characteristics for each bed (Table 2).

Table 2: Sedimentologic Characteristics Recorded for Each Bed

Bed Thickness	(cm)
Allochem Size	(fine,medium-fine, medium, medium-coarse, coarse)
Sorting	(poor, moderately poor, moderate, moderately well, well)
Lower Contact	(gradational, sharp, undulose)
Grading	(none, fining upward, coarsening upward, multitrend)
Cross lamination	(present, absent)
Primary Matrix	(mud, silt, ooze, micrite, microspar,spar)
Secondary Matrix	(if present)
Percent Matrix	(>90%; 75-90%; 50-75%; <50%)
Silt	(>50%, 50-20%; 20-10%; 10-5%; <5%)
Bioturbation	(none,minimal-confined to top of bed, moderate, extensive-bedding obscured)
Fossil Assemblage	(monotaxic/ polytaxic)
Amalgamation evident	(yes / no)

The bed-specific variables included both nominal variables such as presence or absence of grading or cross lamination, the nature of the lower contact, matrix composition, and whether the allochemical component was monotaxic or polytaxic, as

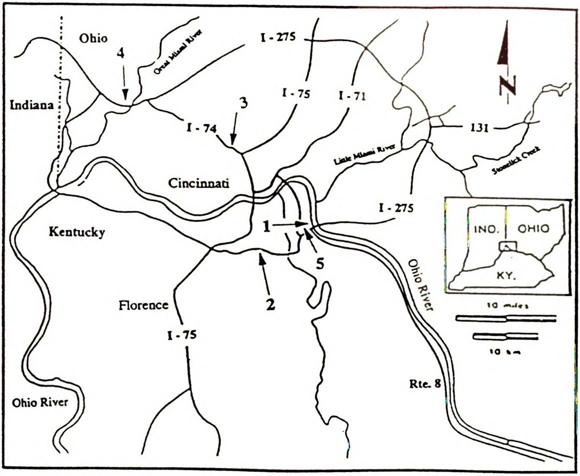

Figure 1: Study area and locations of measures sections of the Kope Formation (1- North Brent; 2- Sanfordtown; 3- Mt. Airy; 4- Miamitown; 5- South Brent)

well as ordinal variables such as bed thickness (measured in centimeters), and ranked values for allochem size, sorting and percent matrix. Ranked values (1= fine through 5 = coarse) were assigned for allochem size based on the average or most frequently occurring (mode) size of the bioclasts within the bed. Similarly, ranked values (1= poor through 5 = very well) were assigned for the degree of size sorting exhibited within the bed. The classification of these attributes was adapted from Folk (1974). The percent silt and matrix were determined petrographically (see Folk, 1962; Dunham, 1962). A ranked value (1 = >90% through 4 = <50%) was assigned for percent matrix and a ranked value (1= >50% through 5 = <5%) was assigned for the percent silt observed.

The allochems within the beds were broadly grouped at phylum or class level and by shape categories that presumably reflect similar hydrodynamic properties. The vast majority (91%) of the beds contained fossil assemblages that were polytaxic. Preliminary observation of these assemblages indicated that evidence of taphonomic effects (eg. breakage, abrasion, orientation, etc.) varied between the taxonomic groups within the same assemblage. Therefore, each taxonomic group present in the bed was evaluated and values for taphonomically significant variables were recorded for each taxonomic group present in the assemblage. Based on the observed condition of the skeletal material, each taxon within the assemblage was assigned a numerical score for all quantifiable variables (Table 3).

Taxon-specific data, recorded for each taxon observed in the assemblage, included the nominal variables 1) taxon , 2) predominant shape category and 3) secondary shape category (if any); and ordinal variables such as 1) the relative abundance of the taxon (based on point count), 2) the size range of individuals within each taxon (measurement of maximum and minimum size); and ranked variables that reflected 1) the overall degree of sorting within the taxon (very-poor = 1, poor =1.5, moderately-poor =

2, moderate = 2.5, moderately-well = 3, well = 3.5,very well = 4); 2) the percentage of specimens exhibiting reorientation (parallel alignment or concordance *sensu* Kidwell, 1986; Brandt, 1989) (<10% = 1, 10%-50% = 2, 50%-75% = 3, >75% = 4); 3) depositional fabric (random = 0, random/concordant = 0.5, concordant = 1, concordant/oblique = 1.5, oblique = 2, oblique/perpendicular = 3, clustered/nested = 4); 4) the average state of disarticulation and breakage (unbroken and/or fully articulated = 1, minimal peripheral = 1.5, disarticulated or broken at suture (bryozoans) = 2.0, minor internal breakage = 2.5, internal breakage = 3, extensive = 3.5, and fragmented = 4); and 5) the percentage of the abraded specimens observed within that taxonomic group (<10% =1, 10%-205% = 1.5, 20%-40% = 2, 40%-50% = 2.5, 50%-60% = 3, 60%-80% = 3.5, >80% = 4).

Table 3: Taphonomic Characteristics (within taxon) Recorded for Each Sample

Taxon	(phylum/class)
Abundance	(approximate %)
Small Size	(smallest individuals present)
Large Size	(largest individuals present)
Sorting	(uniformity of size within taxon)
Shape 1	(predominant shape category - branching, platey, discoidal, concavo/convex,semi-spheroidal.solid-cylindrical,hollow-cylindrical, elongate or "stick -like")
Shape 2	(secondary shape category, if any. See list above)
Reorientation	(percentage of taxon oriented parallel to bedding)
Fabric	(nature of reorientation within the bed: random, concordant, oblique, imbricated)
Disarticulation & Breakage	(articulated and/ or unbroken, disarticulated and/or minimal peripheral, disarticulated, minor internal, internal, extensive, fragmented)
Abrasion	(percentage of taxon with observed abrasion

Data Base and Statistical Analysis

The bed and taxon-specific information detailed above was compiled into a data base (Appendix A). The sedimentological and taphonomic data were then analyzed to determine general characteristics of the Kope limestones beds. Most of the limestone beds within the Kope Formation are of low taphonomic grade (Grades C and D of Brandt (1989)), yet still exhibit a visible range of variation. One of the objects of this study is to characterize the variation within limestones of similar taphonomic grade, and determine if the degree of variation may be useful in determining relatively small scale variations in biostratinomic process that may in turn reflect interpretable changes in environmental conditions.

In preliminary observations of the Kope limestones, it was noted that while the beds were generally of similar taphonomic grade, the bioclasts within many of the beds exhibited a range of taphonomic alteration. In some polytaxic assemblages, it was observed that bioclasts of one taxonomic group often exhibited a different degree of breakage, abrasion, reorientation or sorting than bioclasts from another taxonomic group. Possible explanations for the observed variation in taphonomic alteration between taxonomic groups within the same bed could be 1) different exposure and/or transport history; 2) reworking and mixing of material during storm events ; or 3) different susceptibilities based on skeletal shape, composition, or other taxon specific properties, to sedimentary processes. All three scenarios are possible, and each has very different paleoecological and sedimentological implications.

To address this question, comparisons were made of the observed condition for each of the taphonomic variables listed in Table 3 between each taxon present in a bed, and between all other occurrences of that taxon. The number of beds in the study (N= 232) was large enough that an "average" or typical condition for each of the taphonomic variables (Table 3) could be determined for each taxonomic group. The taphonomic condition of each taxon within in a given bed could then be compared to the "average" for that taxon. If a bed contained a polytaxic assemblage where all taxa exhibited a relatively similar degree of taphonomic alteration (based on within taxon comparisons) then it may not be unreasonable to assume a similar exposure history for both groups (case 3 above). If a polytaxic assemblage was comprised of material where specimens of one taxonomic group exhibited less taphonomic alteration than average, while specimens of another taxonomic group exhibited significantly more alteration than average for their respective taxonomic groups, it would not be unreasonable to assume that the two groups had a different exposure and / or transport history (case 1, or possibly case 2 above). A range of taphonomic alteration exhibited within specimens of the same taxon (some specimens exhibit significantly more degradation than average and some significantly less) may indicate a mixed assemblage of reworked material (case 2).

In this study, variation in the extent of taphonomic effects between the different taxonomic groups was examined first. The reasons for analyzing each taxonomic group separately were;

1) To establish a standard by which to measure variance in within group alteration as discussed above.

2) To develop a method for taphonomic characterization of polytaxic beds. The overall characterization of a bed may be quite different if it is classified based on the taphonomic characteristics of one taxon alone, as opposed to a comprehensive, comparative approach that considers the degree of taphonomic alteration of all taxa within the bed.

3) To determine if certain taxa were more reliable indicators of particular taphonomic processes than others, so that, assuming those processes were discernible, the state of alteration within that group might serve as an index for characterizing the taphonomic history of the bed.

4) To determine the reliability and constraints upon comparisons between beds of different taxonomic composition. For example, can a bed composed of well sorted, disarticulated ostracod valves, with 20% to 40% of the valves showing abrasion, be

compared to a bed composed of well sorted, disarticulated crinoid columnals, with 20% to 40% of the columnals showing evidence of abrasion? Do these beds reflect the same type and intensity of biostratinomic processes? Is it possible to determine if similar environmental and sedimentological conditions are reflected in a bed composed of imbricated brachiopod valves and one composed of ramose bryozoan colonies with less than 50% exhibiting parallel alignment? These concerns need to be addressed before comparisons between beds of different taxonomic composition are made, or affiliation with a particular taphofacies or set of environment conditions inferred.

Preliminary analysis of taphonomic alteration between the taxonomic groups within the polytaxic assemblages (see taphonomic alteration of taxonomic groups below) indicated that an across-taxa, comparative approach to taphonomic characterization of the beds was warranted for taphonomic classification. To use this comparative approach, it was necessary to determine the average value of a taphonomic variable for each taxon (as discussed above), then determine the degree of variation from average that was displayed by the observed specimens of that taxon within each bed. To this end, averages were computed for all variables for each taxon and Z-scores were generated (Appendix B) for every taxon present in each bed.

$$\text{Z Score} = \frac{\text{Data value - Mean}}{\text{Standard Deviation}}$$

The standardized scores for each taxa were then summed and averaged within each bed in order to obtain a single aggregate value for each taxon-specific variable within the bed. These normalized values, combined with bed-specific variables were utilized in the taphonomic classification (cluster and gradient analysis) of the beds.

In an attempt to illuminate underlying causes of the taphonomic variation between beds, R-mode factor analysis was performed on the data. This ordination technique utilizes correlations between a larger number of observable variables, to produce a pattern that may reflect a smaller, more interpretable number of underlying factors responsible for the variation in the data. This statistical method is a useful interpretive tool in large data sets, such as the one generated in this study, that have a limited range of variation (Gauch, 1991).

Q- mode cluster analysis was performed as an exploratory technique to delineate patterns of similarity between the samples (beds) in the data set. The cluster analysis used unweighted pair-group method to link clusters. Cluster analysis is a widely used classification technique. It has been used successfully in other studies dealing with taphonomic data (Meldahl and Flessa, 1990; Miller and Cummings, 1990; Springer and Bambach, 1985). Although the method has a tendency to obscure gradational relationships and overlap within the data , it is an effective and appropriate classification technique for both numeric and ranked data.

Because of the tendency for cluster analysis to produce artificial discontinuities within continuous data, gradient analysis was used as a complimentary ordination technique along with factor and cluster analysis. Ordination techniques more accurately reflect gradual transitions and overlap within samples than classification techniques. Gradient analysis was developed to relate community composition (species abundance) to environmental variation (Ter Braak, 1986 and 1987; Whittaker, 1987; Hill and Gauch, 1980). Q-mode gradient analysis was used as a confirmatory canonical technique for the cluster analysis. R-mode gradient analysis was utilized as a complimentary canonical technique to factor analysis. Similar complimentary and/or confirmatory use of classification and ordination techniques are not uncommon (e.g. Miller and Cummings, 1990; Springer and Bambach, 1985; Gauch 1991).

Statistical analysis of the data was performed using SPSS for cluster analysis and factor analysis. Gradient analysis was performed using the detrended correspondence analysis program DECORANA (Hill, 1979). The original fortran program was modified (by increasing the size of the dimensioned arrays) to accommodate the large data base generated in this study.

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GEOLOGIC BACKGROUND

Geologic Setting

In the Ordovician, a broad carbonate platform covered the North American midcontinent. At that time, the eastern portion of continent was located at approximately 20^{o} S latitude, and was rotated several degrees dextrally from its present orientation (Scotese and McKerrow, 1991). In the Early Middle Ordovician, subduction of the Iapetus ocean resulted in the emergence of the Taconic Highlands. Erosion of the highlands produced a prograding wedge of clastic sediments resulting in a broad band of mixed carbonate and clastic deposition in the midcontinent area, between the highlands in the southeast and the clearwater deposits still forming further to the north and west (Weir, Swadley and Pojeta, 1984) (Figure 2). Thrust loading associated with the Taconic Orogen produced the Appalachian Foreland Basin and uplifted the Cincinnati Arch as a peripheral bulge (Beaumont et al., 1988).

As the zone active tectonism shifted from the southern Appalachians into eastern Pennsylvania during Middle Ordovician time, a topographic high, interpreted as representing the incipient Cincinnati Arch, was propagated northward from Tennessee into Kentucky (Jennette and Pryor, 1992). A carbonate shoal known as the Tanglewood Bank developed in central Kentucky (Cressman, 1973). Coarse bioclastic carbonate accumulated on the shoal, while silts and muds, representing deeper-water deposition, were deposited further out on the gently northward-dipping intracratonic ramp. The Lexington Limestone, which underlies the Cincinnatian Kope Formation, represents carbonate accumulation on the shoal (Cressman, 1973).

In the Late Ordovician, deepening occurred which resulted in the drowning of the shoal, and the subsequent deposition of the siliciclastic muds, silts, and deeper water

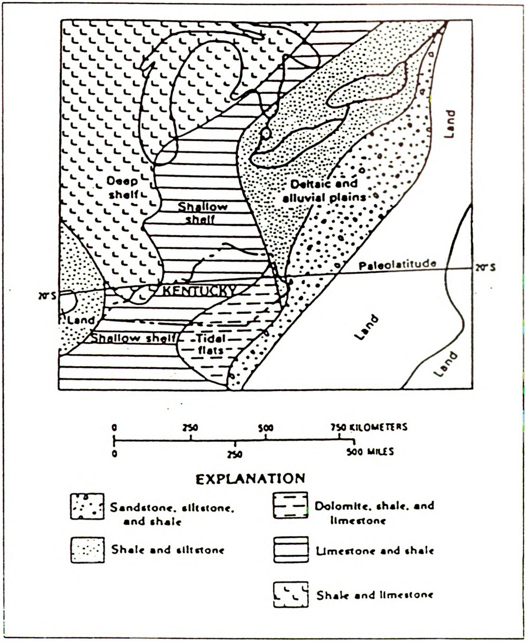


Figure 2: Paleolatitude and depositional environments of Eastern North America in Late Cincinnatian time from Wier et al (1984, fig. 69, p. 109).

bioclastics that comprise the Kope Formation (Anstey and Fowler, 1969; Jennette and Pryor, 1993).

Continued development of the Taconic landmass and infilling of the Appalachian Basin resulted in gradual shoaling through the remainder of the Ordovician Period. Infilling of the Appalachian Basin allowed fine-grained clastics to periodically enter the Cincinnati region, disrupting the formerly predominant pattern of carbonate sedimentation, resulting in the deposition of the interlayered carbonates and shales of the Cincinnatian Series (Weir et al., 1984) (Figure 3).

Cyclicity

The cyclic nature of the mixed carbonate-siliciclastic lithologies that compose the Cincinnatian Series was recognized more than a century ago (Orton, 1878). More recently, several studies (e.g. Tobin, 1982; Tobin and Pryor, 1985; Jennette and Pryor, 1993) have documented three orders of cyclicity within the Cincinnatian strata (Tobin, 1982) (Figure 4). The first-order cycles are large-scale shoaling upward cycles. The shoaling cycles are in turn composed of a series of carbonate-clastic parasequences or "megacycles" *sensu* Tobin (1982). The parasequences in turn are composed of small-scale fining upward sedimentary sequences that are generally interpreted as tempestite deposits (Tobin, 1982; Jennette and Pryor, 1993) .

Shoaling Sequences

First order cycles are large scale (40 to 200 meter) shallowing upward sequences that have been interpreted as reflecting long term eustatic change, or tectonically controlled variation in accommodation space due to thrust loading across the ramp (Anstey and Fowler, 1969; Hay, 1981; Tobin, 1982; Holland, 1993). Three-to-six shallowing upward depositional sequences, interpreted as eustatically controlled

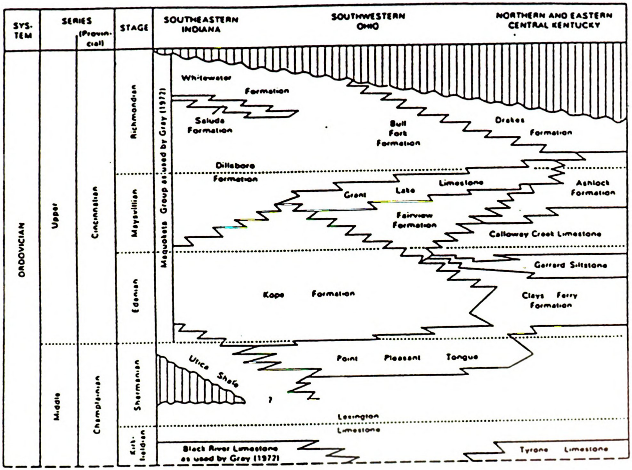


Figure 3: Approximate relationship of major stratigraphic units in Cincinnatian region. Modified from Sweet (1979, fig. 3, p. G13; in Wier et al (1984, fig. 50, p. 80))

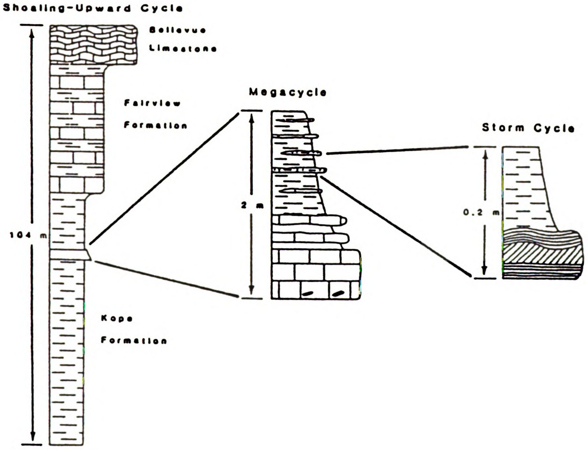


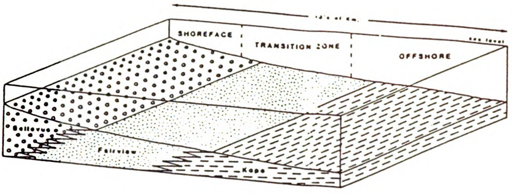
Figure 4: Three orders of cyclicity preserved within Cincinnatian strata from Tobin (1982, fig. 30, p. 97)

progradational successions across the ramp, have been described within the Cincinnatian Series (Tobin, 1982; Anstey and Fowler, 1969; Holland, 1993) (Figure 5).

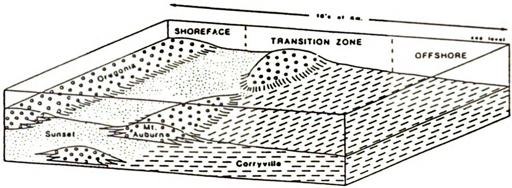
The progradational sequences are defined by a sharp contact at the base of each successive transgressive systems tract (Holland, 1993 and 1995). The first of the shoaling upward sequences is recorded in the Kope Formation. The maximum deepening of the Cincinnatian sea is represented in this sequence. The thickest of the progradational cycles, this lithologic spans the entireEdenian Stage (Holland, 1995). The second cycle is represented by the Fairview-to-Bellevue sequence which spans most of the Maysvillian stage. The third shoaling cycle is represented in the upper Maysvillian Corryville sequence. The fourth cycle is recorded in the Oregonia sequence in the lower Richmondian Stage. The fifth transgressive cycles resulted in formation of the Waynesville-to-Saluda shoaling sequences, which spans the remainder of the Richmondian and is truncated by the unconformity that marks the Ordovician Silurian boundary. Holland (1993) has suggested that the Upper Whitewater Formation represents a final sixth transgressive cycle in the Upper Richmondian.

Depositional Cycles

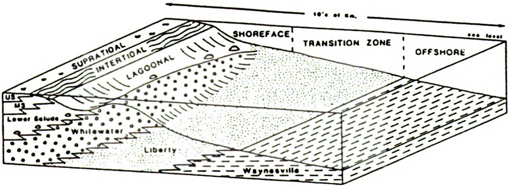
The large scale shoaling upward depositional sequences described above are in turn composed of one-to-three meter thick, fining upward parasequences of limestones and siliciclastic shales. These depositional or "megacycles" (*sensu* Tobin, 1982) are composed of a basal carbonate hemicycle overlain by a shale hemicycle. The carbonate/shale cycles are thickest and most completely preserved within the Kope Formation (Tobin, 1982) (Figure 6). Recent work indicates that they are laterally continuous across wide areas of the Cincinnatian ramp, and may represent fluctuations in depth-related hydrodynamic conditions (i.e. changes in storm wavebase), possibly



Kope to Bellevue



Corryville to Oregonia



Waynesville to Saluda

Figure 5: Lithotype interpretation of shoaling-upward sequences within the Cincinnatian Series from Tobin (1982, figs. 52, 55 and 64).

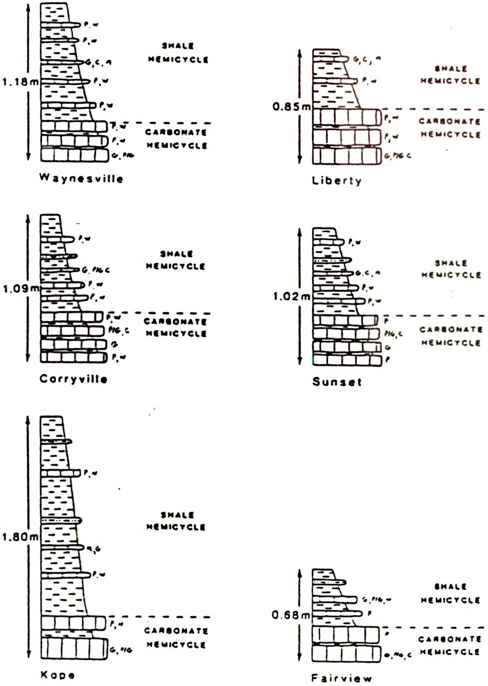


Figure 6: Comparison of "average" carbonate / shale hemicycles from six Cincinnatian formations from Tobin (1982, fig.43, p. 136).

resulting from short term (20,000 -100,000 years) glacio-eustatic variation in sea level (Brookfield and Brett, 1988; Jennette and Pryor, 1993).

Bedding Cycles

Over the past decade, the role of storms as a depositional agent in shallow marine environments has been widely explored (Aigner, 1982; 1985; Allen, 1984; Kreisa, 1981). The preservation of tempestites deposits, with their fining-upward bedding character, has produced the appearance of small scale carbonate/clastic cycles. The bedding-scale fining-upward sedimentary sequence preserved in storm deposits was first described by Kreisa (1981) in the Upper Ordovician Martinsburg Formation of Southwestern Virginia. The ideal Kreisa sequence consists of a graded packstone with an erosional base, overlain by a laminated silt or mudstone unit deposited during the waning stage of the storm. This produces a couplet with a basal carbonate layer overlain by a fining upward clastic /carbonate mudstone layer (Kreisa, 1982) (Figure 7).

During the upper Ordovician, the Cincinnati arch was part of a gently northward-dipping carbonate ramp located at approximately 22^{o} S latitude (Wier et al., 1984). Given the latitudinal position of the region at that period of time, and based on analogy with modern storm tracts, it is highly probable that occasional hurricane force storms would pass over the region and seasonal storms would be annual events (Marsaglia and Klein, 1983). Sedimentological evidence indicates that Cincinnati arch was a relatively shallow area, and storm wave base may have periodically exceeded water depth (Jennette and Pryor, 1993).

The abundance and variety of tempestite beds preserved within Cincinnatian strata are typical of deposition on a storm dominated carbonate ramp (Tobin and Pryor, 1981; Tobin, 1982). Tobin (1982) recognized nine variations of tempestite deposits within the Cincinnatian. The majority of limestone beds preserved within the Kope Formation have been interpreted as storm beds (Rabbio, 1988).

Stratigraphy of the Study Interval

Formerly known as the Eden Shale (Anstey and Fowler, 1969), the Kope Formation is the lowermost unit of the Cincinnatian Series. It was renamed by Weiss and Sweet (1964) to avoid confusion with the chronostratigraphic Edenian Stage which the formation intersects. The Kope Formation ranges in thickness from approximately 60 meters in southeastern Indiana (Brown and Lineback, 1966) to approximately 80 meters in the Maysville Kentuckyarea (Peck, 1966). In the study area, the Kope Formation overlies the Shermanian age Point Pleasant Formation. Farther to the south, the Kope intergrades laterally into the Clays Ferry Formation. The two formations are similar in many respects, except that the Clays Ferry Formation has a higher percentage of limestone, which occurs in planar to lenticular beds, and thinner and fewer shale layers (Tobin, 1982).

The upper Kope grades into the overlying Fairview Formation which consists of evenly bedded limestone interlayered with siltstone and shale. The proportion of limestone to shale is approximately subequal in the Fairview (Tobin, 1982).

Lithology

The Kope Formation consists of interbedded mudstone, siltstone and limestone. Mudstones represent 60 to 80 percent of the beds within the Kope Formation (Weir et al., 1984). These mudstones are medium to greenish gray in color, and are collectively referred to as shales, a term that has been applied to all fine grained argillaceous rock layers within the Cincinnatian regardless of fabric, texture or composition. The mudstones are predominantly siliceous with minor calcitic content. The predominant

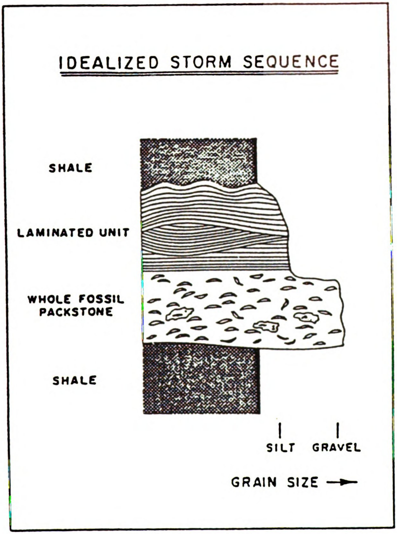


Figure 7: Vertical sequence of fining upward litholigies and sedimentary structures associated with storm deposits from Kresia (1982, fig. 3).

siliciclastic clays are illite, chlorite and vermiculite. Silt content is variable (Bassarab and Huff, 1969). In general, the Kope shales are devoid of fossils, although some layers contain well sorted sand to silt sized skeletal fragments (Tobin, 1982). Trace fossils in the form of vertical and horizontal burrows are present in some of the shales, and conspicuously absent in others. Grading is also present in some of the shale beds. These units generally have a sharp basal contact and fine upwards. Burrowing, when present, is typically confined to the upper surface of the bed (Jennette and Pryor, 1993).

The siltstones within the Kope Formation are generally thin, well-defined beds. Their mineral composition is primarily quartz, with some clay and occasionally bioclastic fragments (Tobin, 1982). Many of the siltstones display storm-related sedimentary characteristics such as amalgamation, hummocky cross-stratification, parallel orientation of elongate bioclasts and gutter casts, as well as bidirectional and multidirectional tool marks (Jennette and Pryor, 1993).

Interbedded with the argillaceous shales and siltstones, are limestones. Limestones comprise approximately 20 to 40 percent of the Kope Formation and contain diverse, abundant fossils, and a wide range of bedding styles (Jennette and Pryor, 1993; Tobin, 1982). The limestones within the study area range from thin (1 to 8 cm), discontinuous lenses of packstone, to laterally continuous grainstone layers up to 35 cm thick (Rabbio, 1988). Many of the limestones exhibit grading, cross lamination, and variable amounts of bioturbation, winnowing and reworking.

Storm Beds within the Kope Formation

The intensity of storm effects on the sea floor are dependent on water depth and storm intensity (Kreisa, 1981; Aigner, 1985). The character of event beds will vary with depth, creating variation within the resulting deposits that reflects a proximality trend or gradient that results from differences in bottom energy during storm events (Aigner, 1982; 1985). Thus, proximal tempestites, which reflect near-shore or shallow-water conditions will differ in character from distal tempestites that form under off-shore or deeper-water conditions. Proximal tempestites within the Kope Formation are generally thicker than distal tempestites (Jennette and Pryor, 1993). They have erosional bases, are typically sparry, medium to coarse grained, graded and are frequently rippled (Rabbio, 1988). The bioclasts typically undergo more cycles of reworking and therefore exhibit more breakage and abrasion than the material associated with more distal environments (Jennette and Pryor, 1993). The limestone portion of the tempestite couplet is generally overlain by a thin, occasionally burrowed, laminated siltstone. As would be expected, amalgamation is more common in proximal beds than in distal (Brett, 1983); therefore the laminated siltstone portion of the bed may be truncated or absent (Tobin, 1982; Jennette and Pryor, 1993).

Distal tempestites within the Kope Formation are quite variable, and may range from thin graded shale layers to siltstone layers with erosional, tool-marked bases and hummocky cross-stratification to planar or lenticular packstone beds overlain by laminated silt or mudstone (Jennette & Pryor, 1993). The skeletal material associated with distal tempestites presumably would be subjected to lower bottom energy conditions and fewer cycles of reworking than their counterparts in more proximal environments. Therefore, the allochems preserved in distal tempestite deposits typically exhibit lower levels of breakage and abrasion, as well as higher diversity than those incorporated in more proximal deposits (Seilacher, 1982; Kreisa, 1981; Aigner, 1985).

ANALYSIS OF TAPHONOMIC DATA

Characteristics of the Kope Limestones

At first glance the limestones within the Kope Formation appear to be relatively simple, flat bedded to lenticular, packstone and grainstone units of varying thickness and texture. However; closer examination indicates that many of the limestone units contain multiple beds with complex sedimentological features. The 172 limestone layers that were examined from the measured sections in the Kope Formation contained at least 232 distinct beds. 40% of these beds showed evidence of amalgamation in the form of scoured or erosional horizons and multiple trends in internal sorting and fabric. 176 of the beds (76%) exhibited some form of grading. The most common form of grading was fining upward, which was observed in 155 (67%) of the beds. Coarsening upward trends were observed in 7 (< 3%) of the beds, and 14 of the beds (6%) exhibited both coarsening and fining trends. These internally complex beds are probably amalgamations of several partially cannibalized deposits. Planar to cross lamination was noted in 188 (81%) of the beds. Occasionally the entire bed was cross-laminated, but generally cross lamination was confined to the fine-grained bioclastic material and/or silt near the upper surface of the bed.

Allochem composition of the individual beds was variable. Bryozoans were the most commonly occurring bioclast and were present in 95% of the beds. Brachiopod material was present in 91% of the beds. Although less abundant than bryozoa and brachiopods, trilobite remains were the third most frequently observed bioclast and were present in nearly 70% of the beds. Echinoderm material was present in 60% of the beds and ostracods were present in 13% of the beds. Molluscan remains, in the form of gastropods and pelecypods were also encountered, as were graptolites. However, these last taxonomic groups were relatively rare in the assemblages, and were volumetrically unimportant in terms of bioclast contribution within the bed samples observed. Overall bioclast size (adapted from Folk, 1980) was variable between the beds, with 18.5% of the beds characterized as coarse grained; 8.2% medium-coarse; 27.5% medium grained, 15% medium-fine grained and 30.8% classified as fine grained.

Taphonomic alteration of taxonomic groups

The various taxonomic components of a fossil assemblage may exhibit different degrees of taphonomic alteration even though subjected to similar environmental conditions (Meldahl and Flessa, 1990; Kidwell, Fursich and Aigner, 1986; Driscoll, 1970). This is due to differences in skeletal composition and complexity, robustness, density, size and shape-related hydrodynamic properties (Brett and Baird, 1986). Table 4 summarizes the predicted susceptibility of various skeletal types to biostratinomic processes (adapted from Brett and Baird, 1986).

Table 4: Susceptibility of Skeletal Types to Biostratinomic Process (adapted from Brett and Baird, 1986)

Skeletal Type	Disart	Break	Cor /Abr	Intact Trans	Current Reorient	Wave Reorient
Single Unit						
a. massive	NA	(-)	(+)	(-)	(-)	(-)
b. encrusting	NA	(-)	(++)	(-)	(-)	(-)
c. ramose- robust	NA*	(-)	(-)	(+)	(+)	(-)
d. ramose- fragile	NA*	(++)	(-)	(-)	(++)	(-)
e. univalved	NA	(-)	(+)	(+)	(++)	(+)
Multiple Unit						
a. bivalved - thick	(+)	(+)	(+)	(+)	(+)	(+)
b. bivalved- thin	(++)	(++)	(-)	(++)	(+)	(+)
c. tightly sutured	(++)	(+)	(+)	(+)	(+)	(-)
d. loosely articulated	(++)	(++)	(-)	(-)	(+)	(-)

disart =Disarticulation; Break = breakage; Cor/Abr = corrosion & abrasion; Int. Trans = intact transport of complete skeleton; NA=not applicable; NA*= breakage at joints; (-) = usually not susceptible to process; (+) = susceptible to process; (++) very susceptible to process.

This range of responses to biostratinomic processes indicates that while the conditions of skeletal remains are useful indicators of taphonomic history, the same biostratinomic process may affect the remains of different taxa preferentially.

To determine the net effects of the biostratinomic processes acting on bioclasts that accumulated in the Kope Formation, the range of taphonomic alteration exhibited within each taxonomic group was examined. The degree of breakage and sorting, and amount of abrasion characteristic of each group was then compared. The results of these comparisons are summarized in Figures 8 through 11, and comparisons of the five most abundant taxonomic groups (volumetrically important) are discussed below.

Within a single bed, the degree of breakage and abrasion evidenced by individual specimens of a taxonomic group may vary. This was often the case in beds that showed sedimentological evidence of amalgamation, and is typically attributed to the mixing of relatively new, articulated and/or unbroken material with more degraded, or "taphonomically mature" skeletal debris during high energy storm events or episodes of reworking (Seilacher, 1982). However; in most beds, the observed range of variation for a particular taphonomic characteristic within one taxonomic group was limited. Within each taxon, a mean was calculated for each of the taxon specific variables (Appendix B). This allowed for comparison of taxon specific variables (see methods) between different taxa within the same assemblage, and determination of the way different taxa were affected by similar taphonomic and sedimentological processes.

Breakage

Comparisons of the degree and pattern of breakage observed among brachiopods, bryozoa, crinoids, trilobites and ostracods in the Kope assemblages indicate that the percentages of specimens showing breakage, as well as the extent of breakage exhibited, differ markedly between the taxonomic groups. Analysis of the taphonomic data obtained for brachiopods preserved in the limestone samples from the Kope Formation indicate that the overall degree of breakage is relatively skewed toward the fragmented end of the continuum (Figure 8). Brachiopod skeletal material was present in 212 (91%) of the beds examined.

In these assemblages, less than 2% preserved the majority of brachiopods in an articulated and unbroken state; in approximately 20% of the assemblages brachiopods were disarticulated, but unbroken; an additional 15% contained disarticulated brachiopod valves that exhibited minimal breakage, which was generally confined to the perimeter of the valve; 35% of the assemblages contained disarticulated valves that showed extensive fracturing and breakage; and in 27% of the beds, brachiopod material was present only as fragments.

The general distribution pattern of breakage among bryozoa was notably different than for brachiopods. Approximately 3% of the assemblages contained substantially intact colonies; 32% of the assemblages were composed of zoarial sections that were broken at joints or sutures. An additional 22% showed further evidence of minor peripheral breakage; and 29% evidenced significant internal fracturing and breakage; extensive breakage was characteristic of 4% of the assemblages, and fragmentation of 9%.

Echinoderm (pelmatozoan material) was present in 139 (60%) of the beds. The distribution of breakage states in crinoids followed a normal distribution curve. Due to the rapid rate of post mortem disarticulation of crinoid skeletal material (Schaefer, 1972; Meyer and Meyer, 1986), intact calyx and stems containing 20 or more articulated columnals were scored as unbroken. Less than 2% of beds examined contained intact

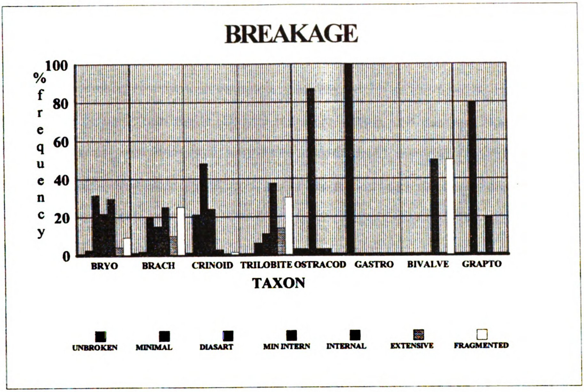


Figure 8: Comparison of breakage levels exhibited in the major taxonomic groups within Kope assemblages. Unbroken = fully intact, undamaged skeleton; Minimal = minor peripheral breakage; Disart = disarticulated or equivalent breakage at major joints in ramose byrozoans; Min Intern= minor peripheral breakage beyond disarticulation; Internal= breakage across valves or colonies; Extensive = breakage into four or more pieces; Fragmented = breakage into fine-grained material (mm-sized), generally less than 1/8th the size of the original skeleton. % Frequency is the relative percentage of assemblages where a given breakage state was characteristic for that taxon (N= number of assemblages in which the taxon was observed.)

crinoid material. Stem segments containing seven or more articulated columnals were representative of 23% of the beds; 48% of the beds contained crinoid segments with three or fewer articulated columnals; and 24% of the beds contained individual columnals; in 5% of the beds, disarticulated crinoid material showed evidence of further internal breakage.

Trilobite material was observed in 162 (70%) of the beds. Fewer than 1% of the observed assemblages contained complete trilobites. Much of the trilobite material was presumably derived from molts (Speyer and Brett, 1986). Of the beds that contained trilobite material, 6% contained minimally disarticulated material (multiple thoracic segments, intact cephala or pygidia); 11% of the assemblages contained disarticulated, but unbroken trilobite material; 38% of the assemblages contained fully disarticulated material with some degree of peripheral breakage; an additional 14% of the assemblages contained trilobite plates with significant breakage, and in 30% of the assemblages that contained trilobite material, that material was extensively broken and fragmented. Assemblages where the dominant size of fragmented trilobite debris was less than 0 .5 mm were rare, but this did occur in slightly over 1% of the cases.

Ostracods were present in 31 (13%) of the beds examined. The distribution of breakage patterns displayed in this group was extremely leptokurtic, with 87% of the ostracod-bearing assemblages containing disarticulated, but unbroken valves. Unbroken, articulated ostracods, and articulated ostracods with minor valve damage were each represented in 3% of the assemblages respectively; and at the higher end of the breakage spectrum, disarticulated valves with minor peripheral damage and disarticulated broken valves were observed in the same proportions.

Abrasion

Of the 223 beds that contained bryozoans, 145 (65%) of the them contained assemblages where less than 10% of the bryozoans specimens observed showed evidence of abrasion (Figure 9). In 51 of the beds (23%), 10 to 40% of the bryozoans observed were abraded to some degree. In 20 beds (9%) the proportion of bryozoan colonies showing evidence of abrasion ranged between 40 to 80%, and in the remaining 7 beds (3%), over 80% of the bryozoans showed evidence of significant abrasion .

In 59 (28%) of the 212 beds bearing brachiopods, fewer than 10% of the specimens were abraded. 54 (26%) of the beds contained assemblages where 20 to 40% of thebrachiopods were abraded; 59 of the beds (30%) contained assemblages in which between 40 and 80% of the brachiopods exhibited significant abrasion; and 36 beds (17%) contained highly abraded brachiopod material in which more than 80% of the specimens showed evidence of abrasion.

Abrasion in crinoids was far less common. In the 139 beds that contained crinoid material, 92 (65%) of them contained assemblages where fewer than 10% of the crinoids showed any evidence of abrasion. In twenty six (20%) of the examined assemblages, abrasion was noted on 20% to 40% of the specimens observed, and in 18 (13%) of the assemblages up to 60% of the crinoid material was abraded. In only three (2%) of the beds evidence of abrasion was observed on 80% or more of the specimens.

Trilobite bioclasts appear to be even less likely to become abraded than those of crinoid material. In 97% of the 162 beds containing trilobite material, 10% or fewer of the observed specimens exhibited evidence of abrasion. In four beds bearing trilobite material, abrasion was evident in 20% to 40% of the trilobite fragments, and only one bed contained trilobite material where abrasion was evident in more that 80% of the

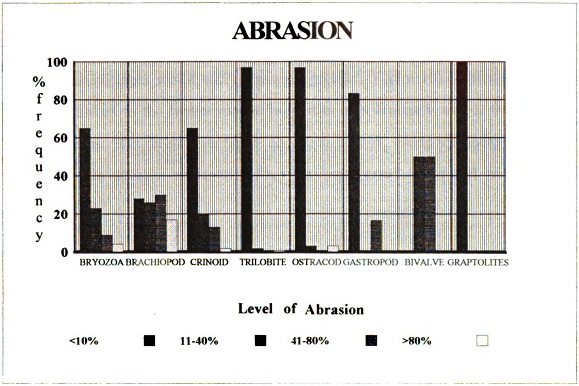


Figure 9: Comparison of the levels of abrasion exhibited in the major taxonomic groups in the Kope assemblages. <10% = assemblages where fewer than 10% of the observed specimens within the taxon evidenced abrasion; 11-40% = assemblages where evidenced of abrasion was observed on more than 10%, but fewer than 40% of the specimens within the taxon; 41-80% = assemblages where evidenced of abrasion was observed on more than 40%, but fewer than 80% of the specimens within the taxon; >80% = assemblages where abrasion was noted on more than 80% of the specimens within that taxonomic group. % frequency = the relative percentage of beds where that level of abrasion was observed (N= number of assemblages in which the taxon was present).

observed skeletal material. Similarly ostracods within the Kope assemblages do not exhibit extensive abrasion. In the 31 beds that contained ostracods, only one contained ostracod valves that showed evidence of abrasion.

Sorting

As with other taphonomic characteristics, comparisons of within taxon sorting in the Kope assemblages varied widely between groups (Figure 10). Because sorting is inherently linked to the hydrodynamic properties of a bioclast's shape, the degree of overall sorting was also determined for each "shape" category independently in assemblages in which a taxonomic group was represented by several phenotypically diverse genera.

The bryozoan assemblages in the Kope limestones exhibited a wide range of size-sorting. In approximately 30% of the beds that contained them, the size-sorting of bryozoan material was poor to moderately poor (see Methods). Moderate to moderately well-sorted bryozoan material was observed in 35% of the beds; 35% contained well to very well-sorted bryozoan material.

Brachiopods displayed a range of sorting within their associated assemblages. In 26% of the beds containing brachiopods, the sorting of the brachiopod material was poor to moderately poor. Brachiopods were moderately to moderately well sorted in 32% of the assemblages, and well to very well sorted in 42% of the assemblages that contained them.

In 50% of the assemblages containing trilobite material, sorting of that material was poor to moderately poor. In 22% of the beds containing trilobite material, the material was moderately to moderately-well sorted, and in 29% of the assemblages,

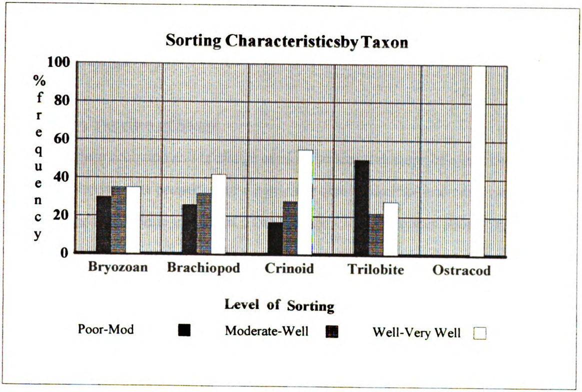


Figure 10: Comparison of sorting tendencies by taxonomic group. % frequency = the relative percentage of beds where sorting for the taxon was characterized as poor to moderately-poor (Poor-Mod); moderate to moderately-well (Moderate-well); and well to very-well (Well-Very Well). N for each taxon = the number of beds in which that taxon was observed.

primarily those composed of very fine-grained, highly fragmented skeletal debris, the trilobite material was well to very-well sorted.

Crinoid material tended toward better within-group sorting in the beds in which it was preserved. Poor to moderately-poor sorting of crinoid material was observed in approximately 17% of the beds containing pelmatazoan debris. Crinoid material was moderate to moderately-well sorted in 28% of the beds, and well to very-well sorted in 55% of the beds where this material was preserved. Ostracods displayed the highest degree of sorting and were only observed in well to very-well sorted accumulations whenever present in a bed.

Sorting as a Function of Shape

As disarticulation and breakage occurs, the size and shape of a bioclast change, so that the hydrodynamic properties of a particular type of skeletal grain can vary greatly as it undergoes taphonomic alteration. The tendency to form either poorly or well-sorted associations may be more dependent on characteristics of shape than size or taxonomic affiliation (Speyer and Brett, 1986). Because of the strong correlation between sorting- and shape-related hydrodynamic properties, sorting as a function of shape was examined.

To determine the effect of bioclast shape on sorting, independent of taxonomic affiliation, the bioclasts in each assemblage were categorized by shape into one of nine basic categories. The shape categories were semi-spheroidal, conical, discoidal, concave/convex, hollow cylinder, solid cylinder, branching stick-like and platey. Although some shape categories are associated with specific taxonomic groups (e.g. branching with ramose bryozoans and concave/convex with brachiopods), the shape category of the skeletal material changes as it undergoes progressive degrees of breakage, so that skeletal remains that were once branching in shape may become solid cylinders; or a bivalved skeleton that was originally semi-spheroidal, may disarticulate into two concave/convex bioclasts, which may in turn break into smaller, platey bioclasts. The results of the analysis of shape related sorting are shown in Figure 11 and discussed below.

In the assemblages examined from the Kope limestones, spheroidal and conical bioclasts, represented by articulated ostracods, brachiopods, and gastropods, exhibited the highest tendency toward sorting, with approximately 87% of spheroidal and conical shaped skeletal elements being classified as very well sorted, and 22% as well-sorted within the assemblages in which they were preserved. Stick-like bioclasts were also associated with high degrees of sorting. In this shape category only 2% were associated with poorly sorted groupings, 12% and 16% were associated with moderate and well sorted accumulations respectively, and approximately 70% with very well sorted accumulations. Discoidal bioclasts also tended to form well-sorted accumulations, with approximately 3% classified as poorly sorted; 12% as moderately sorted; 37% classified as well sorted; and 45% classified as very well sorted. A similarly skewed distribution of sorting was found in concave/convex bioclasts where approximately 11% were classified as poorly sorted; 18% as moderately sorted; 32% as well sorted; and 39% as very well sorted. Sorting was not as pronounced among bioclasts categorized as hollow cylinders. In this category, 11% of the accumulations were classified as poorly sorted; 18% as moderately sorted; 50 % as well sorted and 21% as very well sorted. 23% of the accumulations of branching bioclasts were characterized as poorly sorted; 25% exhibiting moderate sorting, 33% were well sorted; and 19% very well sorted. Solid cylinder shaped bioclasts exhibited a range of sorting conditions in the accumulations in which they were found. Approximately 27% of the bioclasts in this shape category were in poorly sorted accumulations, 17% were in moderately sorted accumulations, 28% were

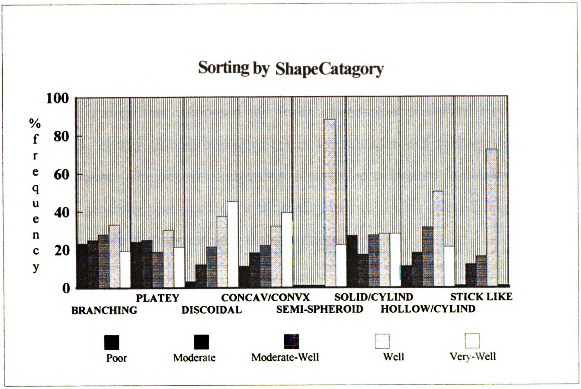


Figure 11: Comparison of sorting tendencies by shape. % frequency = the relative percentage of beds where size sorting in bioclasts within the shape category was characterized as poor, moderately, moderate, moderately-well, well or very-well. N for each shape category = the number of beds in which bioclasts in that shape category were observed.

in well and 28% in very well sorted accumulations. Platey bioclasts showed similar patterns of sorting, with approximately 24% in poorly sorted accumulations, 25% in moderately sorted accumulations, 30% in well sorted accumulations and the remaining 21% in very well sorted accumulations.

Discussion of Taphonomic Alteration within Taxonomic Groups

As a whole, patterns of progressive taphonomic alteration differed between the taxonomic groups that composed the fossil assemblages preserved within the Kope limestones. Nearly all beds contained mixed assemblages with two or more taxonomic groups present. The degree of taphonomic alteration evidenced in bioclasts within the same bed generally corresponded with trends observed in the over-all analysis of each taxonomic group or shape category discussed above.

Bryozoans, the most volumetrically abundant taxonomic group in the Kope assemblages, tended to exhibit the least taphonomic degradation (Appendix A). In 31 of the beds (14%) in which they were preserved, ramose forms were preserved as branching zoaria, indicating minimal breakage, but even in these minimally broken accumulations, bryozoan bioclasts in 23 of the 31 beds (75%) showed evidence of hydrodynamic size-sorting, with over 12 (50%) of these accumulations characterized as well to very well sorted. Most bryozoan bioclasts preserved in the Kope assemblages had undergone a greater degree of breakage than those mentioned above, and were categorized as solid or hollow cylinders. Bryozoan bioclasts in these shape categories were present in 144 of the beds observed. The hollow-cylinder shape category was most often preserved in well-to very-well-sorted accumulations (71% cumulative for both sorting conditions) and solid-cylinder shapes bryozoan bioclasts were preserved in well-to very-well-sorted accumulations in 56% of the beds in which they were preserved. This degree of size-sorting indicates that hydrodynamic reworking and/or transport may have been an important factor producing the assemblage. Platey shaped bryozoan bioclasts, most frequently representing either robust encrusting or more delicate fondescent zoarial forms, were common in approximately 18% of the beds. Fondescent forms were generally associated with fine-textured beds, and robust encrusting forms were associated with medium and coarse textured beds. A range of size and sorting characteristics was noted for both types of bryozoan bioclasts in this shape category, but most were characterized as poorly to moderately sorted (see data, Appendix A).

The combination of breakage, selective size and shape sorting and degree of parallel orientation observed in bryozoan bioclasts within many of the beds indicate hydrodynamic reworking and some degree of transport. Many of the bryozoan-dominated accumulations observed were in beds comprised of relatively coarse bioclasts. The winnowed nature of these coarse bryozoan accumulations indicates that these may have formed as lag deposits. Generally, bioclastic lag deposits are considered parautochthonous assemblages (Johnson, 1960; Kidwell, 1986). However; the degree of size sorting and parallel alignment exhibited within many of the bryozoan accumulations, particularly those composed of "hollow cylinder" shape forms (represented by the genus Ceramophylla), which may be preferentially prone to transport (Anstey and Rabbio, 1989), suggests that some of these accumulations may be allochthonous assemblages of hydraulically transported and selectively redeposited material.

Over all, the level of abrasion observed in the bryozoan component of the assemblages tended to be consistently low (Figure 9). In 65% of the beds fewer than 10% of the bioclasts evidenced abrasion. Only 13% of the beds containing bryozoan material had high percentages (more than 40%) of bryozoan bioclasts that evidenced abrasion. The apparent resistance of bryozoans to abrasion may be the result of two shape and density related factors. Most bryozoan bioclasts had undergone breakage and were categorized as solid or hollow cylinders. These may have been relatively light-weight bioclasts and the hydrodynamic properties associated with this shape may have produced a tendency to roll rather than drag across the bottom during transport events. Abrasion levels were observed to be somewhat higher in robust "platey" shaped colony fragments.

More extensive levels of breakage and disarticulation were evidenced in brachiopod bioclasts. In 35% of the beds containing brachiopod bioclasts, valves were disarticulated and exhibited significant breakage and in 27% of the beds containing brachiopod material only fragmented brachiopod bioclasts were observed. (Figure 8) Within-taxon sorting characteristics of brachiopod material were also high (more than 75% characterized as well to very well sorted). (Figure 10) Brachiopod bioclasts also showed a greater degree of abrasion than did bryozoan bioclasts. In 47% of the assemblages containing brachiopod material, more than 40% of the bioclasts exhibited abrasion. (Figure 9)

The amount of breakage and abrasion that bioclasts experience is related to the duration of exposure time, bottom-energy conditions and the frequency and intensity of reworking events (Johnson, 1960; Driscoll, 1970; Driscoll and Weltin, 1973; Brett and Baird, 1986). Assuming the bioclasts incorporated within the same bed experienced a similar exposure and reworking history, the higher degree of taphonomic alteration (breakage and abrasion) observed in the brachiopod bioclasts may indicate a greater susceptibility to taphonomic processes. The higher percentage of abrasion evidenced in brachiopod bioclasts may be attributed to shape characteristics. The predominant shape categories for brachiopod bioclasts were concave/convex (66%) and platey (33%). The hydrodynamic properties of these shapes would tend to result in dragging motions during winnowing and transport (Driscoll, 1970). As noted above, platey-shaped bryozoan bioclasts also exhibited a higher proportion of abrasion than did cylinder-shaped bryozoan bioclasts.

A comparison between bryozoan and brachiopod bioclasts within the same bed indicates that brachiopod bioclasts often exhibit a greater degree of taphonomic alteration than bryozoan bioclasts. In bed samples containing both bryozoan and brachiopod material, levels of breakage, abrasion and within-taxon sorting were typically higher in the brachiopod bioclasts (Table 5).

Table 5: Comparison of relative levels of breakage, abrasion and size-sorting in 178 beds with mixed bryozoan-brachiopod assemblages (Appendix A).

Breakage:	
brachiopods exhibit a higher degree of breakage	N= 91 (51%)
bryozoans exhibit a higher degree of breakage	N= 40 (23%)
approx. equal breakage exhibited in both taxa	N= 47 (26%)
Abrasion:	
brachiopods exhibit higher percentage of abrasion	N= 103 (58%)
bryozoans exhibit higher percentage of abrasion	N= 16 (9%)
approx. equal percentage of abrasion on both taxa	N= 59 (33%)
Sorting (within taxon):	
brachiopods exhibit a higher degree of sorting	N= 70 (39%)
bryozoans exhibit a higher degree of sorting	N= 51 (29%)
approx. equal degree of sorting in both taxa	N= 57 (32%)

The effects of taphonomic processes on the degradation of trilobite bioclasts within the mixed assemblages was distinctive from bioclasts derived from other taxonomic groups. The differences may be attributable to the composition as well as the variety of skeletal components. Trilobite bioclasts tended to fall into three shape categories. Disarticulated, but unbroken skeletal elements were typically concave/convex in shape. In approximately 18% of the beds containing of the trilobite material, the majority of the trilobite bioclasts observed fell into this shape category. In 79% of the beds containing trilobite material, the trilobite bioclasts were broken into smaller, platey-shaped bioclasts. The remaining 3% of the beds containing trilobite material were extremely fine grained, and identifiable trilobite bioclasts were fragments categorized as solid cylinder and stick-like shapes.

Sorting in accumulations of trilobite material appears to be bimodal. Poorly sorted trilobite material was frequently incorporated in beds of all bioclast sizes. The most common (56%) accumulations of trilobite skeletal material were deposits where the trilobite bioclasts exhibited a range of disarticulation and breakage that included fairly intact elements incorporated with more fragmented ones. This was interpreted as indicating a tendency toward progressive disarticulation and breakage during both pre-burial exposure and subsequent reworking episodes (Schaefer, 1972; Plotnick, 1986; Speyer and Brett, 1986). The poor to moderately sorted trilobite material was composed of a correspondingly wide range of size and shape categories. The orientation of larger, concave/convex thoracic segments were typically observed in a hydrodynamically stable position, either imbricated or convex up. This type of reorientation is generally associated with "mechanical aggregates" of parautochthonous material (Brett and Baird, 1986; Kidwell,1986) and is typical in shallow water wave and/or current influenced lag deposits (Speyer and Brett, 1986). A much higher degree of sorting was observed in very fine grained beds comprised of highly comminuted bioclastic material. Identifiable trilobite bioclast in these beds tended to be platey-shaped or stick-like elements of a slightly- to moderately-larger size than the bioclastic debris in which they were incorporated. These fine grained deposits may represent distal accumulations of material winnowed from the reworked proximal lag deposits described above (Speyer and Brett, 1986).

Highly abraded accumulations of trilobite material were rare. In 96% of the beds, less that 10% of the trilobite elements showed evidence of abrasion. (Figure 9) Even in accumulations composed of highly comminuted, well sorted trilobite debris, less than 20% of the bioclasts exhibited evidence of abrasion. Progressive fragmentation appears to be the predominant mode of taphonomic degradation in trilobite bioclasts within the Kope deposits.

Crinoid material was also fairly resistant to abrasion. In 65% of the beds containing crinoid material, fewer than 10% of the crinoid bioclasts evidenced abrasion and only 12% of the beds observed contained crinoid bioclasts where more than 40% of the specimens showed indications of abrasion (Figure 9; Appendix A). Disarticulation of crinoid stems into segments of three or fewer columnals was the most frequent mode of occurrence for crinoid material. Studies of the *in situ* disarticulation of modern crinoids indicate that within a very short time (hours to days) disarticulation is nearly complete (Schaefer, 1972; Brett and Baird, 1986; Meyer and Meyer, 1986). The presence of highly articulated crinoid skeletal material is generally associated with rapid or catastrophic burial (Schaefer, 1972; Brett and Baird, 1986). In this study, the incorporation of articulated crinoid segments (seven or more columnals) in beds predominantly comprised of more taphonomically degraded material (e.g. broken, abraded brachiopod bioclasts and broken, moderately to well sorted bryozoan material) was interpreted as evidence of mixing older, reworked bioclasts with fresh crinoidal material during storm events.

Once disarticulation occurs, the shape and low density of crinoid columnals makes them highly susceptible to winnowing and transport (Seilacher, 1973). The incorporation of disarticulated crinoid material within a mixed assemblage of less easily transported material may indicate a lack of subsequent reworking after initial deposition.

This is consistent with the observation that winnowed medium to coarse grained bryozoan/brachiopod dominated packstone/grainstones within the Kope Formation were generally devoid of unarticulated crinoid material, while individual columnals are frequently preserved in wackestone beds of similar texture and taxonomic composition (Tobin,1982; Rabbio, 1988).

Within the Kope Formation disarticulated columnals tend to be concentrated in well to very well sorted packstone and grainstone beds (Appendix A). After disarticulation individual columnals appear to be resistant to extensive breakage (Figure 8; Appendix A). Resistance to breakage and abrasion makes crinoid columnals durable within the sedimentary environment (Seilacher, 1973). Well sorted, cross laminated crinoidal grainstones are associated with high energy bottom conditions in proximal or shallow water environments (Kreisa and Bambach, 1982; Seilacher, 1982; Jennette and Pryor, 1993). In this study, disarticulated crinoid material was observed to accumulate in cross-laminated crinoidal grainstones that were associated with proximal environments, and occasionally as thin laminae in very fine-grained accumulations of highly-comminuted bioclastic material associated with distal tempestite deposits.

Ostracod bioclasts demonstrated the most extreme response to taphonomic processes. No accumulations of extensively broken or highly abraded ostracod material were observed. This may be an artifact if the limits of the observational techniques employed in this study (optical microscope), or indicate that ostracod bioclasts, because of their small size are prone to dissolution (Driscoll, 1970; Speyer and Brett, 1987). In approximately 7% of the beds containing accumulations of ostracod material, the bioclasts were articulated and unbroken, or exhibited only minor peripheral breakage on the valves (Figure 8). In 86% of beds containing ostracods, the valves were disarticulated, but relatively unbroken or abraded. This state of preservation indicates rapid burial often associated with bottom smothering during the deposition of distal tempestites (Seilacher,1972; Brett and Baird, 1986).

In this study, ostracod material was generally not observed in beds that displayed evidence of extensive reworking or winnowing. 63% of the beds that contained ostracods were thin, fine-grained, fining-upward, occasionally cross-laminated beds with sharp basal contacts (Appendix A). The characteristics of these beds were consistent with distal tempestite deposits. Ostracod valves were also noted in coarser textured, bryozoan and brachiopod dominated wackestones. In these beds, ostracod material was generally not distributed throughout the bed, but confined to patches or thin lenses of biosiltite within the matrix material.

Summary

The differences in breakage, abrasion and sorting displayed between the biotic components within the Kope limestone deposits may be used in determining the general taphonomic history of the bed (Kidwell,1985; Kidwell, Furish and Aigner, 1986; Brett and Baird,1986; Speyer and Brett,1988; Brandt,1989). Based on observations of taphonomic alteration of bioclasts within the Kope limestones, the following general statements can be made:

1) Because of their susceptibility to abrasion, brachiopods may be more sensitive indicators of wave winnowing and transport than either bryozoa or trilobites, which appear to be more prone to progressive fragmentation than to abrasion, even in fine grained, size selective allochthonous deposits.

2) Sorting in trilobite material was generally poor in coarse grained and poorly winnowed (i.e. more than 50% matrix) beds, this may be interpreted as an indication of

in situ breakage during reworking and sediment mixing events. Well sorted, disarticulated trilobite material was most frequently observed in fine-grained deposits associated with distal facies (see facies discussion below), indicating transport and size-selective redeposition (Appendix A).

3) The size and shape of disarticulated crinoid columnals appears to make them highly susceptible to current and wave transport (Seilacher, 1982). The presence of disarticulated columnals within medium to coarse grained beds indicates a lack of significant post-depositional winnowing. Because of the rapid rate of disarticulation due to the decay of connective tissues, the observation of partially articulated crinoid material within a graded or cross laminated beds was unusual, and was considered an indication of sediment mixing.

4) Ostracods do not appear to survive taphonomic processes associated with reworking and/or prolonged exposure and transport. Amalgamated beds, and coarse grained beds were generally devoid of ostracod material. Abundant well preserved ostracod material was most frequently observed in fine grained, graded beds associated with distal tempestite deposits (see cluster analysis below).

5) In beds containing both cylindrical shaped bryozoan colonies and brachiopods, the bryozoans typically evidence significantly less abrasion than brachiopods; this suggests greater resistance to the effects of abrasion during transport and/or reworking. Size-selection, and fabric (e.g. parallel alignment) appear to be more reliable indicators of both reworking and transport for cylindrically shaped bryozoan bioclasts.

FACTOR ANALYSIS

Factor analysis is an ordination technique similar to principal components analysis. The purpose of factor analysis is to regroup large amounts of data into patterns that may be meaningfully interpreted in terms of the underlying causes or *factors* that produced the variation in the data. It attempts to account for the correlations in many observable variables in terms of a smaller number of unobservable variables. Factor analysis produces the most effective results in data sets that encompass a fairly limited range of variation (Gauch, 1991; Whittaker, 1967). This method assumes that the observed variables are parametric, and respond linearly to the underlying factors (Gauch, 1991; Gill,1987; Ludwig and Reynolds, 1988). In this study, R -mode factor analysis was employed in an attempt to determine the underlying causes of the taphonomic variation in fossil material preserved within the Kope Formation limestones.

Because different taxa within the polytaxic assemblages of the Kope limestones typically exhibit different degrees of taphonomic alteration (see above), normalized scores (z transformations) were computed for the 816 sets of taxon-specific variables within the 232 beds examined (Appendix B). The normalized scores were then averaged within each bed in order to obtain a single aggregate or index value for each taxon-specific variable represented in the bed. These taphonomic index values, combined with the bed-specific variables were used to ascertain the intercorrelation of taphonomic variables (Appendix C).

Results

Factor analysis of the bedding and taphonomic data from the Kope limestones indicated that three factors accounted for approximately 53.1% of the variation between the beds (Table 6). The variables associated with the first factor were breakage, abrasion, allochem size, overall sorting of bioclasts, fabric and within taxon sorting. The variables included in this group accounted for 28.1% of the variation between the beds. The variables associated with the second factor were fabric, within taxon sorting, percent matrix and reorientation. These variables accounted for 13.9% of the between bed variation. The variables associated with the third factor were over all sorting of the bed, grading and cross-lamination. The third factor accounted for 11.1% of the variation between beds.

Table 6: Factor Analysis - factor loadings for each variable and the total % of variance accounted for by each factor.

	FACTOR 1	FACTOR 2	FACTOR 3
Breakage	**.852**		
Abrasion	**.788**		
Allochem Size	**-.667**		
Sorting	**.544**		**.398**
Grading			**-.682**
Fabric	**.422**	**.614**	
Sorting (within taxon)	**.311**	**.604**	
Percent Matrix		**.401**	
Reorientation		**.374**	
Cross Lamination			**.867**
% Variance	**28.1%**	**13.9%**	**11.1%**

Interpretation

The group of variables correlated in Factor One (breakage, abrasion, allochem size, within-bed sorting, within-taxon sorting and fabric) may be interpreted as reflecting the exposure and transport history of the bioclasts, and bottom energy, as it relates to the nature of deposition and reworking history of the beds. Within this group of variables, allochem size showed a strong negative correlation with breakage and abrasion. This intuitively makes sense, because the coarse-grained beds were typically composed of minimally broken and abraded bioclasts and the fine grained beds were volumetrically dominated by highly comminuted and abraded bioclastic material.

In general, the degree of breakage and abrasion shells exhibit is related to the duration of exposure time as well as the bottom energy conditions on the sea floor (Johnson, 1960; Driscoll, 1967; Speyer and Brett, 1988). In low energy environments, bioerosion and corrosion are the predominant forces in shell destruction. In high energy environments, mechanical breakage and abrasion play a more important role (Meldahl and Flessa, 1990; Speyer and Brett, 1988; Driscoll, 1967; Chave, 1964). In any environment, the longer skeletal material is exposed, the greater the effects of these processes (Speyer and Brett, 1988). The total length of exposure time is related to sedimentation rate (burial), and depositional environment (frequency and intensity of reworking) (Brandt, 1989; Kidwell, 1986).

Bioclast size is related to taxonomic composition of the assemblage, and to the degree of disarticulation and breakage of the skeletal material (Kidwell, Fusrich and Aigner, 1986). Fossil accumulations that represent an ecological assemblage should contain a range of different sized skeletal material reflective of the biota (Johnson, 1960). Uniformity of bioclast size within a bed (sorting) indicates selective removal or deposition of skeletal material based on hydrodynamic properties of the bioclasts (Maiklem, 1968). Well-sorted assemblages are associated with higher-energy environments and/ or events (Brandt, 1989; Speyer and Brett, 1987; Johnson, 1960).

If it can be assumed that the size-frequency distribution of individuals within the original biological populations (represented by within-taxon sorting), generally approximate a normal distribution, a similar size-frequency distribution pattern might still be predicted in an undisturbed death assemblage. Higher than average values for within-taxon sorting (based on comparison of normalized scores for that taxon within all beds in this study) suggest selective hydrodynamic reworking of that component of the assemblage (Hallam, 1967; Shimoyama, 1985).

In rapidly buried, *in situ* assemblages, fabric may reflect the ecology of the organisms (life and death positions), with reorientation the result of predation, scavenging and bioturbating activities. In the higher energy environments, where wave and current reworking affects the bottom sediment, fabric is primarily controlled by shape- and density-related hydrodynamic properties of the bioclasts, and by the nature and intensity of bottom energy (Futterer, 1982; Kidwell, Fursich and Aigner, 1986; Speyer and Brett, 1987). In ecologically produced fabrics, the predominant orientation of bioclasts may range from perpendicular to concordant with respect to the bedding plane (life / death position) or random as a result of scavenging and bioturbation. Hydrodynamically produced fabrics are more ordered, and the bioclasts will generally reflect greater degree of alignment (parallelism) with respect to each other (Kidwell, Fursich and Aigner, 1986). Hydrodynamic fabrics will reflect shape-related hydrodynamic properties of the bioclasts and the nature (wave vs. current) and strength of the force(s) that produced them (Futterer, 1982; Kidwell, Fursich and Aigner, 1986; Speyer and Brett, 1987). Original depositional fabric may also be modified during compaction and diagenesis (Kidwell, Fursich and Aigner, 1986).

Factor One may be interpreted as representing a super variable that reflects "taphonomic maturity" of the beds. This is reflected in the amount of breakage and abrasion exhibited in the bioclasts, as well as the degree of over-all bioclast sorting, within-taxon sorting and fabric preserved within the beds. Degradation of bioclastic material may occur under a range of environmental and energy-related conditions. Breakage may result from either bioerosion or mechanical processes (Chave, 1964;

Driscoll, 1967; Speyer and Brett, 1988; Meldahl and Flessa, 1990). As bioclast size decreases due to breakage, susceptibility to suspension and transport increase. In a storm-dominated shelf environment, high-energy events periodically rework sediments. The frequency of reworking events and the depth to which the sediment is affected are related to water depth and storm intensity (Kreisa, 1981; Tobin, 1982; Aigner, 1985). Evidence of reworking may be preserved as selective size-sorting and reorientation of bioclasts into hydrodynamically stable positions (Kidwell, Furish and Aigner, 1986; Speyer and Brett, 1987). During high-energy reworking events sediment is resuspended. Coarse-grained material may be reorientated and left as lag deposit. Finer-grained material is preferentially subject to winnowing, transport and size-selective redeposition (Johnson, 1960; Kidwell, Furish and Aigner, 1986; Speyer and Brett, 1987).

The theoretical end members of the exposure/transport and energy continuums represented by Factor One would be an *in situ* smothered bottom assemblage that had undergone rapid burial with no post mortem exposure, transport or subsequent reworking, to an allochthonous assemblage of highly comminuted, reworked and transported bioclastic debris. Ideally, rapidly buried *in situ* assemblages would be characterized as "taphonomically immature". These beds would contain a high percentage of articulated, unbroken and unabraded skeletal material. Over-all bioclast sorting would reflect the size distribution of the populations within the buried community, and within-taxon sorting would display a relatively normal size-frequency distribution. A fossil assemblage that accumulated in a quiet bottom environment with a low net sedimentation rate, without rapid burial, would show the effects of post mortem exposure in the form of more extensive disarticulation in loosely articulated taxa, and more breakage and surface wear due to bioerosion and corrosion. The extent of these effects would correspond to the duration of exposure. In higher energy environments, a higher proportion of breakage and abrasion would be attributable to mechanical effects than bioerosion and chemical dissolution. Accumulations of skeletal material that have undergone multiple episodes of reworking and mixing contain bioclasts that exhibit a range of disarticulation, breakage, and abrasion states. In fossil material it can be difficult to distinguish between exposure-related breakage and surface effects caused by bioerosion and corrosion, versus energy-related mechanical breakage and abrasion. However, consideration of sedimentological evidence (i.e. over-all sorting, within-taxon sorting, and fabric) in combination with the condition of the skeletal material gives a better indication of the bottom energy and the extent of reworking. The higher energy levels will be reflected in better size- and shape-sorting of the skeletal material, and in the depositional fabric of the bed. In fossil accumulations that form in high energy environments selective size-sorting and hydrodynamic fabrics reflect the process that formed the bed (i.e. edgewise imbrication associated with currents, convex-upward orientation with resuspension by wave activity, etc.).

The variables correlated in Factor Two (fabric, within-taxon sorting, percent matrix and reorientation) may be interpreted as reflecting variations in depositional energy. The variation in energy may correlate with water depth. As discussed above, fabric may range from random to concordant in ecologically produced assemblages. Hydrodynamic assemblages exhibit a greater degree of bioclast alignment and parallelism. Hydrodynamic assemblages also exhibit better sorting than ecological assemblages. The percentage of matrix material within a bed is attributable to the rate of background sedimentation and the intensity and frequency of current and wave winnowing (Kidwell, 1986; Brandt, 1989). Assuming a reasonably constant background sedimentation rate, at least some of the variation in the percentage of matrix material in the Kope limestones reflects sediment winnowing. The effects of winnowing are most pronounced at shallow depths where wave motion (both fairweather and storm) impinges on the bottom with greater intensity and frequency.

The idealized continuum of energy conditions reflected in Factor Two would range from high-energy, wave-winnowed bottom conditions generally associated with shallow water, to low-energy, quiet-bottom conditions associated with deeper water below storm wave-base. In this respect, Factor Two may be depth related. On a storm-dominated ramp, sediments deposited in shallow-water, high-energy environments would be predominantly well-sorted, current-winnowed lag deposits, wave-washed, imbricated, shell pavements and well-sorted, cross-laminated proximal tempestite deposits (Kreisa, 1981; Aigner, 1982; Tobin,1982; Jennette and Pryor, 1993). Bottom conditions at mid-depths (below fair weather, but above storm wave base) would experience proportionately less energy in the form of intermittent reworking during storm events. The frequency and intensity of these events would be expected to decrease with increasing water depth (Aigner, 1982; Kreisa, 1981). Depending on the intensity of the reworking event, partial amalgamation to total cannibalization of previously deposited sediment layers would occur, following the proximality trends described by Aigner (1982; 1985; and Aigner et al., 1982). In this study, higher ranked fabrics, such as oblique and imbricated, were most frequently associated with amalgamated beds and well sorted lag deposits typically associated with mid to shallow water depths.

Deeper-water environments, below storm wave base, are characterized by low energy bottom conditions. Sedimentation rates in distal environments are typically low. Storm-generated gradient currents produce episodic influxes of sediment, that may result in the deposition of well-sorted, fine-grained material winnowed from more proximal areas (Swift et al., 1983; Allen, 1982; 1984).

Whether or not the depositional fabric is a bed is preserved depends upon a number of factor that may also relate to depositional environment. In relatively low-energy environments, accumulation of water-saturated, fine-grained sediments favor development of infaunal deposit feeders, which may obscure the depositional fabric of unconsolidated sediments (Driscoll, 1969). In higher energy, or more proximal environments, beds are more frequently subject to reworking and amalgamation which may alter the original depositional fabric of the bed and greatly reduce the amount of matrix material preserved in the upper portions of the bed (Kreisa, 1981; Aigner 1982; Aigner et al., 1982).

The variables correlated with Factor Three were bioclast sorting and cross lamination and grading. In this group of variables, grading correlates negatively with sorting and cross-lamination. Cross-lamination is produced by currents within specific flow regimes, and from oscillating movements as waves impinge on the bottom. The positive correlation between sorting and cross-lamination reflects the discreet size range of saltating particles.

Within the Kope environments there are three areas where the preservation of cross stratification would be likely. In shallow water, buoyant, well-sorted and highly-winnowed material may accumulate in shoal deposits during high-energy events (Kreisa and Bambach, 1982; Seilacher, 1982). The well-sorted, cross-laminated crinoid grainstones found within the Kope Formation have been interpreted as representing this type of accumulation (Jennette and Pryor, 1992).

Hummocky cross-stratification would be produced at mid-depths during storm events, and tend to be preserved in the upper portions of graded storm-beds at depths below fair-weather and seasonal storm wave-base. The probability of complete tempestite sequences being preserved increases with water depth. Therefore, it follows that increased preservation of grading and cross-lamination within beds will correlate positively with increasing depth. This is consistent with the generally accepted idea that grading in storm-related deposits is best preserved in non-amalgamated beds associated with deeper-water environments (Kriesa, 1981; Tobin, 1982).

In deeper water, or in areas where the bottom is not affected by high energy storm reworking (i.e. below storm wave-base), fine-grained debris, winnowed from more intensely reworked up-ramp areas may be transported by storm-induced gradient currents associated with bottom flow during high-energy events (Allen, 1984; Aigner, 1985). This episodic sediment influx would result in the deposition of thin, fine-grained, graded and/ or cross-laminated beds (Swift et al., 1983; Allen, 1982; 1984). Cross-bedded ostracod-rich layers, and thinly-bedded, fine-grained, cross-laminated crinoid packstones are associated with deeper-water tempestites within the Kope (Tobin, 1982; Jennette and Pryor, 1993).

CLUSTER ANALYSIS

The utility of developing a systematic taphonomic classification scheme or grading system has been widely recognized, and several conceptual frameworks for taphonomic grading have been proposed (e.g. Kidwell, 1986; Speyer and Brett, 1988; Brandt, 1989). These conceptual frameworks were instrumental in determining the variables selected for analysis in this study. Although ordination techniques may more realistically describe the actual distribution of taphonomically significant characteristics along environmental gradients, the classification of data into discrete patterns is a useful conceptual tool. Classification provides a method for recognizing taphonomic similarities within and between beds. Therefore, there is a complimentary use of ordination and classification techniques in statistical analysis of data.

While classification techniques may produce somewhat arbitrary divisions within relatively continuous variation, such techniques are useful in determining similarities between samples, particularly in large data sets (Digby and Kempton, 1987; Gauch, 1991). As long as the method classifies the samples on relevant taphonomic and sedimentologic similarities, the resulting groups or clusters of samples will represent beds associated with similar environments and taphonomic histories. If the clusters reflect the taphonomic history of deposits associated with particular sedimentary environments and processes, they should also be recognizable and diagnostic of similar environments and process at other localities and stratigraphic horizons (Speyer and Brett, 1988). The recognition of discrete groups of taphonomic characteristics associated with particular environments and sedimentary processes can ultimately lead to a "gold standard" that may facilitate categorization of taphonomic data in a genetically interpretable way.

Results of Cluster Analysis

Cluster analysis based on the taphonomic and bedding characteristics of the 232 limestone beds produced nine distinct clusters. Although the beds within each cluster displayed a range of variation, the clustered beds shared a significant degree of similarity with other members of their group. Based on visual assessment of the taphonomic and sedimentologic characteristics of the beds within each cluster group, similarities of the beds were interpreted as indicative of the general mode and environment of deposition for the beds within the cluster group. The ranked characteristics of each cluster group are shown graphically in Figure 12. The characteristics of the cluster groups and the sedimentologic / taphonomic inferences made for each group are discussed below.

Cluster 1

This cluster group is composed of moderately thick (mean thickness 5.6 cm), fine to medium grained packstones and includes 28 (12 %) of the beds analyzed (Appendix D). The beds within this cluster group are graded. Some are cross laminated. The degree of bioclast reorientation is high, and platey allochems exhibit a concordant fabric. The bioclasts generally show a higher degree of breakage than abrasion. Overall sorting within the beds is moderately well to well, but within-taxon sorting is poor to moderate.

The beds in Cluster 1 are interpreted as event beds deposited at depths below normal wave base. The relatively high levels of breakage and low levels of abrasion may be attributable to high energy transport and deposition, rather than prolonged exposure and reworking. The low level of within taxon sorting is also consistent with limited reworking and winnowing. The degree of bioclast reorientation and strongly aligned fabric preserved within these graded beds, as well as the relatively low amount of matrix material, suggests transport and deposition of size selected skeletal material by currents.

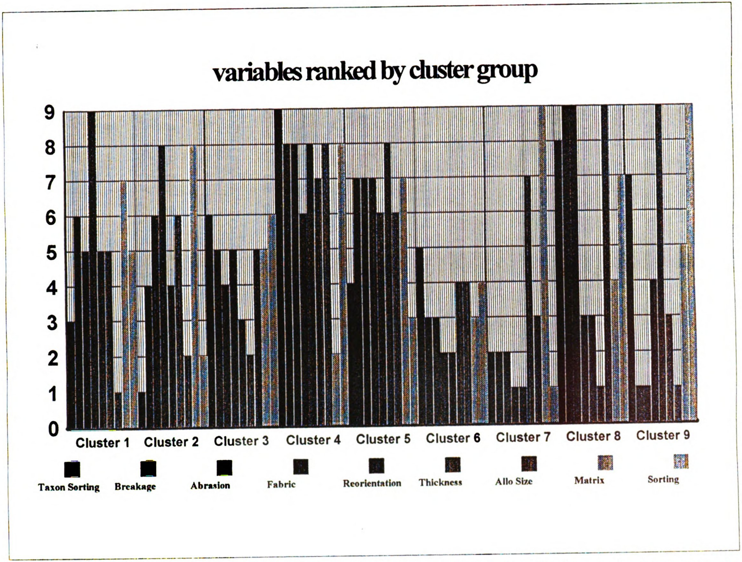


Figure 12: Comparison of variables based on ranking (1-9) across the nine cluster groups. The higher the ranking the greater the relative value associated with the variables.

Cluster 2

The beds in cluster group 2 are relatively thick (mean thickness 8 cm), coarse grained wackestones. This cluster contains 8 beds and represents only 3.5% of the beds analyzed. These beds are only moderately winnowed and retain at least 75% matrix material composed of silt-sized biogenetic debris and micrite or spar. Both overall sorting and within taxon sorting are poor to moderate. Levels of breakage and abrasion are moderate, with relative levels of abrasion greater than breakage. Grading is present in some of the beds, as is evidence of bioturbation. Fabric is random to concordant depending on bioclast shape.

These beds are interpreted as autochthonous to parautochthonous assemblages. The poor to moderate sorting within this cluster group suggests little transport. The thickness of the beds, as well as grading and the presence of cross laminations within some of the beds suggest event deposition and some degree of amalgamation. Although the level of breakage and abrasion, as well as the preservation of grading and cross-lamination in some of the beds, indicates formation under periodic high energy conditions, the amount and nature of the matrix material indicates little winnowing of the beds. In some of these beds, the original depositional fabric is obscured by bioturbation. The fine-grained matrix and presence of biosiltite, which is generally absent in the graded and/or coarse-grained beds observed in this study (see Appendix A), may indicate bioerosion, rather than mechanical processes as a factor in the degradation of some of the bioclasts. The extent of bioturbation indicates colonization of the beds under relatively low-energy conditions (Driscoll, 1969; Kidwell and Jablonski, 1983; Speyer and Brett, 1988).

Based on the sedimentological characteristics and taphonomic condition of the bioclasts, it may be reasonable to interpret these beds as forming in mid-depth environments where quiet-bottom conditions predominate, but occasional high-energy events may periodically affect the bottom. This would account for the grading and amalgamation evidenced in these beds, as well as for the extent of postdepositional colonization, the lack of subsequent winnowing and preservation of the predominantly bioturbated-texture in these beds.

Cluster 3

Cluster group three is the largest group, containing 61 (approximately 26%) of the beds analyzed. Within this cluster are three lower-order clusters with characteristics distinct enough to warrant individual description (Appendix D).

Cluster 3a

This subcluster includes 35 (15%) of the beds examined and is composed of thinly bedded (mean thickness 2 cm), medium to coarse grained packstones/wackestones. These are well-sorted, fining-upward beds. Some are cross-laminated. The tops of beds are frequently truncated and scoured by the overlying bed. The levels of bioclast breakage and abrasion are relatively high within these beds. Some of the beds in this group contain a robust fauna that includes gastropods and encrusting bryozoa. The beds in this group are interpreted as representing winnowed, shallow-water deposits. The bioclasts have undergone some transport and size-selective redeposition under high-energy bottom conditions.

Cluster 3b

The limestone beds within this subcluster are thinly bedded, fine to medium-grained, moderately-sorted wackestones. These beds are graded but generally not cross-laminated. Levels of breakage are relatively high, but abrasion is low. The beds exhibit incomplete winnowing, and some appear to be amalgamated. 22 (approximately 9.5%) of the beds analyzed were included in this group.

The bioclasts within the beds in cluster 3b contain a higher percentage of fine-grained matrix material, indicating less wave/current reworking than those within the beds in cluster 3a. The higher matrix content and lower degree of overall bioclast sorting suggest deposition under lower energy conditions. However, the graded nature of these beds and the amount of reorientation and concordant fabric exhibited by the bioclasts indicates that these are event beds. The incomplete winnowing of these beds indicates a lower-energy environment than that of the beds in cluster 3a, probably below fair-weather wave-base, where postdepositional reworking would be less intense (Kidwell, Fursich and Aigner, 1986; Speyer and Brett, 1988).

Cluster 3c

This group is composed of only 5 beds (1.8% of the beds in the study). The mean thickness of beds in this subcluster is 4 cm. These are ungraded, poorly sorted mudstones (*sensu* Dunham). The bioclasts are medium to coarse. The levels of breakage and abrasion are low, as is within-taxon sorting. The bioclasts exhibit reorientation, but the depositional fabric is generally random. The beds within this group are interpreted as low energy, possibly autochthonous deposits, that accumulated below wave base, and were subjected to little postdepositional winnowing, reworking or transport.

Cluster 4

16 beds (approximately 7% of the beds analyzed) are included in this cluster group. The beds within this cluster consist of moderately thick (mean thickness 8 cm), fine to medium textured grainstones. The beds are graded and cross-laminated. Allochems are well to very well sorted. The levels of reorientation, breakage, abrasion

and within taxon sorting are high. Most of the beds in this group are texturally mature, cross-laminated crinoidal grainstones. These beds are interpreted as high energy, allochthonous deposits that represent proximal tempestites and multiply reworked beds in proximal environments (Seilacher,1982; Kreisa and Bambach, 1982; Jennette and Pryor, 1993).

Cluster 5

This cluster group is composed of thick (mean thickness 11 cm) medium textured, moderately well sorted packstones/wackestones. All beds in this cluster are graded. Complex fabrics or multiple fining upward trends suggests amalgamation. Most beds exhibit some degree of bioturbation, generally confined to the upper portion of the bed. Average levels of reorientation, breakage and abrasion are high, but variable between taxa (e.g. articulated crinoid stems incorporated with broken and abraded brachiopod and bryozoan material). Within taxon sorting is moderately poor. These beds are interpreted as mixed assemblages of poorly-winnowed parautochthonous material. The degree of amalgamation, sorting and variable breakage states of allochems within the beds, suggests mixing of fresh and reworked skeletal material during storm events in an a mid-depth area below fair-weather wave-base, but shallow enough to be reworked during subsequent storm events.

Cluster 6

The beds within this cluster are of medium thickness (mean thickness 4.2 cm), poor to moderately-sorted, medium to coarse-textured packstones. Most of the beds are graded. Bioclast fabric is random to concordant. Most of the beds are bioturbated. The degree of winnowing is variable. Some of the beds have thin shale partings and silt preserved under larger bioclasts. Breakage and abrasion are generally low, indicating that the bioclasts have not been subject to extensive reworking. These beds are interpreted as parautochthonous accumulations that have undergone varying amounts of winnowing under relatively low energy conditions. 23 (10%) of the beds are in this cluster.

Cluster 7

The beds grouped in this cluster are moderately thin beds (mean thickness 3.5 cm), medium to coarse-textured, poorly-sorted wackestones. The levels of breakage and abrasion are low. Bioclast fabric is random to random/concordant. Matrix material typically contains biosiltite and micrite or spar. Although the major bioclast are typically medium to coarse, small, fragile bioclasts such as ostracods and graptolites are preserved as well. These beds represent approximately 8% (19) of the beds examined, and are interpreted as autochthonous/parautochthonous deposits that formed in low-energy environments below wave base.

Cluster 8

The beds within this cluster are relatively thin (mean thickness 2.6 cm), fine-textured packstones/wackestones. These beds are graded and many are laminated. The bioclasts within these beds exhibit high levels of reorientation, breakage, abrasion, and within-taxon sorting. 39 (approximately 17%) of the beds analyzed are included in this cluster group.

The sedimentological and taphonomic characteristics of beds in this group are consistent with distal tempestite deposits (Aigner,1982 and 1985; Tobin, 1982; Brett and Baird, 1985; Jennette and Pryor, 1993). These beds differ from the proximal tempestite beds in Cluster 4 in several ways. The amount of matrix within the beds in Cluster 8 is greater than in Cluster 4 beds, and while the orientation of bioclasts within both groups is concordant, the fabric is less pronounced than in the proximal beds, suggesting lower levels of depositional energy and a lack of postdepositional reworking. The level of abrasion and breakage is slightly higher in Cluster 8 beds, while the level of sorting (both over all and within-taxon) are slightly lower than in the proximal beds. This may be attributable to the greater taxonomic diversity of the bioclastic material observed within these beds as well as lower environmental energy. Crinoid material is abundant in many of the assemblages within both clusters, but consists of finer-sized columnals in Cluster 8. Several of the assemblages in Cluster 8 are dominated by ostracods, which were not observed in the fine-grained, high-energy deposits of Cluster 4.

Cluster 9

There is only one limestone unit associated with this cluster. This is a thick (15 cm) coarse textured packstone layer that appears to consist of at least three amalgamated beds. It is graded and cross-laminated. The bioclasts within the unit exhibit a higher degree of sorting and lower levels of breakage and abrasion than other coarse-textured beds associated with clusters 7, 5 and 3a. The bioclasts within the bed(s) consist of bryozoa, brachiopod and trilobite material, with a notable absence of crinoid material. The brachiopod valves exhibit both convex-up and convex-down orientation. These characteristics are interpreted as the product of high-energy post-depositional resuspension and winnowing by wave activity.

Distribution of Clusters on Factor Axis

Estimated factor scores for the three factors extracted during the factor analysis discussed above were calculated and averaged across beds within each of the nine cluster groups. The clusters were plotted on the factor axis (Figure 13).

Factor One, which correlates breakage, abrasion and bioclast size, fabric and sorting, was interpreted as reflecting the transport and exposure history of the skeletal material . Factor Two, which correlates within-taxon sorting, fabric, percent matrix and reorientation was interpreted as reflecting depth-related bottom energy (see interpretation of factor analysis above). When plotted on factor axis 1 and 2 (Figure 13) the distribution of cluster groups indicates the relative amount of bioclast transport, depositional energy and subsequent reworking recorded in the beds.

Location of clusters on the lower portion of axis one (Figure 13) indicates less than "average" transport. Clusters 7, 6, 2 and 9 all are located at the low end of this axis. However; their distribution on axis two reflects a difference in energy conditions between beds associated with those cluster groups. Cluster 7 is located at the low ends of both axis one and two. The beds in Cluster 7 are interpreted as autochthonous assemblages that show little indication of transport or reworking. These beds are interpreted as relatively undisturbed deposits. The beds in Cluster 6 are in many ways similar to Cluster 7. Cluster 6 is located in a higher position on axis one, indicating a slightly different exposure and/or transport histories between the beds in the two clusters. The location of Cluster 6 on axis two indicates a much greater difference in environmental energy between the two groups. This is supported by subtle differences in taphonomic and sedimentological characteristic preserved within the beds. Both clusters are composed of poor to moderately-sorted, medium to coarse-textured bioclasts that exhibit low levels of breakage and abrasion relative to other beds in this study. However, the beds in Cluster 6 contain less matrix material and exhibit more evidence of winnowing and grading. These beds also show a slightly higher degree of over-all sorting, and significantly better within-taxon sorting. Cluster 6 represents accumulations of parautochthonous / autochthonous material, similar in composition to Cluster 7 beds, that have undergone some degree of intermittent reworking and winnowing during storm events. Both of these cluster groups are associated with deeper-water environments

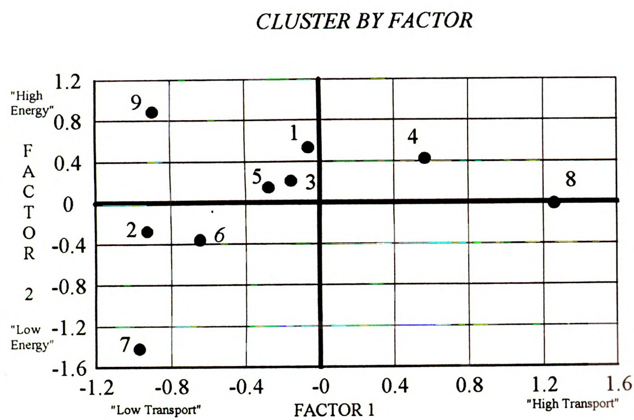


Figure 13: Distribution of Cluster groups (mean values) on Factor Axes 1 and 2.

relative to other beds within the Kope. The difference in bottom energy may be related to fluctuations in water depth, or to the intensity of particular storms events.

The beds in Clusters 2 and 9 are located at the low end of axis one, but at higher levels on axis two than Cluster 7, which is consistent with the degree of winnowing and amalgamation noted in the beds within these clusters. The beds within Clusters 2 are coarse-textured, moderately-winnowed, bioturbated wackestones. The beds in this cluster were interpreted as representing event deposition in generally quiet-bottom, mid-depth environments. Cluster 9 is composed of coarse-textured, very well sorted, wave-winnowed packstone. Fine-grained skeletal material, appears to have been selectively removed from these beds producing parautochthonous lag- type accumulation of skeletal material. The location of these clusters on axis two is suggestive of depth-related, bottom-energy gradients.

Cluster 5 is located midway between Clusters 2 and 9 on axis two, indicating a level of bottom energy intermediate between the latter two. The location of Cluster 5 on axis one indicates a more extensive transport history for the bioclasts within the beds in this cluster, than for those in Clusters 7, 6, 2 and 9. The beds within Cluster 5 are medium-textured, graded and amalgamated, and exhibit a range of winnowing. The bioclasts within these beds typically exhibit a greater range of breakage and abrasion and within-taxon sorting. The beds in this cluster are interpreted as event-beds composed of mixed-assemblages of moderately transported allochthonous/parautochthonous material.

Cluster 3 also is interpreted as representing parautochthonous/autochthonous accumulations. The averaged factor score for Cluster 3 places the group near the mid-range of both axes. The variation between the subclusters within the group indicates a range of breakage, abrasion and sorting that actually indicates a fairly wide distribution along both axes. The location of the cluster on the factor axis plot generally reflects the characteristics of subcluster 3a, which contains the preponderance of beds associated with Cluster 3.

Based on sedimentological characteristics, (i.e. Kreisa [1981] sequences) Clusters 1, 4 and 8 are all interpreted as representing event-beds. Cluster 1 has a low position on axis one relative to axis two. The beds in Cluster 1 are interpreted as representing accumulations of parautochthonous material that was deposited during high energy events and subject to little postdepositional reworking. Cluster 4 has a positive position on both axis. This cluster is composed of fine to medium- textured grainstones. The level of breakage and abrasion evidenced in this group is indicative of repeated cycles of transport and reworking under high energy conditions. These beds were interpreted as proximal tempestites (see cluster description above). Cluster 8 is located at the high end of axis one, reflecting the highest degree of transport. The location of Cluster 8 on axis two indicates that the depositional energy of these beds is significantly lower than event beds associated with Cluster 1 or Cluster 4. This suggests deposition of allochthonous material under waning energy conditions in storm-generated gradient flows.

Facies Associations of Cluster Groups

The sedimentological and biostratinomic characteristics of each of the cluster groups are associated with particular depth-related facies within the Kope environment. The strata that compose the shale / carbonate hemicycles within the Kope Formation have been traditionally categorized into two groups interpreted as representing deposition in two distinct facies. Distal facies, representing comparatively deeper-water deposition, are composed primarily of terrigenous shales interlayered with thin silt and packstone beds. Proximal facies representing comparatively shallower-water deposition are predominantly carbonate and are composed of amalgamated beds of abraded, winnowed and reworked skeletal material. The facies are defined by fluctuating energy levels that have been interpreted as corresponding to depth-related changes in wave-base and bottom-energy (Jennette & Pryor, 1992; Holland 1993). (For a more detailed discussion of "distal /proximal" facies characteristics within the Kope Formation see Jennette and Pryor, 1993).

The proximal/distal terminology used to describe the carbonate/ shale cycles within the Cincinnatian may be misleading when applied to the taphonomic facies within the limestones. This terminology implies position relative to sediment source. In marine environments this generally implies location along an onshore-offshore gradient. The taphonomic facies within the limestones of the Kope Formation reflect changes in water-depth, as well as variations in the nature and intensity of bottom-energy. The relationship between water depth and bottom-energy as related to normal wave-base is relatively straight-forward. However; in "off-shore" regions on a storm-dominated ramp, the nature and intensity of the wave and/or current activity on seafloor will also reflect the intensity of storm events, and relative distance from storm centers. Therefore, the taphonomic facies within the Kope limestones reflect differences in water depth, as well as the nature and intensity of reworking and depositional events. Table 7 shows the relationship of cluster groups relative to the depth, depositional energy and reworking intensity.

Deeper-Water Facies

The facies representing comparatively deep-water conditions within the Kope are composed primarily of terrigenous shales and calcitic to dolomitic mudstones, interlayered with thin silt and packstone beds. Although these units may appear massive, they actually contain relatively thin bedding layers that represent interruptions in background deposition (Jennette and Pryor, 1993). The shale units may contain numerous discrete beds of bioturbated muds, unbioturbated graded silty muds, occasional thin sheets or discontinuous lenses of fossil material (Tobin, 1982). Skeletal material, when present within the shales, may range from unbroken, articulated material, covered by several centimeters of unbioturbated silt or mud representing an *in situ*, smothered bottom assemblage; to thin layers of fine-grained comminuted allochthonous skeletal debris (Jennette and Pryor, 1993). Siltstones associated with distal facies form thin, well defined beds, that typically display some range of storm-related features such as planar-lamination

to hummocky cross-stratification, amalgamation, parallel aligned gutter-casts, tool-marks, orientated body-fossils, erosional sole-marks and mud-filled scours (Tobin, 1982; Jennette and Pryor, 1993).

The limestones associated with deeper-water facies are generally described as thin, parautochthonous packstones that form moderately-continuous planar beds, to small lenticular units composed of coarse-grained skeletal fragments. The lenticular nature of many of these beds may be attributable to the patchy distribution of the benthic communities within this environment (Anstey and Fowler, 1969; Meyer et al. 1981). Fossil content of the packstones is fairly diverse (Jennette and Pryor, 1993). Most beds are dominated by either bryozoa or brachiopods. Trilobites, crinoids and pelecypods are generally present as subordinate constituents. Skeletal breakage and abrasion are fairly low (Jennette and Pryor, 1993; this study).

Table 7: Relationship of taphonomic cluster groups relative to depth/intensity gradients.

Inferred Depth Gradient

Shallower-water — Mid-Depth — Deeper-Water

High-Intensity Reworking

XXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX — XXX
Cluster 3a (n=35) — Cluster 9 (n=3?)

Moderate Intensity / Intermittent Reworking

XXXXXXXXXXXXXXXXXXXXXXX — XXXXXX
Cluster 3b (n=22) — Cluster 5 (n= 6)

Low- Energy Reworking

XXXX — XXXXXXX — XXXXXXXXXXXXXX
XXXXXXXXXX
Cluster 3c (n=5) — Cluster 2 (n= 8) — Cluster 6 (n=23)

Low-Energy Accumulation / Minimal Reworking

XXXXXXXXXXXXXXXXXXXX
Cluster 7 (n=19)

Event Beds (Tempestites)

XXXXXXXXXXXXXXXXX — XXXXXXXXXXXXX — X XXXXXXXXXXXXXX
Cluster 4 (n=16) — XXXXXXXXXXXXX — XXXXXXXXXXXXXX
XXXX — XXXXXXXXXXXXXXXX
Cluster 1 (n= 28) — Cluster 8 (n= 39)

In this study four of the cluster groups are associated with deeper-water facies. The beds in Cluster 7 are interpreted as representing accumulation under relatively quiet, deep-water conditions. The skeletal material in these beds exhibits very little evidence of transport. The amount of matrix and orientation of the bioclasts indicated minimal reworking by waves or currents.

The beds grouped in Cluster 3c are in many respects similar to the beds in Cluster 7, except that these beds are generally thinner and contain a higher percentage of matrix (Appendix A and Appendix D). The bioclasts within these mudstones display a random fabric and exhibit minimal breakage and abrasion. These beds are relatively deep-water deposits associated with very quiet, low-energy bottom conditions.

In Cluster 6 beds, sorting, breakage, the incidence of cross-lamination increases, while the percentage of matrix decreases with respect to the beds in Clusters 7 and 3c. Thin silt partings within the beds, and the presence of silt in shelter-voids indicate that these are wave-winnowed accumulations that have under gone little transport (Kreisa and Bambach, 1982; Jennette and Pryor, 1992). Like Cluster 7, Cluster 6 beds are associated with deeper water facies. The difference between the two cluster groups is defined by a higher energy level associated with wave reworking (see Figures 13 and 14). Both groups are interpreted as representing deposits that formed below normal wave-base. Cluster 6 beds may have been deposited in slightly shallower water, or simply been exposed during high-energy (hurricane-force) events when wave-base extended to greater than usual depths.

Cluster 1 beds are also associated with mid to deep-water environments. These are well-sorted, medium-grained, graded packstones interpreted as storm deposits. These beds are frequently capped by a siltstone veneer, forming storm-generated couplets

(Kreisa, 1981; Aigner, 1982). The preservation of grading, depositional fabric, and occasional siltstone cap, indicates that many of these beds were deposited at depths great enough to prevent reworking during subsequent high-energy events. The beds in Cluster 8, interpreted as deeper-water tempestites, are composed of highly-comminuted and fine-grained material transported by storm-generated gradient currents and deposited in quiet-bottom environments below wave-base.

Shallower-Water Facies

The carbonate portion of the Kope hemicycles are associated with shallower-water facies (Tobin,1982). These facies are equivalent to the highstand transition zone shoreface lithofacies of Holland (1993). The lithotypes interpreted as representing shallow-water environments are highly variable and frequently considered complex (Holland, 1993).

Thin silt layers associated with shallow water facies are composed of bioclastic material that forms fissile, poorly-indurated layers between the grainstone beds. These bioclastic silts are distinctly different in character from the siltstones and shales of the deeper-water facies. They are generally fossiliferous, and do not contain trace fossils (Jennette and Pryor, 1992).

Shallower-water limestones consist of grainstones, poorly-washed grainstones and winnowed packstones that form thick, laterally continuous bed-sets (Jennette and Pryor, 1992). Amalgamation is common in proximal deposits so that a single bed may actually record multiple events of reworking (Brett, 1983; Aigner, 1985). The mixed states of breakage and abrasion of bioclasts within a single bed has been interpreted as indicating multiple episodes of recolonization and reworking, or sediment-mixing during storm events (Seilacher, 1982). A single limestone layer may frequently contain several

Figure 14: Example of a Cluster 3c bed. The beds grouped in this cluster are moderately thin beds (mean thickness 3.5 cm), medium to coarse-textured, poorly-sorted wackestones. The levels of breakage and abrasion are low. Bioclast fabric is random to random/concordant. Matrix material typically contains biosiltite and micrite or spar. Although the major bioclast are typically medium to coarse, small, fragile bioclasts such as ostracods and graptolites are preserved as well. These beds represent approximately 8% (19) of the beds examined, and are interpreted as autochthonous/parautochthonous deposits that formed in low-energy environments below wave base.

Figure 15: Example of a Cluster 6 bed. Beds within this cluster are of medium thickness (mean thickness 4.2 cm), poor to moderately-sorted, medium to coarse-textured packstones. Most of the beds are graded. Bioclast fabric is random to concordant. Some of the beds are bioturbated. The degree of winnowing is variable. Some of the beds have thin shale partings and silt preserved under larger bioclasts. Breakage and abrasion are generally low, indicating that the bioclasts have not been subject to extensive reworking. These beds are interpreted as parautochthonous accumulations that have undergone varying amounts of winnowing under relatively low energy conditions. 23 (10%) of the beds are in this cluster.

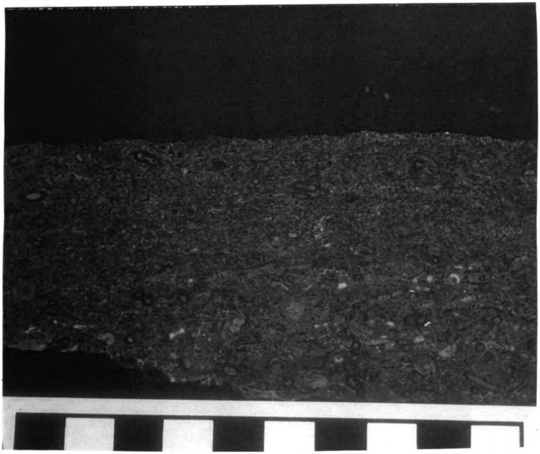


Figure 16: Example of a Cluster 8 bed. The beds within this cluster are relatively thin (mean thickness 2.6 cm), fine-textured packstones/wackestones. These beds are graded and many are laminated. The bioclasts within these beds exhibit high levels of reorientation, breakage, abrasion, and within-taxon sorting. 39 (approximately 17%) of the beds analyzed are included in this cluster group. These beds are interpreted as deeper-water / lower-energy storm deposits.

Figure 17: Example of a Cluster 1 bed. This cluster group is composed of moderately thick (mean thickness 5.6 cm), fine to medium grained packstones and includes 28 (12 %) of the beds analyzed . The beds within this cluster group are graded. Some are cross laminated. The degree of bioclast reorientation is high, and platey allochems exhibit a concordant fabric. The bioclasts generally show a higher degree of breakage than abrasion. Overall sorting within the beds is moderately well to well, but within-taxon sorting is poor to moderate. These beds are interpreted as event beds deposited under moderately high energy conditions.

beds displaying different ranges of bioclast size, sorting, breakage and abrasion, as well as variation in matrix type and content (Appendix A).

In this study, the beds grouped in Cluster 5 represent mixed assemblages of reworked and relatively fresh (i.e. unbroken and unabraded) material. The grading and cross-lamination frequently preserved in these beds suggests rapid deposition of sediment during high-energy events at depths below normal wave-base, but within wave-base during high energy storm events. This, and two other cluster groups defined in this study (Clusters 2and 3b) are interpreted as representing mid-depth deposits. These beds are associated with shallower-water facies, but are taphonomically distinct from the higher energy grainstone and packstones that define the shallow-water end members of the deep to shallow-water continuum. The bioclasts in these beds exhibit less breakage and/or abrasion, and are less size-sorted and generally have a lower order of depositional fabric (i.e. concordant rather than edgewise or imbricated).

The beds grouped in Cluster 2 are interpreted as representing deposition in an environment intermediate between the comparatively deeper-water deposits of Cluster 6 and the higher-energy bottom conditions reflected in Cluster 5 beds. Some of the beds in Cluster 2 exhibit evidence of amalgamation near their upper surfaces. Most of these beds are poorly-winnowed as evidenced by the preservation of sand and silt-sized fossil fragments within the matrix. The extent of bioturbation indicates that these deposits formed at mid-depths, below fairweather and seasonal-storm wave-base, but at depths shallow enough to be affected by occasional major storm events.

The beds grouped in Cluster 3b are also associated with mid-depth environments. These fine to medium-grained wackestones beds are thinner than the beds associated with Clusters 5 and 2 (Appendix A). The relatively high level of breakage, relatively fine bioclast size and graded bedding suggest that the bioclastic material in these beds was transported and selectively redeposited below wave base under waning storm condition conditions (Kelling and Mullin, 1975; Jennette and Pryor, 1992). The fabric of these beds indicates lower depositional energy conditions and less postdepositional reworking than the beds in Cluster 5.

The characteristics of the amalgamated unit associated with Cluster 9 are interpreted as representing a transition between mid-depth to shallow-water deposits. This layer consists of well-sorted, coarse-textured packstones. The fabric of the layer suggests multiple resuspension of bioclasts during high-energy events. The low-levels of breakage and abrasion are not consistent with the more extensively wave-reworked skeletal material associated with the shallower-water deposits. This layer is interpreted as representing amalgamated lag deposits that accumulated below fairweather, but within storm wave-base.

The beds in Cluster 3a are representative of comparatively shallower-water deposits. These beds are thin, well-sorted, medium to coarse-grained packstones / wackestones that frequently contain robust skeletal forms not generally observed in the beds associated with deeper-water deposits. The bioclasts in these beds are broken and abraded indicating prolonged high energy reworking. Most beds are graded, and many are cross-laminated.

Cluster 4 beds are fine to medium-grained, typically well-sorted and contain highly abraded and rounded bioclasts, indicating that these grains experienced prolonged exposure and extensive or multiple events of transportation. These fine-grained beds are frequently enriched in crinoid material forming fine to medium-grained, cross-laminated crinoidal grainstones associated with shallow-water tempestite deposits.

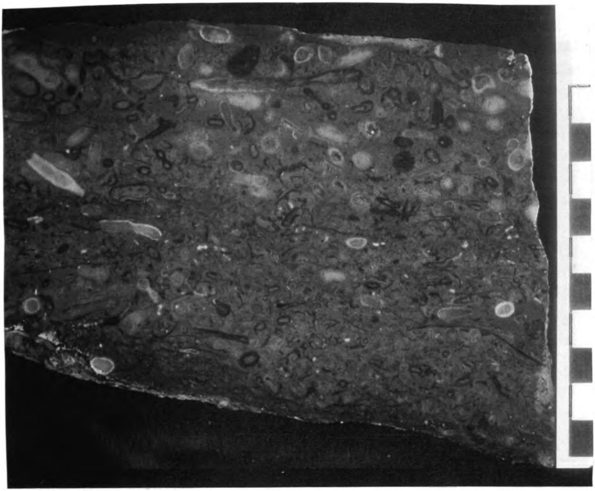


Figure 18: Example of a Cluster 5 bed. This cluster group is composed of thick (mean thickness 11 cm) medium textured, moderately well sorted packstones/wackestones. All beds in this cluster are graded. Complex fabrics or multiple fining upward trends suggests amalgamation. Average levels of reorientation, breakage and abrasion are high, but variable between taxa (e.g. articulated crinoid stems incorporated with broken and abraded brachiopod and bryozoan material). Within taxon sorting is moderately poor. These beds are interpreted as mixed assemblages of poorly-winnowed parautochthonous material. The degree of amalgamation, sorting and variable breakage states of allochems within the beds, suggests mixing of fresh and reworked skeletal material during storm events in an a mid-depth area below fair-weather wave-base, but shallow enough to be reworked during subsequent storm events. Bioturbation, if present is generally confined to the upper portion of the bed.

Figure 19: Example of a Cluster 2 bed. These beds are interpreted as autochthonous to parautochthonous assemblages. The poor to moderate sorting within this cluster group suggests little transport. These beds are only moderately winnowed and retain at least 75% matrix material composed of silt-sized biogenetic debris and micrite or spar. Both overall sorting and within taxon sorting are poor to moderate. Levels of breakage and abrasion are moderate, with relative levels of abrasion greater than breakage. Grading is present in some of the beds, as is evidence of bioturbation. Fabric is random to concordant depending on bioclast shape. This cluster contains 8 beds and represents only 3.5% of the beds analyzed

Figure 20: Example of a Cluster 3b bed. The limestone beds within this subcluster are thinly bedded, fine to medium-grained, moderately-sorted wackestones. These beds are graded but generally not cross-laminated. Levels of breakage are relatively high, but abrasion is low. The beds exhibit incomplete winnowing, and some appear to be amalgamated. 22 (approximately 9.5%) of the beds analyzed were included in this group.

Figure 21: Example of a Cluster 4 bed. The beds within this cluster consist of moderately thick (mean thickness 8 cm), fine to medium textured grainstones. The beds are graded and cross-laminated. Allochems are well to very well sorted. The levels of reorientation, breakage, abrasion and within taxon sorting are high. Most of the beds in this group are texturally mature, cross-laminated crinoidal grainstones. These beds are interpreted as high energy, allochthonous deposits that represent tempestites and multiply reworked beds in shallower water environments. Approximately 7% of the beds analyzed are included in this cluster group

GRADIENT ANALYSIS

As a complimentary technique to factor and cluster analysis, gradient analysis was performed on the data. The purpose of this analysis was to confirm the underlying factors associated with the distribution of variables within the beds, as well as to examine the distribution of beds along the factor gradients that may more accurately reflect the range of variation among beds within each cluster group.

Gradient analysis was performed using a detrended correspondence analysis (DCA) (program DECORANA [Hill, 1979]). The normalized data utilized in the factor and cluster analysis were ranked by percentile to eliminate the negative numbers produced in the Z transformation and eliminate the weighting bias produced by larger values in measured scales compared to the values assigned to ranked data (example: measured bed thickness ranging from 2.5 cm to 15 cm vs. sorting, numerically ranked 1-7). Both Q-mode (variable by variable) and R-mode (sample by sample) analyses were run .

Results

The results of DCA R-mode analysis are shown in Figure 22. Variables are plotted on axes one and two. On axis one allochem size is negatively correlated with bed thickness, bioclast reorientation, sorting, abrasion and breakage and cross-lamination. On axis two allochem size, reorientation, grading, within-taxon sorting, abrasion and breakage correlate negatively with bed thickness, percent matrix, fabric, overall-sorting and cross-lamination. The distribution of variables along axis one and two indicate similar trends that generally parallel the results of the factor analysis. Axis one may be

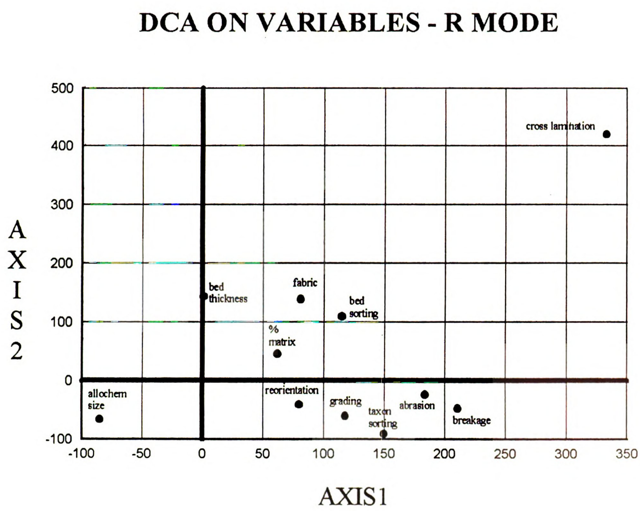


Figure 22: R-mode distribution of variables on detrended correspondence analysis (DCA) axis 1 and 2.

interpreted as reflecting a transport gradient with allochem size decreasing as sorting, reorientation, abrasion and breakage increase. Axis two is more difficult to interpret, but may reflect a reworking / energy gradient that entails depositional energy and postdepositional reworking and amalgamation of the beds.

Q-mode analysis was performed to determine the distribution of the beds along the gradients reflected in the analysis. The distribution of all beds is shown in Figure 23. Inspection confirmed that beds associated with each cluster group tended to be similarly clustered on the DCA plot. For example, beds grouped in Cluster 8 are concentrated in the area between 80 and 120 on axis one, and below 60 on axis two. Beds associated with Cluster 1 are located between 40 and 80 on axis one, and above 40 on axis two.

The second axis may be more easily interpreted on the Q-mode plot than on the R-mode plot. The high-energy event beds represented by Cluster 1 (mid- to deeper-water storm beds) and Cluster 4 (shallow-water tempestites), and highly-winnowed and amalgamated bed represented by Clusters 5 and 9 have a higher position on axis 2 than the lower-energy, less reworked beds represented by Clusters 2 and 6. The low-energy, deeper-water beds associated with Cluster 7 (quiet-bottom) and Cluster 8 (deeper-water tempestites) have the lowest position on Axis 2. Axis 2 may be interpreted as representing a complex gradient that reflects depth, as well as, frequency and intensity of bottom-energy. Bottom-energy includes current intensity during depositional events, as well as the influence of current and wave activity during postdepositional reworking of the sediments.

The similarity in bed clustering between the two methods appears to confirm the underlying similarities of the beds within the cluster groups. The dispersion of the beds along the DCA axes reflects the range of variation between beds within each cluster

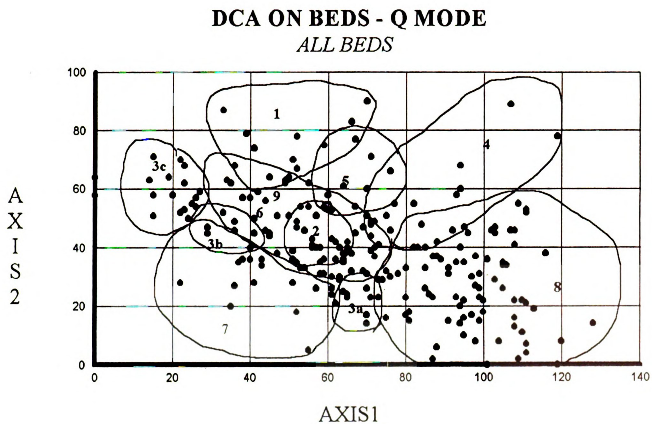


Figure 23: Q-Mode distribution of beds (n-232) on detrended correspondence axes 1 and 2. Circles indicate the location of beds associated with cluster groups 1 through 9.

group. The overlapping clusters also reflects the gradational nature of the data, and the transitional variations in beds between cluster groups.

Distribution of Beds within Sections

The cluster groups defined in this study are not uniformly distributed throughout the vertical extent of the Kope Formation. The distribution of cluster types within the five measured sections of the Kope Formation was examined to determine if the taphonomic variation as reflected in the clusters groups could be used to detect lateral facies migration, eustatic fluctuations and shoaling trends described by other authors. Q-mode plots were generated for each of the five measured sections in the study and compared (Figures 24 through 28).

The overlapping coverage of the lower Kope Formation is represented in the North Brent and Sandfordtown sections. The Sandfordtown section is located approximately 10 km southwest of the Brent section and would have occupied a slightly up ramp position (Meyer et. al., 1981; Rabbio, 1988; Jennette and Pryor, 1993). The Sandfordtown section consists of approximately 26 meters of interbedded shale, siltstone and limestone. Twenty-four limestone layers containing a total of 43 discernible beds are exposed in the section. Classification of the limestones into facies associations based on cluster-group membership indicates that twenty-one of the beds are associated with deeper-water conditions, 14 of these are Cluster 8 beds (deep-water/lower energy tempestites), 5 are Cluster 6 beds (lower-energy, partially-winnowed) and 3 are Cluster 1 beds (deeper-water/higher energy event beds). Although the lower Kope is generally thought to be associated with the deepest water-levels of the Cincinnatian sea, the deeper-water beds exposed at Sandfordtown reflect some significant level of bottom-energy (see Figure 23 and cluster descriptions above). Mid-depth conditions are represented by eight beds that include the sole representative of Cluster 9, one thick Cluster 5 bed and four thinner beds associated with Cluster 3b. The remaining beds represent comparatively shallower-water conditions and include three Cluster 3a beds and four Cluster 4 beds. The vertical distribution of the beds define eleven upward shoaling cycles of highly variable thickness (1 to 9 meters). Each cycle is capped with a shallow-water bed (Cluster 3a or 4). The middle portion of the exposure (approximately 8 meters) is characterized by mid-depth limestones (see Figure 24 and discussion below).

The North Brent section consists of approximately 36 meters of exposure. This section contains 39 limestone layer that comprise 48 beds. While the proportion of beds representing deep, shallow and mid-depth environments is proportionately similar to the Sandfordtown exposure, the cluster distribution of the beds is quite different. There are conspicuously fewer Cluster 8 (deeper-water/lower-energy) tempestite beds (3 as opposed to 14 in the Sandfordtown section) and eight Cluster 1 beds (deeper-water/high-energy storm beds). The nature of the mid-depth beds also varies between the two sections. Mid-depth beds exposed at the North Brent cut are primarily lower-energy beds (six Cluster 2 beds, three Cluster 3b beds and two Cluster 5 beds). The Q-mode scatter plot for the North Brent section is shown in Figure 25. Comparison of the North Brent Q-mode scatter plot with the Sandfordtown scatter plot (Figure 24) indicates a slight shift in the location of the placement of the beds along both axes, this corresponds to the different characteristics noted in the deeper-water and mid-depth beds between the two sections. The mid-depth beds preserved in the Sandfordtown section (Cluster 9, 5 and 3b) reflect a greater degree of winnowing and amalgamation than the Cluster 2 beds that are more prevalent in the North Brent Section. This may reflect the slightly up-ramp location of the Sanfordtown section.

Similar changes in bedding style are discernible in the overlapping exposures of the upper portion of the Kope Formation exposed at the South Brent, Mt. Airy and

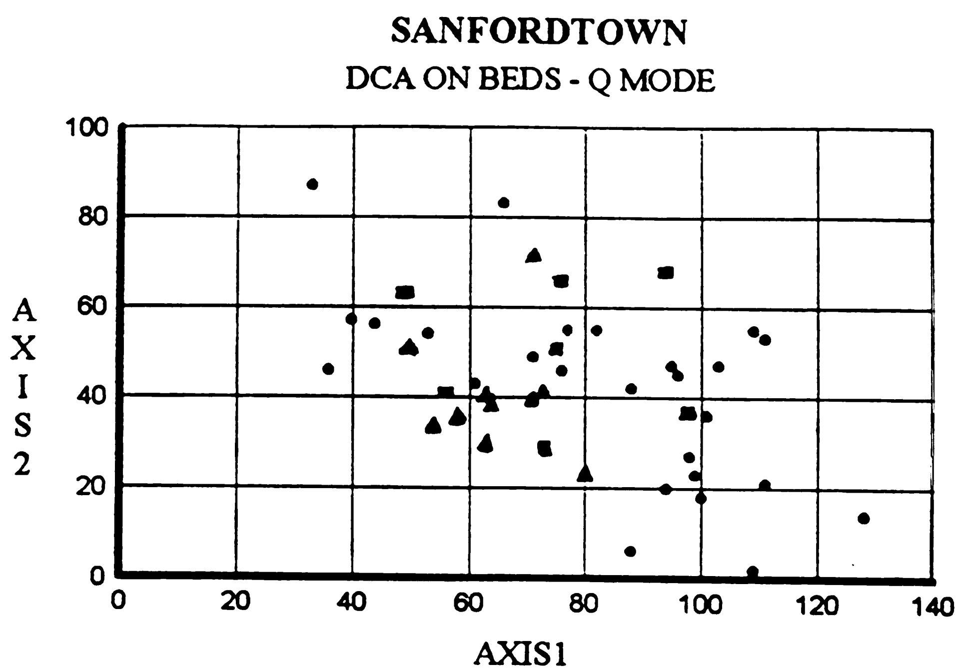


Figure 24: Q-mode distribution of beds (N=43) from the Sandfordtown section on DCA axes 1 and 2. Axis 1 may reflect a winnowing / transport gradient. Axis 2may represent a gradient that reflects bottom-energy and reworking history. Circles indicate the beds associated with deeper-water facies. Triangles indicate beds associated with mid-depth facies. Squares indicate the beds associated with shallower-water facies.

Miamitown sections. The South Brent section is adjacent to the North Brent section, and provides exposure of the Upper Kope. Approximately 18 meters of section are exposed in this cut. The South Brent section contains twenty-five limestone beds. The deeper-water facies are represented by four Cluster 8 (deeper-water/lower energy) tempestite beds, four Cluster 7 (low energy) beds. Mid-depth facies are represented by one Cluster 2 bed (below wave-base), two Cluster-5 (amalgamated) beds and 3 Cluster-3b (thin, graded) beds. Beds associated with shallower-water facies include four Cluster 3a beds (higher-energy bottom conditions, probably above wave-base) and three Cluster 4 beds (shallower-water tempestites). There is a higher proportion of shallow and mid-depth deposits in the South Brent than in the underlying North Brent section. This is consistent with the shoaling upward trends previously documented within the Kope Formation (Anstey and Fowler, 1969; Tobin,1982; Jennette & Pryer, 1990; Holland, 1993).

Comparison of the Q-mode plots for the South Brent (Figure 26) and North Brent section (Figure 25) indicates changes in bottom-energy conditions between the two sections. Distribution of the beds on the Q-mode plot for the South Brent section indicate higher placement on the first axis (38-115 for South Brent vs. 15-95 for North Brent) for beds with deeper-water associations (Clusters 7, and 8). There is less dispersion for the beds associated with mid-depth facies along both axes in the South Brent section than underlying North Brent section (South Brent distribution ranges from 48 - 75 on axis 1 and 18 - 48 on axis 2 as compared to 35 - 108 on axis 1 and 18 - 70 on axis 2 for the North Brent plot). The distribution of beds associated with shallower-water facies on the Q-mode plots are similar for both the Brent sections.

The shifts in the Q-mode distribution of beds may reflect shoaling water conditions. This may be reflected in the shift toward higher-energy in the beds associated with deeper-water conditions. The compression along both axes of the mid-

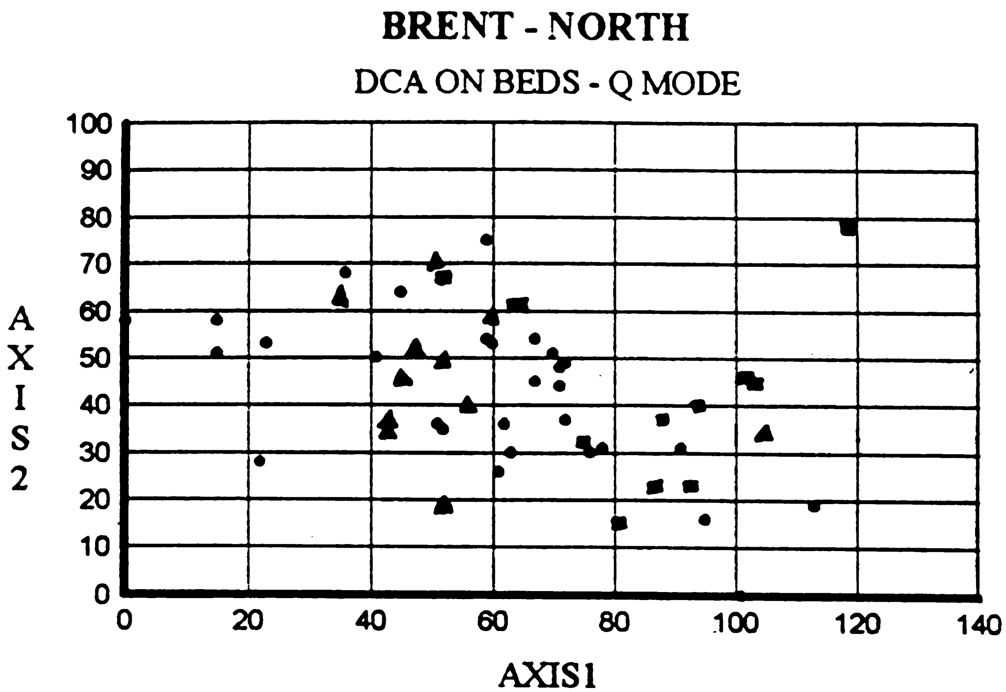


Figure 25: Q-mode distribution of beds (N=48) from the North Brent section on DCA axes 1 and 2. Axis 1 may reflect a winnowing / transport gradient. Axis 2 may represent a gradient that reflects bottom-energy and reworking history. Circles indicate the beds associated with deeper-water facies. Triangles indicate beds associated with mid-depth facies. Squares indicate the beds associated with shallower-water facies.

depth beds may reflect less variation in bottom-energy conditions that corresponds to higher levels of reworking associated with shoaling water conditions.

Thirty-four meters of the Upper Kope Formation are exposed in the Mt. Airy section. This section is located approximately 15 km northeast of the Brent sections, in a down ramp direction (Meyer et. al., 1981; Rabbio, 1988; Jennette and Pryor, 1993). Limestone types associated with all three depth-related facies are represented, but the cluster membership of the beds is dissimilar to the other sections. Deeper-water deposits are represented by three Cluster 7 and three Cluster 3c beds. Both of these beds types are associated with quiet-water, low- energy conditions. One Cluster 6 bed is present. The nature of the event beds is different between the Mt. Airy and South Brent locations. There are four Cluster 1 beds (mid-to deeper-water, high-energy tempestites) and four Cluster 8 beds (deeper-water, lower-energy tempestites). The lower-energy tempestites (Cluster 8) are confined to the lower 5 meters of the section. There is only one Cluster 4 (shallower-water, high-energy tempestite) bed preserved in this section (also within the lower 5 meters). The shallower-water facies at this locality are represented by eleven Cluster 3a beds (comparatively shallow-water, wave-washed) which are concentrated in the upper portion (6 meters)of the section. Mid-depth facies are represent by two Cluster 2 beds, one Cluster 5 bed and five Cluster 3b beds.

More extensive shoaling conditions are detected in the distribution of limestone beds in this section. The Q-mode scatter plot for the beds at this locality (Figure27) show a generally upward shift on axis two relative to the beds at the South Brent locality. The comparative distribution of deeper-water beds is similar between the two section (18-119 on axis 1 and 0-65 on axis 2 for Mt. Airy beds; and 35- 117 on axis 1 and 8-75 on axis 2 for South Brent beds). A greater shift can be seen in comparisons between the mid-depth and shallower-water beds in these two sections. The mid-depth beds in the

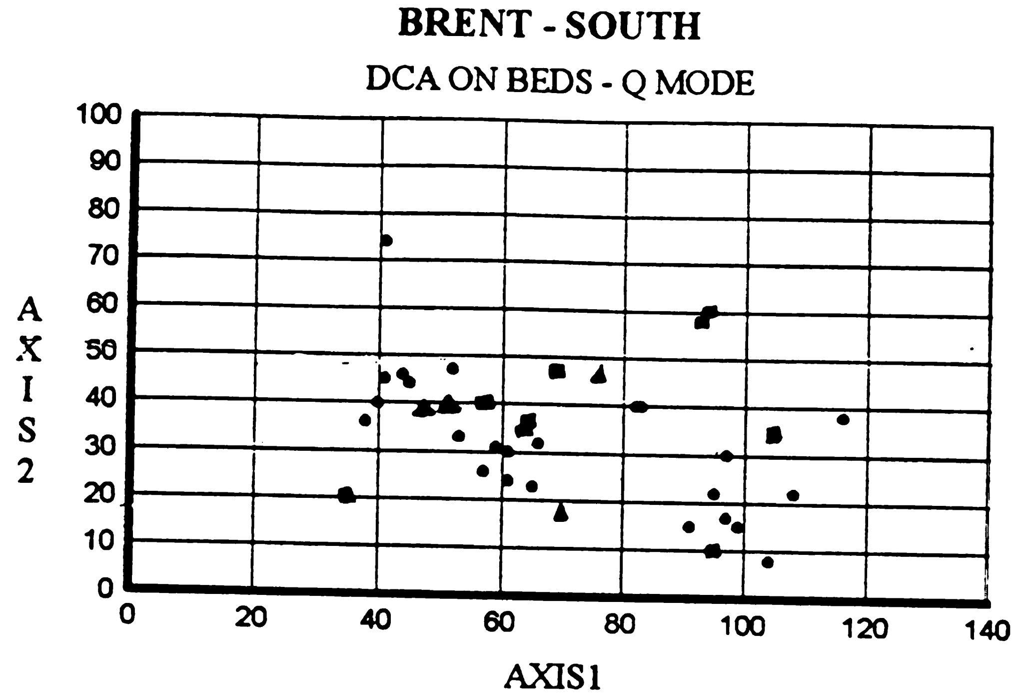


Figure 26: Q-mode distribution of beds (N=37) from the South Brent section on DCA axes 1 and 2. Axis 1 may reflect a winnowing / transport gradient. Axis 2 may represent a gradient that reflects bottom-energy and reworking history. Circles indicate the beds associated with deeper-water facies. Triangles indicate beds associated with mid-depth facies. Squares indicate the beds associated with shallower-water facies.

Mt. Airy section how a more scattered distribution along axis one (ranging from 0-68) than the South Brent beds (ranging from 47-76). This indicates a wider range of exposure and/or transport histories for the bioclasts incorporated in the Mt. Airy beds. The relative positions of the beds on axis 2 indicate higher bottom-energy levels in the Mt. Airy beds (31 -64 for Mt Airy vs. 18-45 for South Brent). This shift on axes 1 and 2 are interpreted as reflecting increased frequency and intensity of postdepositional reworking that may reflect shoaling-water conditions.

The Miamitown locality is located approximately 18 km northwest of Mt. Airy, and provides overlapping down ramp exposure of the Upper Kope Formation. A distinctive lateral change in the nature of the limestone beds can be discerned between the Mt. Airy and Miamitown localities. The preponderance of the beds in the Miamitown exposure are associated with deeper-water facies, but despite the fragile fauna associated with the locality, most of the beds are associated with the higher-energy groups in the deeper-water facies association. The Miamitown section contains four Cluster 7 beds (low-energy, quiet-bottom), nine Cluster 6 beds (moderately reworked), eight Cluster 1 (high-energy tempestites) and ten Cluster 8 beds (lower-energy tempestites). Mid-depth facies are represented by one Cluster 2 bed (moderately winnowed), and two Cluster 3b beds. Shallower-water facies are represented by three 3a beds (higher-energy, well-sorted, winnowed) and one Cluster 4 bed (shallower-water, higher-energy tempestite).

The Q mode plot of the Miamitown beds (Figure 28) shows a broader distribution of beds across both axis than the plots of other Kope localities. Beds associated with deeper-water facies range from 15 to 120 on axis 1 and from 4 to 90 on axis 2. This is similar to the distribution of deeper-water beds from the Mt. Airy and South Brent. The mid-depth beds have a similar distribution along axis 1 (ranging from 34 -70) as the

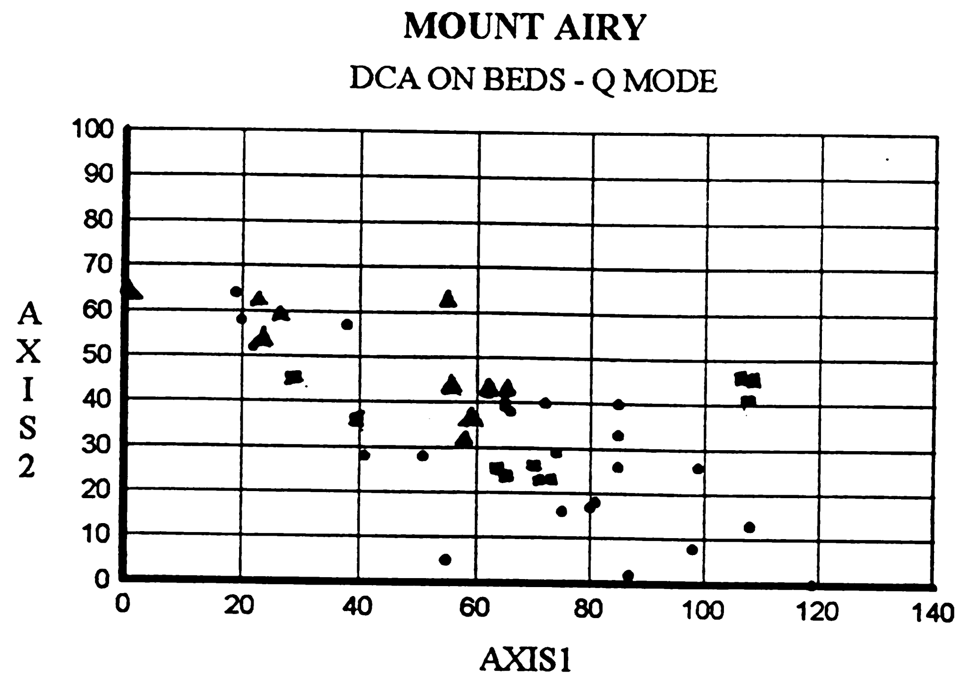


Figure 27: Q-mode distribution of beds (N=39) from the Mt. Airy section on DCA axes 1 and 2. Axis 1 may reflect a winnowing / transport gradient. Axis 2 may represent a gradient that reflects bottom-energy and reworking history. Circles indicate the beds associated with deeper-water facies. Triangles indicate beds associated with mid-depth facies. Squares indicate the beds associated with shallower-water facies.

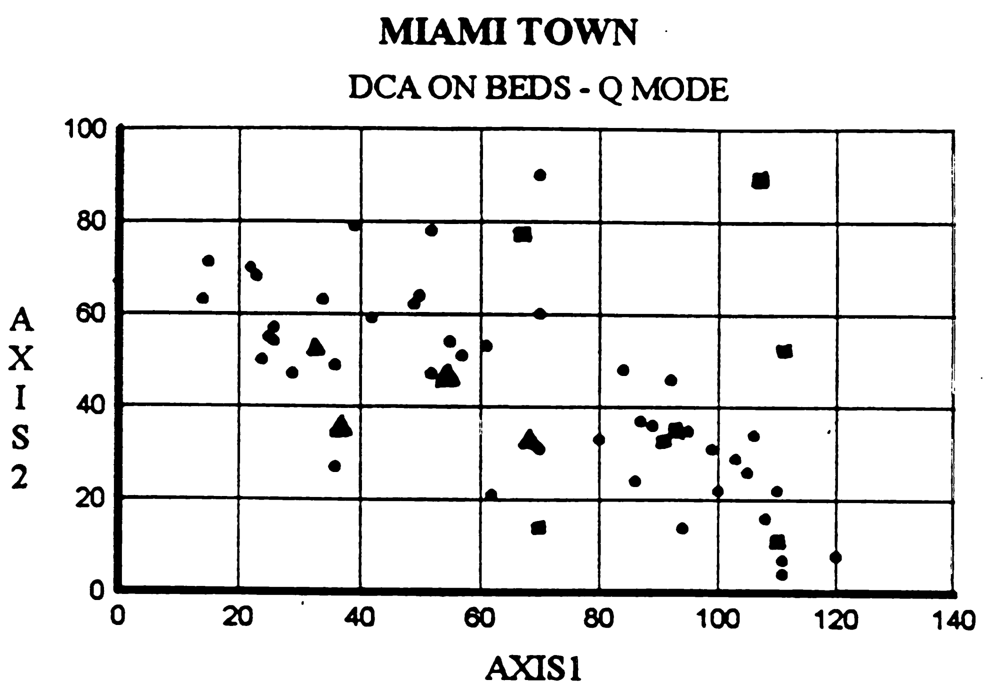


Figure 28: Q-mode distribution of beds (N=56) from the Miamitown section on DCA axes 1 and 2. Axis 1 may reflect a winnowing / transport gradient. Axis 2 may represent a gradient that reflects bottom-energy and reworking history. Circles indicate the beds associated with deeper-water facies. Triangles indicate beds associated with mid-depth facies. Squares indicate the beds associated with shallower-water facies.

South Brent beds, but have a higher distribution on axis 2 (ranging from 30 to 50), similar to the distribution of the Mt. Airy beds on axis 2. The distribution of the beds associated with shallower-water facies shows a shift toward the higher end of both axes relative to both of the other Upper Kope sections (ranging from 68 to 116 on axis 1 and 15 to 90 on axis 2). This may indicate that the shallower-water beds preserved in the Miamitown section contain bioclasts with a more prolonged exposure and/or transport history; and were deposited under higher-energy conditions than beds associated with shallower-water facies in the South Brent and Mt. Airy sections.

DISCUSSION

Cyclicity

In this study an attempt was made to delineate shoaling cycles within the Kope Formation (*sensu* Tobin (1982) and Jennette and Pryor (1993) etc.) based on the taphonomic analysis of the limestone beds. The widely used proximal /distal terminology may be misleading when applied to the limestone facies of the Cincinnatian. The terminology is traditionally used to indicate position relative to sediment source, and in marine environments generally implies location along an onshore-offshore gradient. The cyclicity within the limestones of the Kope Formation reflect changes in water-depth, as well as variations in the nature and intensity of bottom-energy. The relationship between water depth and bottom-energy as related to normal wave-base is relatively straight-forward. However; in "off-shore" regions of a storm-dominated ramp, the nature and intensity of the wave and/or current activity on seafloor will also reflect the intensity of storm events, and relative distance from storm centers.

The vertical distribution of beds associated with deeper-water, mid-depth and shallower-water facies was determined in each of the five stratigraphic sections analyzed in this study (see Figure 29). The base of each cycle was defined by a limestone bed associated with deeper-water facies (i.e. Cluster 8, 6, 7, or 3c). The lowermost "deeper-water" bed was followed by other beds with deeper-water associations, or by one or more beds associated with mid-depth facies (i.e. Cluster 2, 5 or 3b) or shallower-water facies (i.e. Cluster 4, or 3a). In most of the cycles limestone beds were separated by mudstone, siltstone and shale layers of varying thickness. Not all cycles contained a complete sequence of shoaling upward facies. Each time a limestone bed was superseded by a bed indicating a relative deepening event (*sensu* Van Wagoneer et al., 1990), the "deeper-water" bed marked the base of the next cycle. Therefore, in some cycles, a bed associated with mid-depth facies was followed by a deeper-water bed. In this case, the mid-depth bed was considered the upper limestone bed in the cycle. In some cycles the basal limestone of a cycle was a bed associated with mid-depth facies that was superpositioned above a "shallower-water" bed.

The combined North and South Brent sections represent the most complete vertical exposure of the Kope Formation at any given locality. The vertical distribution of the limestone beds indicate the presence of twenty-two shoaling cycles within the Brent exposures. The limestone, siltstone and mudstones within these cycles are consistent with the characteristics of offshore, shale-dominated and transition-zone mixed packstone/shale lithologies of the highstand facies described by Holland (1993).

Stratigraphic Correlation

On storm-dominated ramps, the gently-sloping topography facilitates distribution of sediment across the ramp in thin, laterally continuous sheets during high-energy storm events (Markello and Read, 1981; Aigner, 1985). While the lateral extent of individual limestone beds may be limited, the lateral continuity of depth related facies associations (i.e. shoaling cycles) may be traceable across broad areas of the ramp (Osleger, 1991).

The irregular bedding and lack of continuous exposure has made high resolution stratigraphic correlation between outcrops difficult in the Kope Formation. Jennette and Pryor (1993) found that while individual beds lacked significant lateral continuity to be identifiable from outcrop to outcrop, the continuity of the "distal /proximal" facies were persistent enough to correlate from section to section in exposures of the Upper Kope and Fairview Formations. In their study, cycles were defined based on the vertical distribution of lithological, sedimentological and ichnological characteristics of the limestone, siltstone and mudstone beds. A persistent gutter-cast siltstone storm-bed in the Upper Kope was used as an isochron, and correlation was made based on the stacking arrangement of the "distal/proximal" cycles. (This is presumably the same gutter-cast bed identified in Mt. Airy section in this study. It was not observed in the South Brent or Miamitown sections [Rabbio, 1988]).

In this study, prominent shallower-water/ high-energy tempestite beds (Cluster 4) were noted in cycles 10 and 16 of the composite Brent section (Figure 29). In both cases, the overlying cycles indicated less than typical deepening with relatively thick beds associated lated facies associations within the cycles. with mid-depth conditions (Cluster 2 beds). The shallower-water facies horizons of cycles 10 and 16 were used as stratigraphic time-lines to correlate between the Brent sections and the other localities (see Figure 29). Similar geometries were detected in the vertical stacking of the cycles across the four localities, allowing for high-resolution correlation based on depth/energy intensity related facies associations within the cycles.

Two rather extreme shoaling intervals are indicated in cycles 10 and 16. The upper boundaries of these cycles are delineated by the presence of shallower-water/ high-energy tempestite (Cluster 4 -type) beds across the entire study area. The overlying cycles are relatively compressed and contain a higher proportion of limestone beds representing mid-depth facies rather than deeper-water facies. These shoaling intervals could be detected across the study area. The condensed cycles may reflect a decrease in accommodation space attributable to eustatic sea-level fall (Brett et al., 1990; Jennette and Pryor, 1993).

Four deepening intervals are indicated in cycles 6, 9, 13 and 16. The limestones within these cycles are representative of bed types associated with deeper-water facies (Clusters 8, 6, 7 and 1). These are relatively thick cycles, containing a higher percentage

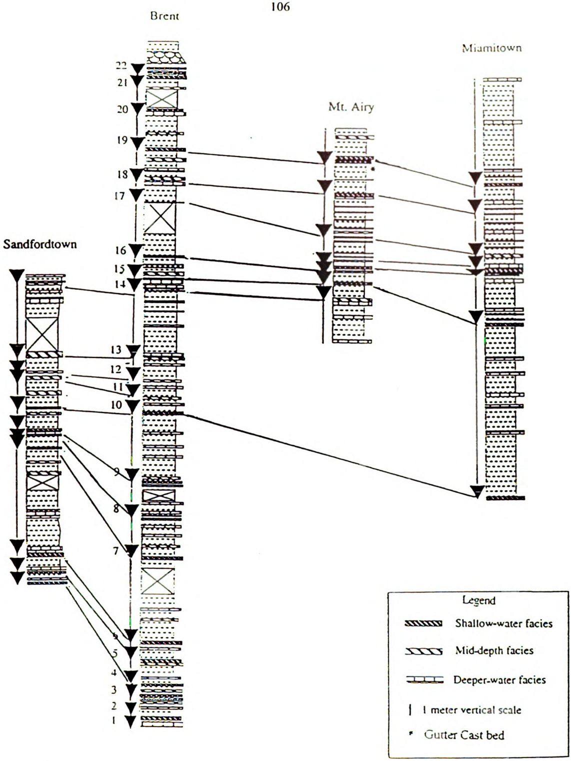


Figure 29: Stratigraphic correlation of depth/intensity facies cycles across the study area. 22 cycles were detected in the composite section (North and South Brent) of the Kope Formation. In the composite section the cycles are defined by a limestone bed associated with a deeper-water or mid-depth facies near the base and a limestone associated with a shallower-water facies at the top.

of mud and siltstone beds. Several explanations have been offered for the variations in cycle thickness on carbonate ramps. Cycle thickening may be attributed to sea-level rise and a corresponding increase in accommodation space (Goldhammer et al., 1990), or to a depth-dependent increase in sediment supply (Osleger and Read; 1991). An increase in the sedimentation rate would result in increased cycle thickness. The influx of terrigenous sediment may also inhibit carbonate production by altering the nature of the substrate and adversely affecting filter feeders (Jennette and Pryor, 1993).

Temporal Scale and Causes of Cyclicity

Several explanations for the cyclicity observed in the Kope and other mixed carbonate/ clastic ramp environments have been suggested. They include fluctuations in sediment-supply and corresponding suppression of carbonate production (Osleger and Read, 1991), eustatic fluctuations associated with tectonic uplift and subsidence (Tobin, 1982; Aigner, 1985), changes in accommodation space (Goldhammer et al., 1990), and climatic oscillations (glacio-eustacy) (Jennette and Pryor, 1993).

Determination of the underlying causal mechanisms of the cyclicity within the Kope formation requires some resolution of the temporal scale of the cycles. Tobin (1982) estimated the average periodicity of Cincinnatian "megacycles" (i.e. proximal/distal cycles) to be 57,000 years. This estimate was based on an assumed sedimentation rate of 2 cm/ 1,000 years, and an average cycle thickness of 1.4 meters.

The Kope Formation spans the Edenian Stage. Based on bryozoan zonation (Anstey and Rabbio, 1990) and conodont zonation (Sweet, 1984) of the Composite Standard Section, the estimated duration of the Edenian Stage is approximately 3.5 m.y. The composite Brent sections used in this study contain the vertical extent of the Kope Formation, and therefore, represent sediment accumulation over a time period approximately equivalent to the Edenian Stage. In this study, 22 shoaling cycles were delineated in the composite Kope section based on the taphonomic analysis of the limestone beds (Figure 29). Based on temporal duration of 3.5 million years for the Edenian Stage (Sweet, 1984; Anstey and Rabbio, 1989), the stratigraphic cyclicity within the Kope appears to occur on a scale of approximately 160,000 years. This estimate assumes that all cycles were detected, and that variation in cycle thickness is related to depth-related changes in sediment influx.

Glacio-eustatic oscillations driven by changes in earth-sun geometry (Milankovich Cycles) have been proposed by Jennette and Pryor (1993) as the mechanism driving the changes in hydrodynamic regimes (ie. storm wave-base) that produced the shallowing cycles within the Kope. A periodicity of 160,000 years is significantly longer than the 57,000 years estimated by Tobin (1982), yet this estimate may still be within the time range for glacio-eustatic fluctuations in sea-level attributed to orbital perturbations predicted by the Milankovich theory.

CONCLUSIONS

Superficially similar deposits can be produced in any of the high-energy environments represented in storm-dominated systems. This similarity can lead to difficulty in interpreting facies associations or determining genetic relationships between different beds within the same facies association. For the purposes of many studies, classification of limestone beds into broad categories (eg. packstone/ wackestone) or assignment to general facies category (eg. proximal/distal) may be adequate, a more detailed genetic classification of beds may be developed if taphonomic data are considered. Taphonomic variation evidenced in the bioclastic component of the beds, in combination with sedimentological data provides useful information that aids in the determination of the mode of deposition, the intensity of the depositional event, and the extent and intensity of postdepositional reworking.

In this study a comparative approach was used to determine the general effects of taphonomic processes on different taxonomic groups. This information facilitated comparisons between beds with similar taphonomic histories but different taxonomic compositions. Statistical analysis has proven useful in determining the range of taphonomic variation, as well as the causal factors that produced the variation within the Kope Limestones. A complimentary combination of cluster analysis, factor analysis and gradient analysis was used to analyze the data. This comprehensive approach to taphonomic analysis was sensitive to subtle variations within sedimentologically and paleontologically similar beds and was useful in determining facies associations, as well as the history of the bioclastic component of the bed.

The taphonomic variation in Kope limestones reflects changes in water depth as well as the nature of the background and event related energy associated with the depositional environment in which the beds were deposited. Cluster analysis of the taphonomic and bedding characteristics of the limestones within the Kope Formation allows the beds to be categorized into eleven taphonomically distinct groups. Factor analysis indicates that these groups reflect a complex range of depth and energy-intensity conditions that represent depositional facies associated with deeper-water, mid-depth and shallower-water environments. Classification of the limestones on taphonomic criteria facilitates the interpretation of beds that exhibit a range of characteristics, yet are still associated with similar facies.

The classification of beds into genetically related groups with similar facies associations is a useful tool in lateral correlation (Jennette and Pryor, 1993; Holland 1993; 1995). Quantitative taphonomic analysis appears to be a useful tool in high resolution stratigraphic correlation in area where limited exposure and a lack of lateral continuity in beds makes correlation difficult. In this study, 22 depth/intensity cycles were detected within the Kope Formation. These cycles were detected across the study area and used as a basis for stratigraphic correlation between the four section localities.

Future Work

The comparative taphonomic analysis developed in this study may be useful in the interpretation and correlation of the limestone beds in the Cincinnatian formations overlying the Kope Formation. Many of these units are associated with shallower water conditions, and generally higher energy levels than the beds in the Kope formation.

While this approach was developed in an attempt to explain the causes of the variation within the limestones of the Cincinnatian, it should be applicable to limestones in any storm-dominated or high energy depositional system. These methods may also be useful in the determining the cause of subtle variation in limestone beds associated with lower energy depositional systems.

The continued development of a comparative taphonomic approach requires that more work be done to determine the susceptibilities of different taxonomic groups to taphonomic alteration in a wide range of depositional environments. This will require the detailed analysis and comparison of the extent and nature of taphonomic alteration of each taxon within a polytaxic assemblage across a wide range of depositional environments. The quantitative taphonomic data collected in this and future studies can be used to determine "taphonomic pathways" for different taxa.

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APPENDIX A
Data Base

TAPHONOMY OF KOPE LIMESTONES

SAMPLE	PERCENT MATRIX	PERCENT SILT	BIOTURBA TION	POLYTAXI	AMALGAMATED
1-10	<50%	5%-10%	MODERATE	YES	.
1-11	75%-90%	5%-10%	MODERATE	YES	UNCERTAIN (?)
1-12	.	<5%	.	YES	NO (N)
1-13	>90%	<5%	MODERATE	YES	.
1-14	<50%	5%-10%	EXTREME	YES	.
1-15	75%-90%	5%-10%	MODERATE	YES	UNCERTAIN (?)
1-16	<50%	>50%	MODERATE	YES	UNCERTAIN (?)
1-17	<50%	5%-10%	MINIMAL	YES	.
1-18	50%-75%	5%-10%	MODERATE	NO	UNCERTAIN (?)
1-19	<50%	5%-10%	MODERATE	YES	.
1-1\2	75%-90%	5%-10%	MODERATE	YES	.
1-1^1	50%-75%	5%-10%	.	YES	.
1-1^2	50%-75%	5%-10%	.	YES	.
1-20	50%-75%	5%-10%	MINIMAL	YES	YES (Y)
1-21^1	50%-75%	5%-10%	MODERATE	YES	YES (Y)
1-21^3	50%-75%	5%-10%	MODERATE	YES	.
1-22	50%-75%	5%-10%	MINIMAL	YES	.
1-23	50%-75%	<5%	HIGH	YES	.
1-25^1	<50%	10%-20%	MODERATE	YES	.
1-25^2	<50%	10%-20%	MODERATE	YES	.
1-25^3	<50%	5%-10%	MODERATE	YES	.
1-26	.	10%-20%	MODERATE	YES	.
1-27	50%-75%	5%-10%	EXTREME	YES	.
1-28	.	5%-10%	HIGH	YES	UNCERTAIN (?)
1-29^1	50%-75%	5%-10%	MODERATE	NO	.
1-29^2	50%-75%	<5%	MODERATE	YES	.
1-2^1	75%-90%	5%-10%	MODERATE	YES	.
1-2^2	<50%	5%-10%	.	YES	.
1-30	<50%	<5%	MODERATE	YES	.
1-31^1	.	.	.	NO	.
1-31^2	<50%	5%-10%	MODERATE	YES	.
1-31^3	<50%	5%-10%	MODERATE	NO	.
1-31^4	<50%	5%-10%	MODERATE	NO	.
1-32	50%-75%	5%-10%	MODERATE	YES	.
1-33	50%-75%	10%-20%	MODERATE	YES	.
1-34	<50%	<5%	MINIMAL	YES	.
1-35^1	<50%	10%-20%	MODERATE	YES	.
1-35^2	50%-75%	5%-10%	MODERATE	YES	.
1-36	<50%	10%-20%	MODERATE	NO	YES (Y)
1-37	50%-75%	10%-20%	HIGH	YES	UNCERTAIN (?)
1-38	50%-75%	<5%	MODERATE	YES	.
1-39^1	<50%	20%-50%	MODERATE	YES	.
1-39^2	50%-75%	<5%	MODERATE	YES	UNCERTAIN (?)
1-3^1	<50%	5%-10%	.	YES	.
1-3^2	<50%	5%-10%	.	YES	.
1-3^3	<50%	5%-10%	.	YES	.
1-4b	50%-75%	5%-10%	MODERATE	YES	UNCERTAIN (?)
1-5	75%-90%	<5%	MODERATE	YES	.
1-6	50%-75%	5%-10%	MODERATE	YES	.
1-7	<50%	5%-10%	HIGH	YES	YES (Y)
1-8	<50%	<5%	MINIMAL	YES	.
1-9	<50%	10%-20%	MODERATE	YES	.
2-1	.	.	.	YES	.
2-10^1	.	.	EXTREME	YES	.
2-10^2	50%-75%	10%-20%	EXTREME	YES	.
2-11	50%-75%	<5%	MODERATE	YES	.
2-12	50%-75%	5%-10%	MODERATE	YES	.
2-13^1	<50%	5%-10%	MODERATE	YES	.
2-13^2	50%-75%	<5%	MODERATE	YES	.
2-13^2	50%-75%	<5%	MODERATE	YES	.
2-14	<50%	10%-20%	MODERATE	YES	YES (Y)
2-15	50%-75%	10%-20%	HIGH	YES	YES (Y)

2-16	50%-75%	10%-20%	HIGH	YES	.
2-17	50%-75%	5%-10%	HIGH	YES	.
2-18	50%-75%	<5%	MODERATE	YES	YES (Y)
2-19a	<50%	5%-10%	HIGH	YES	NO (N)
2-19b	50%-75%	10%-20%	EXTREME	YES	.
2-19c	<50%	5%-10%	MODERATE	YES	.
2-2	50%-75%	5%-10%	MODERATE	YES	YES (Y)
2-20	75%-90%	10%-20%	MODERATE	YES	UNCERTAIN (?)
2-21	50%-75%	5%-10%	MODERATE	YES	.
2-22a	<50%	10%-20%	HIGH	YES	.
2-22a^2	<50%	5%-10%	MINIMAL	YES	.
2-22a^3	.	.	.	YES	.
2-23	.	.	.	YES	.
2-3a	<50%	5%-10%	.	YES	.
2-3b^1	50%-75%	10%-20%	MINIMAL	YES	.
2-3b^2	<50%	5%-10%	MODERATE	YES	.
2-4	50%-75%	5%-10%	.	NO	.
2-4a	<50%	5%-10%	MODERATE	YES	.
2-4b^1	<50%	5%-10%	MODERATE	YES	.
2-4b^2	50%-75%	10%-20%	MODERATE	YES	.
2-4c	50%-75%	5%-10%	MODERATE	YES	.
2-5	>90%	5%-10%	MODERATE	YES	.
2-5b^1	.	.	.	YES	.
2-5b^2	.	.	.	YES	.
2-5b^3	.	.	.	YES	.
2-5b^4	.	.	.	YES	.
2-6^1	>90%	5%-10%	MODERATE	YES	.
2-6^2	<50%	10%-20%	MODERATE	YES	.
2-6^3	50%-75%	20%-50%	HIGH	YES	.
2-7	>90%	5%-10%	EXTREME	YES	.
2-8^1	50%-75%	5%-10%	MODERATE	YES	.
2-8^2	>90%	5%-10%	MODERATE	YES	.
2-9a	50%-75%	10%-20%	MINIMAL	YES	.
2-9b	50%-75%	10%-20%	MINIMAL	YES	.
3-1	<50%	5%-10%	MINIMAL	YES	.
3-10	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-11	50%-75%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-13^1	>90%	<5%	MODERATE	YES	.
3-13^2	>90%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-15	50%-75%	10%-20%	MODERATE	YES	UNCERTAIN (?)
3-16	50%-75%	5%-10%	HIGH	YES	NO (N)
3-17	75%-90%	5%-10%	MODERATE	YES	YES (Y)
3-18	50%-75%	10%-20%	.	NO	YES (Y)
3-19	>90%	5%-10%	.	YES	NO (N)
3-2	<50%	5%-10%	MINIMAL	YES	UNCERTAIN (?)
3-20	>90%	5%-10%	.	YES	NO (N)
3-21	50%-75%	5%-10%	MODERATE	YES	.
3-22	.	.	.	NO	.
3-23	>90%	5%-10%	MODERATE	YES	.
3-24	75%-90%	5%-10%	HIGH	YES	UNCERTAIN (?)
3-25	>90%	5%-10%	HIGH	YES	.
3-26	<50%	10%-20%	MODERATE	YES	.
3-27	50%-75%	10%-20%	MODERATE	NO	.
3-28	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-29	50%-75%	5%-10%	MODERATE	YES	.
3-3	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-30	<50%	5%-10%	MODERATE	YES	.
3-31	50%-75%	5%-10%	MODERATE	YES	UNCERTAIN (?)
3-32^1	50%-75%	5%-10%	MODERATE	YES	YES (Y)
3-32^2	<50%	5%-10%	MODERATE	YES	YES (Y)
3-32^3	<50%	5%-10%	MODERATE	YES	YES (Y)
3-32^4	50%-75%	5%-10%	MODERATE	YES	.
3-33	.	.	MODERATE	YES	YES (Y)
3-34^1	<50%	10%-20%	MODERATE	YES	UNCERTAIN (?)
3-34^2	<50%	10%-20%	MODERATE	YES	YES (Y)
3-34^3	<50%	10%-20%	MODERATE	YES	YES (Y)
3-35^1	<50%	10%-20%	MODERATE	YES	YES (Y)

3-35^2	<50%	10%-20%	MODERATE	YES	YES (Y)
3-36	75%-90%	.	MODERATE	YES	NO (N)
3-4a^1	50%-75%	10%-20%	MODERATE	YES	.
3-4a^2	<50%	10%-20%	MODERATE	YES	.
3-4b^1	50%-75%	>50%	MODERATE	YES	UNCERTAIN (?)
3-4b^2	<50%	10%-20%	MODERATE	YES	UNCERTAIN (?)
3-5	<50%	20%-50%	MINIMAL	YES	YES (Y)
3-6	>90%	5%-10%	HIGH	YES	.
3-7	<50%	<5%	MODERATE	YES	.
3-8	75%-90%	10%-20%	HIGH	YES	UNCERTAIN (?)
3-9^1	.	.	.	YES	.
3-9^2	.	.	.	YES	.
4-1	.	5%-10%	.	YES	.
4-10a^1	<50%	5%-10%	.	YES	YES (Y)
4-10b	50%-75%	5%-10%	MODERATE	YES	.
4-10c	50%-75%	5%-10%	MODERATE	YES	.
4-14^a	50%-75%	5%-10%	MINIMAL	YES	UNCERTAIN (?)
4-14b	>90%	5%-10%	MODERATE	YES	.
4-14c	<50%	5%-10%	.	NO	.
4-15b	<50%	5%-10%	.	YES	.
4-16a	75%-90%	10%-20%	.	NO	.
4-16b^1	50%-75%	10%-20%	MINIMAL	YES	.
4-16b^2	.	10%-20%	.	NO	.
4-16c^1	50%-75%	5%-10%	MODERATE	YES	.
4-16c^2	<50%	5%-10%	MODERATE	NO	.
4-16c^3	50%-75%	10%-20%	MODERATE	NO	.
4-16d^1	75%-90%	10%-20%	MINIMAL	YES	.
4-16d^2	<50%	5%-10%	HIGH	NO	.
4-16d^3	<50%	5%-10%	.	NO	.
4-17a	<50%	5%-10%	MODERATE	YES	YES (Y)
4-17b^1	<50%	<5%	MINIMAL	YES	NO (N)
4-17b^2	>90%	<5%	MODERATE	YES	NO (N)
4-17b^3	<50%	5%-10%	MODERATE	YES	YES (Y)
4-17b^4	<50%	5%-10%	MODERATE	YES	.
4-17b^5	<50%	5%-10%	MODERATE	YES	.
4-17c	75%-90%	<5%	MODERATE	YES	.
4-17d^2	>90%	<5%	MODERATE	YES	.
4-18	50%-75%	5%-10%	.	YES	NO (N)
4-19^1	50%-75%	<5%	.	YES	.
4-19^2	.	.	HIGH	YES	NO (N)
4-19^3	50%-75%	<5%	HIGH	YES	NO (N)
4-2	<50%	.	.	YES	.
4-20^1	<50%	5%-10%	MODERATE	YES	.
4-20^2	<50%	5%-10%	MODERATE	YES	NO (N)
4-22	50%-75%	10%-20%	MODERATE	YES	UNCERTAIN (?)
4-23	50%-75%	10%-20%	MODERATE	YES	NO (N)
4-24a	50%-75%	<5%	MINIMAL	YES	NO (N)
4-24b	.	<5%	HIGH	NO	.
4-24c	50%-75%	<5%	MINIMAL	YES	.
4-25	<50%	<5%	MODERATE	YES	UNCERTAIN (?)
4-26	50%-75%	5%-10%	MODERATE	YES	.
4-27^1	75%-90%	5%-10%	MINIMAL	YES	.
4-27^2	75%-90%	5%-10%	MODERATE	YES	.
4-28	50%-75%	5%-10%	MINIMAL	YES	.
4-29	<50%	5%-10%	MODERATE	YES	.
4-3	<50%	<5%	MODERATE	YES	.
4-30	>90%	5%-10%	MODERATE	YES	.
4-31a	<50%	<5%	MINIMAL	YES	.
4-31b	50%-75%	5%-10%	MODERATE	YES	.
4-4	<50%	5%-10%	.	YES	.
4-5	<50%	<5%	MODERATE	YES	.
4-5	<50%	<5%	MODERATE	YES	.
4-6^1	<50%	5%-10%	.	NO	.
4-6^2	50%-75%	5%-10%	.	YES	NO (N)
4-7	50%-75%	5%-10%	MODERATE	YES	.
4-8	50%-75%	5%-10%	MODERATE	YES	.
4-9	<50%	5%-10%	MINIMAL	YES	.

4^a	50%-75%	5%-10%	MODERATE	YES	.
5-1	50%-75%	10%-20%	MODERATE	YES	UNCERTAIN (?)
5-10	<50%	10%-20%	MODERATE	YES	UNCERTAIN (?)
5-11^1	<50%	5%-10%	MODERATE	YES	YES (Y)
5-11^2	<50%	5%-10%	MODERATE	YES	YES (Y)
5-11^3	.	.	.	NO	.
5-12	<50%	20%-50%	MODERATE	YES	.
5-13	>90%	10%-20%	MODERATE	YES	.
5-15	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
5-16	<50%	5%-10%	MODERATE	YES	NO (N)
5-17^1	<50%	5%-10%	MODERATE	YES	YES (Y)
5-17^2	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
5-18^1	<50%	5%-10%	MODERATE	YES	YES (Y)
5-18^2	<50%	5%-10%	MODERATE	YES	YES (Y)
5-19	75%-90%	>50%	MINIMAL	YES	YES (Y)
5-2	50%-75%	10%-20%	MINIMAL	YES	.
5-20^1	<50%	5%-10%	MODERATE	YES	YES (Y)
5-20^2	<50%	5%-10%	MODERATE	YES	YES (Y)
5-21	<50%	10%-20%	HIGH	YES	YES (Y)
5-22	50%-75%	20%-50%	EXTREME	YES	.
5-23	50%-75%	10%-20%	MINIMAL	YES	UNCERTAIN (?)
5-24	50%-75%	<5%	.	YES	.
5-25	<50%	10%-20%	MODERATE	YES	.
5-26	>90%	5%-10%	EXTREME	YES	.
5-26^1	>90%	5%-10%	EXTREME	YES	.
5-26^2	>90%	5%-10%	EXTREME	YES	.
5-26^3	>90%	5%-10%	EXTREME	YES	.
5-3^1	<50%	10%-20%	MODERATE	YES	YES (Y)
5-3^2	.	10%-20%	MODERATE	YES	UNCERTAIN (?)
5-3^3	<50%	10%-20%	MODERATE	YES	YES (Y)
5-4	<50%	5%-10%	MODERATE	YES	.
5-4^1	>90%	5%-10%	MINIMAL	YES	.
5-4^2	75%-90%	5%-10%	MODERATE	YES	.
5-5^1	<50%	5%-10%	MODERATE	YES	UNCERTAIN (?)
5-5^2	<50%	10%-20%	MODERATE	YES	UNCERTAIN (?)
5-6	50%-75%	5%-10%	MODERATE	YES	YES (Y)
5-7	50%-75%	10%-20%	MINIMAL	YES	YES (Y)
5-8	<50%	5%-10%	MODERATE	YES	.
5-9	<50%	10%-20%	MODERATE	YES	.
Mean	3	4	2	1	2

TAPHONOMY OF KOPE LIMESTONES

P.1

SAMPLE	THICKNESS	ALLOCHEM SIZE	BED SORTING	LOWER CONTACT	GRADING	CROSS LAMINATION	MATRIX	MATRIX
1-10	6.5	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	MICRITE
1-11	7.5	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-11	7.5	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-12	7.0	FINE	WELL	BASE OF UNIT 4A	NONE (N)	UNCERT (?)	SPAR	NO 2ND MATRIX
1-13	5.5	COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	SPAR
1-14	9.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
1-15	10.0	MEDIUM	MOD POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
1-16	7.0	MEDIUM FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	SPAR
1-17	10.0	MEDIUM FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	MICRITE
1-18	12.0	MEDIUM FINE	POOR	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	OOZE
1-19	6.0	COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-1\2	4.0	COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	MICRITE
1-1^1	2.0	MEDIUM FINE	POOR	SHARP	COARSENING UP (C)	NO (N)	MICRITE	NO 2ND MATRIX
1-1^2	1.5	COARSE	.	UNDULOSE	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
1-20	6.5	MEDIUM	MOD	BASE OF UNIT 4A	MULTITREND (F-C)	YES (Y)	MICRITE	NO 2ND MATRIX
1-21^1	2.8	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-21^3	2.0	MEDIUM FINE	WELL	INFERED/TEXT DIFF	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-22	7.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-23	4.0	MEDIUM COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	NO 2ND MATRIX
1-25^1	2.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	MICROSPAR
1-25^2	7.0	MEDIUM	WELL	INFERED/TEXT DIFF	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
1-25^3	.9	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-26	3.4	COARSE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE
1-27	4.5	COARSE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE
1-28	7.5	MEDIUM	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-29^1	4.0	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-29^2	2.0	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-2^1	4.0	COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	MICRITE
1-2^2	2.0	MEDIUM	MOD POOR	SHARP	NONE (N)	NO (N)	OOZE	NO 2ND MATRIX
1-30	6.0	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
1-31^1	1.0	FINE	MOD WELL	BASE OF UNIT 4A	.	.	.	NO 2ND MATRIX
1-31^2	3.0	COARSE	WELL	INFERED/TEXT DIFF	FINING UP (F)	NO (N)	MICRITE	SPAR
1-31^4	4.2	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	SPAR
1-32	6.0	MEDIUM FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
1-33	7.5	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	OOZE
1-34	6.0	FINE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	MICROSPAR	NO 2ND MATRIX
1-35^1	1.3	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-35^2	9.0	COARSE	MOD	UNDULOSE	FINING UP (F)	NO (N)	SPAR	OOZE
1-36	7.0	MEDIUM FINE	MOD WELL	UNDULOSE	FINING UP (F)	YES (Y)	SPAR	OOZE
1-37	5.5	MEDIUM	POOR	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	SPAR	OOZE
1-3	7.5	FINE	MOD WELL	BASE OF UNIT 4A	NONE (N)	YES (Y)	SPAR	NO 2ND MATRIX
1-39^1	1.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SILT

1-39^2	9.0	FINE	WELL	SHARP	NONE (N)	YES (Y)	MICRITE	NO 2ND MATRIX
1-3^1	2.5	MEDIUM FINE	MOD WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	NO 2ND MATRIX
1-3^2	2.0	MEDIUM	WELL	INFERED/TEXT DIFF	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
1-3^3	1.8	MEDIUM	MOD	SHARP	NONE (N)	NO (N)	SPAR	NO 2ND MATRIX
1-4b	6.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	SPAR
1-5	7.5	COARSE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	OOZE	SPAR
1-6	8.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
1-7	8.0	MEDIUM COARSE	WELL	BASE OF UNIT 4A	MULTITREND (F-C)	.	SPAR	MICRITE
1-8	11.0	FINE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	SPAR	NO 2ND MATRIX
1-9	3.0	MEDIUM FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	MICROSPAR
2-1	7.0	FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
2-10^1	4.5	FINE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	.	NO 2ND MATRIX
2-10^2	4.0	FINE	MOD	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-11	12.0	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
2-12	3.5	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-13^1	.8	FINE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	MICRITE	NO 2ND MATRIX
2-13^2	2.0	MEDIUM FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	SPAR
2-14	.	MEDIUM FINE	.	BASE OF UNIT 4A	MULTITREND (F-C)	.	MICROSPAR	SPAR
2-15	8.4	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
2-16	12.0	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
2-17	.	COARSE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	NO 2ND MATRIX
2-18	15.0	COARSE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	OOZE
2-19a	5.0	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	MICROSPAR
2-19b	3.8	FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-19c	3.8	FINE	WELL	BASE OF UNIT 4A	NONE (N)	YES (Y)	MICROSPAR	NO 2ND MATRIX
2-2	6.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	MULTITREND (F-C)	YES (Y)	MICRITE	NO 2ND MATRIX
2-20	4.5	MEDIUM COARSE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	SPAR
2-21	6.3	MEDIUM COARSE	MOD	BASE OF UNIT 4A	COARSENING UP (C)	YES (Y)	MICRITE	SPAR
2-22a	2.5	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	SPAR	NO 2ND MATRIX
2-22a^2	2.0	FINE	WELL	UNDULOSE	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-22a^3	1.8	FINE	WELL	SHARP	FINING UP (F)	.	.	NO 2ND MATRIX
2-23	6.7	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	.	MICRITE	SPAR
2-3a	8.5	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
2-3b^1	2.2	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	OOZE
2-3b^2	6.0	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
2-4	9.0	COARSE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	MICRITE
2-4a	5.5	FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	SPAR	NO 2ND MATRIX
2-4b^1	3.0	FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
2-4b^2	1.5	FINE	MOD	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-4c	4.0	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
2-5	4.0	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
2-5b^1	2.0	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
2-5b^2	2.5	FINE	WELL	SHARP	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
2-5b^2	2.5	FINE	WELL	SHARP	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
2-5b^3	2.5	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
2-5b^4	3.5	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
2-6^1	1.0	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	MUD
2-6^2	5.0	FINE	WELL	SHARP	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX

2-6^3	2.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
2-7	6.0	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	OOZE
2-8^1	2.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
2-8^2	3.0	FINE	WELL	SHARP	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
2-9a	4.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	SPAR
2-9b	3.5	MEDIUM	MOD WELL	UNDULOSE	NONE (N)	NO (N)	MICRITE	SPAR
3-1	1.8	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-10	4.5	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
3-11	10.0	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	OOZE
3-13^1	3.5	COARSE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	OOZE	SPAR
3-13^2	2.0	COARSE	POOR	UNDULOSE	NONE (N)	NO (N)	MICRITE	OOZE
3-15	4.5	MEDIUM COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	MICROSPAR
3-16	6.0	FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-17	4.5	MEDIUM	WELL	SHARP	FINING UP (F)	NO (N)	OOZE	SPAR
3-18	2.8	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	NO 2ND MATRIX
3-19	5.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
3-2	4.5	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-20	3.5	MEDIUM COARSE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
3-21	2.8	MEDIUM	MOD	SHARP	FINING UP (F)	NO (N)	OOZE	MICRITE
3-22	3.7	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	.	OOZE	SPAR
3-23	4.0	COARSE	MOD WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
3-24	5.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
3-25	4.8	MEDIUM COARSE	POOR	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	MICRITE	SPAR
3-26	2.8	MEDIUM FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICROSPAR	NO 2ND MATRIX
3-27	4.8	COARSE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	MICROSPAR	OOZE
3-28	2.8	MEDIUM	MOD WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	MICRITE	SPAR
3-29	2.8	MEDIUM	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
3-3	.	MEDIUM	POOR	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	SPAR
3-30	3.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-31	3.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	OOZE
3-32^1	2.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	MICRITE	NO 2ND MATRIX
3-32^2	2.0	MEDIUM	WELL	SHARP	FINING UP (F)	UNCERT (?)	SPAR	OOZE
3-32^3	2.0	MEDIUM	WELL	SHARP	FINING UP (F)	UNCERT (?)	MICRITE	SPAR
3-32^4	2.0	MEDIUM	WELL	SHARP	FINING UP (F)	UNCERT (?)	MICRITE	SPAR
3-33	4.0	.	.	.	MULTITREND (F-C)	.	SPAR	NO 2ND MATRIX
3-34^1	2.5	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	SPAR
3-34^2	2.5	MEDIUM	WELL	SHARP	FINING UP (F)	NO (N)	OOZE	SPAR
3-34^3	1.4	MEDIUM	WELL	SHARP	FINING UP (F)	NO (N)	OOZE	SPAR
3-35^1	1.5	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-35^2	1.0	COARSE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-36	9.0	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
3-4a^1	2.5	FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-4a^2	3.5	MEDIUM FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-4b^1	2.5	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-4b^2	1.0	FINE	MOD	UNDULOSE	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
3-5	8.0	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
3-6	2.6	MEDIUM	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	OOZE	MICRITE
3-7	6.5	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX

3-8	3.0	MEDIUM COARSE	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	MICRITE
3-9^1	3.0	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
3-9^1	3.0	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
3-9^2	6.0	COARSE	MOD	UNDULOSE	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
4-1	4.0	FINE	WELL	BASE OF UNIT 4A	NONE (N)	YES (Y)	SPAR	NO 2ND MATRIX
4-10a^1	6.0	MEDIUM FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-10b	2.0	MEDIUM COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MUD	NO 2ND MATRIX
4-10c	5.0	MEDIUM COARSE	MOD POOR	SHARP	NONE (N)	NO (N)	MUD	NO 2ND MATRIX
4-14^a	3.5	FINE	WELL	BASE OF UNIT 4A	.	UNCERT (?)	SPAR	OOZE
4-14b	3.8	.	POOR	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	OOZE
4-14c	5.5	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MUD	NO 2ND MATRIX
4-15b	5.5	MEDIUM FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	NO 2ND MATRIX
4-16a	4.0	COARSE	POOR	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	OOZE	NO 2ND MATRIX
4-16b^1	5.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE
4-16b^2	1.0	FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	OOZE	MICRITE
4-16c^1	1.5	COARSE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-16c^2	4.5	MEDIUM	MOD	UNDULOSE	FINING UP (F)	NO (N)	OOZE	NO 2ND MATRIX
4-16c^3	1.0	FINE	WELL	UNDULOSE	COARSENING UP (C)	NO (N)	MICRITE	OOZE
4-16d^1	1.5	MEDIUM	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	NO 2ND MATRIX
4-16d^2	2.0	MEDIUM	WELL	UNDULOSE	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-16d^3	1.5	MEDIUM	WELL	UNDULOSE	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-17a	5.5	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
4-17b^1	1.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE
4-17b^2	2.0	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-17b^3	.8	MEDIUM FINE	WELL	SHARP	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
4-17b^4	3.0	FINE	WELL	UNDULOSE	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-17b^5	3.0	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-17c	7.0	COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE
4-17d^2	2.0	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-18	4.5	COARSE	MOD WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
4-19^1	2.6	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-19^2	.5	MEDIUM FINE	WELL	INFERED/TEXT DIFF	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-19^3	.5	MEDIUM FINE	POOR	SHARP	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
4-2	4.5	FINE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	MICROSPAR
4-20^1	5.0	COARSE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
4-20^2	2.0	COARSE	MOD	UNDULOSE	COARSENING UP (C)	NO (N)	MICROSPAR	NO 2ND MATRIX
4-22	6.0	COARSE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	OOZE
4-23	5.0	COARSE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	MUD	SPAR
4-24a	7.5	MEDIUM FINE	WELL	BASE OF UNIT 4A	NONE (N)	YES (Y)	SPAR	NO 2ND MATRIX
4-24b	4.0	FINE	WELL	BASE OF UNIT 4A	.	.	SPAR	NO 2ND MATRIX
4-24c	5.5	COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	OOZE
4-25	6.0	MEDIUM COARSE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
4-26	4.0	MEDIUM	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	SPAR
4-27^1	2.0	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	OOZE	MICRITE
4-27^2	2.5	MEDIUM COARSE	MOD	SHARP	FINING UP (F)	YES (Y)	OOZE	MICRITE
4-28	5.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	UNCERT (?)	SPAR	OOZE
4-29	5.0	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	MICROSPAR

4-3	3.5	FINE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	YES (Y)	MICROSPAR	NO 2ND MATRIX
4-30	6.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	SPAR	MICROSPAR
4-31a	4.5	FINE	WELL	BASE OF UNIT 4A	NONE (N)	NO (N)	SPAR	MICROSPAR
4-31b	6.5	COARSE	WELL	BASE OF UNIT 4A	.	NO (N)	SPAR	NO 2ND MATRIX
4-4	2.8	MEDIUM	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
4-5	5.0	FINE	MOD WELL	SHARP	NONE (N)	YES (Y)	SPAR	NO 2ND MATRIX
4-6^1	2.2	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	NO 2ND MATRIX
4-6^2	.5	FINE	WELL	SHARP	FINING UP (F)	NO (N)	MICROSPAR	NO 2ND MATRIX
4-7	5.0	FINE	WELL	SHARP	COARSENING UP (C)	YES (Y)	SPAR	NO 2ND MATRIX
4-8	3.0	MEDIUM	MOD POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MUD	NO 2ND MATRIX
4-9	5.5	FINE	MOD WELL	SHARP	FINING UP (F)	UNCERT (?)	SPAR	NO 2ND MATRIX
4^a	7.5	COARSE	MOD POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	OOZE	SPAR
5-1	11.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	SPAR
5-10	5.7	FINE	WELL	BASE OF UNIT 4A	NONE (N)	UNCERT (?)	MICRITE	NO 2ND MATRIX
5-11^1	6.5	COARSE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-11^2	3.5	MEDIUM	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-11^3	3.2	.	. .	SHARP	FINING UP (F)	YES (Y)	.	NO 2ND MATRIX
5-12	4.5	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	NO 2ND MATRIX
5-13	7.0	FINE	POOR	BASE OF UNIT 4A	.	.	MICRITE	OOZE
5-15	9.0	COARSE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-16	4.2	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	OOZE
5-17^1	2.7	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	OOZE
5-17^2	1.9	MEDIUM FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-18^1	6.0	COARSE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-18^2	2.5	COARSE	WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-19	7.5	FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	YES (Y)	MICRITE	NO 2ND MATRIX
5-2	5.4	COARSE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	SPAR
5-20^1	5.0	FINE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-20^2	4.0	FINE	MOD	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-21	7.0	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
5-22	4.0	MEDIUM FINE	MOD WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
5-23	9.0	FINE	WELL	BASE OF UNIT 4A	NONE (N)	UNCERT (?)	MICRITE	SPAR
5-24	5.0	MEDIUM	WELL	BASE OF UNIT 4A	.	.	MICRITE	MUD
5-25	5.0	COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICROSPAR	NO 2ND MATRIX
5-26	5.0	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
5-26^1	5.0	COARSE	POOR	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
5-26^2	1.0	FINE	MOD WELL	SHARP	NONE (N)	NO (N)	MICRITE	OOZE
5-26^3	2.0	MEDIUM COARSE	MOD POOR	SHARP	NONE (N)	NO (N)	MICRITE	NO 2ND MATRIX
5-3^1	4.0	MEDIUM FINE	WELL	BASE OF UNIT 4A	COARSENING UP (C)	NO (N)	MICRITE	NO 2ND MATRIX
5-3^2	4.0	MEDIUM FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-3^3	1.8	MEDIUM FINE	MOD WELL	SHARP	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-4	8.2	MEDIUM FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-4^1	2.0	COARSE	MOD	BASE OF UNIT 4A	NONE (N)	NO (N)	MICRITE	OOZE
5-4^2	1.4	MEDIUM	MOD WELL	SHARP	NONE (N)	NO (N)	SPAR	OOZE
5-5^1	3.5	MEDIUM	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	SPAR	OOZE
5-5^2	3.5	MEDIUM FINE	MOD	INFERED/TEXT DIFF	FINING UP (F)	NO (N)	SPAR	NO 2ND MATRIX
5-6	3.4	MEDIUM	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	NO 2ND MATRIX
5-7	11.0	MEDIUM COARSE	MOD	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	OOZE

5-8	5.7	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
5-8	5.7	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
5-9	3.0	FINE	WELL	BASE OF UNIT 4A	FINING UP (F)	NO (N)	MICRITE	SPAR
Mean	4.6	3	4	5	1	2	3	5

TAPHONOMY OF KOPE LIMESTONES

SAMPLE	TAXON	ABUNDANCE	MINIMUM SIZE	MAXIMUM SIZE	SORTING	PREDOM SHAPE	MINOR SHAPE
1-10	BRYOZOA	A	1.0	5.0	MODERATE/WELL (2.5)	BRANCHING	.
1-10	BRACHIOPOD	B	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-10	CRINOID	B	1.0	3.0	MODERATE (2.0)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-10	TRILOBITE	B	2.0	10.0	VERY POOR (1.0)	PLATEY	.
1-11	BRYOZOA	A	1.0	10.0	VERY POOR (1.0)	BRANCHING	HOLLOW/CYLINDRICAL
1-11	BRACHIOPOD	C	3.0	7.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-11	TRILOBITE	B	2.0	15.0	VERY POOR (1.0)	PLATEY	.
1-12	BRYOZOA	C	1.0	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-12	BRACHIOPOD	B	2.0	5.0	POOR (1.5)	CONCAVO/CONVEX	PLATEY
1-12	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-12	TRILOBITE	D	1.0	4.0	POOR (1.5)	PLATEY	STICK LIKE
1-13	BRYOZOA	A	4.0	20.0	VERY POOR (1.0)	BRANCHING	HOLLOW/CYLINDRICAL
1-13	CRINOID	B	3.0	9.0	POOR (1.5)	HOLLOW/CYLINDRICAL	DISCOIDAL
1-14	BRYOZOA	B	3.0	15.0	POOR (1.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-14	BRYOZOA	B	2.0	2.0	POOR (1.5)	PLATEY	.
1-14	BRACHIOPOD	C	1.0	5.0	POOR (1.5)	PLATEY	.
1-14	CRINOID	A	1.0	3.0	POOR (1.5)	HOLLOW/CYLINDRICAL	DISCOIDAL
1-14	TRILOBITE	D	1.0	5.0	POOR (1.5)	PLATEY	.
1-15	BRYOZOA	B	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-15	BRYOZOA	C	1.0	1.0	MODERATE (2.0)	PLATEY	.
1-15	CRINOID	A	1.0	3.0	POOR (1.5)	HOLLOW/CYLINDRICAL	DISCOIDAL
1-15	TRILOBITE	D	2.0	5.0	MODERATE (2.0)	PLATEY	.
1-16	BRYOZOA	B	2.0	20.0	MODERATE (2.0)	PLATEY	.
1-16	CRINOID	A	.5	3.0	POOR (1.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-16	TRILOBITE	C	3.0	25.0	VERY POOR (1.0)	PLATEY	STICK LIKE
1-17	BRYOZOA	B	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-17	BRACHIOPOD	M	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
1-17	CRINOID	A	.5	3.0	MODERATE/WELL (2.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-17	TRILOBITE	C	1.0	2.0	MODERATE/WELL (2.5)	STICK LIKE	.
1-18	BRYOZOA	C	1.0	6.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
1-18	BRACHIOPOD	A	10.0	20.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-18	CRINOID	B	.5	3.0	POOR (1.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-18	GASTROPOD	E	4.0	5.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
1-19	BRYOZOA	C	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
1-19	BRACHIOPOD	E	4.0	6.0	MODERATE (2.0)	PLATEY	.
1-19	CRINOID	A	.5	2.0	MODERATE (2.0)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-19	TRILOBITE	D	1.0	5.0	POOR (1.5)	PLATEY	STICK LIKE
1-19	GASTROPOD	B	5.0	8.0	MODERATE (2.0)	SEMI-SPHEROIDAL	.
1-1\2	BRYOZOA	A	3.0	5.0	POOR (1.5)	BRANCHING	SOLID/CYLINDRICAL
1-1^1	BRYOZOA	B	1.0	1.0	MODERATE/WELL (2.5)	SOLID/CYLINDRICAL	.
1-1^1	BRACHIOPOD	A	.5	1.5	MODERATE (2.0)	PLATEY	.
1-1^1	TRILOBITE	C	2.0	3.0	MODERATE/WELL (2.5)	PLATEY	STICK LIKE
1-1^2	BRYOZOA	A	3.0	4.0	MODERATE (2.0)	BRANCHING	SOLID/CYLINDRICAL
1-1^2	BRACHIOPOD	B	10.0	15.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.

1-1^2	CRINOID	C	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-20	BRYOZOA	D	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	SEMI-SPHEROIDAL
1-20	BRACHIOPOD	C	3.0	6.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-20	CRINOID	A	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-20	TRILOBITE	B	1.0	4.0	POOR (1.5)	PLATEY	STICK LIKE
1-20	GASTROPOD	M	4.0	6.0	WELL/VERY WELL (3.5)	SEMI-SPHEROIDAL	.
1-21^1	BRYOZOA	C	3.0	4.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-21^1	BRACHIOPOD	D	5.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-21^1	CRINOID	A	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
1-21^1	TRILOBITE	B	2.0	7.0	POOR (1.5)	PLATEY	STICK LIKE
1-21^3	BRYOZOA	D	4.0	4.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-21^3	BRACHIOPOD	C	5.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-21^3	CRINOID	A	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
1-21^3	TRILOBITE	B	2.0	7.0	POOR (1.5)	PLATEY	STICK LIKE
1-22	BRYOZOA	B	1.0	4.0	POOR (1.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-22	BRACHIOPOD	D	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-22	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-22	TRILOBITE	C	2.0	6.0	POOR (1.5)	PLATEY	STICK LIKE
1-23	BRYOZOA	A	2.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	SEMI-SPHEROIDAL
1-23	BRACHIOPOD	B	10.0	12.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-23	CRINOID	C	1.0	3.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-23	TRILOBITE	D	3.0	5.0	MODERATE (2.0)	PLATEY	.
1-25^1	BRYOZOA	C	1.0	2.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
1-25^1	BRYOZOA	D	1.0	3.0	MODERATE (2.0)	PLATEY	.
1-25^1	BRACHIOPOD	B	4.0	6.0	MODERATE/WELL (2.5)	PLATEY	.
1-25^1	CRINOID	A	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
1-25^2	BRYOZOA	B	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-25^2	BRACHIOPOD	A	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-25^2	CRINOID	C	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-25^3	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-25^3	BRACHIOPOD	A	5.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-25^3	BRACHIOPOD	A	4.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
1-26	BRYOZOA	B	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-26	BRACHIOPOD	A	6.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-26	CRINOID	M	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-27	BRYOZOA	B	5.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-27	BRACHIOPOD	A	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-27	CRINOID	C	1.0	4.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-27	TRILOBITE	M	2.0	10.0	VERY POOR (1.0)	PLATEY	.
1-28	BRYOZOA	B	1.0	2.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
1-28	BRACHIOPOD	A	3.0	6.0	POOR (1.5)	CONCAVO/CONVEX	.
1-28	CRINOID	C	1.0	2.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
1-28	TRILOBITE	D	3.0	5.0	MODERATE (2.0)	PLATEY	.
1-29^1	FRAGMENTS	A	.5	1.0	.	.	.
1-29^2	BRYOZOA	D	2.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-29^2	BRACHIOPOD	C	2.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-29^2	CRINOID	A	.5	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-29^2	TRILOBITE	B	2.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-2^1	BRYOZOA	B	3.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.

1-2^1	CRINOID	C	1.0	2.0	MODERATE (2.0)	DISCOIDAL	.
1-2^1	TRILOBITE	D	1.0	5.0	POOR (1.5)	CONCAVO/CONVEX	.
1-2^2	BRYOZOA	B	.3	1.0	POOR (1.5)	BRANCHING	.
1-2^2	BRACHIOPOD	A	1.0	1.3	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-2^2	CRINOID	C	.5	2.0	VERY POOR (1.0)	DISCOIDAL	HOLLOW/CYLINDRICAL
1-2^2	TRILOBITE	D	2.0	3.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-30	BRYOZOA	C	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-30	BRACHIOPOD	B	2.0	5.0	MODERATE (2.0)	PLATEY	CONCAVO/CONVEX
1-30	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-30	TRILOBITE	D	2.0	3.0	MODERATE (2.0)	PLATEY	.
1-31^1	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
1-31^2	BRYOZOA	A	4.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
1-31^2	BRACHIOPOD	B	5.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-31^2	TRILOBITE	C	1.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-31^3	FRAGMENTS	.	.	.	.	.	.
1-31^4	FRAGMENTS	.	.	.	.	.	.
1-32	BRYOZOA	B	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-32	BRACHIOPOD	A	2.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-32	CRINOID	M	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
1-32	TRILOBITE	C	2.0	10.0	POOR (1.5)	PLATEY	.
1-33	BRYOZOA	A	1.0	7.0	VERY POOR (1.0)	BRANCHING	HOLLOW/CYLINDRICAL
1-33	BRACHIOPOD	M	3.0	4.0	MODERATE (2.0)	PLATEY	.
1-33	TRILOBITE	M	2.0	10.0	VERY POOR (1.0)	PLATEY	.
1-34	BRYOZOA	C	.5	3.0	MODERATE/WELL (2.5)	PLATEY	.
1-34	BRACHIOPOD	A	.5	3.0	MODERATE/WELL (2.5)	PLATEY	.
1-34	BRACHIOPOD	B	5.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
1-34	CRINOID	D	1.0	2.0	MODERATE (2.0)	DISCOIDAL	.
1-35^1	BRYOZOA	A	3.0	12.0	VERY POOR (1.0)	SOLID/CYLINDRICAL	PLATEY
1-35^1	BRYOZOA	B	1.0	2.0	MODERATE/WELL (2.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-35^1	BRACHIOPOD	B	3.0	20.0	VERY POOR (1.0)	PLATEY	.
1-35^2	BRYOZOA	A	1.0	10.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	PLATEY
1-35^2	BRACHIOPOD	B	2.0	4.0	VERY POOR (1.0)	PLATEY	.
1-35^2	BRACHIOPOD	B	4.0	20.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
1-35^2	TRILOBITE	D	2.0	12.0	VERY POOR (1.0)	PLATEY	.
1-36	BRYOZOA	C	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-36	BRYOZOA	D	.5	1.0	MODERATE/WELL (2.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-36	BRACHIOPOD	B	5.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-36	BRACHIOPOD	C	4.0	5.0	VERY POOR (1.0)	PLATEY	.
1-36	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-37	BRYOZOA	B	1.0	2.0	MODERATE/WELL (2.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-37	BRYOZOA	C	5.0	20.0	MODERATE (2.0)	PLATEY	HOLLOW/CYLINDRICAL
1-37	BRACHIOPOD	C	3.0	10.0	POOR (1.5)	PLATEY	.
1-37	CRINOID	A	.5	3.0	MODERATE (2.0)	DISCOIDAL	.
1-38	BRACHIOPOD	B	3.0	7.0	VERY POOR (1.0)	PLATEY	.
1-38	BRACHIOPOD	C	8.0	12.0	MODERATE (2.0)	CONCAVO/CONVEX	.
1-38	CRINOID	A	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
1-38	CRINOID	D	2.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
1-38	TRILOBITE	E	2.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.

1-39^1	BRYOZOA	A	2.0	4.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
1-39^1	BRACHIOPOD	B	4.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-39^2	BRYOZOA	B	4.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
1-39^2	BRACHIOPOD	C	1.0	5.0	POOR (1.5)	PLATEY	.
1-39^2	CRINOID	A	.5	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-39^2	TRILOBITE	D	1.0	5.0	POOR (1.5)	PLATEY	.
1-3^1	BRYOZOA	A	2.0	4.0	MODERATE (2.0)	SOLID/CYLINDRICAL	.
1-3^1	BRACHIOPOD	C	3.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-3^1	BIVALVE	D	3.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
1-3^2	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	BRANCHING	SOLID/CYLINDRICAL
1-3^2	TRILOBITE	C	3.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
1-3^2	GASTROPOD	F	6.0	6.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
1-3^2	BIVALVE	F	1.0	12.0	POOR (1.5)	PLATEY	.
1-3^3	BRYOZOA	A	3.0	4.0	MODERATE/WELL (2.5)	BRANCHING	SOLID/CYLINDRICAL
1-3^3	BRACHIOPOD	D	3.0	10.0	VERY POOR (1.0)	PLATEY	.
1-3^3	BRACHIOPOD	C	3.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
1-3^3	TRILOBITE	D	1.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
1-3^3	TRILOBITE	C	3.0	6.0	POOR (1.5)	CONCAVO/CONVEX	.
1-4b	BRYOZOA	C	2.0	5.0	VERY WELL (4.0)	CONCAVO/CONVEX	.
1-4b	BRACHIOPOD	A	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-4b	CRINOID	D	2.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-4b	TRILOBITE	B	3.0	10.0	VERY POOR (1.0)	PLATEY	.
1-5	BRYOZOA	A	1.0	6.0	VERY POOR (1.0)	BRANCHING	HOLLOW/CYLINDRICAL
1-5	BRACHIOPOD	B	2.0	6.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
1-5	CRINOID	M	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-5	TRILOBITE	C	2.0	6.0	VERY POOR (1.0)	PLATEY	.
1-6	BRYOZOA	B	2.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-6	BRACHIOPOD	A	5.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
1-6	CRINOID	D	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-6	TRILOBITE	C	1.0	7.0	VERY POOR (1.0)	PLATEY	.
1-7	BRYOZOA	B	4.0	6.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
1-7	BRACHIOPOD	A	10.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-7	CRINOID	C	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	SOLID/CYLINDRICAL
1-7	TRILOBITE	D	2.0	8.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
1-7	TRILOBITE	E	1.0	2.0	MODERATE/WELL (2.5)	STICK LIKE	.
1-8	BRYOZOA	C	2.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
1-8	BRACHIOPOD	B	2.0	5.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
1-8	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
1-8	TRILOBITE	D	2.0	5.0	MODERATE (2.0)	PLATEY	.
1-9	BRYOZOA	A	1.0	5.0	POOR (1.5)	BRANCHING	HOLLOW/CYLINDRICAL
1-9	BRACHIOPOD	M	5.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
1-9	TRILOBITE	C	1.0	5.0	POOR (1.5)	PLATEY	HOLLOW/CYLINDRICAL
2-1	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-1	BRACHIOPOD	B	2.0	15.0	MODERATE (2.0)	CONCAVO/CONVEX	.
2-1	CRINOID	A	1.0	2.0	MODERATE (2.0)	DISCOIDAL	.
2-1	TRILOBITE	C	1.0	5.0	POOR (1.5)	PLATEY	.
2-10^1	BRYOZOA	M	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-10^1	BRACHIOPOD	B	5.0	7.0	WELL/VERY WELL (3.5)	PLATEY	.
2-10^1	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.

2-10'1	TRILOBITE	B	5.0	8.0	WELL/VERY WELL (3.5)	PLATEY	.
2-10'2	BRYOZOA	D	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-10'2	BRACHIOPOD	B	5.0	7.0	WELL/VERY WELL (3.5)	PLATEY	.
2-10'2	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-10'2	TRILOBITE	C	5.0	8.0	WELL/VERY WELL (3.5)	PLATEY	.
2-11	BRYOZOA	B	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-11	BRACHIOPOD	C	6.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-11	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
2-11	TRILOBITE	D	2.0	5.0	POOR (1.5)	PLATEY	.
2-12	BRYOZOA	B	1.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-12	BRYOZOA	C	2.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
2-12	BRACHIOPOD	C	5.0	8.0	WELL/VERY WELL (3.5)	PLATEY	.
2-12	CRINOID	A	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-12	TRILOBITE	C	5.0	8.0	WELL/VERY WELL (3.5)	PLATEY	.
2-13'1	BRYOZOA	D	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-13'1	BRACHIOPOD	B	2.0	8.0	MODERATE/WELL (2.5)	PLATEY	.
2-13'1	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
2-13'1	TRILOBITE	C	2.0	6.0	MODERATE/WELL (2.5)	PLATEY	.
2-13'2	BRYOZOA	A	2.0	6.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-13'2	BRYOZOA	B	1.0	2.0	VERY WELL (4.0)	PLATEY	.
2-13'2	BRACHIOPOD	D	2.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
2-13'2	CRINOID	C	1.0	2.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
2-13'2	TRILOBITE	E	4.0	8.0	MODERATE/WELL (2.5)	PLATEY	.
2-14	BRYOZOA	A	3.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-14	BRACHIOPOD	C	.	.	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-14	CRINOID	B	.5	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-14	TRILOBITE	.	.	.	MODERATE/WELL (2.5)	PLATEY	.
2-15	BRACHIOPOD	A	3.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-16	BRYOZOA	C	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-16	BRACHIOPOD	A	5.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-16	CRINOID	B	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-16	TRILOBITE	D	2.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
2-17	BRYOZOA	B	2.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-17	BRYOZOA	C	2.0	3.0	MODERATE (2.0)	PLATEY	.
2-17	BRACHIOPOD	A	5.0	10.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
2-17	TRILOBITE	D	5.0	25.0	VERY POOR (1.0)	PLATEY	.
2-18	BRYOZOA	A	2.0	7.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-18	BRACHIOPOD	B	5.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-18	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
2-19a	BRYOZOA	B	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-19a	BRACHIOPOD	A	5.0	8.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
2-19a	CRINOID	E	.5	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-19a	TRILOBITE	C	3.0	10.0	MODERATE/WELL (2.5)	PLATEY	.
2-19b	BRYOZOA	C	.	.	WELL/VERY WELL (3.5)	PLATEY	.
2-19b	BRACHIOPOD	M	3.0	3.5	.	PLATEY	.
2-19b	CRINOID	B	.5	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-19b	TRILOBITE	.	.	.	WELL/VERY WELL (3.5)	.	.
2-19b	OSTROCOD	E	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.

2-19c	BRYOZOA	A	2.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
2-19c	BRACHIOPOD	B	3.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
2-19c	CRINOID	M	1.0	1.5	MODERATE/WELL (2.5)	DISCOIDAL	.
2-19c	TRILOBITE	B	2.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
2-2	BRYOZOA	C	5.0	25.0	VERY POOR (1.0)	PLATEY	.
2-2	BRYOZOA	D	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-2	BRACHIOPOD	A	5.0	7.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-2	BRACHIOPOD	B	1.0	4.0	POOR (1.5)	PLATEY	.
2-2	CRINOID	M	1.0	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-2	TRILOBITE	E	2.0	25.0	VERY POOR (1.0)	PLATEY	.
2-20	BRYOZOA	A	4.0	6.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-20	BRACHIOPOD	B	3.0	12.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-20	CRINOID	D	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
2-20	TRILOBITE	C	2.0	8.0	MODERATE/WELL (2.5)	PLATEY	CONCAVO/CONVEX
2-20	OSTROCOD	B	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-20	GASTROPOD	M	12.0	12.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
2-21	BRYOZOA	B	1.0	20.0	POOR (1.5)	PLATEY	.
2-21	BRYOZOA	C	.5	1.0	WELL/VERY WELL (3.5)	BRANCHING	.
2-21	BRACHIOPOD	B	1.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
2-21	BRACHIOPOD	C	16.0	20.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-21	CRINOID	E	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-21	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
2-22a	BRYOZOA	B	3.0	20.0	POOR (1.5)	PLATEY	.
2-22a	BRYOZOA	B	2.0	4.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-22a	BRACHIOPOD	A	5.0	7.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-22a	TRILOBITE	C	2.0	8.0	MODERATE/WELL (2.5)	PLATEY	.
2-22a	GASTROPOD	E	3.0	4.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-22a^2	BRYOZOA	C	1.0	1.5	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-22a^2	TRILOBITE	B	1.0	1.5	MODERATE/WELL (2.5)	PLATEY	.
2-22a^2	OSTROCOD	A	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-22a^3	BRYOZOA	D	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-22a^3	BRACHIOPOD	A	3.0	7.0	MODERATE/WELL (2.5)	PLATEY	.
2-22a^3	TRILOBITE	C	2.0	5.0	POOR (1.5)	PLATEY	.
2-22a^3	OSTROCOD	B	1.0	1.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-23	BRYOZOA	B	1.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-23	BRYOZOA	B	1.0	5.0	POOR (1.5)	PLATEY	.
2-23	BRACHIOPOD	A	2.0	7.0	WELL/VERY WELL (3.5)	PLATEY	.
2-23	CRINOID	M	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-23	TRILOBITE	C	2.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
2-3a	BRYOZOA	C	1.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-3a	BRACHIOPOD	B	3.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
2-3a	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
2-3a	TRILOBITE	M	3.0	10.0	VERY POOR (1.0)	PLATEY	.
2-3b^1	BRYOZOA	B	2.0	10.0	VERY POOR (1.0)	PLATEY	.
2-3b^1	BRACHIOPOD	C	2.0	10.0	VERY POOR (1.0)	PLATEY	.

2-3b^1	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
2-3b^2	BRYOZOA	C	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-3b^2	BRACHIOPOD	D	4.0	8.0	WELL/VERY WELL (3.5)	PLATEY	.
2-3b^2	CRINOID	A	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
2-3b^2	TRILOBITE	B	4.0	12.0	VERY POOR (1.0)	PLATEY	.
2-4	BRYOZOA	A	1.0	6.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	BRANCHING
2-4	BRACHIOPOD	C	5.0	10.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
2-4	TRILOBITE	B	2.0	28.0	VERY POOR (1.0)	PLATEY	.
2-4	OSTROCOD	D	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-4a	BRYOZOA	B	2.0	3.0	MODERATE/WELL (2.5)	BRANCHING	.
2-4a	BRYOZOA	C	10.0	30.0	VERY POOR (1.0)	PLATEY	.
2-4a	BRACHIOPOD	C	4.0	10.0	POOR (1.5)	PLATEY	CONCAVO/CONVEX
2-4a	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
2-4a	TRILOBITE	E	2.0	6.0	MODERATE (2.0)	PLATEY	.
2-4b^1	BRYOZOA	B	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-4b^1	BRACHIOPOD	D	1.0	5.0	VERY POOR (1.0)	PLATEY	.
2-4b^1	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
2-4b^1	TRILOBITE	M	1.0	5.0	VERY POOR (1.0)	PLATEY	.
2-4b^2	BRYOZOA	A	1.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-4b^2	TRILOBITE	B	1.0	3.0	MODERATE (2.0)	PLATEY	.
2-4c	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-4c	BRACHIOPOD	D	1.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
2-4c	CRINOID	D	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-4c	TRILOBITE	B	2.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
2-4c	OSTROCOD	A	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-5	BRYOZOA	A	10.0	18.0	MODERATE (2.0)	PLATEY	.
2-5	BRYOZOA	A	1.0	6.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
2-5	BRACHIOPOD	C	3.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.
2-5	TRILOBITE	B	1.0	5.0	POOR (1.5)	PLATEY	.
2-5	GRAPTOLITES	E	2.0	5.0	MODERATE (2.0)	STICK LIKE	.
2-5b^1	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-5b^1	CRINOID	B	2.0	3.0	MODERATE (2.0)	DISCOIDAL	.
2-5b^1	TRILOBITE	D	2.0	6.0	MODERATE (2.0)	PLATEY	.
2-5b^1	OSTROCOD	C	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-5b^1	GRAPTOLITES	M	2.0	4.0	MODERATE/WELL (2.5)	STICK LIKE	.
2-5b^2	BRYOZOA	B	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-5b^2	BRACHIOPOD	D	.5	4.0	MODERATE (2.0)	PLATEY	.
2-5b^2	CRINOID	C	2.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
2-5b^2	TRILOBITE	E	2.0	6.0	MODERATE (2.0)	PLATEY	.
2-5b^2	OSTROCOD	A	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-5b^2	GRAPTOLITES	M	2.0	4.0	MODERATE/WELL (2.5)	STICK LIKE	.
2-5b^3	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-5b^3	BRACHIOPOD	C	.5	4.0	MODERATE (2.0)	PLATEY	.
2-5b^3	CRINOID	F	3.0	3.0	MODERATE (2.0)	CONCAVO/CONVEX	.
2-5b^3	TRILOBITE	E	1.0	5.0	MODERATE (2.0)	PLATEY	.
2-5b^3	OSTROCOD	D	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-5b^4	BRYOZOA	B	1.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-5b^4	BRACHIOPOD	D	.5	4.0	MODERATE (2.0)	PLATEY	.
2-5b^4	CRINOID	A	2.0	3.0	MODERATE (2.0)	DISCOIDAL	.

2-5b^4	TRILOBITE	E	1.0	6.0	MODERATE (2.0)	PLATEY	.
2-5b^4	OSTROCOD	C	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-5b^4	GRAPTOLITES	M	2.0	4.0	MODERATE/WELL (2.5)	STICK LIKE	.
2-6^1	BRYOZOA	C	1.0	3.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
2-6^1	BRACHIOPOD	D	1.0	2.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-6^1	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-6^1	TRILOBITE	B	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
2-6^2	BRYOZOA	C	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
2-6^2	BRACHIOPOD	B	5.0	18.0	VERY POOR (1.0)	PLATEY	.
2-6^2	CRINOID	A	1.0	4.0	MODERATE (2.0)	PLATEY	HOLLOW/CYLINDRICAL
2-6^2	TRILOBITE	E	3.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
2-6^3	BRACHIOPOD	A	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-6^3	CRINOID	B	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-7	BRYOZOA	A	2.0	10.0	VERY POOR (1.0)	PLATEY	.
2-7	CRINOID	B	1.0	4.0	POOR (1.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
2-7	FRAGMENTS	B	1.0	5.0	VERY POOR (1.0)	PLATEY	CONCAVO/CONVEX
2-8^1	BRYOZOA	B	1.0	1.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
2-8^1	BRACHIOPOD	A	4.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-8^1	CRINOID	B	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-8^2	BRACHIOPOD	C	5.0	6.0	MODERATE/WELL (2.5)	PLATEY	CONCAVO/CONVEX
2-8^2	CRINOID	B	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
2-8^2	OSTROCOD	A	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
2-8^2	GRAPTOLITES	M	2.0	10.0	POOR (1.5)	STICK LIKE	.
2-9a	BRYOZOA	M	3.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-9a	BRACHIOPOD	B	5.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
2-9a	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	BRANCHING	HOLLOW/CYLINDRICAL
2-9a	TRILOBITE	C	4.0	10.0	POOR (1.5)	PLATEY	.
2-9b	BRYOZOA	M	3.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
2-9b	BRACHIOPOD	B	5.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
2-9b	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	DISCOIDAL
2-9b	TRILOBITE	C	4.0	10.0	POOR (1.5)	PLATEY	.
3-1	BRYOZOA	B	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	PLATEY
3-1	BRACHIOPOD	A	.5	4.0	MODERATE/WELL (2.5)	PLATEY	.
3-1	CRINOID	M	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
3-1	TRILOBITE	C	1.0	5.0	POOR (1.5)	PLATEY	.
3-1	OSTROCOD	M	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-10	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-10	BRACHIOPOD	B	3.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	PLATEY
3-10	TRILOBITE	C	1.0	2.0	POOR (1.5)	CONCAVO/CONVEX	.
3-11	BRYOZOA	A	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-11	BRACHIOPOD	B	2.0	32.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	PLATEY
3-11	CRINOID	M	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
3-11	TRILOBITE	C	1.0	10.0	VERY POOR (1.0)	PLATEY	.
3-13^1	BRYOZOA	A	1.0	8.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-13^1	BRACHIOPOD	B	1.0	21.0	VERY POOR (1.0)	PLATEY	.
3-13^1	CRINOID	C	2.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-13^1	TRILOBITE	D	1.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
3-13^1	OSTROCOD	E	.5	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.

3-13^2	BRYOZOA	A	2.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-13^2	BRACHIOPOD	C	1.0	4.0	VERY POOR (1.0)	PLATEY	.
3-13^2	TRILOBITE	C	1.0	6.0	VERY POOR (1.0)	PLATEY	.
3-15	BRYOZOA	A	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
3-15	BRYOZOA	C	5.0	12.0	VERY POOR (1.0)	PLATEY	.
3-15	BRACHIOPOD	B	1.0	5.0	VERY POOR (1.0)	CONCAVO/CONVEX	PLATEY
3-15	CRINOID	E	1.0	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-15	TRILOBITE	D	1.0	10.0	VERY POOR (1.0)	PLATEY	.
3-16	BRYOZOA	B	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-16	BRACHIOPOD	E	1.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-16	CRINOID	C	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
3-16	TRILOBITE	D	.5	25.0	VERY POOR (1.0)	PLATEY	.
3-16	OSTROCOD	A	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-17	BRYOZOA	B	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-17	BRACHIOPOD	A	5.0	10.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
3-17	TRILOBITE	D	1.0	7.0	VERY POOR (1.0)	PLATEY	.
3-17	OSTROCOD	C	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-18	BRYOZOA	B	.5	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	BRANCHING
3-18	BRACHIOPOD	A	6.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-18	TRILOBITE	M	.5	4.0	MODERATE (2.0)	PLATEY	.
3-19	BRYOZOA	A	1.0	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-19	BRACHIOPOD	B	10.0	40.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-2	BRYOZOA	B	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-2	BRYOZOA	B	1.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
3-2	BRACHIOPOD	C	2.0	6.0	MODERATE (2.0)	PLATEY	.
3-2	CRINOID	A	.5	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	DISCOIDAL
3-2	TRILOBITE	E	2.0	7.0	POOR (1.5)	PLATEY	.
3-20	BRYOZOA	A	1.0	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-20	BRACHIOPOD	B	10.0	40.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-21	BRYOZOA	A	1.0	8.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-21	BRACHIOPOD	B	5.0	20.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-21	TRILOBITE	C	1.0	11.0	VERY POOR (1.0)	PLATEY	.
3-22	BRYOZOA	A	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
3-22	BRACHIOPOD	B	4.0	8.0	POOR (1.5)	CONCAVO/CONVEX	.
3-22	CRINOID	C	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-22	TRILOBITE	M	1.0	8.0	VERY POOR (1.0)	PLATEY	.
3-23	BRYOZOA	A	1.0	6.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	BRANCHING
3-23	BRACHIOPOD	B	30.0	33.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-23	BRACHIOPOD	C	3.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	PLATEY
3-23	CRINOID	M	3.0	4.0	VERY POOR (1.0)	DISCOIDAL	HOLLOW/CYLINDRICAL
3-23	TRILOBITE	D	.5	8.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-24	BRYOZOA	C	1.0	3.0	MODERATE/WELL (2.5)	BRANCHING	HOLLOW/CYLINDRICAL
3-24	BRACHIOPOD	A	4.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-24	CRINOID	D	2.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
3-24	TRILOBITE	B	1.0	5.0	MODERATE/WELL (2.5)	PLATEY	CONCAVO/CONVEX
3-25	BRYOZOA	A	6.0	1.0	VERY WELL (4.0)	CONCAVO/CONVEX	.
3-25	BRACHIOPOD	B	2.0	8.0	VERY POOR (1.0)	CONCAVO/CONVEX	PLATEY
3-25	TRILOBITE	D	.5	2.0	WELL/VERY WELL (3.5)	PLATEY	.
3-25	OSTROCOD	C	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.

3-26	BRYOZOA	B	1.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-26	BRACHIOPOD	A	1.0	10.0	WELL/VERY WELL (3.5)	PLATEY	.
3-26	CRINOID	C	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
3-26	TRILOBITE	M	2.0	4.0	WELL/VERY WELL (3.5)	PLATEY	.
3-27	BRYOZOA	A	1.0	8.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	BRANCHING
3-27	BRACHIOPOD	B	4.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-27	TRILOBITE	C	2.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
3-27	FRAGMENTS	D	.5	.5	MODERATE/WELL (2.5)	.	.
3-28	BRYOZOA	A	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-28	BRACHIOPOD	B	5.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	PLATEY
3-28	TRILOBITE	M	3.0	6.0	WELL/VERY WELL (3.5)	PLATEY	.
3-29	BRYOZOA	A	2.0	7.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
3-29	BRACHIOPOD	B	5.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-29	CRINOID	M	3.0	3.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-29	TRILOBITE	M	2.0	15.0	VERY POOR (1.0)	PLATEY	.
3-3	BRYOZOA	A	1.0	7.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
3-3	BRACHIOPOD	C	8.0	20.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-3	CRINOID	B	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
3-3	OSTROCOD	M	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-30	BRYOZOA	A	1.0	6.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-30	BRACHIOPOD	B	5.0	10.0	POOR (1.5)	PLATEY	.
3-30	CRINOID	D	1.0	3.0	POOR (1.5)	DISCOIDAL	.
3-30	TRILOBITE	C	2.0	10.0	POOR (1.5)	PLATEY	.
3-31	BRYOZOA	A	2.0	24.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	BRANCHING
3-31	BRACHIOPOD	B	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-31	BRACHIOPOD	C	1.0	4.0	MODERATE (2.0)	PLATEY	.
3-31	TRILOBITE	D	1.0	8.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-32^1	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-32^1	BRACHIOPOD	B	1.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-32^1	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
3-32^2	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-32^2	BRACHIOPOD	B	1.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-32^2	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
3-32^3	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-32^3	BRACHIOPOD	B	1.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-32^3	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
3-32^4	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-32^4	BRACHIOPOD	B	1.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-32^4	TRILOBITE	C	1.0	5.0	MODERATE (2.0)	PLATEY	.
3-33	BRYOZOA	A	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-33	BRACHIOPOD	B	3.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
3-33	TRILOBITE	C	3.0	5.0	WELL/VERY WELL (3.5)	PLATEY	.
3-34^1	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-34^1	BRACHIOPOD	B	4.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-34^1	BRACHIOPOD	B	4.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-34^1	TRILOBITE	C	1.0	6.0	MODERATE/WELL (2.5)	PLATEY	.
3-34^2	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-34^2	BRACHIOPOD	B	4.0	6.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-34^2	TRILOBITE	C	1.0	6.0	MODERATE/WELL (2.5)	PLATEY	.

3-34^3	BRYOZOA	A	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-34^3	TRILOBITE	C	1.0	20.0	MODERATE/WELL (2.5)	PLATEY	.
3-35^1	BRYOZOA	A	2.0	4.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-35^1	BRACHIOPOD	B	6.0	7.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-35^1	TRILOBITE	C	4.0	6.0	MODERATE/WELL (2.5)	PLATEY	.
3-35^2	BRYOZOA	A	3.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
3-35^2	BRACHIOPOD	B	6.0	7.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-35^2	TRILOBITE	C	4.0	6.0	MODERATE/WELL (2.5)	PLATEY	.
3-36	BRYOZOA	A	2.0	7.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-36	BRYOZOA	B	2.0	7.0	VERY POOR (1.0)	PLATEY	.
3-36	BRACHIOPOD	B	8.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-36	CRINOID	C	1.0	7.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-36	CRINOID	D	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
3-36	TRILOBITE	E	2.0	12.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-4a^1	BRYOZOA	B	1.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-4a^1	BRACHIOPOD	A	1.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
3-4a^1	TRILOBITE	C	.5	5.0	VERY POOR (1.0)	PLATEY	.
3-4a^2	BRYOZOA	A	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-4a^2	BRACHIOPOD	B	4.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-4a^2	TRILOBITE	C	.5	5.0	VERY POOR (1.0)	PLATEY	.
3-4b^1	BRYOZOA	A	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-4b^1	BRACHIOPOD	M	1.0	5.0	VERY POOR (1.0)	PLATEY	.
3-4b^1	CRINOID	M	1.0	2.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
3-4b^1	TRILOBITE	M	1.0	4.0	POOR (1.5)	PLATEY	.
3-4b^2	BRYOZOA	B	2.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-4b^2	BRACHIOPOD	A	2.0	4.0	MODERATE (2.0)	PLATEY	.
3-4b^2	TRILOBITE	C	1.0	4.0	POOR (1.5)	PLATEY	.
3-5	BRYOZOA	A	1.0	7.0	VERY POOR (1.0)	BRANCHING	HOLLOW/CYLINDRICAL
3-5	BRACHIOPOD	B	2.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-5	TRILOBITE	C	2.0	8.0	VERY POOR (1.0)	PLATEY	.
3-6	BRYOZOA	A	1.0	7.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-6	BRACHIOPOD	B	2.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
3-6	TRILOBITE	C	.5	10.0	VERY POOR (1.0)	PLATEY	.
3-6	OSTROCOD	D	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-7	BRYOZOA	B	1.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
3-7	BRACHIOPOD	A	1.0	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-7	CRINOID	C	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	HOLLOW/CYLINDRICAL
3-7	TRILOBITE	D	.5	5.0	VERY POOR (1.0)	PLATEY	.
3-8	BRYOZOA	A	.5	8.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-8	BRACHIOPOD	B	1.0	5.0	VERY POOR (1.0)	CONCAVO/CONVEX	PLATEY
3-8	CRINOID	D	3.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
3-8	TRILOBITE	E	1.0	4.0	MODERATE (2.0)	PLATEY	.
3-8	OSTROCOD	M	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
3-9^1	BRYOZOA	B	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
3-9^1	BRACHIOPOD	A	3.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-9^1	TRILOBITE	C	1.0	4.0	MODERATE (2.0)	CONCAVO/CONVEX	.
3-9^2	BRYOZOA	C	2.0	10.0	VERY POOR (1.0)	PLATEY	.
3-9^2	BRYOZOA	A	4.0	10.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
3-9^2	BRACHIOPOD	B	3.0	10.0	POOR (1.5)	CONCAVO/CONVEX	PLATEY

4-17b^5	BRACHIOPOD	A	3.0	3.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17b^5	CRINOID	B	1.0	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-17b^5	TRILOBITE	D	.5	.5	MODERATE/WELL (2.5)	PLATEY	.
4-17b^5	OSTROCOD	E	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17c	BRYOZOA	B	1.0	2.0	MODERATE (2.0)	PLATEY	.
4-17c	BRYOZOA	C	3.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-17c	BRACHIOPOD	A	1.0	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17c	CRINOID	C	1.0	3.0	POOR (1.5)	SOLID/CYLINDRICAL	.
4-17d^2	BRACHIOPOD	D	5.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
4-17d^2	TRILOBITE	B	.5	.5	MODERATE/WELL (2.5)	SOLID/CYLINDRICAL	.
4-18	BRYOZOA	B	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-18	BRACHIOPOD	A	8.0	12.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
4-19^1	BRYOZOA	C	1.0	3.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-19^1	BRACHIOPOD	A	4.0	6.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-19^1	BRACHIOPOD	B	2.0	5.0	MODERATE (2.0)	PLATEY	.
4-19^1	TRILOBITE	E	.5	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-19^1	OSTROCOD	E	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-19^2	BRYOZOA	C	1.0	1.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
4-19^2	BRACHIOPOD	B	1.0	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-19^2	TRILOBITE	A	.5	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-19^2	OSTROCOD	D	1.0	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-19^3	BRYOZOA	B	2.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-19^3	BRACHIOPOD	A	2.0	5.0	POOR (1.5)	CONCAVO/CONVEX	.
4-2	BRACHIOPOD	C	.3	1.0	MODERATE (2.0)	PLATEY	.
4-2	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-2	TRILOBITE	C	.3	1.0	MODERATE (2.0)	PLATEY	.
4-20^1	BRYOZOA	A	2.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-20^1	BRYOZOA	B	2.0	5.0	POOR (1.5)	PLATEY	.
4-20^1	BRACHIOPOD	C	5.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-20^2	BRYOZOA	A	2.0	8.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
4-20^2	BRYOZOA	B	2.0	8.0	VERY POOR (1.0)	PLATEY	.
4-20^2	BRACHIOPOD	C	6.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
4-22	BRYOZOA	A	2.0	5.0	MODERATE (2.0)	BRANCHING	HOLLOW/CYLINDRICAL
4-22	BRACHIOPOD	B	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-22	TRILOBITE	M	.5	2.0	MODERATE/WELL (2.5)	PLATEY	.
4-23	BRYOZOA	A	3.0	6.0	POOR (1.5)	BRANCHING	.
4-23	BRYOZOA	B	3.0	6.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-24a	BRYOZOA	B	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
4-24a	BRACHIOPOD	D	1.0	4.0	POOR (1.5)	PLATEY	.
4-24a	CRINOID	A	2.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-24a	TRILOBITE	D	2.0	4.0	POOR (1.5)	PLATEY	.
4-24a	OSTROCOD	E	1.0	2.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-24b	BRYOZOA	D	.5	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-24b	BRACHIOPOD	C	.5	2.0	MODERATE (2.0)	PLATEY	.
4-24b	CRINOID	B	.5	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-24b	OSTROCOD	A	1.0	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-24c	BRYOZOA	A	1.0	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.

3-9^2	TRILOBITE	D	2.0	10.0	POOR (1.5)	PLATEY	.
4-1	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
4-1	BRACHIOPOD	D	2.0	5.0	POOR (1.5)	CONCAVO/CONVEX	.
4-1	CRINOID	A	.5	2.0	MODERATE (2.0)	DISCOIDAL	CONCAVO/CONVEX
4-1	TRILOBITE	M	2.0	5.0	POOR (1.5)	PLATEY	.
4-10a^1	BRYOZOA	C	1.0	5.0	VERY POOR (1.0)	BRANCHING	SOLID/CYLINDRICAL
4-10a^1	BRACHIOPOD	B	5.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
4-10a^1	CRINOID	A	1.0	2.0	MODERATE (2.0)	DISCOIDAL	.
4-10b	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	SOLID/CYLINDRICAL	.
4-10b	BRACHIOPOD	B	3.0	10.0	VERY POOR (1.0)	PLATEY	CONCAVO/CONVEX
4-10b	BRACHIOPOD	B	2.0	5.0	POOR (1.5)	CONCAVO/CONVEX	.
4-10b	CRINOID	D	1.0	3.0	POOR (1.5)	DISCOIDAL	.
4-10b	TRILOBITE	C	1.0	10.0	VERY POOR (1.0)	PLATEY	.
4-10c	BRYOZOA	A	2.0	5.0	MODERATE (2.0)	BRANCHING	SOLID/CYLINDRICAL
4-14^a	BRYOZOA	B	1.0	3.0	POOR (1.5)	SOLID/CYLINDRICAL	.
4-14^a	CRINOID	A	1.0	2.0	MODERATE (2.0)	DISCOIDAL	.
4-14b	BRYOZOA	A	3.0	8.0	VERY POOR (1.0)	SOLID/CYLINDRICAL	PLATEY
4-14b	CRINOID	B	2.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-14c	BRYOZOA	A	2.0	6.0	POOR (1.5)	PLATEY	HOLLOW/CYLINDRICAL
4-15b	BRYOZOA	A	1.0	3.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-16a	BRYOZOA	A	1.0	5.0	VERY POOR (1.0)	PLATEY	.
4-16a	BRYOZOA	A	1.0	5.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
4-16b^1	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	BRANCHING	.
4-16b^1	BRACHIOPOD	B	5.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-16b^2	BRYOZOA	A	1.0	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-16c^1	BRYOZOA	A	3.0	5.0	MODERATE (2.0)	PLATEY	.
4-16c^1	BRACHIOPOD	B	3.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
4-16c^2	BRYOZOA	A	2.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-16c^3	BRYOZOA	A	1.0	2.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
4-16d^1	BRYOZOA	A	3.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-16d^1	BRACHIOPOD	B	5.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
4-16d^2	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-16d^2	BRYOZOA	B	1.0	3.0	MODERATE (2.0)	BRANCHING	.
4-16d^3	BRYOZOA	A	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-16d^3	BRYOZOA	B	1.0	3.0	MODERATE (2.0)	BRANCHING	.
4-17a	BRYOZOA	B	2.0	5.0	MODERATE (2.0)	BRANCHING	.
4-17a	BRACHIOPOD	A	5.0	8.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17a	CRINOID	C	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-17a	TRILOBITE	D	.5	1.0	MODERATE (2.0)	SOLID/CYLINDRICAL	.
4-17a	OSTROCOD	E	1.0	1.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
4-17b^1	BRACHIOPOD	A	1.0	2.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-17b^1	CRINOID	B	1.0	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-17b^2	CRINOID	A	1.0	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-17b^2	OSTROCOD	C	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17b^3	BRYOZOA	B	4.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
4-17b^3	BRACHIOPOD	A	3.0	3.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-17b^4	BRACHIOPOD	A	3.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
4-17b^4	TRILOBITE	C	1.0	1.0	MODERATE/WELL (2.5)	SOLID/CYLINDRICAL	.
4-17b^4	OSTROCOD	B	1.0	1.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.

4-24c	BRACHIOPOD	B	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-25	BRYOZOA	B	2.0	8.0	MODERATE (2.0)	BRANCHING	HOLLOW/CYLINDRICAL
4-25	BRACHIOPOD	A	10.0	20.0	POOR (1.5)	CONCAVO/CONVEX	PLATEY
4-26	BRYOZOA	B	1.0	6.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
4-26	BRACHIOPOD	A	5.0	10.0	MODERATE (2.0)	DISCOIDAL	.
4-26	CRINOID	C	1.0	5.0	VERY POOR (1.0)	SOLID/CYLINDRICAL	.
4-26	TRILOBITE	D	1.0	5.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
4-27^1	BRYOZOA	A	2.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-27^1	BRACHIOPOD	B	3.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
4-27^2	BRYOZOA	A	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
4-27^2	BRACHIOPOD	B	10.0	20.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-28	BRYOZOA	A	3.0	10.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-28	BRYOZOA	B	28.0	28.0	MODERATE/WELL (2.5)	PLATEY	.
4-28	BRACHIOPOD	B	5.0	15.0	WELL/VERY WELL (3.5)	PLATEY	.
4-28	CRINOID	D	.5	3.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
4-29	BRYOZOA	B	1.0	5.0	MODERATE/WELL (2.5)	BRANCHING	.
4-29	BRACHIOPOD	A	3.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
4-29	CRINOID	C	.5	3.5	VERY POOR (1.0)	DISCOIDAL	.
4-29	CRINOID	E	1.0	3.0	VERY POOR (1.0)	HOLLOW/CYLINDRICAL	.
4-3	BRYOZOA	C	1.0	1.0	MODERATE/WELL (2.5)	BRANCHING	.
4-3	BRACHIOPOD	C	3.0	5.0	POOR (1.5)	PLATEY	.
4-3	CRINOID	A	.5	3.0	POOR (1.5)	DISCOIDAL	.
4-30	BRYOZOA	A	3.0	8.0	VERY POOR (1.0)	BRANCHING	.
4-30	BRACHIOPOD	C	.5	5.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
4-30	CRINOID	B	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
4-31a	BRYOZOA	E	1.0	2.0	POOR (1.5)	PLATEY	.
4-31a	BRACHIOPOD	E	.5	2.0	POOR (1.5)	PLATEY	.
4-31a	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-31b	BRYOZOA	A	4.0	6.0	MODERATE (2.0)	PLATEY	.
4-31b	BRYOZOA	A	3.0	6.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-31b	BRACHIOPOD	C	5.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-4	BRYOZOA	C	1.0	1.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-4	BRACHIOPOD	A	10.0	20.0	POOR (1.5)	CONCAVO/CONVEX	.
4-4	CRINOID	B	2.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-4	TRILOBITE	D	3.0	5.0	POOR (1.5)	PLATEY	CONCAVO/CONVEX
4-5	BRYOZOA	C	1.0	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
4-5	BRACHIOPOD	C	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
4-5	CRINOID	A	2.0	5.0	MODERATE (2.0)	DISCOIDAL	.
4-5	TRILOBITE	M	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^1	BRYOZOA	A	2.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^1	BRACHIOPOD	B	2.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^1	CRINOID	D	2.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-6^1	TRILOBITE	C	2.0	3.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^2	BRYOZOA	B	1.0	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^2	BRACHIOPOD	C	1.0	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-6^2	CRINOID	A	1.0	1.0	MODERATE/WELL (2.5)	DISCOIDAL	.
4-6^2	TRILOBITE	D	.5	1.0	MODERATE/WELL (2.5)	PLATEY	.
4-7	BRACHIOPOD	B	2.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-7	CRINOID	A	2.0	.5	POOR (1.5)	DISCOIDAL	.

4-8	BRYOZOA	C	2.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
4-8	CRINOID	A	.5	3.0	VERY POOR (1.0)	DISCOIDAL	SOLID/CYLINDRICAL
4-8	TRILOBITE	B	1.0	15.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
4-9	BRACHIOPOD	B	3.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.
4-9	CRINOID	A	.5	2.0	POOR (1.5)	DISCOIDAL	SOLID/CYLINDRICAL
4-9	OSTROCOD	D	1.0	1.0	MODERATE/WELL (2.5)	SEMI-SPHEROIDAL	.
4^a	BRYOZOA	A	2.0	5.0	POOR (1.5)	BRANCHING	HOLLOW/CYLINDRICAL
5-1	BRYOZOA	C	2.0	10.0	VERY POOR (1.0)	PLATEY	.
5-1	BRYOZOA	M	1.0	4.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-1	BRACHIOPOD	A	2.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-1	TRILOBITE	B	1.0	30.0	VERY POOR (1.0)	PLATEY	CONCAVO/CONVEX
5-10	BRYOZOA	E	2.0	3.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-10	BRACHIOPOD	A	2.0	10.0	MODERATE/WELL (2.5)	PLATEY	.
5-10	CRINOID	C	1.0	3.0	MODERATE (2.0)	DISCOIDAL	.
5-10	TRILOBITE	B	2.0	10.0	MODERATE/WELL (2.5)	PLATEY	.
5-11^1	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-11^1	BRACHIOPOD	C	2.0	6.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-11^1	CRINOID	A	1.0	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	DISCOIDAL
5-11^1	TRILOBITE	B	1.0	5.0	POOR (1.5)	PLATEY	.
5-11^2	BRYOZOA	M	1.0	3.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
5-11^2	BRACHIOPOD	B	2.0	30.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-11^2	CRINOID	A	1.0	2.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	DISCOIDAL
5-11^2	TRILOBITE	B	1.0	5.0	POOR (1.5)	PLATEY	.
5-11^3	BRYOZOA	M	1.0	1.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-11^3	BRACHIOPOD	A	.	.	MODERATE (2.0)	CONCAVO/CONVEX	.
5-11^3	CRINOID	A	1.0	1.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-11^3	TRILOBITE	B	1.0	5.0	POOR (1.5)	PLATEY	.
5-12	BRYOZOA	C	2.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-12	BRACHIOPOD	A	2.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-12	TRILOBITE	B	.5	4.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-12	FRAGMENTS	A	.5	1.0	.	.	.
5-13	BRYOZOA	C	3.0	6.0	MODERATE/WELL (2.5)	BRANCHING	HOLLOW/CYLINDRICAL
5-13	BRACHIOPOD	A	6.0	25.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
5-13	CRINOID	C	.5	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-13	TRILOBITE	C	.5	3.0	WELL/VERY WELL (3.5)	PLATEY	CONCAVO/CONVEX
5-13	FRAGMENTS	B	.5	2.0	POOR (1.5)	PLATEY	.
5-15	BRYOZOA	B	2.0	6.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-15	BRACHIOPOD	C	.5	10.0	POOR (1.5)	CONCAVO/CONVEX	.
5-15	CRINOID	A	1.0	2.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-15	TRILOBITE	C	.5	10.0	POOR (1.5)	CONCAVO/CONVEX	.
5-16	BRYOZOA	M	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	.
5-16	BRACHIOPOD	A	2.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-16	CRINOID	B	.5	2.0	POOR (1.5)	DISCOIDAL	.
5-16	TRILOBITE	C	.5	3.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-17^1	BRYOZOA	A	2.0	7.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-17^1	BRACHIOPOD	B	1.0	5.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-17^1	CRINOID	C	2.0	3.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-17^1	TRILOBITE	B	.5	3.0	POOR (1.5)	CONCAVO/CONVEX	.
5-17^2	BRYOZOA	A	1.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.

5-17^2	BRACHIOPOD	A	1.0	5.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-17^2	CRINOID	M	1.0	2.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-17^2	TRILOBITE	B	.5	5.0	POOR (1.5)	CONCAVO/CONVEX	.
5-18^1	BRYOZOA	A	2.0	8.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-18^1	BRACHIOPOD	B	2.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-18^1	TRILOBITE	B	1.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
5-18^2	BRYOZOA	A	2.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
5-18^2	BRACHIOPOD	B	2.0	10.0	POOR (1.5)	CONCAVO/CONVEX	.
5-18^2	TRILOBITE	C	2.0	4.0	MODERATE (2.0)	PLATEY	.
5-19	BRACHIOPOD	C	.5	2.0	MODERATE/WELL (2.5)	PLATEY	.
5-19	CRINOID	A	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-19	TRILOBITE	B	.5	7.0	VERY POOR (1.0)	PLATEY	.
5-19	OSTROCOD	C	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-2	BRYOZOA	A	2.0	5.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
5-2	BRYOZOA	B	2.0	5.0	POOR (1.5)	PLATEY	.
5-2	BRACHIOPOD	C	3.0	8.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-2	BRACHIOPOD	C	1.0	3.0	WELL/VERY WELL (3.5)	PLATEY	.
5-2	BRACHIOPOD	A	2.0	4.0	WELL/VERY WELL (3.5)	PLATEY	.
5-2	CRINOID	M	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-2	TRILOBITE	B	1.0	25.0	VERY POOR (1.0)	PLATEY	CONCAVO/CONVEX
5-20^1	BRYOZOA	B	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-20^1	CRINOID	B	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-20^1	FRAGMENTS	A	.5	2.0	MODERATE/WELL (2.5)	PLATEY	.
5-20^2	BRYOZOA	B	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-20^2	CRINOID	B	1.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-20^2	FRAGMENTS	A	.5	2.0	MODERATE/WELL (2.5)	PLATEY	.
5-21	BRYOZOA	A	1.0	6.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-21	BRYOZOA	B	1.0	2.0	WELL/VERY WELL (3.5)	PLATEY	.
5-21	BRACHIOPOD	M	.5	1.0	MODERATE (2.0)	PLATEY	.
5-22	BRYOZOA	A	2.0	7.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-22	BRACHIOPOD	B	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-22	CRINOID	E	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-22	TRILOBITE	D	2.0	4.0	WELL/VERY WELL (3.5)	PLATEY	.
5-23	BRYOZOA	C	1.0	2.0	MODERATE/WELL (2.5)	PLATEY	HOLLOW/CYLINDRICAL
5-23	BRACHIOPOD	B	4.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-23	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-23	TRILOBITE	C	4.0	6.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-24	BRYOZOA	C	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-24	BRACHIOPOD	B	2.0	5.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
5-24	CRINOID	A	1.0	4.0	MODERATE/WELL (2.5)	PLATEY	HOLLOW/CYLINDRICAL
5-24	TRILOBITE	D	1.0	3.0	WELL/VERY WELL (3.5)	PLATEY	.
5-25	BRYOZOA	A	2.0	8.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	PLATEY
5-25	BRACHIOPOD	B	5.0	10.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-25	TRILOBITE	M	2.0	5.0	MODERATE (2.0)	PLATEY	.
5-26	BRYOZOA	A	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-26^1	CRINOID	M	3.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-26^2	BRYOZOA	A	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-26^2	CRINOID	C	3.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-26^3	BRYOZOA	A	.5	1.0	MODERATE/WELL (2.5)	PLATEY	.

5-26^3	BRYOZOA	A	2.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-26^3	CRINOID	M	2.0	3.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-3^1	BRYOZOA	B	1.0	8.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-3^1	BRACHIOPOD	A	2.0	7.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-3^1	TRILOBITE	C	1.0	3.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-3^2	BRYOZOA	B	1.0	8.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-3^2	BRACHIOPOD	A	2.0	7.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-3^2	TRILOBITE	C	1.0	3.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-3^3	BRYOZOA	B	2.0	6.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	PLATEY
5-3^3	BRACHIOPOD	A	2.0	7.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-3^3	TRILOBITE	C	1.0	3.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-4	BRYOZOA	A	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-4	BRACHIOPOD	C	4.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-4	TRILOBITE	B	1.0	14.0	POOR (1.5)	CONCAVO/CONVEX	.
5-4	OSTROCOD	D	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-4^1	BRYOZOA	A	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-4^1	BRACHIOPOD	C	1.0	4.0	MODERATE/WELL (2.5)	PLATEY	.
5-4^1	CRINOID	C	2.0	4.0	WELL/VERY WELL (3.5)	DISCOIDAL	.
5-4^1	TRILOBITE	B	.5	4.0	POOR (1.5)	PLATEY	.
5-4^2	BRYOZOA	B	1.0	5.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-4^2	BRACHIOPOD	D	2.0	10.0	VERY POOR (1.0)	PLATEY	.
5-4^2	CRINOID	C	2.0	4.0	WELL/VERY WELL (3.5)	HOLLOW/CYLINDRICAL	.
5-4^2	TRILOBITE	A	.5	4.0	POOR (1.5)	PLATEY	STICK LIKE
5-5^1	BRYOZOA	A	1.0	7.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-5^1	BRACHIOPOD	B	4.0	10.0	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-5^1	TRILOBITE	B	1.0	7.0	POOR (1.5)	CONCAVO/CONVEX	.
5-5^2	BRYOZOA	A	3.0	8.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	.
5-5^2	BRACHIOPOD	B	2.0	6.0	POOR (1.5)	CONCAVO/CONVEX	.
5-5^2	TRILOBITE	C	3.0	10.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
5-6	BRYOZOA	A	1.0	5.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-6	BRYOZOA	C	2.0	2.0	MODERATE (2.0)	PLATEY	.
5-6	BRACHIOPOD	B	6.0	10.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-6	TRILOBITE	M	3.0	5.0	MODERATE/WELL (2.5)	PLATEY	.
5-7	BRYOZOA	A	1.0	6.0	POOR (1.5)	HOLLOW/CYLINDRICAL	.
5-7	BRACHIOPOD	M	4.0	6.0	WELL/VERY WELL (3.5)	CONCAVO/CONVEX	.
5-7	TRILOBITE	B	1.0	18.0	VERY POOR (1.0)	CONCAVO/CONVEX	.
5-7	OSTROCOD	E	.5	.5	MODERATE/WELL (2.5)	CONCAVO/CONVEX	.
5-8	BRYOZOA	C	.5	2.0	MODERATE (2.0)	BRANCHING	HOLLOW/CYLINDRICAL
5-8	BRACHIOPOD	C	6.0	16.0	MODERATE (2.0)	CONCAVO/CONVEX	.
5-8	CRINOID	A	.5	3.0	MODERATE (2.0)	HOLLOW/CYLINDRICAL	DISCOIDAL
5-8	TRILOBITE	B	2.0	18.0	VERY POOR (1.0)	PLATEY	.
5-9	BRYOZOA	E	1.0	5.0	MODERATE/WELL (2.5)	HOLLOW/CYLINDRICAL	.
5-9	BRACHIOPOD	B	2.0	10.0	POOR (1.5)	PLATEY	.
5-9	CRINOID	A	1.0	2.0	MODERATE/WELL (2.5)	DISCOIDAL	.
5-9	TRILOBITE	C	1.0	5.0	MODERATE/WELL (2.5)	PLATEY	CONCAVO/CONVEX
Mean	3	3	2.1	5.8	3.3	4	5

APPENDIX B
Data Transformation
Z-scores

«RM140» SPSS/PC+ The Statistical Package for IBM PC 4/25/92

SAMPLE	TAXON	ABUNDANC	SMSIZE	LGSIZE	SORTING	SHAPE1	REORIENT	FABRIC	BREAKAGE	ABRASION
1-10	1	1	1.0	5.0	4.0	1	4.0	1.0	2.0	1.0
1-10	2	2	6.0	10.0	3.0	4	4.0	1.0	3.0	1.0
1-10	3	2	1.0	3.0	3.0	3	4.0	1.5	1.5	1.0
1-10	4	2	2.0	10.0	1.0	2	4.0	1.5	2.5	1.0
1-11	1	1	1.0	10.0	1.0	1	4.0	1.5	2.0	2.0
1-11	2	3	3.0	7.0	4.0	4	4.0	.5	3.0	4.0
1-11	4	2	2.0	15.0	1.0	2	4.0	1.0	2.5	1.0
1-12	1	3	1.0	2.0	3.0	7	1.0	1.0	3.5	1.5
1-12	2	2	2.0	5.0	2.0	4	4.0	1.0	3.5	3.0
1-12	3	1	1.0	2.0	4.0	3	4.0	1.0	2.0	1.5

Number of cases read = 10 Number of cases listed = 10

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```
This procedure was completed at 17:39:21
AGGREGATE OUTFILE=*
  /BREAK=TAXON
  /MSIZESM MSIZELG MSORTING MREORIEN MFABRIC MBREAKAG MABRASIO=
      MEAN(SMSIZE LGSIZE SORTING REORIENT FABRIC BREAKAGE ABRASION)
  /DSIZESM DSIZELG DSORTING DREORIEN DFABRIC DBREAKAG DABRASIO=
      SD(SMSIZE LGSIZE SORTING REORIENT FABRIC BREAKAGE ABRASION).
      9 cases are written to the compressed active file.

A new (AGGREGATED) active file has replaced the existing active file.
It contains   18 variables (including system variables).
```

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```
This procedure was completed at 17:39:24
LIST VAR=TAXON MSIZESM TO DABRASIO/CASES=FROM 1 TO 10.
```

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TAXON	MSIZESM	MSIZELG	MSORTING	MREORIEN	MFABRIC	MBREAKAG	MABRASIO	DSIZESM	DSIZELG	DSORTING	DREORIEN	DFABRIC	DBREAKAG	DABRASIO
1	1.88	5.33	3.29	3.70	1.01	2.64	1.50	2.06	4.24	1.54	.71	.40	.65	.81
2	3.70	8.27	3.35	3.85	1.04	2.99	2.35	3.10	6.02	1.43	.55	.34	.85	1.06
3	1.15	2.64	3.65	3.77	.83	2.07	1.53	.59	1.05	1.33	.73	.71	.49	.81
4	1.62	6.99	2.79	3.90	1.01	3.25	1.04	1.05	5.36	1.57	.45	.56	.62	.27
5	.61	.77	3.97	3.77	.87	2.00	1.03	.21	.36	.18	.80	.37	.29	.18
6	5.67	6.83	4.17	4.00	.75	1.00	1.33	3.27	2.86	.98	.00	.96	.00	.82
7	2.00	7.50	3.00	3.00	1.00	3.50	2.50	1.41	6.36	1.41	.00	.	.71	.71
8	.57	1.93	3.00	4.00	.90	4.00	3.60	.19	1.48	1.41	.00	.22	.00	.55
9	2.00	5.40	3.40	2.80	1.00	2.20	1.00	.00	2.61	.89	1.10	.00	.45	.00

Number of cases read = 9 Number of cases listed = 9

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```
This procedure was completed at 17:39:25
SAVE OUTFILE='TAX1.SYS'.
The SPSS/PC+ system file is written to
    file TAX1.SYS
     18 variables (including system variables) will be saved.
      0 variables have been dropped.

The system file consists of:

         432 Characters for the header record.
         576 Characters for variable definition.
        2088 Characters for labels.
        2048 Characters for data.
        5144 Total file size.

      9 out of       9 cases have been saved.
```

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```
This procedure was completed at 17:39:26

GET FILE='ANN1.SYS'.
The SPSS/PC+ system file is read from
    file ANN1.SYS
The file was created on 10/21/92 at  4:47:20
and is titled TAPHONOMY OF KOPE LIMESTONES
The SPSS/PC+ system file contains
```

```
    815 cases, each consisting of
     28 variables (including system variables).
     28 variables will be used in this session.
--------------------------------------------------------------------------------
Page    9                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:26
SORT CASES BY TAXON.

Size of File to Be Sorted:       815 Cases of     224 Bytes Each.
    815 cases are written to the compressed active file.
SORT completed successfully.
--------------------------------------------------------------------------------
Page   10                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:34
JOIN MATCH FILE=*/DROP=THICKNESS ALLOSIZE LCONTACT GRADING
  XLAM MATRIX1 MATRIX2 PERCENTM SILT BIOTURB POLYTAXI AMALGAMA/
  TABLE='TAX1.SYS'/BY TAXON.

WARNING 1037
Duplicate key encountered.
Key values:
        1
--------------------------------------------------------------------------------
Page   11                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:39
SORT CASES BY SAMPLE TAXON.

Size of File to Be Sorted:       815 Cases of     240 Bytes Each.
    815 cases are written to the compressed active file.
SORT completed successfully.
--------------------------------------------------------------------------------
Page   14                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:48
COMPUTE ZSMSIZE=((SMSIZE-MSIZESM)/DSIZESM).
COMPUTE ZLGSIZE=((LGSIZE-MSIZELG)/DSIZELG).
COMPUTE ZSORTING=((SORTING-MSORTING)/DSORTING).
COMPUTE ZREORIEN=((REORIENT-MREORIEN)/DREORIEN).
COMPUTE ZFABRIC=((FABRIC-MFABRIC)/DFABRIC).
COMPUTE ZBREAKAG=((BREAKAGE-MBREAKAG)/DBREAKAG).
COMPUTE ZABRASIO=((ABRASION-MABRASIO)/DABRASIO).
RECODE ZSMSIZE TO ZABRASIO (SYSMIS=0) (MISSING=0).
LIST VAR=SAMPLE ZSMSIZE TO ZABRASIO/CASES=FROM 1 TO 10.
The raw data or transformation pass is proceeding
    815 cases are written to the compressed active file.
--------------------------------------------------------------------------------
Page   15                          SPSS/PC+                              4/25/92

SAMPLE     ZSMSIZE  ZLGSIZE ZSORTING ZREORIEN  ZFABRIC ZBREAKAG ZABRASIO

1-10           -.43     -.08      .46      .43     -.04     -.98     -.62
1-10            .74      .29     -.24      .26     -.12      .01    -1.27
1-10           -.26      .35     -.49      .32      .94    -1.16     -.65
1-10            .36      .56    -1.13      .22      .88    -1.21     -.15
1-11           -.43     1.10    -1.49      .43     1.21     -.98      .62
1-11           -.22     -.21      .46      .26    -1.60      .01     1.56
1-11            .36     1.50    -1.13      .22     -.01    -1.21     -.15
1-12           -.43     -.79     -.19    -3.80     -.04     1.32      .00
1-12           -.55     -.54     -.94      .26     -.12      .60      .61
1-12           -.26     -.61      .26      .32      .24     -.13     -.04


Number of cases read =       10    Number of cases listed =       10
--------------------------------------------------------------------------------
Page   16                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:54
AGGREGATE OUTFILE=*
  /BREAK=SAMPLE
  /MSIZESM MSIZELG MSORTING MREORIEN MFABRIC MBREAKAG MABRASIO=
      MEAN(ZSMSIZE ZLGSIZE ZSORTING ZREORIEN ZFABRIC ZBREAKAG ZABRASIO).
    233 cases are written to the compressed active file.

A new (AGGREGATED) active file has replaced the existing active file.
It contains    11 variables (including system variables).
--------------------------------------------------------------------------------
Page   17                          SPSS/PC+                              4/25/92

This procedure was completed at 17:39:57
LIST VAR=SAMPLE MSIZESM TO MABRASIO/CASES=FROM 1 TO 10.
--------------------------------------------------------------------------------
Page   18                          SPSS/PC+                              4/25/92

SAMPLE     MSIZESM  MSIZELG MSORTING MREORIEN  MFABRIC MBREAKAG MABRASIO

1-10            .11      .28     -.35      .31      .42     -.83     -.67
1-11           -.10      .80     -.72      .30     -.13     -.72      .68
1-12           -.46     -.62     -.34     -.75      .02      .75      .11
1-13           2.08     4.77    -1.37      .02    -1.85    -1.07     -.64
1-14           -.22      .19     -.87      .33      .15     -.39     -.48
1-15           -.19     -.40     -.37     -.91     1.64      .09     -.51
1-16            .09     2.39     -.86      .32     -.53     -.59     -.47
1-17           -.75     -.49      .32      .31      .19      .52      .03
1-18            .00      .45     -.62      .25      .35      .11     -.74
1-19           -.45     -.21     -.65      .25     -.14     -.20     -.43
```

Number of cases read = 10 Number of cases listed = 10

SAMPLE	THICKNES	ALLOSIZE	SORT	GRADING	XLAM	MATRIX1	PERCENTM	POLYTAXI
1-10	6.5	3	5	1	2	5	4	1
1-11	7.5	4	3	1	2	3	2	1
1-12	7.0	1	5	2	3	5	.	1
1-13	5.5	5	1	1	2	2	1	1
1-14	9.5	3	4	1	1	5	4	1
1-15	10.0	3	2	1	2	3	2	1
1-16	7.0	2	4	1	1	3	4	1
1-17	10.0	2	4	1	1	5	4	1
1-18	12.0	2	1	1	1	3	3	2
1-19	6.0	5	1	1	2	3	4	1

Number of cases read = 10 Number of cases listed = 10

SAMPLE	MSIZESM	MSIZELG	MSORTING	MREORIEN	MFABRIC	MBREAKAG	MABRASIO	THICKNES	ALLOSIZE	SORT	GRADING	XLAM	MATRIX1	PERCENTM	POLYTAXI
1-10	.11	.28	-.35	.31	.42	-.83	-.67	6.5	3	5	1	2	5	4	1
1-11	-.10	.80	-.72	.30	-.13	-.72	.68	7.5	4	3	1	2	3	2	1
1-12	-.46	-.62	-.34	-.75	.02	.75	.11	7.0	1	5	2	3	5	.	1
1-13	2.08	4.77	-1.37	.02	-1.85	-1.07	-.64	5.5	5	1	1	2	2	1	1
1-14	-.22	.19	-.87	.33	.15	-.39	-.48	9.5	3	4	1	1	5	4	1
1-15	-.19	-.40	-.37	-.91	1.64	.09	-.51	10.0	3	2	1	2	3	2	1
1-16	.09	2.39	-.86	.32	-.53	-.59	-.47	7.0	2	4	1	1	3	4	1
1-17	-.75	-.49	.32	.31	.19	.52	.03	10.0	2	4	1	1	5	4	1
1-18	.00	.45	-.62	.25	.35	.11	-.74	12.0	2	1	1	1	3	3	2
1-19	-.45	-.21	-.65	.25	-.14	-.20	-.43	6.0	5	1	1	2	3	4	1

Number of cases read = 10 Number of cases listed = 10

0

ALLOSIZE ALLOCHEM SIZE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
FINE	1	249	30.6	30.9	30.9
MDFINE	2	123	15.1	15.3	46.2
MEDIUM	3	229	28.1	28.4	74.6
MCORSE	4	66	8.1	8.2	82.8
COARSE	5	139	17.1	17.2	100.0
	.	9	1.1	Missing	
	Total	815	100.0	100.0	

GRADING GRADING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
FINNING UP	1	538	66.0	67.6	67.6
NONE	2	186	22.8	23.4	91.0
COARSNING UP	3	49	6.0	6.2	97.1
MULTITREND	4	23	2.8	2.9	100.0
	.	19	2.3	Missing	
	Total	815	100.0	100.0	

XLAM CROSS LAMINATION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
YES	1	165	20.2	21.3	21.3
NO	2	541	66.4	69.7	91.0
UNC	3	70	8.6	9.0	100.0
	.	39	4.8	Missing	
	Total	815	100.0	100.0	

PERCENTM PERCENT MATRIX

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
>90%	1	68	8.3	9.3	9.3
75%-90%	2	60	7.4	8.2	17.5
50%-75%	3	277	34.0	37.9	55.5
<50%	4	325	39.9	44.5	100.0
	.	85	10.4	Missing	
	Total	815	100.0	100.0	

AMALGAMA AMALGAMATED

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
YES	1	121	14.8	40.7	40.7
NO	2	53	6.5	17.8	58.6
UNC	3	123	15.1	41.4	100.0
	.	518	63.6	Missing	
	Total	815	100.0	100.0	

TAXON TAXON

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
BRYOZOA	1	248	30.4	30.4	30.4
BRACHIOPOD	2	212	26.0	26.0	56.4
CRINOID	3	139	17.1	17.1	73.5
TRILOBITE	4	163	20.0	20.0	93.5
OSTRACOD	5	31	3.8	3.8	97.3
GASTROPOD	6	6	.7	.7	98.0
BIVALVE	7	2	.2	.2	98.3
FRAGMENTS	8	9	1.1	1.1	99.4
GRAPTOLITS	9	5	.6	.6	100.0
	Total	815	100.0	100.0	

ABUNDANC ABUNDANCE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
A	1	235	28.8	29.0	29.0
B	2	223	27.4	27.5	56.5
C	3	183	22.5	22.6	79.0
D	4	80	9.8	9.9	88.9
E	5	34	4.2	4.2	93.1
F	6	3	.4	.4	93.5
M	7	53	6.5	6.5	100.0
	.	4	.5	Missing	
	Total	815	100.0	100.0	

PROCESS IF (TAXON EQ 1).

SORTING SORTING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
VP	1.0	36	14.5	14.5	14.5
POOR	2.0	37	14.9	14.9	29.4
MOD	3.0	72	29.0	29.0	58.5
M/W	4.0	65	26.2	26.2	84.7
W/VW	6.0	35	14.1	14.1	98.8
VW	7.0	3	1.2	1.2	100.0
	Total	248	100.0	100.0	

BREAKAGE BREAKAGE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
UNBROKEN	1.0	1	.4	.4	.4
	1.5	7	2.8	2.8	3.3
MINIMAL	2.0	78	31.5	31.7	35.0
	2.5	54	21.8	22.0	56.9
DISARTIC	3.0	73	29.4	29.7	86.6
	3.5	10	4.0	4.1	90.7
MIN INTRN	4.0	23	9.3	9.3	100.0
	.	2	.8	Missing	
	Total	248	100.0	100.0	

ABRASION ABRASION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
<10%	1.0	154	62.1	63.9	63.9
	1.5	11	4.4	4.6	68.5
10%-20%	2.0	45	18.1	18.7	87.1
	2.5	3	1.2	1.2	88.4
20%-40%	3.0	18	7.3	7.5	95.9
40%-50%	4.0	10	4.0	4.1	100.0
	.	7	2.8	Missing	
	Total	248	100.0	100.0	

SHAPE1 PREDOM SHAPE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
BRANCHING	1	35	14.1	14.1	14.1
PLATEY	2	45	18.1	18.1	32.3
CONCAVO/CONVEX	4	6	2.4	2.4	34.7
SEMI-SPHEROIDAL	5	1	.4	.4	35.1
SOLID/CYLNDRCLE	6	6	2.4	2.4	37.5
HOLLOW/CYLNDRCL	7	155	62.5	62.5	100.0
	Total	248	100.0	100.0	

PROCESS IF (TAXON EQ 2).

SORTING SORTING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
VP	1.0	28	13.2	13.3	13.3
POOR	2.0	28	13.2	13.3	26.5
MOD	3.0	50	23.6	23.7	50.2
M/W	4.0	79	37.3	37.4	87.7
W/VW	6.0	26	12.3	12.3	100.0
	.	1	.5	Missing	
	Total	212	100.0	100.0	

BREAKAGE BREAKAGE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.5	1	.5	.5	.5
UNBROKEN	1.0	2	.9	.9	1.4
	1.5	4	1.9	1.9	3.3
MINIMAL	2.0	43	20.3	20.4	23.7
	2.5	32	15.1	15.2	36.9
DISARTIC	3.0	53	25.0	25.1	64.0
	3.5	21	9.9	10.0	73.9
MIN INTRN	4.0	53	25.0	25.1	99.1
EXTENSIVE	6.0	2	.9	.9	100.0
	.	1	.5	Missing	
	Total	212	100.0	100.0	

ABRASION ABRASION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
<10%	1.0	57	26.9	27.3	27.3
	1.5	4	1.9	1.9	29.2
10%-20%	2.0	49	23.1	23.4	52.6
	2.5	4	1.9	1.9	54.5
20%-40%	3.0	59	27.8	28.2	82.8
	3.5	2	.9	1.0	83.7
40%-50%	4.0	34	16.0	16.3	100.0
	.	3	1.4	Missing	
	Total	212	100.0	100.0	

SHAPE1 PREDOM SHAPE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
PLATEY	2	71	33.5	33.5	33.5
DISCOIDAL	3	1	.5	.5	34.0
CONCAVO/CONVEX	4	140	66.0	66.0	100.0
	Total	212	100.0	100.0	

PROCESS IF (TAXON EQ 3).

SORTING SORTING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
VP	1.0	10	7.2	7.2	7.2
POOR	2.0	13	9.4	9.4	16.5
MOD	3.0	34	24.5	24.5	41.0
M/W	4.0	61	43.9	43.9	84.9
W/VW	6.0	21	15.1	15.1	100.0
	Total	139	100.0	100.0	

BREAKAGE BREAKAGE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	.5	1	.7	.7	.7
UNBROKEN	1.0	1	.7	.7	1.5
	1.5	29	20.9	21.2	22.6
MINIMAL	2.0	66	47.5	48.2	70.8
	2.5	33	23.7	24.1	94.9
DISARTIC	3.0	4	2.9	2.9	97.8
	3.5	1	.7	.7	98.5
MIN INTRN	4.0	2	1.4	1.5	100.0
	.	2	1.4	Missing	
	Total	139	100.0	100.0	

ABRASION ABRASION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
<10%	1.0	86	61.9	64.7	64.7
	1.5	2	1.4	1.5	66.2
10%-20%	2.0	23	16.5	17.3	83.5
	2.5	1	.7	.8	84.2
20%-40%	3.0	18	12.9	13.5	97.7
40%-50%	4.0	3	2.2	2.3	100.0
	.	6	4.3	Missing	
	Total	139	100.0	100.0	

SHAPE1 PREDOM SHAPE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
BRANCHING	1	1	.7	.7	.7
PLATEY	2	2	1.4	1.4	2.2
DISCOIDAL	3	110	79.1	79.1	81.3
CONCAVO/CONVEX	4	4	2.9	2.9	84.2
SOLID/CYLNDRCLE	6	2	1.4	1.4	85.6
HOLLOW/CYLNDRCL	7	20	14.4	14.4	100.0
	Total	139	100.0	100.0	

PROCESS IF (TAXON EQ 4).

SORTING SORTING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
VP	1.0	43	26.4	26.4	26.4
POOR	2.0	39	23.9	23.9	50.3
MOD	3.0	27	16.6	16.6	66.9
M/W	4.0	36	22.1	22.1	89.0
W/VW	6.0	18	11.0	11.0	100.0
	Total	163	100.0	100.0	

BREAKAGE BREAKAGE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1.5	1	.6	.6	.6
MINIMAL	2.0	10	6.1	6.2	6.8
	2.5	18	11.0	11.1	17.9
DISARTIC	3.0	61	37.4	37.7	55.6
	3.5	23	14.1	14.2	69.8
MIN INTRN	4.0	49	30.1	30.2	100.0
	.	1	.6	Missing	
	Total	163	100.0	100.0	

ABRASION ABRASION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
<10%	1.0	156	95.7	96.9	96.9
	1.5	1	.6	.6	97.5
10%-20%	2.0	3	1.8	1.9	99.4
40%-50%	4.0	1	.6	.6	100.0
	.	2	1.2	Missing	
	Total	163	100.0	100.0	

SHAPE1 PREDOM SHAPE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
PLATEY	2	128	78.5	79.0	79.0
DISCOIDAL	3	1	.6	.6	79.6
CONCAVO/CONVEX	4	28	17.2	17.3	96.9
SOLID/CYLNDRCLE	6	3	1.8	1.9	98.8
STICK LIKE	8	2	1.2	1.2	100.0
	.	1	.6	Missing	
	Total	163	100.0	100.0	

PROCESS IF (TAXON EQ 5).

SORTING SORTING

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
MOD	3.0	1	3.2	3.2	3.2
M/W	4.0	30	96.8	96.8	100.0
	Total	31	100.0	100.0	

BREAKAGE BREAKAGE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
UNBROKEN	1.0	1	3.2	3.2	3.2
	1.5	1	3.2	3.2	6.5
MINIMAL	2.0	27	87.1	87.1	93.5
	2.5	1	3.2	3.2	96.8
DISARTIC	3.0	1	3.2	3.2	100.0
	Total	31	100.0	100.0	

ABRASION ABRASION

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
<10%	1.0	30	96.8	96.8	96.8
10%-20%	2.0	1	3.2	3.2	100.0
	Total	31	100.0	100.0	

SHAPE1 PREDOM SHAPE

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
CONCAVO/CONVEX	4	29	93.5	93.5	93.5
SEMI-SPHEROIDAL	5	2	6.5	6.5	100.0
	Total	31	100.0	100.0	

0

Page 3 TAPHONOMY OF KOPE LIMESTONES 4/26/92
TAXON TAXON by BREAKAGE BREAKAGE

BREAKAGE — Page 1 of 1

Col Pct		.5	UNBROKEN (1.0) 1.0	1.5	MINIMAL (1.5) 2.0	2.5	DISARTIC (2.0) 3.0	3.5	MIN INTR N (2.5) 4.0	EXTENSIV E (3.5) 6.0	Row Total
TAXON											
BRYOZOA	1		9.1	16.7	34.2	39.1	37.6	18.2	17.3		246 30.6
BRACHIOPOD	2	50.0	18.2	9.5	18.9	23.2	27.3	38.2	39.8	100.0	211 26.2
CRINOID	3	50.0	9.1	69.0	28.9	23.9	2.1	1.8	1.5		137 17.0
TRILOBITE	4			2.4	4.4	13.0	31.4	41.8	36.8		162 20.1
OSTROCOD	5		9.1	2.4	11.8	.7	.5				31 3.9
GASTROPOD	6		54.5								6 .7
BIVALVE	7						.5		.8		2 .2
FRAGMENTS	8								3.8		5 .6
GRAPTOLITS	9				1.8		.5				5 .6
Column Total		2 .2	11 1.4	42 5.2	228 28.3	138 17.1	194 24.1	55 6.8	133 16.5	2 .2	805 100.0

Number of Missing Observations: 10

Page 4 TAPHONOMY OF KOPE LIMESTONES 4/26/92
TAXON TAXON by ABRASION ABRASION

ABRASION — Page 1 of 1

Col Pct		<10% (1.0) 1.0	1.5	10%-20% (1.5) 2.0	2.5	20%-40% (2.0) 3.0	3.5	40%-50% (2.5) 4.0	Row Total
TAXON									
BRYOZOA	1	31.2	61.1	36.9	37.5	18.2		19.6	241 30.4
BRACHIOPOD	2	11.6	22.2	40.2	50.0	59.6	100.0	66.7	209 26.4
CRINOID	3	17.4	11.1	18.9	12.5	18.2		5.9	133 16.8
TRILOBITE	4	31.6	5.6	2.5				2.0	161 20.3

Page 5 TAPHONOMY OF KOPE LIMESTONES
TAXON TAXON by SHAPE1 PREDOM SHAPE

SHAPE1 — Page 1 of 1

Row Pct

TAXON		BRANCHING 1	PLATEY 2	DISCOIDAL 3	CONCAVO/CONVEX 4	SEMI-SPHEROIDAL 5	SOLID/CYLNDRCLE 6	HOLLOW/CYLNDRCL 7	STICK LIKE 8	Row Total
BRYOZOA	1	14.1	18.1		2.4	.4	2.4	62.5		248 30.7
BRACHIOPOD	2		33.5	.5	66.0					212 26.2
CRINOID	3	.7	1.4	79.1	2.9		1.4	14.4		139 17.2
TRILOBITE	4		79.0	.6	17.3		1.9		1.2	162 20.0
OSTRACOD	5				93.5	6.5				31 3.8
GASTROPOD	6			16.7		83.3				6 .7
BIVALVE	7		100.0							2 .2
FRAGMENTS	8		100.0							4 .5
GRAPTOLITS	9								100.0	5 .6
Column Total		36 4.4	252 31.1	113 14.0	207 25.6	8 1.0	11 1.4	175 21.6	7 .9	809 100.0

Number of Missing Observations: 6

Page 6 TAPHONOMY OF KOPE LIMESTONES 4/26/92

This procedure was completed at 14:46:37

Page 7 TAPHONOMY OF KOPE LIMESTONES 4/26/92

FINISH.

End of Include file.

APPENDIX C
Factor Analysis

```
 SPSS/PC+ The Statistical Package for IBM PC
5/2/92

TAPHONOMY OF KOPE LIMESTONES
The SPSS/PC+ system file contains
    233 cases, each consisting of
     16 variables (including system variables).
     16 variables will be used in this session.
------------------------------------------------------------
-------------------

FACTOR VAR=MSORTING MREORIEN MFABRIC MBREAKAG MABRASIO MSORT
MALLOSIZ
   MPERCENT MGRADING MXLAM/
  /EXTRACTION=PC
  /PRINT=CORRELATION KMO AIC ROTATION INITIAL EXTRATION
  /PLOT=EIGEN
  /FORMAT=SORT BLANK(.3)
  /ROTATION=VARIMAX
  /SAVE=REG (3 FS)
  /WIDTH=132.

This FACTOR analysis requires      14280 (      13.9K) BYTES
of memory.
------------------------------------------------------------
-------------------
              - - - - - - - - - - - - - - - - - -   F A C T O
R  A N A L Y S I S  - - - - - - - - - - - - - - - - - -

Analysis Number  1  Listwise deletion of cases with missing
values

Correlation Matrix:

          MSORTING  MREORIEN   MFABRIC  MBREAKAG  MABRASIO
MSORT  MALLOSIZ  MPERCENT  MGRADING     MXLAM

MSORTING   1.00000
MREORIEN    .23727   1.00000
MFABRIC     .01576    .07182   1.00000
MBREAKAG    .35659    .18262    .07256   1.00000
MABRASIO    .25253    .17329    .00599    .60591   1.00000
MSORT       .37262    .19126    .24639    .27517    .23146
1.00000
```

MALLOSIZ -.26238 -.20190 -.07767 -.49874 -.35910
-.39853 1.00000
MPERCENT .22065 .08557 .08031 .16198 .20820
.29430 -.26011 1.00000
MGRADING -.12479 -.14711 -.14050 .03891 -.00748
-.23296 .14477 -.20632 1.00000
MXLAM .14539 -.10531 .01677 -.05816 -.02709
.02058 .13975 .06472 -.11459 1.00000

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .71369

Bartlett Test of Sphericity = 330.71424, Significance =
.00000

There are 34 (37.8%) off-diagonal elements of AIC Matrix >
0.09

Anti-Image Covariance Matrix:

	MSORTING	MREORIEN	MFABRIC	MBREAKAG
MABRASIO	MSORT	MALLOSIZ	MPERCENT	MGRADING
MSORTING	.72983			
MREORIEN	-.13501	.88446		
MFABRIC	.08414	-.03496	.91549	
MBREAKAG	-.13241	-.01116	-.05592	.50143
MABRASIO	.00449	-.04921	.05372	-.27924
.61189				
MSORT	-.17748	-.03089	-.17880	.00010
-.02884	.68300			
MALLOSIZ	.00269	.03981	-.02777	.19222
.02322	.15714	.63474		
MPERCENT	-.06736	.02062	-.01385	.02884
-.08306	-.10637	.09248	.84768	
MGRADING	.02526	.10374	.08144	-.09582
-.00582	.09350	-.08314	.11238	.86707
MXLAM	-.15005	.12161	-.01681	.01335
-.01065	-.00092	-.12236	-.04660	.10549

MXLAM

MXLAM .90977

Anti-Image Correlation Matrix:

	MSORTING	MREORIEN	MFABRIC	MBREAKAG	MABRASIO	MSORT	MALLOSIZ	MPERCENT	MGRADING	MXLAM
MSORTING	.73766									
MREORIEN	-.16805	.77115								
MFABRIC	.10294	-.03885	.54871							
MBREAKAG	-.21887	-.01675	-.08253	.66446						
MABRASIO	.00671	-.06689	.07178	-.50412	.71008					
MSORT	-.25137	-.03974	-.22611	.00017	-.04462	.76089				
MALLOSIZ	.00396	.05313	-.03643	.34072	.03726	.23866	.76544			
MPERCENT	-.08564	.02381	-.01572	.04424	-.11533	-.13979	.12607	.80860		
MGRADING	.03175	.11846	.09141	-.14531	-.00799	.12150	-.11207	.13108	.64739	
MXLAM	-.18414	.13558	-.01842	.01977	-.01427	-.00117	-.16102	-.05307	.11878	.43476

Measures of sampling adequacy (MSA) are printed on the diagonal.

Extraction 1 for Analysis 1, Principal-Components Analysis (PC)

Initial Statistics:

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
MSORTING	1.00000	*	1	2.80949	28.1	28.1
MREORIEN	1.00000	*	2	1.38913	13.9	42.0
MFABRIC	1.00000	*	3	1.10682	11.1	53.1
MBREAKAG	1.00000	*	4	.95150	9.5	62.6
MABRASIO	1.00000	*	5	.89087	8.9	71.5

MSORT	1.00000	*	6	.74510	7.5	78.9
MALLOSIZ	1.00000	*	7	.70694	7.1	86.0
MPERCENT	1.00000	*	8	.55825	5.6	91.6
MGRADING	1.00000	*	9	.51354	5.1	96.7
MXLAM	1.00000	*	10	.32836	3.3	100.0

```
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      2.809   *
          |
          |
          |
 E        |
 I        |
 G        |
 E        |
 N        |
 V        |
 A    1.389       *
 L        |
 U    1.107           *
 E     .891               *   *
 S     .745                       *
       .707                           *
       .514                               *   *
       .328                                       *
          |
          |
       .000 --- --- --- --- --- --- --- --- --- ---
--------------------------------------------------------------
-------------------

              1   2   3   4   5   6   7   8   9  10
```

PC Extracted 3 factors.

Factor Matrix:

	FACTOR 1	FACTOR 2	FACTOR 3
MBREAKAG	.72541	-.43347	
MALLOSIZ	-.71366		
MSORT	.66458	.31133	
MABRASIO	.65267	-.40462	
MSORTING	.60812		.34357
MPERCENT	.48526	.30722	
MREORIEN	.42053		-.34201
MGRADING		-.65237	
MXLAM		.46582	.73682
MFABRIC		.40508	-.44597

Final Statistics:

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
MSORTING	.50109	*	1	2.80949	28.1	28.1
MREORIEN	.29417	*	2	1.38913	13.9	42.0
MFABRIC	.41016	*	3	1.10682	11.1	53.1
MBREAKAG	.73040	*				
MABRASIO	.62749	*				
MSORT	.55267	*				
MALLOSIZ	.56234	*				
MPERCENT	.34565	*				
MGRADING	.52121	*				
MXLAM	.76027	*				

Varimax Rotation 1, Extraction 1, Analysis 1 - Kaiser Normalization.

Varimax converged in 6 iterations.

Rotated Factor Matrix:

	FACTOR 1	FACTOR 2	FACTOR 3
MBREAKAG	.85223		
MABRASIO	.78783		
MALLOSIZ	-.66709		
MSORTING	.54431		.39835
MGRADING		-.68206	
MFABRIC		.61360	
MSORT	.42180	.60392	
MPERCENT	.31116	.40121	
MREORIEN		.37430	
MXLAM			.86724

Factor Transformation Matrix:

	FACTOR 1	FACTOR 2	FACTOR 3
FACTOR 1	.87622	.47644	.07241
FACTOR 2	-.44593	.74463	.49666
FACTOR 3	.18271	-.46748	.86492

3 PC EXACT FACTOR SCORES WILL BE SAVED WITH ROOTNAME: FS

FOLLOWING FACTOR SCORES WILL BE ADDED TO THE ACTIVE FILE:

NAME	LABEL
FS1	REGR FACTOR SCORE 1 FOR ANALYSIS 1
FS2	REGR FACTOR SCORE 2 FOR ANALYSIS 1
FS3	REGR FACTOR SCORE 3 FOR ANALYSIS 1

FINISH.

APPENDIX D
Cluster Analysis

«RM135»
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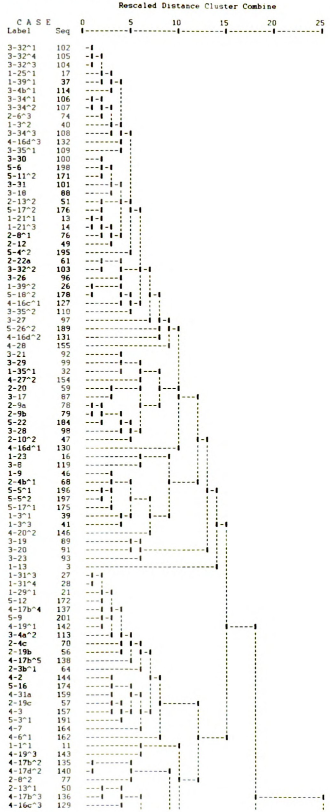
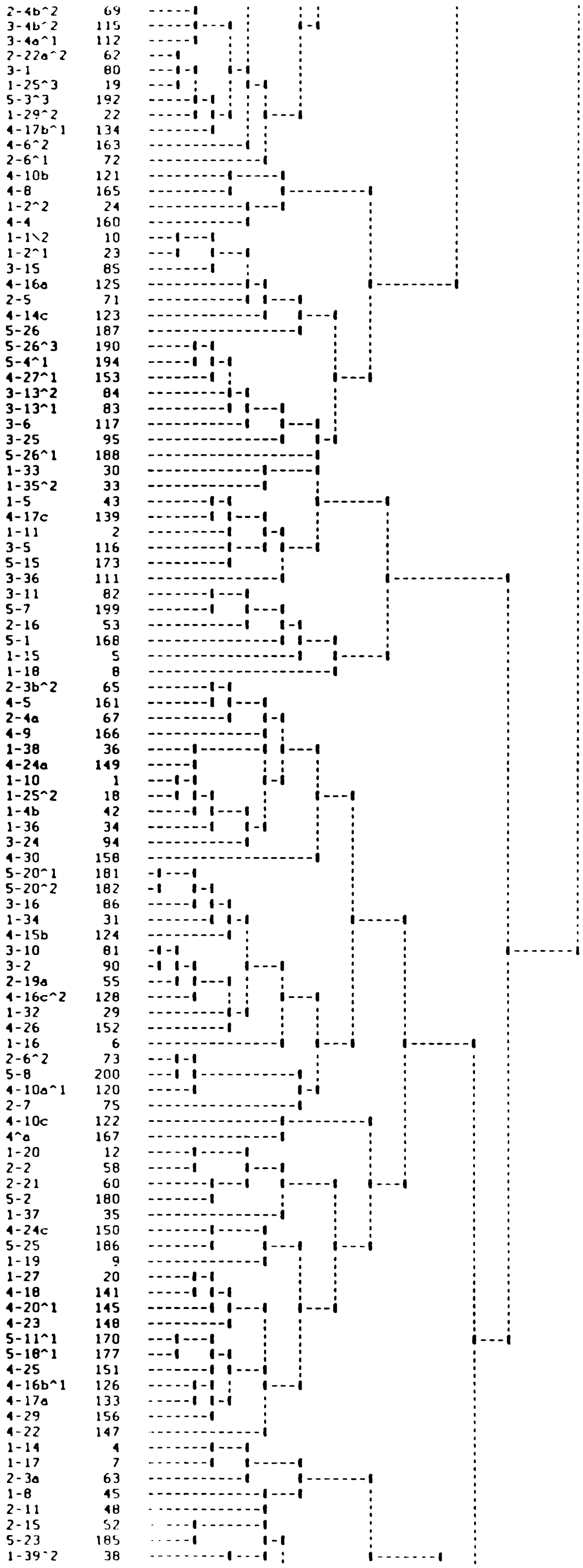
Dendrogram using Average Linkage (Within Group)




2-4b^2 69
3-4b^2 115
3-4a^1 112
2-22a^2 62
3-1 80
1-25^3 19
5-3^3 192
1-29^2 22
4-17b^1 134
4-6^2 163
2-6^1 72
4-10b 121
4-8 165
1-2^2 24
4-4 160
1-1\2 10
1-2^1 23
3-15 85
4-16a 125
2-5 71
4-14c 123
5-26 187
5-26^3 190
5-4^1 194
4-27^1 153
3-13^2 84
3-13^1 83
3-6 117
3-25 95
5-26^1 188
1-33 30
1-35^2 33
1-5 43
4-17c 139
1-11 2
3-5 116
5-15 173
3-36 111
3-11 82
5-7 199
2-16 53
5-1 168
1-15 5
1-18 8
2-3b^2 65
4-5 161
2-4a 67
4-9 166
1-38 36
4-24a 149
1-10 1
1-25^2 18
1-4b 42
1-36 34
3-24 94
4-30 158
5-20^1 181
5-20^2 182
3-16 86
1-34 31
4-15b 124
3-10 81
3-2 90
2-19a 55
4-16c^2 128
1-32 29
4-26 152
1-16 6
2-6^2 73
5-8 200
4-10a^1 120
2-7 75
4-10c 122
4^a 167
1-20 12
2-2 58
2-21 60
5-2 180
1-37 35
4-24c 150
5-25 186
1-19 9
1-27 20
4-18 141
4-20^1 145
4-23 148
5-11^1 170
5-18^1 177
4-25 151
4-16b^1 126
4-17a 133
4-29 156
4-22 147
1-14 4
1-17 7
2-3a 63
1-8 45
2-11 48
2-15 52
5-23 185
1-39^2 38

```
5-19     179   ---------I     :           :       :   :
1-30      25   ---I-I         I----I      :       :   :
3-7      118   ---I I---I     :    :      :       :   :
5-10     169   -----I   I-I   :    :      :       :   :
1-22      15   -------I-I I-I :    I------I       I---I
5-4      193   -------I   : I-I    :              :
5-21     183   -----------I :      :              :
1-6       44   -------------I      :              :
2-4       66   --------------------I              :
2-18      54   -----------------------------------I
```

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Variables (Cluster Membership) Saved into Active File

CLUSMEM9 for Average Linkage (Within Group)

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This procedure was completed at 20:23:04

MEANS TABLES = MSIZESM TO POLYTAXI BY CLUSMEM9.

***** Given WORKSPACE allows for 7132 Cells with 1 Dimensions for MEANS.

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Summaries of MSIZESM
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			.0118	.5831	201
CLUSMEM9	1		.0593	.4206	28
CLUSMEM9	2		-.1682	.2214	8
CLUSMEM9	3		.2584	.7030	62
CLUSMEM9	4		-.2070	.3598	17
CLUSMEM9	5		-.1865	.2167	6
CLUSMEM9	6		.0821	.4282	21
CLUSMEM9	7		.0954	.8565	19
CLUSMEM9	8		-.3287	.3196	39
CLUSMEM9	9		-.0391	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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Summaries of MSIZELG
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			.0113	.7076	201
CLUSMEM9	1		.2338	.6313	28
CLUSMEM9	2		.2762	.5529	8
CLUSMEM9	3		.1952	.9045	62
CLUSMEM9	4		-.1908	.4518	17
CLUSMEM9	5		.3876	.6072	6
CLUSMEM9	6		.1726	.4667	21
CLUSMEM9	7		.0124	.4350	19
CLUSMEM9	8		-.5516	.3968	39
CLUSMEM9	9		-.0079	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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Summaries of MSORTING
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0466	.6561	201
CLUSMEM9	1		-.2993	.5718	28
CLUSMEM9	2		-.7990	.4948	8
CLUSMEM9	3		.0962	.7168	62
CLUSMEM9	4		.2909	.4639	17
CLUSMEM9	5		-.2272	.2445	6
CLUSMEM9	6		-.2116	.5438	21
CLUSMEM9	7		-.4373	.6735	19
CLUSMEM9	8		.2174	.5243	39
CLUSMEM9	9		.1346	.0000	1

Total Cases = 233

Missing Cases = 32 OR 13.7 PCT.

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Summaries of MREORIEN
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0376	.7202	201
CLUSMEM9	1		.0718	.6423	28
CLUSMEM9	2		.0499	.3541	8
CLUSMEM9	3		.0094	.7811	62
CLUSMEM9	4		.1889	.4892	17
CLUSMEM9	5		.0981	.4961	6
CLUSMEM9	6		-.4239	.8870	21
CLUSMEM9	7		-.5549	.9514	19
CLUSMEM9	8		.1231	.4155	39
CLUSMEM9	9		.3036	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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Summaries of MFABRIC
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0313	.7067	201
CLUSMEM9	1		.2625	.7155	28
CLUSMEM9	2		.1784	.8342	8
CLUSMEM9	3		-.0166	.6941	62
CLUSMEM9	4		.0123	.3066	17
CLUSMEM9	5		.1254	.9171	6
CLUSMEM9	6		-.2051	.8831	21
CLUSMEM9	7		-.3933	.8370	19
CLUSMEM9	8		-.0812	.5553	39
CLUSMEM9	9		-.0555	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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Summaries of MBREAKAG
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0464	.6575	201
CLUSMEM9	1		-.1586	.6075	28
CLUSMEM9	2		-.4072	.4775	8
CLUSMEM9	3		-.1990	.4778	62
CLUSMEM9	4		.2581	.5206	17
CLUSMEM9	5		-.0952	.3025	6
CLUSMEM9	6		-.4813	.5252	21
CLUSMEM9	7		-.5290	.4813	19
CLUSMEM9	8		.7084	.5420	39
CLUSMEM9	9		-.5789	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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Summaries of MABRASIO
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0544	.6669	201
CLUSMEM9	1		-.1245	.5983	28
CLUSMEM9	2		-.0469	.5403	8
CLUSMEM9	3		-.1693	.4201	62
CLUSMEM9	4		-.0054	.5155	17
CLUSMEM9	5		-.0273	.6744	6
CLUSMEM9	6		-.3652	.4604	21
CLUSMEM9	7		-.3940	.2918	19
CLUSMEM9	8		.5007	.9806	39
CLUSMEM9	9		-.6819	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

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4/27/92

Variables (Cluster Membership) Saved into Active File

CLUSMEM9 for Average Linkage (Within Group)

MEANS TABLES = MSIZESM TO POLYTAXI BY CLUSMEM9.

***** Given WORKSPACE allows for 7132 Cells with 1 Dimensions for MEANS.

Summaries of MSIZESM
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			.0118	.5831	201
CLUSMEM9	1		.0593	.4206	28
CLUSMEM9	2		-.1682	.2214	8
CLUSMEM9	3		.2584	.7030	62
CLUSMEM9	4		-.2070	.3398	17
CLUSMEM9	5		-.1865	.2167	6
CLUSMEM9	6		.0821	.4282	21
CLUSMEM9	7		.0954	.8565	19
CLUSMEM9	8		-.3287	.3196	39
CLUSMEM9	9		-.0391	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MSIZELG
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			.0113	.7076	201
CLUSMEM9	1		.2338	.6313	28
CLUSMEM9	2		.2762	.5529	8
CLUSMEM9	3		.1952	.9045	62
CLUSMEM9	4		-.1908	.4518	17
CLUSMEM9	5		.3876	.6072	6
CLUSMEM9	6		.1726	.4667	21
CLUSMEM9	7		.0124	.4350	19
CLUSMEM9	8		-.5516	.3968	39
CLUSMEM9	9		-.0079	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MSORTING
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0466	.6561	201
CLUSMEM9	1		-.2993	.5718	28
CLUSMEM9	2		-.7990	.4948	8
CLUSMEM9	3		.0962	.7168	62
CLUSMEM9	4		.2909	.4639	17
CLUSMEM9	5		-.2272	.2445	6
CLUSMEM9	6		-.2116	.5438	21
CLUSMEM9	7		-.4373	.6735	19
CLUSMEM9	8		.2174	.5243	39
CLUSMEM9	9		.1346	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MREORIEN
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0376	.7202	201
CLUSMEM9	1		.0718	.6423	28
CLUSMEM9	2		.0499	.3541	8
CLUSMEM9	3		.0094	.7811	62
CLUSMEM9	4		.1889	.4892	17
CLUSMEM9	5		.0981	.4961	6
CLUSMEM9	6		-.4239	.8870	21
CLUSMEM9	7		-.5549	.9514	19
CLUSMEM9	8		.1231	.4155	39
CLUSMEM9	9		.3036	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MFABRIC
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0313	.7067	201
CLUSMEM9	1		.2625	.7155	28
CLUSMEM9	2		.1784	.8342	8
CLUSMEM9	3		-.0166	.6941	62
CLUSMEM9	4		.0123	.3066	17
CLUSMEM9	5		.1254	.9171	6
CLUSMEM9	6		-.2051	.8831	21
CLUSMEM9	7		-.3933	.8370	19
CLUSMEM9	8		-.0812	.5553	39
CLUSMEM9	9		-.0555	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MBREAKAG
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0464	.6575	201
CLUSMEM9	1		-.1586	.6075	28
CLUSMEM9	2		-.4072	.4775	8
CLUSMEM9	3		-.1990	.4778	62
CLUSMEM9	4		.2581	.5206	17
CLUSMEM9	5		-.0952	.3025	6
CLUSMEM9	6		-.4813	.5252	21
CLUSMEM9	7		-.5290	.4813	19
CLUSMEM9	8		.7084	.5420	39
CLUSMEM9	9		-.5789	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MABRASIO
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			-.0544	.6669	201
CLUSMEM9	1		-.1245	.5983	28
CLUSMEM9	2		-.0469	.5403	8

CLUSMEM9	3	-.1693	.4201	62
CLUSMEM9	4	-.0054	.5155	17
CLUSMEM9	5	-.0273	.6744	6
CLUSMEM9	6	-.3652	.4604	21
CLUSMEM9	7	-.3940	.2918	19
CLUSMEM9	8	.5007	.9806	39
CLUSMEM9	9	-.6819	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of THICKNES THICKNESS
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			4.4900	2.6463	201
CLUSMEM9	1		5.6857	.9732	28
CLUSMEM9	2		8.0625	.8210	8
CLUSMEM9	3		2.7500	1.1015	62
CLUSMEM9	4		8.3706	1.6984	17
CLUSMEM9	5		11.0000	.8944	6
CLUSMEM9	6		5.6524	.7554	21
CLUSMEM9	7		3.4053	1.2263	19
CLUSMEM9	8		2.6051	1.3351	39
CLUSMEM9	9		15.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of ALLOSIZE ALLOCHEM SIZE
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			2.7562	1.4301	201
CLUSMEM9	1		1.8929	.8751	28
CLUSMEM9	2		4.7500	.4629	8
CLUSMEM9	3		3.0645	.9896	62
CLUSMEM9	4		1.8235	1.1311	17
CLUSMEM9	5		3.0000	.8944	6
CLUSMEM9	6		4.2857	.9024	21
CLUSMEM9	7		4.3158	.8201	19
CLUSMEM9	8		1.2051	.4091	39
CLUSMEM9	9		5.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of SORT BED SORTING
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			3.8507	1.3482	201
CLUSMEM9	1		3.9643	.8812	28
CLUSMEM9	2		2.6250	1.0607	8

CLUSMEM9	3	4.1129	1.0574	62
CLUSMEM9	4	4.7059	.5879	17
CLUSMEM9	5	3.0000	1.4142	6
CLUSMEM9	6	3.6667	1.3540	21
CLUSMEM9	7	1.4737	.7723	19
CLUSMEM9	8	4.5897	1.0187	39
CLUSMEM9	9	5.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of GRADING GRADING
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			1.4179	.6741	201
CLUSMEM9	1		1.2500	.5182	28
CLUSMEM9	2		1.3750	.5175	8
CLUSMEM9	3		1.2903	.5548	62
CLUSMEM9	4		1.3529	.6063	17
CLUSMEM9	5		1.0000	.0000	6
CLUSMEM9	6		1.7619	.9952	21
CLUSMEM9	7		1.8947	.5671	19
CLUSMEM9	8		1.4359	.7538	39
CLUSMEM9	9		1.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of XLAM CROSS LAMINATION
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			1.9104	.4919	201
CLUSMEM9	1		1.8214	.6118	28
CLUSMEM9	2		1.8750	.3536	8
CLUSMEM9	3		2.0645	.4387	62
CLUSMEM9	4		1.7647	.7524	17
CLUSMEM9	5		1.8333	.7528	6
CLUSMEM9	6		1.8571	.3586	21
CLUSMEM9	7		2.0000	.0000	19
CLUSMEM9	8		1.8205	.4514	39
CLUSMEM9	9		1.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of MATRIX1 MATRIX
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			3.3284	.9958	201
CLUSMEM9	1		3.7857	1.0666	28
CLUSMEM9	2		3.3750	1.0607	8
CLUSMEM9	3		3.3548	.9767	62

CLUSMEM9	4	3.7059	.9852	17
CLUSMEM9	5	3.1667	.4082	6
CLUSMEM9	6	3.1429	1.0623	21
CLUSMEM9	7	2.2632	.7335	19
CLUSMEM9	8	3.3846	.7114	39
CLUSMEM9	9	5.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Sum
By

Var

For

CL
CV
CD
CY
CI
C
C
C
C

I

Summaries of PERCENTM PERCENT MATRIX
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			3.1741	.9563	201
CLUSMEM9	1		3.5000	.8819	28
CLUSMEM9	2		2.7500	.8864	8
CLUSMEM9	3		3.2097	.9257	62
CLUSMEM9	4		3.4706	.6243	17
CLUSMEM9	5		2.8333	.4082	6
CLUSMEM9	6		3.3810	.4976	21
CLUSMEM9	7		2.0000	1.1547	19
CLUSMEM9	8		3.3590	.9315	39
CLUSMEM9	9		3.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

Summaries of POLYTAXI POLYTAXIC
By levels of CLUSMEM9

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			1.0746	.2634	201
CLUSMEM9	1		1.0714	.2623	28
CLUSMEM9	2		1.0000	.0000	8
CLUSMEM9	3		1.0645	.2477	62
CLUSMEM9	4		1.0588	.2425	17
CLUSMEM9	5		1.1667	.4082	6
CLUSMEM9	6		1.0000	.0000	21
CLUSMEM9	7		1.1053	.3153	19
CLUSMEM9	8		1.1282	.3387	39
CLUSMEM9	9		1.0000	.0000	1

Total Cases = 233
Missing Cases = 32 OR 13.7 PCT.

APPENDIX E
Detrended Correspondence Analysis

DECORANA DIMENSIONED FOR 950 SAMPLES AND 120 SPECIES.

DECORANA OPTIONS -- DOWNWEIGHTING 0; RESCALING 0; ANALYSIS 0; SEGMENTS 0; IWEIGH = 0; SCALING = 0: 0=4 ITERATIONS; -1 = RECIPROCAL AVERAGING, N = 20 ITERATIONS
IRA = 0: 0 = DECORANA, 1 = RANUMBER OF SEGMENTS = 0: 0 = 26 SEGMENTS USED; IF OTHER THAN 0, THEN BETWEEN 14 AND 50 SEGMENTS USED.

THERE ARE 13 SPECIES AND 233 SAMPLES.

```
ALLO SIZE       SORT   GRA DING       XLAM  PERC ENTM
NTHI CKNE  NMSI ZESM  NMSI ZELG  NMSO RTIN  NMRE ORIE
NMFA BRIC  NMBR EAKA  NMAB RASI

1-10       1-11       1-12       1-13       1-14
1-15       1-16       1-17       1-18       1-19
1-1\2      1-1^1      1-1^2      1-20       1-21^1
1-21^3     1-22       1-23       1-25^1     1-25^2
1-25^3     1-26       1-27       1-28       1-29^1
1-29^2     1-2^1      1-2^2      1-30       1-31^1
1-31^2     1-31^3     1-31^4     1-32       1-33
1-34       1-35^1     1-35^2     1-36       1-37
1-38       1-39^1     1-39^2     1-3^1      1-3^2
1-3^3      1-4b       1-5        1-6        1-7
1-8        1-9        2-1        2-10^1     2-10^2
2-11       2-12       2-13^1     2-13^2     2-14
2-15       2-16       2-17       2-18       2-19a
2-19b      2-19c      2-2        2-20       2-21
2-22a      2-22a^2    2-22a^3    2-23       2-3a
2-3b^1     2-3b^2     2-4        2-4a       2-4b^1
2-4b^2     2-4c       2-5        2-5b^1     2-5b^2
2-5b^3     2-5b^4     2-6^1      2-6^2      2-6^3
2-7        2-8^1      2-8^2      2-9a       2-9b
3-1        3-10       3-11       3-13^1     3-13^2
3-15       3-16       3-17       3-18       3-19
3-2        3-20       3-21       3-22       3-23
3-24       3-25       3-26       3-27       3-28
3-29       3-3        3-30       3-31       3-32^1
3-32^2     3-32^3     3-32^4     3-33       3-34^1
3-34^2     3-34^3     3-35^1     3-35^2     3-36
3-4a^1     3-4a^2     3-4b^1     3-4b^2     3-5
3-6        3-7        3-8        3-9^1      3-9^2
4-1        4-10a^1    4-10b      4-10c      4-14^a
4-14b      4-14c      4-15b      4-16a      4-16b^1
4-16b^2    4-16c^1    4-16c^2    4-16c^3    4-16d^1
4-16d^2    4-16d^3    4-17a      4-17b^1    4-17b^2
4-17b^3    4-17b^4    4-17b^5    4-17c      4-17d^2
4-18       4-19^1     4-19^2     4-19^3     4-2
4-20^1     4-20^2     4-22       4-23       4-24a
4-24b      4-24c      4-25       4-26       4-27^1
4-27^2     4-28       4-29       4-3        4-30
4-31a      4-31b      4-4        4-5        4-6^1
4-6^2      4-7        4-8        4-9        4^a
5-1        5-10       5-11^1     5-11^2     5-11^3
5-12       5-13       5-15       5-16       5-17^1
5-17^2     5-18^1     5-18^2     5-19       5-2
5-20^1     5-20^2     5-21       5-22       5-23
5-24       5-25       5-26       5-26^1     5-26^2
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 5-26^3     5-3^1      5-3^2      5-3^3      5-4
 5-4^1      5-4^2      5-5^1      5-5^2      5-6
 5-7        5-8        5-9

    0 SAMPLES WILL BE OMITTED: NO DOWNWEIGHTING: AXES ARE RESCALED

RESIDUAL    .009346       AT ITERATION  0
RESIDUAL    .001566       AT ITERATION  1
RESIDUAL    .000006       AT ITERATION  2
EIGENVALUE     .07144


LENGTH OF GRADIENT     1.297
LENGTH OF SEGMENTS   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13
LENGTH OF GRADIENT     1.294


LENGTH OF GRADIENT     1.288
LENGTH OF SEGMENTS   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13
LENGTH OF GRADIENT     1.286


RESIDUAL    .005320       AT ITERATION  0
RESIDUAL    .002560       AT ITERATION  1
RESIDUAL    .000151       AT ITERATION  2
RESIDUAL    .000011       AT ITERATION  3
EIGENVALUE     .03674


LENGTH OF GRADIENT      .637
LENGTH OF SEGMENTS   .09   .09   .08   .08   .07   .06   .05   .04   .04   .04
LENGTH OF GRADIENT      .799


LENGTH OF GRADIENT      .910
LENGTH OF SEGMENTS   .10   .10   .10   .09   .09   .09   .09   .09   .08   .08
LENGTH OF GRADIENT      .909


RESIDUAL    .004320       AT ITERATION  0
RESIDUAL    .002014       AT ITERATION  1
RESIDUAL    .001199       AT ITERATION  2
RESIDUAL    .000928       AT ITERATION  3
RESIDUAL    .000041       AT ITERATION  4
EIGENVALUE     .02724


LENGTH OF GRADIENT      .845
LENGTH OF SEGMENTS   .10   .09   .09   .09   .09   .08   .08   .08   .08   .08
LENGTH OF GRADIENT      .874


LENGTH OF GRADIENT      .912
LENGTH OF SEGMENTS   .10   .10   .09   .09   .09   .09   .09   .09   .09   .09
LENGTH OF GRADIENT      .921


RESIDUAL    .003811       AT ITERATION  0
RESIDUAL    .002373       AT ITERATION  1
RESIDUAL    .000367       AT ITERATION  2
RESIDUAL    .000028       AT ITERATION  3
EIGENVALUE     .02197


LENGTH OF GRADIENT      .762
LENGTH OF SEGMENTS   .08   .08   .08   .08   .08   .08   .08   .07   .07   .06
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LENGTH OF GRADIENT .772

LENGTH OF GRADIENT .767

LENGTH OF SEGMENTS .08 .08 .08 .08 .08 .08 .08 .08 .08 .07

LENGTH OF GRADIENT .765

SPECIES SCORES

RANKED 1 EIG= .071			RANKED 2 EIG= .037			RANKED 3 EIG= .027			RANKED 4 EIG= .022		
4	XLAM	333	4	XLAM	420	4	XLAM	393	4	XLAM	403
12	NMBREAKA	211	6	NTHICKNE	143	10	NMREORIE	170	6	NTHICKNE	145
13	NMABRASI	184	11	NMFABRIC	138	9	NMSORTIN	151	10	NMREORIE	108
9	NMSORTIN	150	8	NMSIZELG	121	7	NMSIZESM	148	8	NMSIZELG	91
3	GRADING	118	7	NMSIZESM	111	8	NMSIZELG	78	3	GRADING	87
2	SORT	115	2	SORT	109	2	SORT	71	13	NMABRASI	85
11	NMFABRIC	81	5	PERCENTM	46	3	GRADING	40	1	ALLOSIZE	57
10	NMREORIE	80	13	NMABRASI	-23	11	NMFABRIC	-5	5	PERCENTM	57
5	PERCENTM	62	10	NMREORIE	-40	5	PERCENTM	-8	12	NMBREAKA	25
6	NTHICKNE	1	12	NMBREAKA	-47	1	ALLOSIZE	-24	2	SORT	0
7	NMSIZESM	-45	3	GRADING	-60	12	NMBREAKA	-39	9	NMSORTIN	-20
8	NMSIZELG	-75	1	ALLOSIZE	-66	13	NMABRASI	-64	7	NMSIZESM	-40
1	ALLOSIZE	-85	9	NMSORTIN	-91	6	NTHICKNE	-102	11	NMFABRIC	-181

SAMPLE SCORES - WHICH ARE WEIGHTED MEAN SPECIES SCORES

RANKED 1 EIG= .071			RANKED 2 EIG= .037			RANKED 3 EIG= .027			RANKED 4 EIG= .022		
88	2-6^1	128	194	4-9	90	220	5-26^2	92	194	4-9	76
163	4-17b^5	120	145	4-14^a	89	181	4-27^2	83	7	1-16	67
191	4-6^2	120	91	2-7	87	30	1-31^1	70	61	2-15	64
3	1-12	119	89	2-6^2	83	89	2-6^2	70	19	1-25^1	61
131	3-4a^1	119	142	4-10a^1	79	22	1-26	69	196	5-1	61
200	5-11^3	116	3	1-12	78	54	2-10^1	68	53	2-1	60
26	1-29^2	113	175	4-24a	78	71	2-22a	68	68	2-2	60
66	2-19b	111	182	4-28	77	107	3-20	68	193	4-8	60
82	2-4c	111	41	1-38	75	194	4-9	66	34	1-32	59
141	4-1	111	232	5-8	74	221	5-26^3	66	215	5-23	59
154	4-16c^3	111	62	2-16	71	63	2-17	65	231	5-7	59
159	4-17b^1	111	188	4-4	71	129	3-35^2	65	149	4-16a	58
151	4-16b^2	110	9	1-18	70	13	1-1^2	64	2	1-11	57
170	4-2	110	174	4-23	70	55	2-10^2	64	130	3-36	57
81	2-4b^2	109	1	1-10	68	59	2-13^2	64	195	4^a	57
85	2-5b^2	109	61	2-15	68	79	2-4a	64	209	5-19	57
113	3-26	108	177	4-24c	68	85	2-5b^2	64	10	1-19	56
120	3-32^1	108	5	1-14	67	215	5-23	64	14	1-20	56
123	3-32^4	108	71	2-22a	66	19	1-25^1	63	40	1-37	56
134	3-4b^2	108	7	1-16	64	61	2-15	63	62	2-16	55
168	4-19^2	108	105	3-19	64	116	3-29	63	108	3-21	55
204	5-16	108	130	3-36	64	218	5-26	63	207	5-18^1	54
121	3-32^2	107	183	4-29	64	65	2-19a	62	140	3-9^2	53
122	3-32^3	107	79	2-4a	63	105	3-19	62	101	3-15	52
145	4-14^a	107	147	4-14c	63	214	5-22	62	143	4-10b	52
184	4-3	106	171	4-20^1	63	92	2-8^1	61	197	5-10	52
19	1-25^1	105	38	1-35^2	62	21	1-25^3	60	48	1-5	51
167	4-19^1	105	116	3-29	62	93	2-8^2	60	192	4-7	51
209	5-19	105	135	3-5	62	16	1-21^3	59	3	1-12	50
224	5-3^3	104	179	4-26	62	37	1-35^1	59	4	1-13	50
25	1-29^1	103	17	1-22	61	73	2-22a^3	59	64	2-18	49
86	2-5b^3	103	185	4-30	60	117	3-3	59	65	2-19a	49
186	4-31a	103	197	5-10	60	128	3-35^1	59	218	5-26	49
43	1-39^2	102	110	3-23	59	20	1-25^2	58	97	3-10	48
12	1-1^1	101	153	4-16c^2	59	57	2-12	58	114	3-27	48
67	2-19c	101	4	1-13	58	115	3-28	58	133	3-4b^1	48
58	2-13^1	100	6	1-15	58	127	3-34^3	58	146	4-14b	48
190	4-6^1	100	11	1-1\2	58	42	1-39^1	57	210	5-2	48
72	2-22a^2	99	107	3-20	58	120	3-32^1	57	56	2-11	47
96	3-1	99	215	5-23	58	123	3-32^4	57	71	2-22a	47

160	4-17b^2	99	78	2-4	57	62	2-16	56	77	2-3b^2	47
222	5-3^1	99	109	3-22	57	113	3-26	56	132	3-4a^2	47
53	2-1	98	178	4-25	57	121	3-32^2	56	148	4-15b	47
92	2-8^1	98	64	2-18	56	122	3-32^3	56	20	1-25^2	46
133	3-4b^1	98	65	2-19a	55	124	3-33	56	39	1-36	46
201	5-12	97	85	2-5b^2	55	15	1-21^1	55	113	3-26	46
223	5-3^2	97	93	2-8^2	55	81	2-4b^2	55	205	5-17^1	46
87	2-5b^4	96	193	4-8	55	126	3-34^2	55	5	1-14	45
21	1-25^3	95	16	1-21^3	54	161	4-17b^3	55	37	1-35^1	45
84	2-5b^1	95	49	1-6	54	182	4-28	55	213	5-21	45
176	4-24b	95	54	2-10^1	54	125	3-34^1	54	228	5-5^1	45
213	5-21	95	187	4-31b	54	166	4-18	54	100	3-13^2	44
233	5-9	95	195	4^a	54	178	4-25	54	131	3-4a^1	44
8	1-17	94	23	1-27	53	216	5-24	54	135	3-5	44
61	2-15	94	34	1-32	53	95	2-9b	53	139	3-9^1	44
74	2-23	94	82	2-4c	53	152	4-16c^1	53	233	5-9	44
161	4-17b^3	94	101	3-15	53	217	5-25	53	74	2-23	43
197	5-10	94	158	4-17a	53	82	2-4c	52	98	3-11	43
51	1-8	93	108	3-21	52	146	4-14b	52	99	3-13^1	43
156	4-16d^2	93	141	4-1	52	154	4-16c^3	52	138	3-8	43
215	5-23	93	164	4-17c	52	206	5-17^2	52	144	4-10c	43
192	4-7	92	15	1-21^1	51	7	1-16	51	170	4-2	43
36	1-34	91	18	1-23	51	77	2-3b^2	51	202	5-13	43
162	4-17b^4	91	35	1-33	51	180	4-27^1	51	26	1-29^2	42
206	5-17^2	91	68	2-2	51	227	5-4^2	51	51	1-8	42
157	4-16d^3	89	75	2-3a	51	230	5-6	51	79	2-4a	42
29	1-30	88	173	4-22	51	56	2-11	50	80	2-4b^1	42
60	2-14	88	27	1-2^1	50	68	2-2	50	82	2-4c	42
76	2-3b^1	88	144	4-10c	50	108	3-21	50	106	3-2	42
44	1-3^1	87	39	1-36	49	109	3-22	50	178	4-25	42
112	3-25	87	47	1-4b	49	145	4-14^a	50	184	4-3	42
165	4-17d^2	87	77	2-3b^2	49	202	5-13	50	216	5-24	42
169	4-19^3	86	181	4-27^2	49	47	1-4b	49	23	1-27	41
102	3-16	85	32	1-31^3	48	90	2-6^3	49	43	1-39^2	41
132	3-4a^2	85	33	1-31^4	48	94	2-9a	49	76	2-3b^1	41
137	3-7	85	189	4-5	48	219	5-26^1	49	36	1-34	40
189	4-5	84	84	2-5b^1	47	31	1-31^2	48	105	3-19	40
211	5-20^1	83	86	2-5b^3	47	58	2-13^1	48	112	3-25	40
65	2-19a	82	166	4-18	47	60	2-14	48	181	4-27^2	40
212	5-20^2	82	172	4-20^2	47	75	2-3a	48	8	1-17	39
42	1-39^1	81	225	5-4	47	80	2-4b^1	48	22	1-26	39
124	3-33	81	229	5-5^2	47	84	2-5b^1	48	89	2-6^2	39
80	2-4b^1	80	43	1-39^2	46	26	1-29^2	47	203	5-15	39
97	3-10	80	56	2-11	46	39	1-36	47	222	5-3^1	39
148	4-15b	80	83	2-5	46	88	2-6^1	47	70	2-21	38
14	1-20	78	120	3-32^1	46	197	5-10	47	163	4-17b^5	38
93	2-8^2	77	121	3-32^2	46	17	1-22	46	189	4-5	38
24	1-28	76	122	3-32^3	46	72	2-22a^2	46	17	1-22	37
56	2-11	76	123	3-32^4	46	151	4-16b^2	46	50	1-7	37
71	2-22a	76	150	4-16b^1	46	18	1-23	45	94	2-9a	37
196	5-1	76	192	4-7	46	23	1-27	45	180	4-27^1	37
30	1-31^1	75	196	5-1	46	34	1-32	45	182	4-28	37
75	2-3a	75	202	5-13	46	64	2-18	45	229	5-5^2	37
139	3-9^1	75	2	1-11	45	155	4-16d^1	45	9	1-18	36
106	3-2	74	25	1-29^1	45	76	2-3b^1	44	18	1-23	36
57	2-12	73	46	1-3^3	45	83	2-5	44	75	2-3a	36
73	2-22a^3	73	87	2-5b^4	45	140	3-9^2	44	102	3-16	36
126	3-34^2	73	140	3-9^2	45	188	4-4	44	121	3-32^2	36
39	1-36	72	207	5-18^1	45	226	5-4^1	44	122	3-32^3	36
45	1-3^2	72	52	1-9	44	67	2-19c	43	186	4-31a	36
111	3-24	72	216	5-24	44	87	2-5b^4	43	214	5-22	36
32	1-31^3	71	90	2-6^3	43	99	3-13^1	43	119	3-31	35
33	1-31^4	71	98	3-11	43	104	3-18	43	120	3-32^1	35
52	1-9	71	76	2-3b^1	42	139	3-9^1	43	123	3-32^4	35
62	2-16	71	103	3-17	42	208	5-18^2	43	137	3-7	35
70	2-21	71	118	3-30	42	190	4-6^1	42	225	5-4	35
77	2-3b^2	71	59	2-13^2	41	199	5-11^2	42	85	2-5b^2	34

127	3-34^3	71	73	2-22a^3	41	232	5-8	42	107	3-20	34
15	1-21^1	70	113	3-26	41	1	1-10	41	198	5-11^1	34
125	3-34^1	70	8	1-17	40	118	3-30	41	201	5-12	34
152	4-16c^1	70	48	1-5	40	160	4-17b^2	41	223	5-3^2	34
155	4-16d^1	70	55	2-10^2	40	165	4-17d^2	41	25	1-29^1	33
185	4-30	70	102	3-16	40	229	5-5^2	41	230	5-6	33
194	4-9	70	111	3-24	40	4	1-13	40	95	2-9b	32
210	5-2	70	117	3-3	40	74	2-23	40	199	5-11^2	32
146	4-14b	69	199	5-11^2	40	41	1-38	38	217	5-25	32
225	5-4	69	211	5-20^1	40	70	2-21	38	15	1-21^1	31
16	1-21^3	67	212	5-20^2	40	110	3-23	38	104	3-18	31
46	1-3^3	67	219	5-26^1	40	162	4-17b^4	38	124	3-33	31
182	4-28	67	227	5-4^2	40	175	4-24a	38	147	4-14c	31
89	2-6^2	66	70	2-21	39	189	4-5	38	220	5-26^2	31
119	3-31	66	136	3-6	39	228	5-5^1	38	29	1-30	30
230	5-6	66	205	5-17^1	39	86	2-5b^3	37	35	1-33	30
103	3-17	65	69	2-20	38	150	4-16b^1	37	164	4-17c	30
117	3-3	65	119	3-31	38	176	4-24b	37	224	5-3^3	30
128	3-35^1	65	200	5-11^3	38	5	1-14	36	38	1-35^2	29
136	3-6	65	231	5-7	38	40	1-37	36	110	3-23	29
208	5-18^2	65	29	1-30	37	52	1-9	36	136	3-6	29
17	1-22	64	45	1-3^2	37	103	3-17	36	153	4-16c^2	29
69	2-20	64	53	2-1	37	111	3-24	36	159	4-17b^1	29
114	3-27	64	165	4-17d^2	37	168	4-19^2	36	175	4-24a	29
198	5-11^1	64	20	1-25^2	36	45	1-3^2	35	183	4-29	29
203	5-15	64	37	1-35^1	36	91	2-7	35	208	5-18^2	29
31	1-31^2	63	50	1-7	36	138	3-8	35	211	5-20^1	29
55	2-10^2	63	67	2-19c	36	184	4-3	35	12	1-1^1	28
95	2-9b	63	104	3-18	36	12	1-1^1	34	16	1-21^3	28
50	1-7	62	129	3-35^2	36	14	1-20	34	28	1-2^2	28
118	3-30	62	157	4-16d^3	36	32	1-31^3	34	42	1-39^1	28
180	4-27^1	62	198	5-11^1	36	33	1-31^4	34	141	4-1	28
40	1-37	61	217	5-25	36	44	1-3^1	34	41	1-38	27
90	2-6^3	61	28	1-2^2	35	69	2-20	34	44	1-3^1	27
158	4-17a	61	94	2-9a	35	191	4-6^2	34	67	2-19c	27
226	5-4^1	61	143	4-10b	35	196	5-1	34	127	3-34^3	27
228	5-5^1	61	156	4-16d^2	35	224	5-3^3	34	134	3-4b^2	27
6	1-15	60	176	4-24b	35	9	1-18	33	152	4-16c^1	27
34	1-32	60	203	5-15	35	78	2-4	33	212	5-20^2	27
41	1-38	59	209	5-19	35	119	3-31	33	32	1-31^3	26
49	1-6	59	10	1-19	34	210	5-2	33	33	1-31^4	26
104	3-18	59	19	1-25^1	34	50	1-7	32	92	2-8^1	26
214	5-22	59	184	4-3	34	96	3-1	32	115	3-28	26
94	2-9a	58	63	2-17	33	144	4-10c	32	116	3-29	26
115	3-28	58	137	3-7	33	158	4-17a	32	117	3-3	26
227	5-4^2	58	148	4-15b	33	25	1-29^1	31	118	3-30	26
173	4-22	57	162	4-17b^4	33	51	1-8	31	145	4-14^a	26
199	5-11^2	57	220	5-26^2	33	205	5-17^1	31	150	4-16b^1	26
221	5-26^3	57	30	1-31^1	32	233	5-9	31	88	2-6^1	25
48	1-5	56	146	4-14b	32	134	3-4b^2	30	174	4-23	25
59	2-13^2	56	230	5-6	32	3	1-12	29	151	4-16b^2	24
98	3-11	56	14	1-20	31	53	2-1	29	166	4-18	24
100	3-13^2	55	36	1-34	31	174	4-23	29	226	5-4^1	24
135	3-5	55	115	3-28	31	192	4-7	29	232	5-8	24
187	4-31b	55	155	4-16d^1	31	11	1-1\2	28	11	1-1\2	23
63	2-17	54	160	4-17b^2	31	97	3-10	28	83	2-5	23
150	4-16b^1	54	214	5-22	31	133	3-4b^1	28	93	2-8^2	23
54	2-10^1	53	24	1-28	30	222	5-3^1	28	126	3-34^2	23
220	5-26^2	53	31	1-31^2	30	114	3-27	27	154	4-16c^3	23
5	1-14	52	201	5-12	30	130	3-36	27	204	5-16	23
22	1-26	52	228	5-5^1	30	132	3-4a^2	27	1	1-10	22
28	1-2^2	52	57	2-12	29	171	4-20^1	27	57	2-12	22
47	1-4b	52	95	2-9b	29	177	4-24c	27	60	2-14	22
172	4-20^2	52	106	3-2	29	200	5-11^3	27	78	2-4	22
175	4-24a	52	186	4-31a	29	29	1-30	26	87	2-5b^4	22
229	5-5^2	52	13	1-1^2	28	106	3-2	26	161	4-17b^3	22
9	1-18	51	99	3-13^1	28	167	4-19^1	26	219	5-26^1	22

20	1-25^2	51	138	3-8	28	207	5-18^1	26	47	1-4b	21
138	3-8	51	92	2-8^1	27	213	5-21	26	69	2-20	21
205	5-17^1	51	149	4-16a	27	223	5-3^2	26	125	3-34^1	21
68	2-2	50	40	1-37	26	8	1-17	25	167	4-19^1	21
183	4-29	50	96	3-1	26	46	1-3^3	24	200	5-11^3	21
79	2-4a	49	125	3-34^1	26	49	1-6	24	13	1-1^2	20
179	4-26	49	132	3-4a^2	26	100	3-13^2	24	96	3-1	20
35	1-33	47	167	4-19^1	26	131	3-4a^1	24	103	3-17	20
231	5-7	47	221	5-26^3	26	153	4-16c^2	24	128	3-35^1	20
2	1-11	45	114	3-27	25	231	5-7	24	185	4-30	20
7	1-16	45	128	3-35^1	24	101	3-15	23	187	4-31b	20
216	5-24	45	169	4-19^3	24	135	3-5	23	227	5-4^2	20
64	2-18	44	226	5-4^1	24	137	3-7	23	21	1-25^3	19
202	5-13	44	44	1-3^1	23	142	4-10a^1	23	81	2-4b^2	19
10	1-19	43	51	1-8	23	159	4-17b^1	23	111	3-24	19
37	1-35^1	43	72	2-22a^2	23	225	5-4	23	49	1-6	18
153	4-16c^2	42	80	2-4b^1	23	2	1-11	22	191	4-6^2	18
27	1-2^1	41	126	3-34^2	23	24	1-28	22	24	1-28	17
99	3-13^1	41	127	3-34^3	23	98	3-11	22	45	1-3^2	17
207	5-18^1	41	208	5-18^2	23	172	4-20^2	22	109	3-22	17
232	5-8	41	170	4-2	22	43	1-39^2	21	165	4-17d^2	17
78	2-4	40	190	4-6^1	22	148	4-15b	21	176	4-24b	17
129	3-35^2	40	204	5-16	22	179	4-26	21	84	2-5b^1	16
219	5-26^1	40	233	5-9	22	198	5-11^1	21	91	2-7	16
142	4-10a^1	39	66	2-19b	21	209	5-19	21	190	4-6^1	16
109	3-22	38	180	4-27^1	21	212	5-20^2	21	206	5-17^2	16
217	5-25	38	74	2-23	20	28	1-2^2	20	58	2-13^1	15
143	4-10b	37	218	5-26	20	112	3-25	20	66	2-19b	15
1	1-10	36	26	1-29^2	19	169	4-19^3	20	72	2-22a^2	15
83	2-5	36	22	1-26	18	203	5-15	20	86	2-5b^3	15
149	4-16a	36	58	2-13^1	18	36	1-34	19	179	4-26	15
181	4-27^2	36	124	3-33	18	66	2-19b	19	142	4-10a^1	14
38	1-35^2	35	97	3-10	17	141	4-1	19	172	4-20^2	14
218	5-26	35	210	5-2	17	147	4-14c	19	177	4-24c	14
171	4-20^1	34	223	5-3^2	17	164	4-17c	19	6	1-15	13
91	2-7	33	21	1-25^3	16	193	4-8	19	169	4-19^3	13
164	4-17c	33	139	3-9^1	16	173	4-22	18	55	2-10^2	12
140	3-9^2	29	168	4-19^2	16	187	4-31b	18	63	2-17	12
166	4-18	29	42	1-39^1	15	201	5-12	18	129	3-35^2	12
110	3-23	27	206	5-17^2	15	38	1-35^2	17	173	4-22	12
178	4-25	26	222	5-3^1	15	211	5-20^1	17	31	1-31^2	11
195	4^a	26	88	2-6^1	14	157	4-16d^3	16	171	4-20^1	11
193	4-8	25	152	4-16c^1	14	186	4-31a	16	188	4-4	11
144	4-10c	24	161	4-17b^3	14	27	1-2^1	15	155	4-16d^1	10
23	1-27	23	134	3-4b^2	13	143	4-10b	15	90	2-6^3	9
101	3-15	23	151	4-16b^2	11	149	4-16a	15	156	4-16d^2	9
116	3-29	23	213	5-21	10	163	4-17b^5	15	162	4-17b^4	9
177	4-24c	23	133	3-4b^1	8	183	4-29	15	221	5-26^3	9
13	1-1^2	22	163	4-17b^5	8	10	1-19	12	27	1-2^1	8
108	3-21	22	191	4-6^2	8	102	3-16	12	30	1-31^1	8
174	4-23	22	224	5-3^3	8	136	3-6	12	59	2-13^2	8
107	3-20	20	159	4-17b^1	7	35	1-33	11	46	1-3^3	7
105	3-19	19	60	2-14	6	156	4-16d^2	11	73	2-22a^3	6
11	1-1\2	15	100	3-13^2	5	204	5-16	10	52	1-9	5
18	1-23	15	154	4-16c^3	4	170	4-2	9	158	4-17a	5
188	4-4	15	81	2-4b^2	2	185	4-30	9	157	4-16d^3	4
147	4-14c	14	112	3-25	2	195	4^a	8	168	4-19^2	4
4	1-13	0	12	1-1^1	0	6	1-15	6	54	2-10^1	0
130	3-36	0	131	3-4a^1	0	48	1-5	0	160	4-17b^2	0

SPECIES SCORES

N	NAME	AX1	AX2	AX3	AX4
EIGENVALUE:		.071	.037	.027	.022
1	ALLO SIZE	-85	-66	-24	57
2	SORT	115	109	71	0
3	GRA DING	118	-60	40	87
4	XLAM	333	420	393	403
5	PERC ENTM	62	46	-8	57
6	NTHI CKNE	1	143	-102	145
7	NMSI ZESM	-45	111	148	-40
8	NMSI ZELG	-75	121	78	91
9	NMSO RTIN	150	-91	151	-20
10	NMRE ORIE	80	-40	170	108
11	NMFA BRIC	81	138	-5	-181
12	NMBR EAKA	211	-47	-39	25
13	NMAB RASI	184	-23	-64	85

SAMPLE SCORES - WHICH ARE WEIGHTED MEAN SPECIES SCORES

N	NAME	AX1	AX2	AX3	AX4
EIGENVALUE:		.071	.037	.027	.022
1	1-10	36	68	41	22
2	1-11	45	45	22	57
3	1-12	119	78	29	50
4	1-13	0	58	40	50
5	1-14	52	67	36	45
6	1-15	60	58	6	13
7	1-16	45	64	51	67
8	1-17	94	40	25	39
9	1-18	51	70	33	36
10	1-19	43	34	12	56
11	1-1\2	15	58	28	23
12	1-1^1	101	0	34	28
13	1-1^2	22	28	64	20
14	1-20	78	31	34	56
15	1-21^1	70	51	55	31
16	1-21^3	67	54	59	28
17	1-22	64	61	46	37
18	1-23	15	51	45	36
19	1-25^1	105	34	63	61
20	1-25^2	51	36	58	46
21	1-25^3	95	16	60	19

22	1-26	52	18	69	39
23	1-27	23	53	45	41
24	1-28	76	30	22	17
25	1-29^1	103	45	31	33
26	1-29^2	113	19	47	42
27	1-2^1	41	50	15	8
28	1-2^2	52	35	20	28
29	1-30	88	37	26	30
30	1-31^1	75	32	70	8
31	1-31^2	63	30	48	11
32	1-31^3	71	48	34	26
33	1-31^4	71	48	34	26
34	1-32	60	53	45	59
35	1-33	47	51	11	30
36	1-34	91	31	19	40
37	1-35^1	43	36	59	45
38	1-35^2	35	62	17	29
39	1-36	72	49	47	46
40	1-37	61	26	36	56
41	1-38	59	75	38	27
42	1-39^1	81	15	57	28
43	1-39^2	102	46	21	41
44	1-3^1	87	23	34	27
45	1-3^2	72	37	35	17
46	1-3^3	67	45	24	7
47	1-4b	52	49	49	21
48	1-5	56	40	0	51
49	1-6	59	54	24	18
50	1-7	62	36	32	37
51	1-8	93	23	31	42
52	1-9	71	44	36	5
53	2-1	98	37	29	60
54	2-10^1	53	54	68	0
55	2-10^2	63	40	64	12
56	2-11	76	46	50	47
57	2-12	73	29	58	22
58	2-13^1	100	18	48	15
59	2-13^2	56	41	64	8
60	2-14	88	6	48	22
61	2-15	94	68	63	64
62	2-16	71	71	56	55
63	2-17	54	33	65	12
64	2-18	44	56	45	49
65	2-19a	82	55	62	49
66	2-19b	111	21	19	15

67	2-19c	101	36	43	27
68	2-2	50	51	50	60
69	2-20	64	38	34	21
70	2-21	71	39	38	38
71	2-22a	76	66	68	47
72	2-22a^2	99	23	46	15
73	2-22a^3	73	41	59	6
74	2-23	94	20	40	43
75	2-3a	75	51	48	36
76	2-3b^1	88	42	44	41
77	2-3b^2	71	49	51	47
78	2-4	40	57	33	22
79	2-4a	49	63	64	42
80	2-4b^1	80	23	48	42
81	2-4b^2	109	2	55	19
82	2-4c	111	53	52	42
83	2-5	36	46	44	23
84	2-5b^1	95	47	48	16
85	2-5b^2	109	55	64	34
86	2-5b^3	103	47	37	15
87	2-5b^4	96	45	43	22
88	2-6^1	128	14	47	25
89	2-6^2	66	83	70	39
90	2-6^3	61	43	49	9
91	2-7	33	87	35	16
92	2-8^1	98	27	61	26
93	2-8^2	77	55	60	23
94	2-9a	58	35	49	37
95	2-9b	63	29	53	32
96	3-1	99	26	32	20
97	3-10	80	17	28	48
98	3-11	56	43	22	43
99	3-13^1	41	28	43	43
100	3-13^2	55	5	24	44
101	3-15	23	53	23	52
102	3-16	85	40	12	36
103	3-17	65	42	36	20
104	3-18	59	36	43	31
105	3-19	19	64	62	40
106	3-2	74	29	26	42
107	3-20	20	58	68	34
108	3-21	22	52	50	55
109	3-22	38	57	50	17
110	3-23	27	59	38	29
111	3-24	72	40	36	19

112	3-25	87	2	20	40
113	3-26	108	41	56	46
114	3-27	64	25	27	48
115	3-28	58	31	58	26
116	3-29	23	62	63	26
117	3-3	65	40	59	26
118	3-30	62	42	41	26
119	3-31	66	38	33	35
120	3-32^1	108	46	57	35
121	3-32^2	107	46	56	36
122	3-32^3	107	46	56	36
123	3-32^4	108	46	57	35
124	3-33	81	18	56	31
125	3-34^1	70	26	54	21
126	3-34^2	73	23	55	23
127	3-34^3	71	23	58	27
128	3-35^1	65	24	59	20
129	3-35^2	40	36	65	12
130	3-36	0	64	27	57
131	3-4a^1	119	0	24	44
132	3-4a^2	85	26	27	47
133	3-4b^1	98	8	28	48
134	3-4b^2	108	13	30	27
135	3-5	55	62	23	44
136	3-6	65	39	12	29
137	3-7	85	33	23	35
138	3-8	51	28	35	43
139	3-9^1	75	16	43	44
140	3-9^2	29	45	44	53
141	4-1	111	52	19	28
142	4-10a^1	39	79	23	14
143	4-10b	37	35	15	52
144	4-10c	24	50	32	43
145	4-14^a	107	89	50	26
146	4-14b	69	32	52	48
147	4-14c	14	63	19	31
148	4-15b	80	33	21	47
149	4-16a	36	27	15	58
150	4-16b^1	54	46	37	26
151	4-16b^2	110	11	46	24
152	4-16c^1	70	14	53	27
153	4-16c^2	42	59	24	29
154	4-16c^3	111	4	52	23
155	4-16d^1	70	31	45	10
156	4-16d^2	93	35	11	9

157	4-16d^3	89	36	16	4
158	4-17a	61	53	32	5
159	4-17b^1	111	7	23	29
160	4-17b^2	99	31	41	0
161	4-17b^3	94	14	55	22
162	4-17b^4	91	33	38	9
163	4-17b^5	120	8	15	38
164	4-17c	33	52	19	30
165	4-17d^2	87	37	41	17
166	4-18	29	47	54	24
167	4-19^1	105	26	26	21
168	4-19^2	108	16	36	4
169	4-19^3	86	24	20	13
170	4-2	110	22	9	43
171	4-20^1	34	63	27	11
172	4-20^2	52	47	22	14
173	4-22	57	51	18	12
174	4-23	22	70	29	25
175	4-24a	52	78	38	29
176	4-24b	95	35	37	17
177	4-24c	23	68	27	14
178	4-25	26	57	54	42
179	4-26	49	62	21	15
180	4-27^1	62	21	51	37
181	4-27^2	36	49	83	40
182	4-28	67	77	55	37
183	4-29	50	64	15	29
184	4-3	106	34	35	42
185	4-30	70	60	9	20
186	4-31a	103	29	16	36
187	4-31b	55	54	18	20
188	4-4	15	71	44	11
189	4-5	84	48	38	38
190	4-6^1	100	22	42	16
191	4-6^2	120	8	34	18
192	4-7	92	46	29	51
193	4-8	25	55	19	60
194	4-9	70	90	66	76
195	4^a	26	54	8	57
196	5-1	76	46	34	61
197	5-10	94	60	47	52
198	5-11^1	64	36	21	34
199	5-11^2	57	40	42	32
200	5-11^3	116	38	27	21
201	5-12	97	30	18	34

202	5-13	44	46	50	43
203	5-15	64	35	20	39
204	5-16	108	22	10	23
205	5-17^1	51	39	31	46
206	5-17^2	91	15	52	16
207	5-18^1	41	45	26	54
208	5-18^2	65	23	43	29
209	5-19	105	35	21	57
210	5-2	70	17	33	48
211	5-20^1	83	40	17	29
212	5-20^2	82	40	21	27
213	5-21	95	10	26	45
214	5-22	59	31	62	36
215	5-23	93	58	64	59
216	5-24	45	44	54	42
217	5-25	38	36	53	32
218	5-26	35	20	63	49
219	5-26^1	40	40	49	22
220	5-26^2	53	33	92	31
221	5-26^3	57	26	66	9
222	5-3^1	99	15	28	39
223	5-3^2	97	17	26	34
224	5-3^3	104	8	34	30
225	5-4	69	47	23	35
226	5-4^1	61	24	44	24
227	5-4^2	58	40	51	20
228	5-5^1	61	30	38	45
229	5-5^2	52	47	41	37
230	5-6	66	32	51	43
231	5-7	47	38	24	59
232	5-8	41	74	42	24
233	5-9	95	22	31	44

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APPENDIX F
Measured Section Localities

Locations of Measures Sections

North Brent Section - Road cut on KY 445 south of Brent, Campbell County, Kentucky, near intersection with KY 8. Approximate location 39^{o} 03'14" N, 84^{o} 26' 04" E, Newport, KY Quad.

South Brent Section - Road cut on I-275 west, approximately 200m south of the North Brent Section. Approximate location 39^{o} 03'14" N, 84^{o} 26' 04" E, Newport, KY Quad.

Sandfordtown Section - Road cut on the ramp for exit 80 on westbound I-275, north of Sandfordtown, Kenton County, Kentucky. Approximate location 39^{o} 01' 38" N, 84^{o} 32' 10" E, Covington, KY Quad.

Mt. Airy Section - Road cut on eastbound entrance ramp to I-74 at the intersection of Baltimore and Montana Avenues, approximately 1.5 mi southeast of Mt. Airy Center, in Section 33, R.2, T.3, Hamilton County, Ohio, Cincinnatti West Quad.

Miamitown Section - Road cut on the Miamitown exit (#128) off i-74, about 5 mi south of Miamitown. Approximate location SE corner of section1, T.1N, R.1E, KY Hamilton County, Ohio, Addyston Ohio Quad.