KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 92-28

Paleoecology of Chaetetids in the
Amoret Limestone Member (Desmoinesian)
in Southeast Kansas

by

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PALEOECOLOGY OF CHAETETIDS IN THE AMORET LIMESTONE MEMBER (DESMOINESIAN) IN SOUTHEAST KANSAS

by

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B.S., Kansas State University, 1985

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTERS OF SCIENCE

(Geology)

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1992

Approved by:

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INTRODUCTION

General Overview and Location of Study

Chaetetids are a conspicuous element of Marmaton age rocks in much of the midcontinent. In Montgomery and Labette counties of southeastern Kansas, the Amoret limestone (upper Desmoinesian) contains abundant chaetetids. Within this area, four exposures of the Amoret limestone were studied in detail. These four localities are aligned in an east-west direction roughly paralleling US Highway 166 (fig 1).

The Amoret limestone is within the upper part of Marmaton group, Desmoinesian stage. It is the lowest member of the Altamont Limestone (Fig. 2). Other members of this formation include the overlying Lake Neosho shale and Worland limestone. The Altamont Limestone is underlain by the Bandera Shale and overlain by the Nowata Shale.

Purpose of Study

The main emphasis of this study was to examine chaetetids and their occurrences within these four exposures. To do this it was first necessary to understand the detailed stratigraphic relationships and depositional environments at and between all localities. Objectives

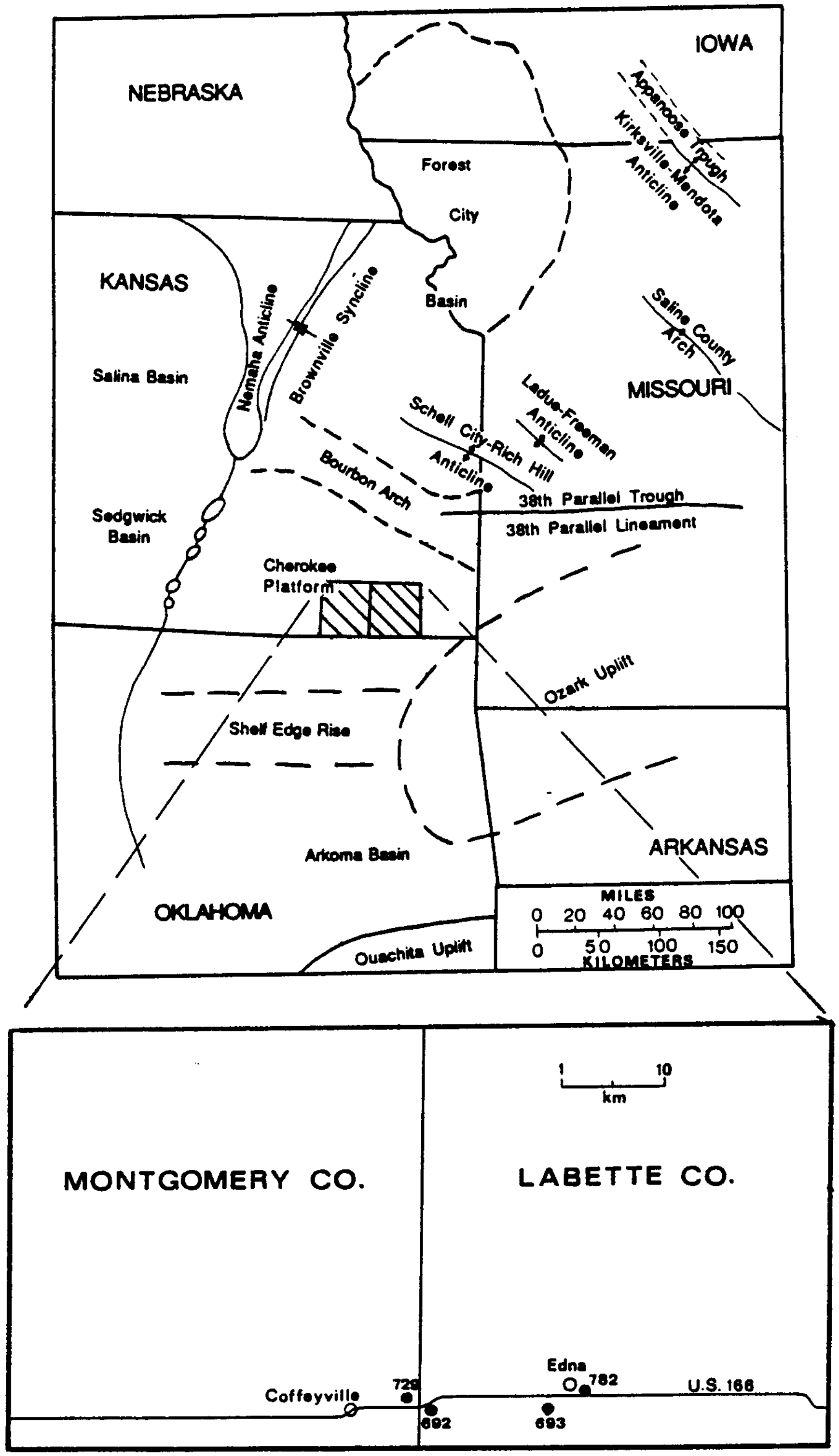


Figure 1. Location of exposures examined, and associated structural features. Map of structural features modified from Knight (1985, fig. 7, p. 38).

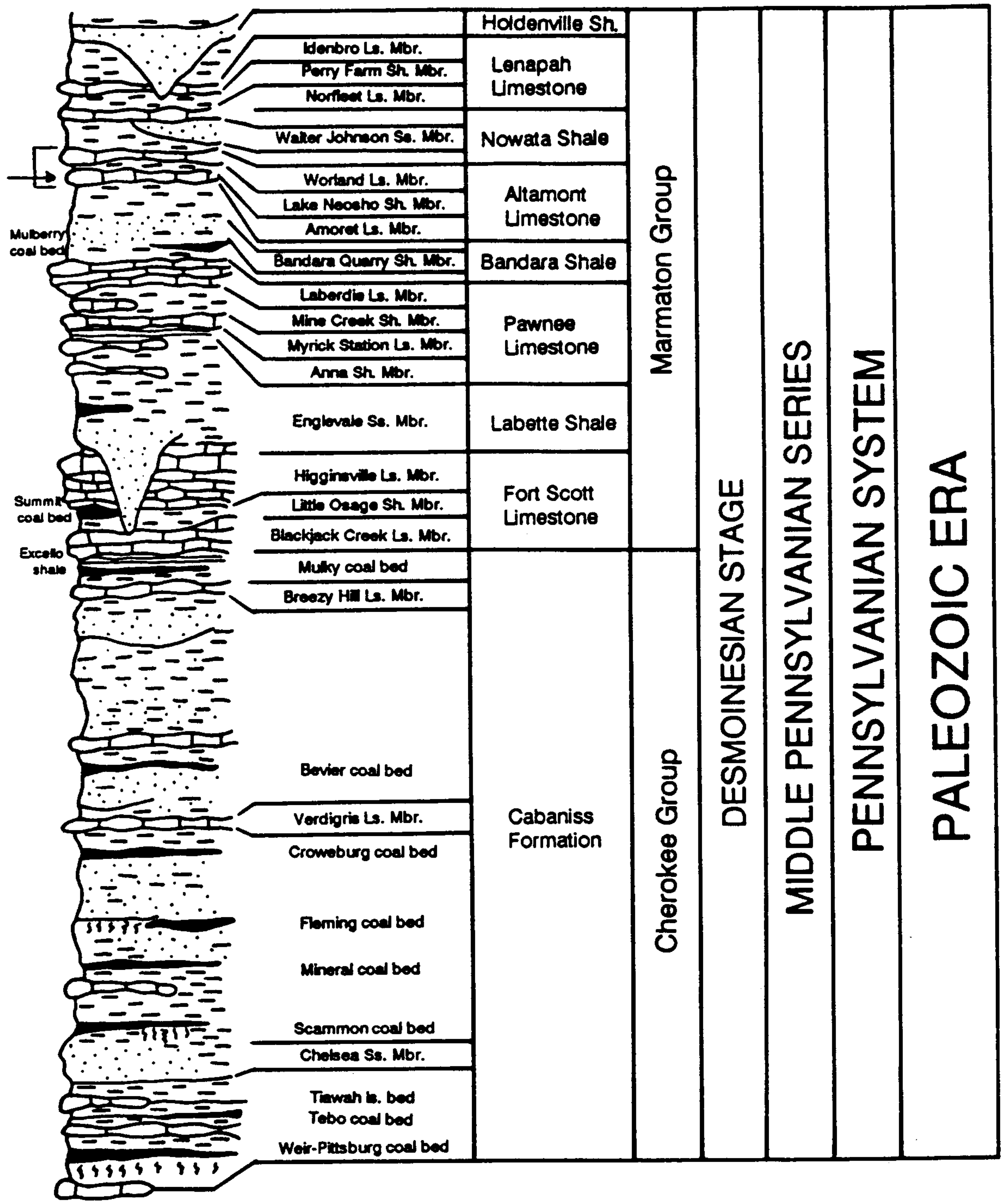


Figure 2. Stratigraphic position of the Altamont Limestone (bracket). The Amoret limestone (arrow) is the lowest member of the Altamont Limestone. (modified from Zeller, 1968).

included:

1) Facies relationships at and between each exposure on a smaller scale than has been done previously.
2) Interpretation of the depositional environment at and between localities.
3) Paleoecology of chaetetids - why they occur where they do, how they grew and interacted, and how they relate to other organisms which are associated with them.
4) Economic importance of chaetetid bearing rocks - for both petroleum sources and industrial uses.

Methods of Study

Field studies were undertaken during parts of the summers of 1987, '88, and '89. All quarry localities were initially mapped using the compass and pace method. These maps were used to plot the locations of areas that were studied in detail.

Using a field questionnaire developed by Ager (1963), questions concerning distribution, association, and preservation of fossils, and rock relationships were answered at each locality.

Sections were measured at each locality and rocks described on a bed by bed basis (Appendices A-D). Oriented samples were collected from each bed, usually at the bottom, middle, and top when possible.

Vertical profiles of sections of the exposed rocks were drawn for localities 729, 693, and 782. On these, the lateral relationship of the beds and all chaetetid occurrences within these beds were noted. Relationships between chaetetids occurrences and associated features were also documented from available bedding surfaces.

Sketches and tracings were made to illustrate unique features at each exposure. Black and white and color photos were used to further document vertical and lateral relationships.

In the laboratory, all samples were cut and polished. These were later examined and used to supplement field descriptions.

Two hundred thin sections were made and examined, 45 of which were described in detail (Appendix E). Seven thin sections were stained with Alizarin Red-S and potassium ferricyanide to help interpret the mineralogy and diagenetic history of the unit.

All clayrock samples were disaggregated and sieved using numbers 16, 40, and 120 mesh sieves; these fractions were examined using a dissecting microscope and described (Appendix F).

X-ray diffraction studies were performed on one chaetetid specimen from locality 692 (in an attempt to get information on original skeletal mineralogy), and on samples of beds 6 and 7 from localities 729 and 692 and of bed 6 from locality 782 (to check for dolomitization).

Previous Work

Stratigraphic Nomenclature--The Altamont Limestone was first described by Adams (1896) for a limestone unit of the Marmaton group in southeastern Kansas and northeastern Oklahoma. Adams (1903) classified the Altamont Limestone and overlying Nowata Shale and Lenapah Limestone as the Parsons Limestone Formation. Moore (1936) recognized that the Altamont and Lenapah limestones represented distinct cyclothems and regarded them as independent units. Cline (1941) delineated three units within the Altamont Limestone, these he named the Tina Limestone, Lake Neosho Shale, and Worland Limestone members. The type section for the Tina limestone described by Cline (1941) was later shown to be the Higgensville member of the Fort Scott Formation by Cline and Greene (1950), who proposed the name Amoret limestone as a substitute and designated an outcrop in the SW 1/4, sec. 33, T. 40 N., R. 33 W., Bates Co., Missouri as the type locality.

Depositional Environment--Pennsylvanian rocks are often described relative to the repetitive occurrences of facies (cyclothems). Wanless and Weller (1932) proposed the term "cyclothem" for formation size sedimentary cycles of the Pennsylvanian. Moore (1936) noted that there were often many smaller cycles present within the so called "cyclothems" and so he proposed the term "megacyclothem" as an equivalent to Wanless and Weller's (1932) cyclothem and used the term cyclothem to describe these smaller cycles within the larger megacyclothem.

Jewett (1945) divided the Marmaton group into 4 megacyclothems : 1) the Fort Scott, 2) the Pawnee, 3) the Altamont, and 4) the Lenapah. Within the Altamont megacyclothem he delineated 4 smaller cyclothems, the lower, middle, and upper Tina (Amoret) cyclothems, and the Worland cyclothem. Of the lower, middle, and upper Tina (Amoret) cyclothems, he noted that the upper one was the most widespread, the other two being locally absent. He interpreted the upper Tina cyclothem as having been deposited in a very shallow marine setting. Cline (1941) found that in Missouri widespread coal smuts occurred between the Tina (Amoret) limestone and the overlying Lake Neosho shale. The most extensive study done on the Altamont Limestone was by Schenk (1963, 1967), who studied it from Oklahoma to Iowa. He believed that lithologic changes within the Amoret limestone were caused by structural elements and that the Amoret represented one gradually deepening event. Overall, Schenk suggested that the Altamont limestone represented one gradual deepening-shallowing event, with the Lake Neosho Shale being deposited in the deepest water, followed by a gradual regression during deposition of the Worland limestone. Mathewson (1978) studied three outcrops of the Amoret limestone in southeast Kansas and interpreted the Amoret as representing one deepening shallowing event with the middle part of this member representing deposition in the deepest water. Mathewson also believed that movement of the Ozark uplift in Missouri influenced sedimentation during deposition of the Amoret in southeast Kansas.

Heckel (1977) proposed his model of the "Kansas Cyclothem" as a replacement for the megacyclothem (fig 3). His model has since been used extensively to interpret Pennsylvanian age rocks in the mid-continent. Within this model the Amoret limestone would represent the middle or transgressive limestone.

Using a combination of this model and conodont data, Swade (1985) interpreted the Amoret as having been deposited in an environment of overall increasing water depth.

West and Busch (1986) and Voegeli (1989) attempted to delineate smaller scale transgressive-regressive events within the Amoret limestone. These smaller scale units are the same scale as the: 1) PAC's of Goodwin and Anderson (1985), 2) sixth-order T-R units of Busch and Rollins (1984), and 3) sixth-order cycles of Brett, et al. (1990). The genetic/event surfaces bounding these smaller scale units aided in recognizing environmental changes within the Amoret limestone. These environmental changes provided a

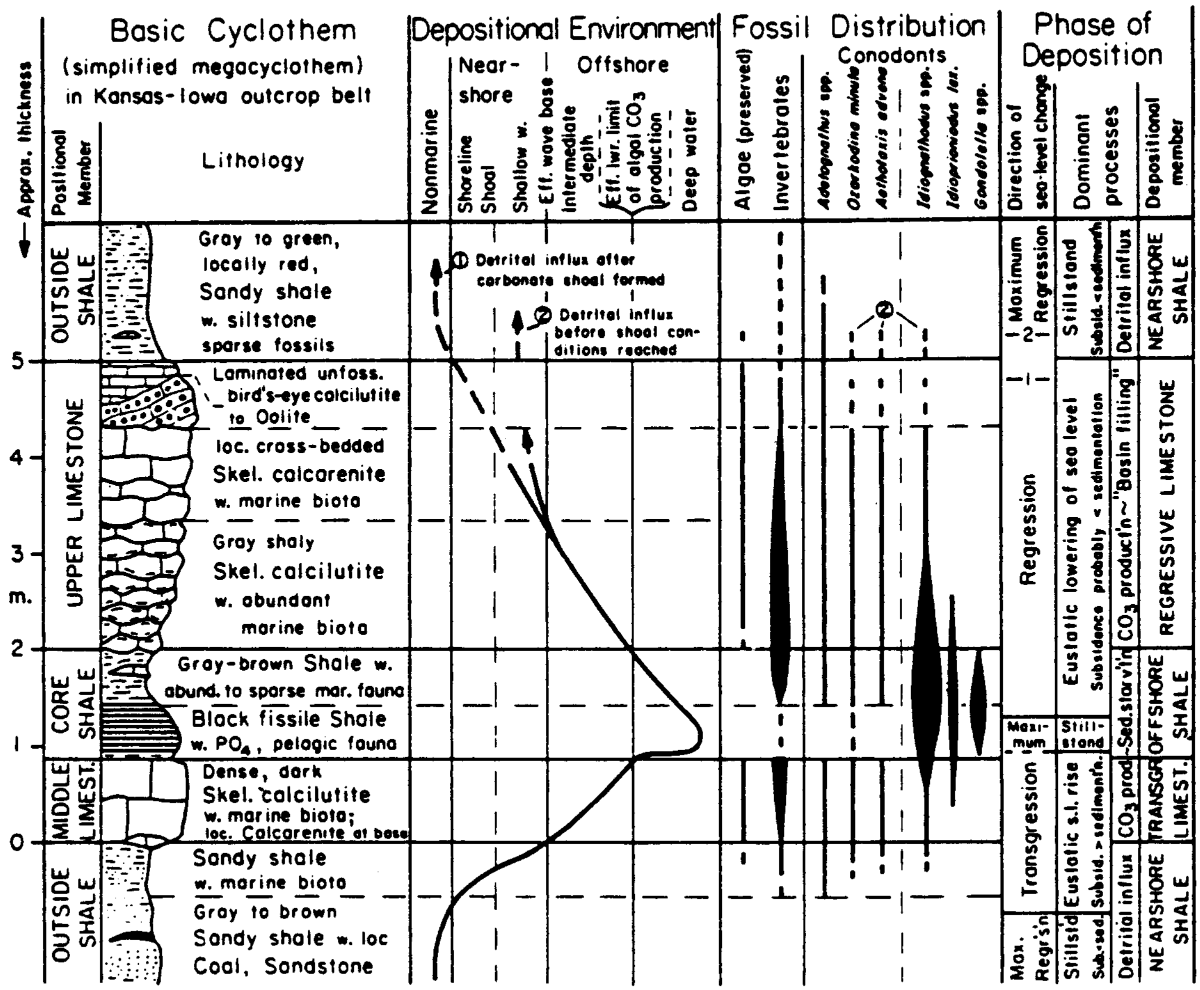


Figure 3. Heckel's "Kansas Cyclothem" (from Heckel, 1977, p. 1047).

better understanding of chaetetid growth habits and occurrences.

Chaetetids--Chaetetids have had a number of taxonomic "homes", including bryozoans, poriferans, corals, and algae. Hill (1981) considered Paleozoic chaetetids as tabulate corals, excluding Mesozoic chaetetids from this category. With the discovery of extant sclerosponges, similar to chaetetids (Hartman and Goreau, 1972), the case for poriferan affinity was strengthened. Mathewson (1978) and West and Clark (1984) included chaetetids with the sclerosponges. Reitner (1986), Connolly et al. (1989), and West (1992), have suggested that chaetetids are coralline demosponges.

Recently, it has been recognized that many fossil sponges classified as chaetetids are made up of several unrelated lineages (Wood, 1990). Thus, the current classification is being revised and "chaetetid" does not represent a systematic grouping, but refers to a skeletal grade of organization (Wood, 1990).

Hill (1981) listed the range of chaetetids as Silurian to Permian. West (1992) discussed reported occurrences of chaetetids and suggest a range of Silurian to Triassic, and noted that chaetetids are most abundant in Lower to Middle Pennsylvanian rocks.

Previous studies and noted occurrences of chaetetids are numerous; these are well discussed by Connolly et al. (1989), Suchy (1987), and West (1992), and except for Marmaton age rocks, will not be discussed further. Chaetetids have been recognized in all the limestone formations of the Marmaton group except for the uppermost Lenapah Formation. Suchy (1987) described chaetetids in the Houx-Higgensville Limestone Member of the Fort Scott Limestone throughout Oklahoma, Kansas, Missouri, and Iowa, including a detailed description of a chaetetid reefal buildup in Crawford Co., Kansas. Roth (1991) reported on chaetetids in the Blackjack Creek Limestone Member of the Fort Scott Limestone. Price (1981) discussed chaetetid occurrences within the Pawnee Limestone of Kansas and Missouri.

Within the Amoret Limestone Member of the Altamont Limestone, Jewett (1941) mentioned the occurrence of laminar chaetetids in Missouri and massive chaetetid buildups in southeast Kansas. Jewett (1945) recognized that chaetetids were important rock builders during most of Amoret limestone deposition, noting that many sections were composed almost entirely of this organism. Jewett (1945, pg. 67) stated that: "...colonies gained a footing soon after the beginning of deposition of the limestone phase....and they continued to flourish in areas.... protected from incoming clays during the waxing and waning of (Amoret) cycles....aided by the accumulation of calcareous algae, they continued to build up....until covered by muds that now form the Lake Neosho Shale." Jewett (1945) believed that chaetetids did not occur in the Worland Limestone Member of the Altamont in southeast Kansas, but noted that they were common in this member in Missouri. Chaetetids from the Worland limestone in Missouri are reported by Cline and Green (1950) and Gentile (1976). No mention of chaetetids within the Amoret member in Missouri is given by either author. Johansson (1959) noted the presence of chaetetids within the Worland limestone in northern Missouri and Iowa. A chaetetid bafflestone in the Worland member has been reported from the subsurface of western Kansas (Caldwell, 1983). DeVries (1955) described a chaetetid biostrome in the Amoret limestone of Madison Co., Iowa. He found that the chaetetids were adapted to a wide range of environmental conditions and that development appeared to be favored by topographic highs. Schenk (1963, 1967) recognized a chaetetid biofacies within the Amoret limestone in southeast Kansas. Chaetetids from two localities (692, 693) included in this study were examined by Mathewson (1978), including a "patch reef" composed almost entirely of chaetetid colonies. He suggested that chaetetids grew in a "relatively shallow, normal marine, moderate energy environment, well within the photic zone ..." (p. 75).

Mathewson's (1978) localities 692 and 693 served as the starting point for this investigation.

STRATIGRAPHY

General Comments

As stated previously, four exposures of the Altamont Limestone were examined in detail for this study. Three exposures (729, 692, 693) were quarries where three dimensional examination of the different facies could be made. The fourth exposure (782) was a road cut. Each locality was mapped using the pace and compass method. On these maps the locations of measured sections, vertical profiles, and other areas of specific study were plotted. Lateral relationships were recorded on vertical profiles that were drawn to scale using closely spaced measured sections. Using a theodolite, strike and dip was measured at each locality using the three point method.

Bed descriptions in the following sections are based on field and laboratory examinations. Descriptions represent an overall picture of the bed, and as such are generalized. Detailed information for each bed can be found in the appendices where measured section descriptions (Appendices A-D), thin section descriptions (Appendix E), and washed residue (Appendix F) are recorded.

Stratigraphy at Locality 729

Introduction--Locality 729 is an active quarry operated by Midwest Minerals Inc., Pittsburg, Kansas. This quarry represents the westernmost locality studied (see fig. 1), and is the most complete section of the Altamont Limestone among the four locations studied. All but the lower 0.5 m of the Amoret Limestone, along with the entire Lake Neosho Shale and Worland Limestone Members are exposed. Above this, the lowermost part of the Nowata Shale is sometimes present within depressions of the Worland Limestone. The lower 0.5 m of the Amoret limestone and the uppermost part of the Bandera Shale were retrieved by coring.

Figure 4 is a map of the quarry as it looked in the summer of 1989. In the northern part of the quarry all but the lower 0.5 m of the Amoret limestone was removed, in the southern part only the Lake Neosho shale and Worland limestone had been removed. This left the upper part of the Amoret exposed over a large area. Four detailed stratigraphic sections were measured within the quarry (labelled 729-S1 through 729-S4 on the map), these are described in detail in appendix A. Two profiles, one ten meters long (729-P1) and one twelve meters long (729-P2), were drawn to show lateral relationships and chaetetid occurrences within beds exposed in the quarry (beds 12 through 19 were not included in the profiles because they

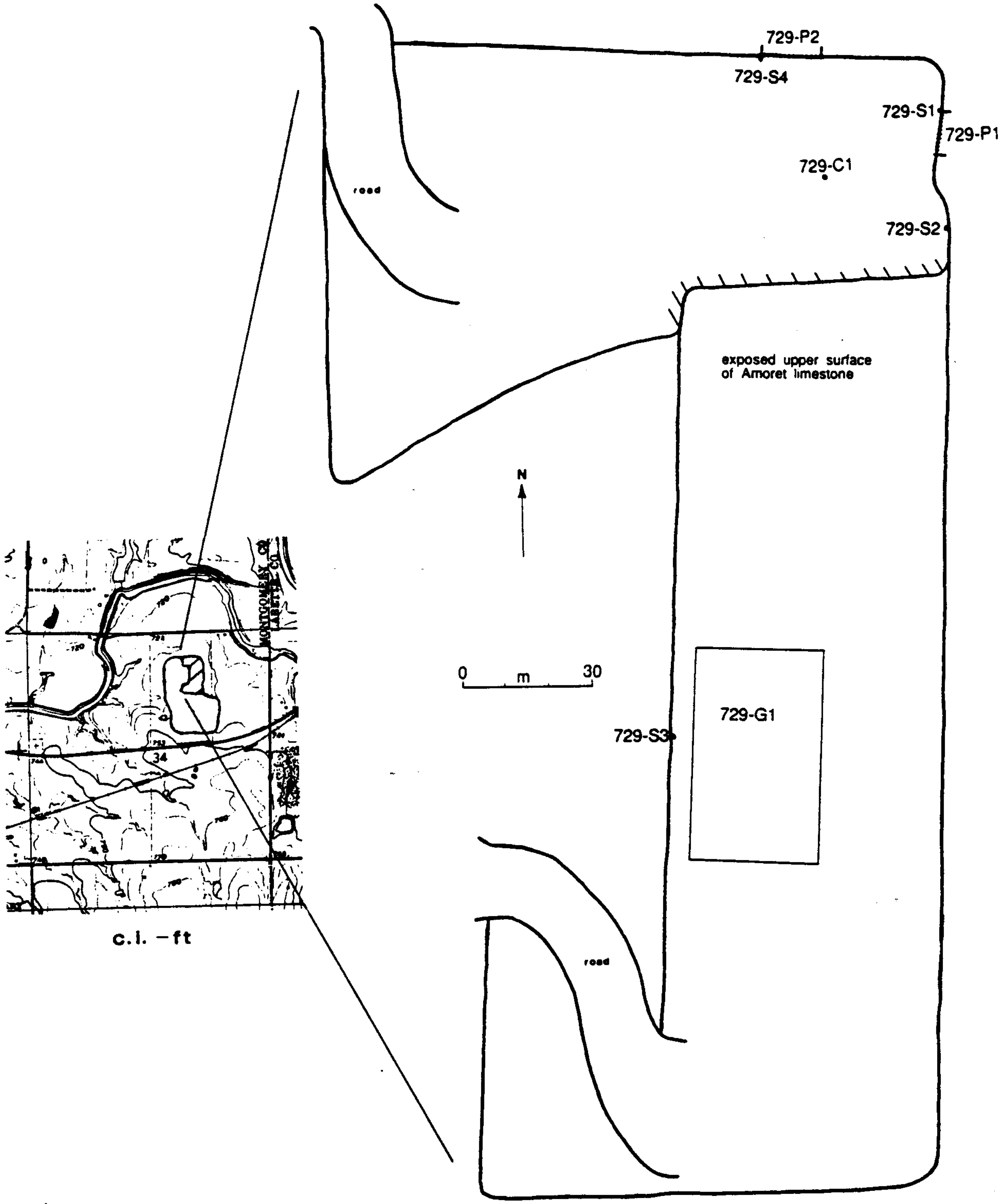


Figure 4. Pace and compass map of locality 729 showing the location of measured stratigraphic sections, profiles, core, and surface map of the upper Amoret. Closed area is entire quarry complex. Quarry pit is cross-hatched area. Topographic map is from USGS 7.5 minute Coffeyville East Quadrangle (1962, revised 1979).

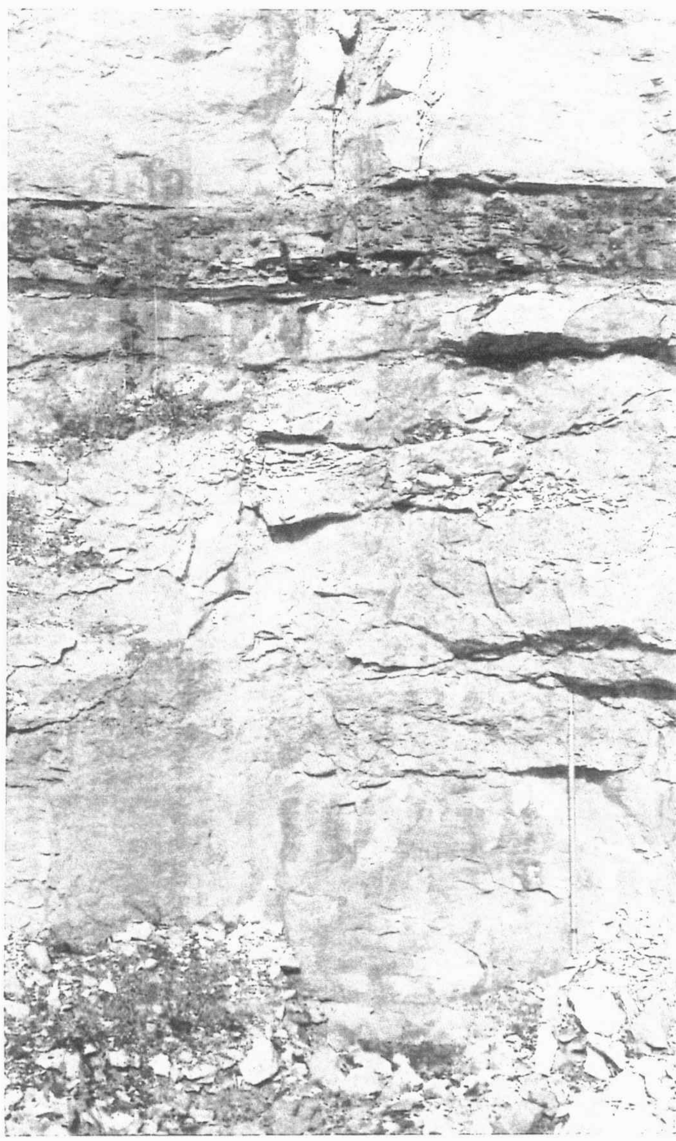
showed little lateral variation, lacked chaetetids, and were out of reach in the areas were the profiles were made). A map, 30 x 50 m (729-G1), was made of the upper surface of the Amoret limestone in the southern part of the quarry. This map shows surface irregularities and chaetetid occurrences. A one inch diameter core (729-C1) was taken in the northern part of the quarry using a portable coring device to examine the lower contact with the Bandera Shale. Coring began at the surface of the quarry floor (near the base of the Amoret limestone) and continued downward until the coring device began to bind at 51 cm.

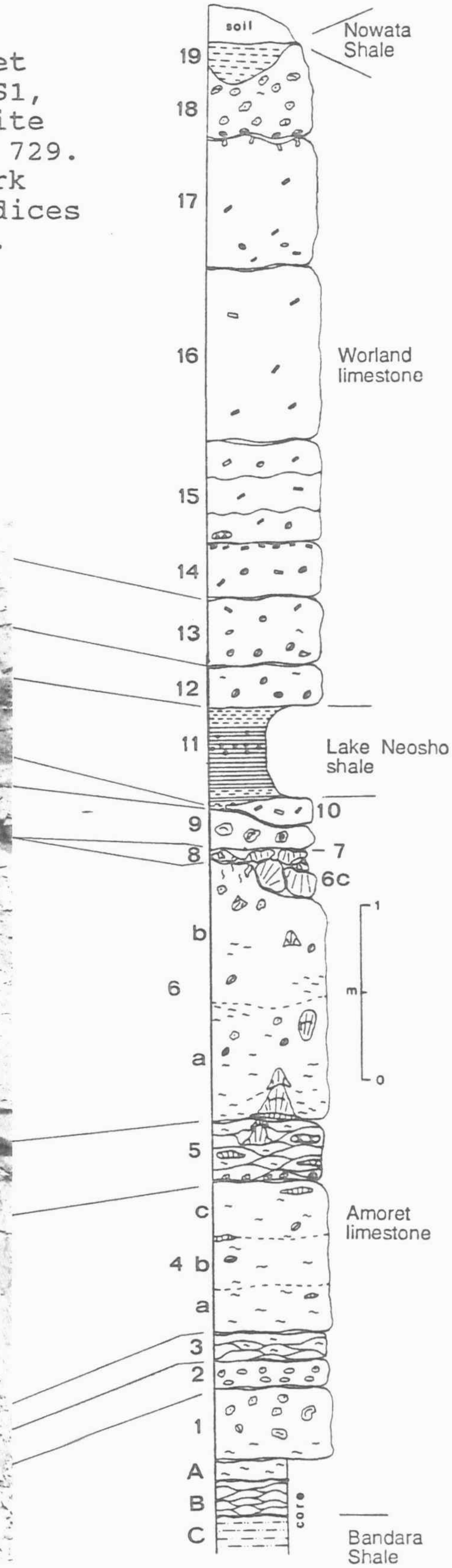
Rocks exposed at section 729-S1 are shown in fig. 5. Each member and the individual beds described in the following section are indicated. Bed 1 is the lowermost bed exposed in the quarry. Beds A-C were recognized in the core. The photo shows most of the Amoret limestone as it appeared in the quarry.

Using the erosional surface at the top of Bed 6 as a datum, the strike and dip of the beds is N 46°E and 0.78°SE.

<u>Descriptions of Beds</u>--Bed C, a micaceous siltstone, is the uppermost part of the Bandera Shale at this locality. The total thickness of this bed is unknown; only 33 cm were obtained from coring and no lower contact was evident. Prominent features were dark gray laminae throughout and bioturbation features (vertical escape structures and

Figure 5. Photograph of the Amoret limestone exposed at section 729-S1, and associated position on composite stratigraphic section of locality 729. Pole is one meter between wide dark bands. See Introduction to Appendices for a description of symbols used.





Planolites-like traces). Small pieces of unidentifiable skeletal debris were dispersed throughout. Most of bed C was noncalcareous except for the upper 3 to 4 cm. The upper contact is sharp and marked by a thin (1 cm thick) mudstone parting.

The lowermost part of the Amoret limestone (bed B) is a 24 cm thick crinoidal wackestone. It contains numerous clay-rich laminae which are concentrated in the lower third. Fossils consist of small(<0.3 cm diam) disarticulated crinoid columnals and unidentifiable skeletal grains. Wavy bedding is evident throughout. Grain size increases upward to a sharp contact with the overlying bed.

Above the crinoidal wackestone is a 14 cm thick wackestone (bed A). Phylloid algal fragments are the most conspicuous skeletal element (up to 1 cm long). Other fossils include brachiopod shell fragments, bryozoan fragments, crinoid debris, fusulinids, and unidentifiable skeletal grains. Some phylloid algal fragments and other skeletal debris are partially algal coated. Dark gray mottling is common, possible the result of bioturbation. The upper 1 cm is a crinoidal skeletal packstone with numerous clay-rich laminae. The upper contact is gradational, marked by a 0.5 cm thick sparsely fossiliferous fissile shale parting.

A coated grain wackestone to carbonate mudstone ranging from 33 to 40 cm thick (bed 1) is the lowermost bed exposed at the surface in the quarry. Most skeletal debris is unidentifiable and medium to fine sand-sized. Larger identifiable fossils include productids, Composita, fusulinids, phylloid algae fragments, bellerophontids, low and high-spired gastropods, fenestrate and ramose bryozoan fragments, ostracodes, Endothyra, Tetrataxis (some attached to skeletal debris), micrite pellets, and partially to completely "algal"-coated grains. Several brachiopods were articulated and spar filled, but were not in life position. The lower contact contains clay-rich laminae which show evidence of compaction and pressure solution. Fossil diversity and abundance decreases upward, with unidentifiable skeletal debris, "algal"- coated grains, and fusulinids common in the upper part of this bed. The contact with the overlying bed is sharp and marked by clay rich laminae.

The overlying wackestone to packstone (bed 2) is 10 to 16 cm thick. Skeletal debris is predominantly fusulinids, but Crurithyris and other brachiopod shell fragments, bivalve shell fragments, gastropods, crinoid debris, phylloid algae, small foraminiferids (Endothyra, Globivalvulina), and ostracodes are also present.

Most fusulinids show evidence of abrasions and/or are "algal"-coated, and much of the other skeletal debris is also partially to completely "algal"-coated. Wavy bedding is evident throughout. Compaction and pressure solution has occurred along clay-rich laminae near the lower contact. In the upper part of this bed, the number of fusulinids and the overall fossil abundance decreases, although phylloid algae becomes more common (and less fragmented) upward. The contact with the overlying bed is sharp to gradational.

Bed 3, a phylloid algal wackestone, is 5 to 11 cm thick across the quarry. Fossil debris consist predominantly of phylloid algal fragments up to several cm long. Additionally, Crurithyris, bryozoans, Composita, Lophophyllidium, foraminiferids, ostracodes, pellets, and unidentifiable fine sand-size skeletal debris are also present. Spar-filled areas under some phylloid algae fragments appears to have been originally areas of shelter porosity. Abundant clay-rich laminae occur in the lower part of the bed, but decrease in number upward. Compaction and pressure solution along these seams has created a stylobrecciod structure (after Flugel, 1982, p. 93) throughout much of the bed. The contact with the overlying bed is placed where clay-rich laminae disappear.

Bed 4, a wackestone (84 to 100 cm thick), is similar to the underlying wackestone bed, but contains a more diverse fossil assemblage and lacks clay-rich laminae. Additional fossils present include laminar chaetetids, echinoid spines, trilobite fragments, and Lithophyllum-like red algae. Dark gray mottling occurs throughout bed 4, and skeletal debris is often clumped within these mottled zones. Some laminar chaetetids are fragmented and/or overturned, and other skeletal debris is generally randomly oriented. Articulated Composita in apparent life position occur in the upper third of this bed. The bed can be divided roughly into three units, based on skeletal abundance. This sub-division, although suggested in outcrop, is clearly obvious in thin section. The greatest diversity and abundance of fossils occurs in the middle unit, with lower diversity and abundance above and below. The abrupt appearance of clay-rich laminae marks the contact with the overlying bed.

Above this wackestone bed is a phylloid algal brachiopod wackestone (bed 5), which varies in thickness from 20 to 45 cm. Bed 5 is somewhat similar to bed 3, but contains a more diverse fossil assemblage. As in bed 3, this interval contains numerous clay-rich laminae, which impart a brecciated appearance to the bed. Phylloid algal fragments are the most conspicuous skeletal elements, with Composita, productids, gastropods, crinoid ossicles, fenestrate and ramose bryozoan fragments, fusulinids, ostracodes, small foraminiferids, and micrite pellets also occurring. Chaetetids are present; most are laminar forms, although a few low domical forms occur. Occasionally the domical forms continue into the overlying bed. Some chaetetids show evidence of brecciation and/or overturning. The lower 5 cm of this bed occasionally contains a skeletal hash consisting of "algal"-coated grains, crinoid fragments, and unidentifiable skeletal debris (medium to fine sand-sized). The contact with the overlying bed is gradational to sharp, and placed where the clay-rich laminae disappear.

Because of the lateral irregularity of beds 6, 7, 8, 9, and 10, figures 6 and 7 (profiles of the quarry walls) are introduced here.

As seen in figures 6 and 7, bed 6, a wackestone to rudstone, varies considerable in thickness across the quarry, ranging from 130 to 180 cm. This bed contains the greatest concentration and the best developed chaetetids of any bed at this locality. Associated fossils are <u>Composita</u>, crinoid debris, gastropods, bellerophontids, bryozoan fragments, fusulinids, and an abundance of medium to fine-grained skeletal debris. Dark gray mottling, possible the result of bioturbation, is well developed and conspicuous in places. These mottled areas appear coarser grained than the surrounding lighter colored rock. Bed 6 is divisible into three units (a-c on figures 6 and 7), although in places this division is difficult to distinguish. The contact between units a and b, where evident, is marked by thin black clay-rich stringers and/or occasional small vertical burrow-like structures. Unit a contains the greatest number of chaetetids, and these chaetetids occasionally continue into unit b. Phylloid algal fragments are also more conspicuous in unit a. Phylloid algae are not always present throughout this bed, but tend to occur in

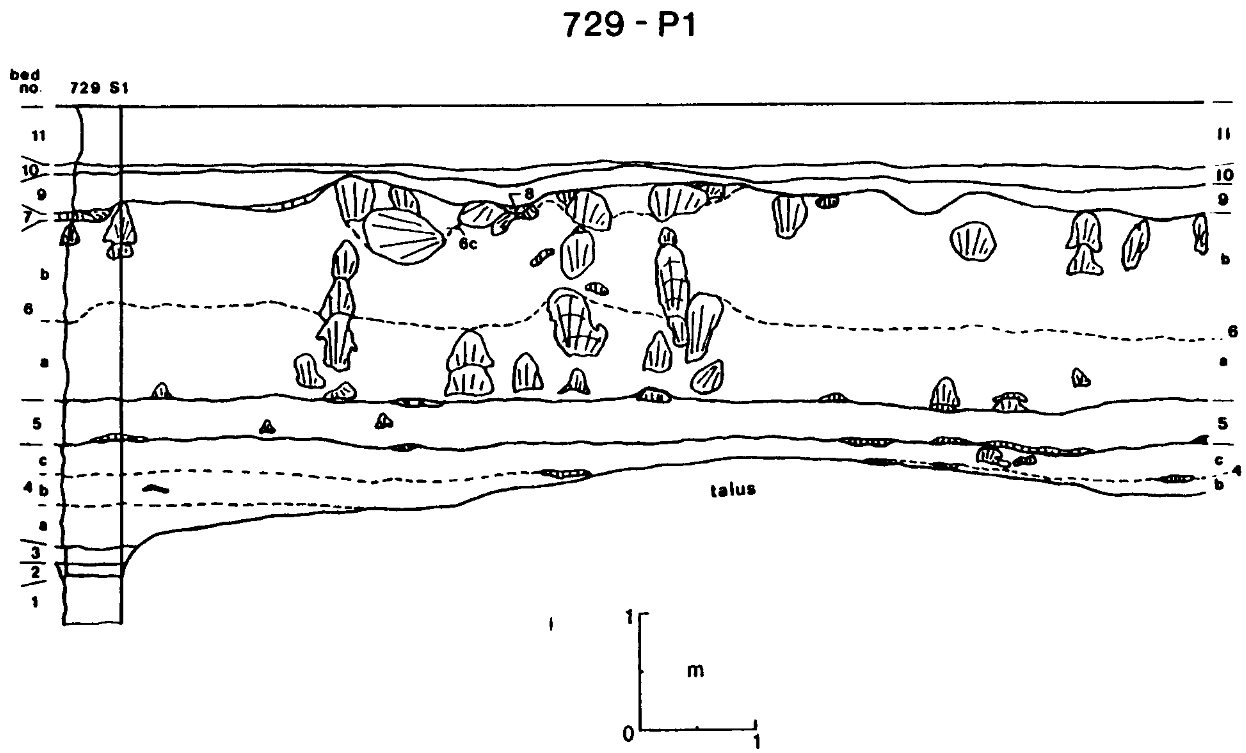


Figure 6. Profile 729-P1 showing chaetetid occurrences and the irregularity of the upper beds of the Amoret limestone. Bed contacts are solid lines; unit contacts are dashed lines (see text). Datum is top of the Lake Neosho Shale Member. See figure 4 for location in quarry.

729-P2

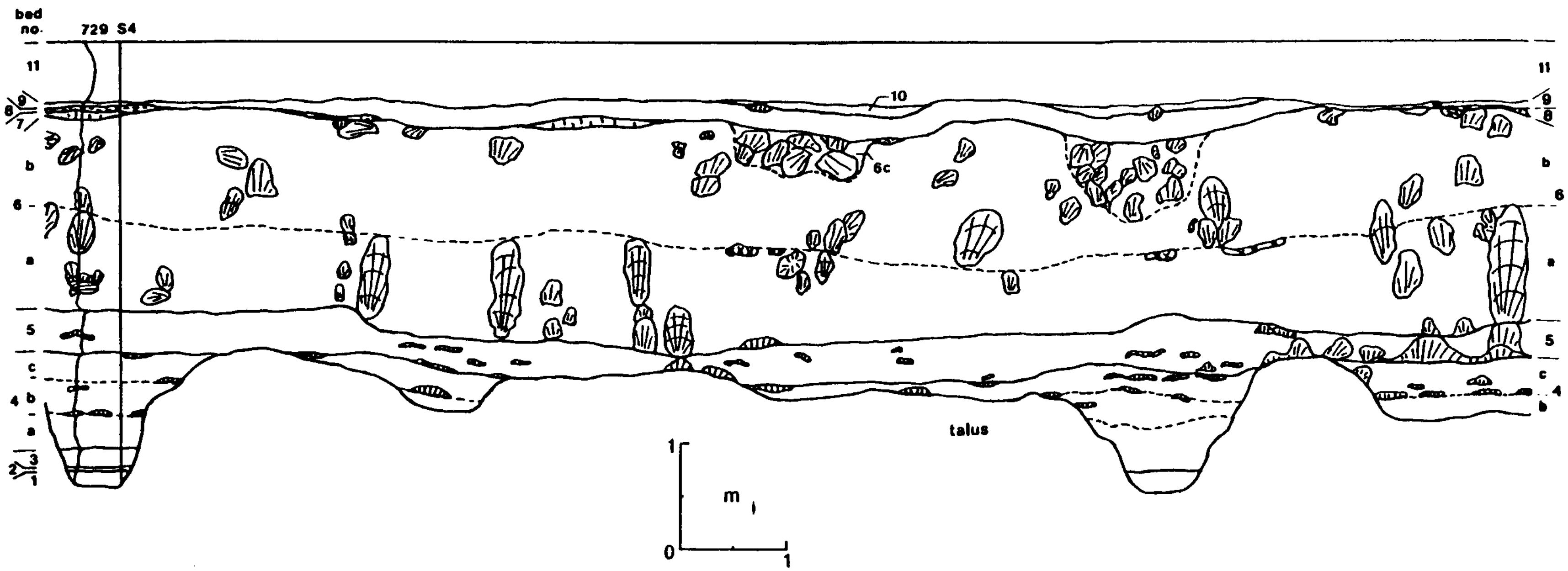
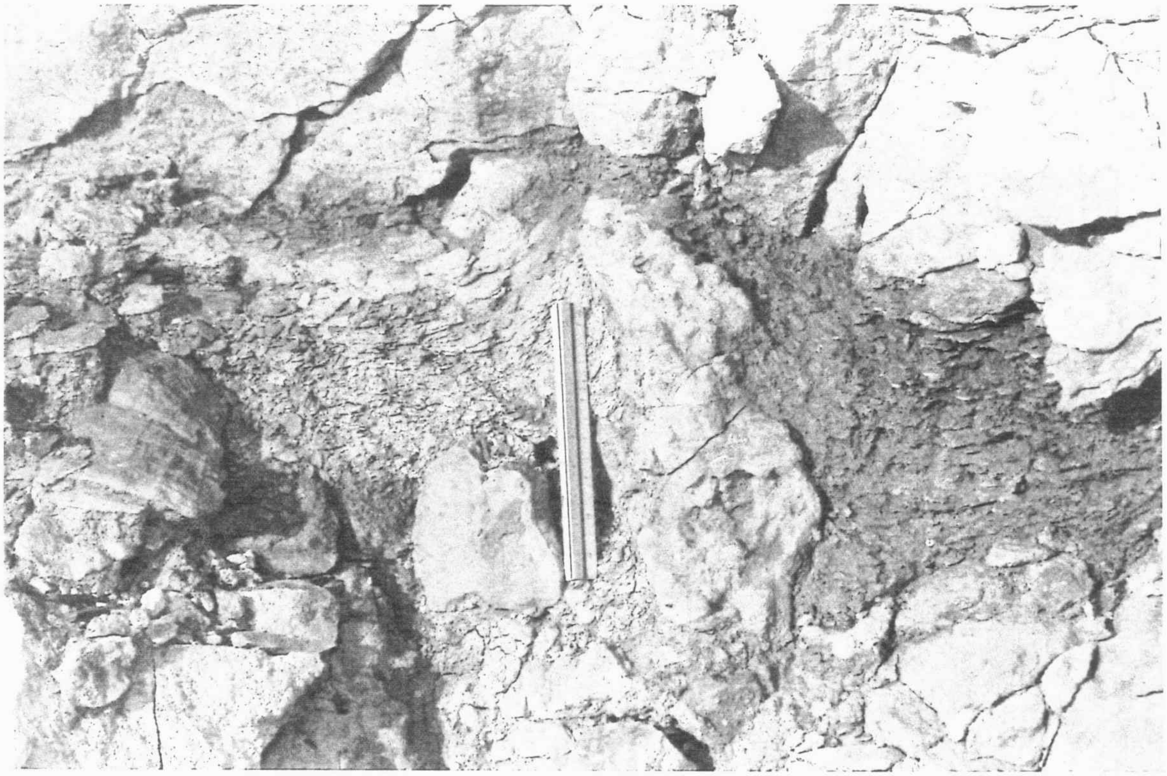


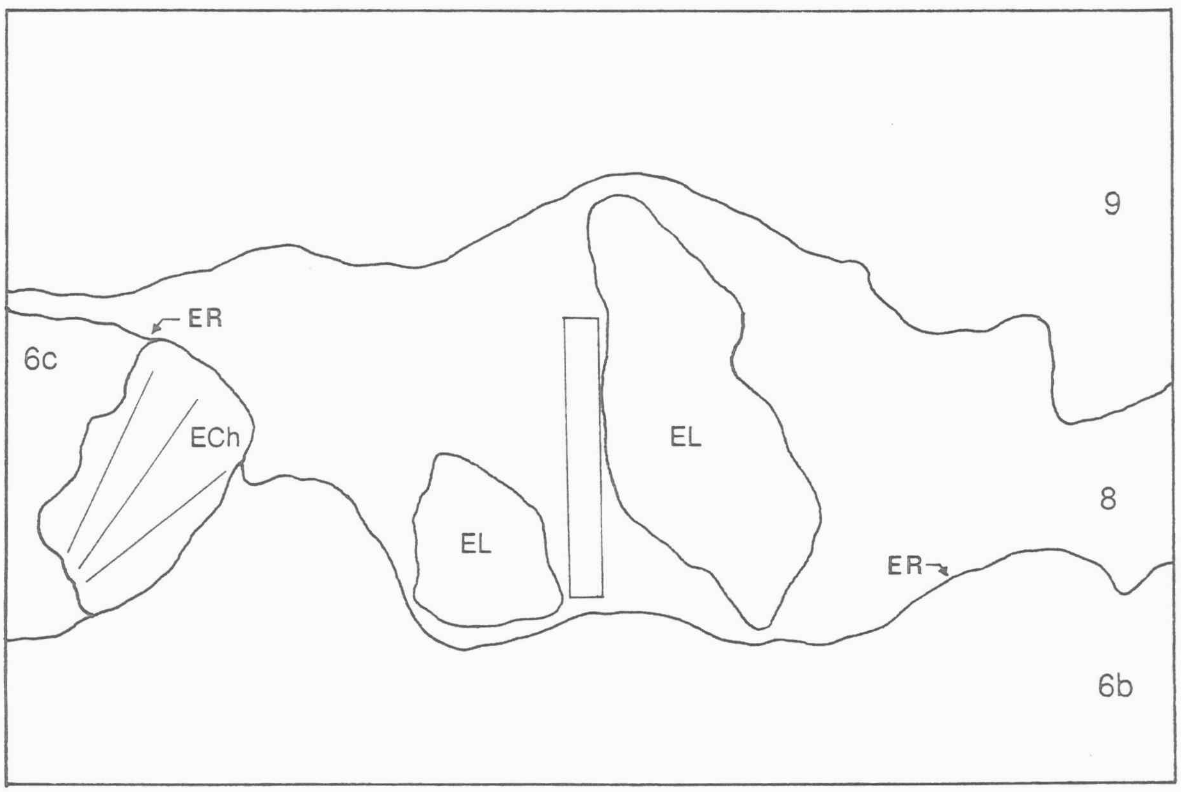
Figure 7. Profile 729-P2 showing chaetetid occurrences and the irregularity of the upper beds of the Amoret limestone. Bed contacts are solid lines; unit contacts are dashed lines (see text). Datum is top of the Lake Neosho Shale Member. See figure 4 for location in quarry.

discontinuous lenses, at times making up nearly all of the recognizable skeletal debris. Within the phylloid algal lenses the rock is a wackestone, whereas away from these lenses the rock is a skeletal wackestone to packstone. Unit c is discontinuous across the quarry, and consists mainly of jumbled, abraded, and fragmented chaetetids. The contact with unit b is relatively sharp, and it's irregularity suggest scouring of unit b during unit c deposition. Where the overlying bed (7) is absent, the upper surface of bed 6 contains solution pits, chert-filled fractures, in-place brecciation, and evidence of erosion (fig 8).

Bed 7, a skeletal mudstone to wackestone, is discontinuous across the quarry, ranging up to 20 cm in thickness. In most areas bed 7 is absent, and where it does occur it generally occupies depressions in bed 6. Skeletal debris is uncommon, and is mostly unidentifiable and fine sand-sized. Endothyroid foraminiferids and calcispheres can be recognized. This bed commonly contains rootlets and/or burrow structures, spar-filled fractures, and a pitted and corroded upper surface. The contact with the underlying bed is often stylolitic, and this, along with the effects of the upper erosional surface, often makes this bed hard to distinguish from the upper part of bed 6. In-place brecciation of bed 7 has resulted in some inter-fingering with the overlying bed, although the upper contact is very sharp and easily recognized.

Figure 8. Erosional surface (ER) on bed 6 at locality 729. Note large pitted and eroded limestone fragments (EL) at the center of the photo, eroded chaetetid (ECh) at the left center in bed 6c, absence of bed 7, and bed 8 filling in depressions on the upper surface of bed 6b. Scale is 15.24 cm.




9
ER
6c
ECh
EL
EL
8
ER
6b

The overlying clayshale (bed 8) occurs infrequently, mostly within depressions on the upper surface of bed 7, or bed 6 where bed 7 is missing. Bed 8 ranges from non-calcareous in the lower part to calcareous in the upper part. It contains abraded and corroded skeletal debris, including endothyroid foraminiferids, and chaetetid, bryozoan, crinoid, and brachiopods fragments. Some black organic fragments occur and may be plant debris. The contact with the overlying bed is sharp.

Bed 9, an oncolitic wackestone, ranges in thickness from 5-30 cm across the quarry. Productids and Composita are the main skeletal constituents, frequently articulated but seldom occurring in life position. Other skeletal elements are crinoid debris, bryozoan fragments, ostracodes, endothyroid and other small foraminiferids, laminar to low domical chaetetids, and calcispheres. Chaetetids occur most frequently in the upper half of the bed, and usually show evidence of overturning until a critical size (generally 3-5 cm long) was reached. Most skeletal grains are "algal"-coated, often forming large oncolites up to several cm in diameter. Some articulated Composita (which are not "algal"-coated) occur and appear to be attached directly to chaetetids. Foraminiferids and calcispheres are rarely "algal"-coated.

Clayshale partings occur throughout this bed, but these are most abundant near the lower and upper contact. Where this bed thins (generally when less than 8 cm thick), it is a nodular clayshale. Articulated brachiopods are more conspicuous in the upper part of this bed, and fewer skeletal grains are "algal"-coated. The contact with the overlying bed varies from sharp to gradational in the quarry.

The overlying wackestone (bed 10) is discontinuous across the quarry, varying in thickness from 0 to 50 cm. Fossils are relatively uncommon, consisting mostly of unidentifiable skeletal grains (medium to fine sand-sized). The most frequently occurring larger identifiable fossils are crinoid and bryozoan fragments. Other skeletal debris includes brachiopod shell fragments and spines, ostracodes, and foraminiferids. Skeletal grains are mostly fragmented and abraded, with some partially to completely "algal"-coated. In thin sections, crinoid fragments appear bored and corroded, and platy fossil debris shows some horizontal alignment. Thin sections also revealed the presence of some silt-sized quartz grains. Orientation of skeletal debris accentuates the wavy bedding present at some localities across the quarry. Where the bed is present, the contact with the overlying bed is sharp. Bed 10 is the uppermost bed of the Amoret limestone at this locality.

Bed 11, a phosphatic black shale (50 to 60 cm thick) makes up the Lake Neosho Shale, and seven distinct units (a-g) were recognized within it.

Unit a is a calcareous olive gray clayshale, 3 to 6 cm thick, containing an abundance of compacted and crushed skeletal debris including productids, Composita, Derbyia, Aviculopecten, scaphopods, crinoids, and high-spired gastropods.

Unit b is a grayish black, slightly calcareous shale, 3 to 4 cm thick, with some fossils including Mesolobus, bryozoan holdfasts, pyritized Donaldina-like gastropods, and scaphopods. Horizontal trace fossils, similar to Planolites, are present.

Unit c is an olive black calcareous clayshale, 5 to 6 cm thick. Skeletal debris within this unit includes Mesolobus, Orbiculoidea, Myalina, Crurithyris, productid shell fragments, and conodonts. Planolites-like trace fossils, and a few small (< 1 cm dia.) phosphate nodules are also present.

Unit d is a noncalcareous, fissile black shale (11 to 12 cm thick). Fossils are scarce within this unit, but Orbiculoidea, Clinophysta-like bivalves, Dunbarella, Crurithyris, fish scales, Listrocanthus spines, plant fragments, conodonts, and Planolites-like traces were found.

Unit e (22 to 24 cm thick) is similar to unit d, but is more indurated and contains less skeletal debris, consisting of Orbiculoidea, Listrocanthus spines, dermal denticles (Petrodus), plant fragments (Calamites), and conodonts. Discoidal to spherical phosphate nodules (up to several centimeters in diameter) are conspicuous in the upper half of this unit. The nucleus of these nodules is generally unidentifiable debris or Orbiculoidea, but occasionally dermal denticles and plant fragments are present.

Unit f, 10-12 cm thick, is also a fissile black shale, but is less indurated than unit e. Planolites-like trace fossils occur within the unit, and are occasionally pyritized. Fossils are uncommon and consist of Orbiculoidea, fish bones and scales, conodonts, and plant debris. Phosphate nodules are present, similar to those in unit e, but less abundant.

Unit g is an olive gray calcareous clayshale (5-10 cm thick) with frequent skeletal debris consisting predominantly of Crurithyris and crinoid ossicles. Other skeletal debris includes Orbiculoidea, Hustedia, Juresania, Aviculopecten, ramose bryozoan fragments, Donaldina-like gastropods, dermal denticles, sharks teeth, and conodonts. Occasional phosphate nodules occur, similar to the nodules in units e and f. Unit g is the uppermost part of the Lake Neosho shale, and has a gradational contact with the overlying bed.

Bed 12, a brachiopod wackestone (23 to 26 cm thick), is the lowermost bed of the Worland limestone. Composita is conspicuous, but productids and Mesolobus also occur. Articulated Composita with geopetal structure occur, and are occasionally in apparent life position. Other fossils include crinoid debris, gastropods, Aviculopecten, ramose bryozoan fragments, bivalve shell fragments, and abundant unidentifiable skeletal debris that is medium to fine sand-sized. A mottled texture is apparent, suggesting bioturbation. The gradational contact with the overlying bed contains closely spaced dark gray clay-rich laminae.

Above bed 12 is a brachiopod skeletal wackestone (bed 13), 36 to 38 thick. Composita is the conspicuous brachiopod, but productids are also present. Other fossils include bryozoan fragments, crinoid debris, Lophophyllidium, gastropods, and phylloid algal fragments. Unidentifiable (medium to fine sand-sized) skeletal debris predominates, and may be phylloid algal fragments. The upper contact with bed 14 is gradational and contains thin clay-rich laminae.

Bed 14, a skeletal wackestone (31 to 33 cm thick), is similar to bed 13, although brachiopods are less conspicuous, and crinoid debris and unidentifiable skeletal debris is more prevalent. The contact with bed 15 is sharp, and contains prominent crinoid stems (up to 4 cm long).

Skeletal grains in the overlying 55 to 60 cm thick wackestone (bed 15) are mostly unidentifiable and medium to fine sand-sized. Recognizable fossils are mostly crinoid and fenestrate bryozoan fragments. Black clay-rich stylolitic laminae occur throughout bed 15. The contact with bed 16 is gradational.

Bed 16, a wackestone (90 to 100 cm thick), is similar to bed 15 in composition, although unidentifiable medium to fine sand-sized skeletal debris is more prominent relative to other fossils grains. A small thin Multithecopora colony with a linear dimension of 15 cm was noted. Clay-rich laminae are less conspicuous than in bed 15, and are concentrated near the gradational contact with bed 17.

Bed 17, a carbonate mudstone, ranges in thickness from 65 to 75 cm and contains sparse skeletal debris. Much of the skeletal debris is fine sand-sized and unidentifiable. Occasional fragments of crinoids, bryozoans, fusulinids, Crurithyris, and Composita were noted, mostly in the lower half of the bed. Discontinuous lenses of a crinoidal-bryozoan packstone occurs near the lower contact with bed 16. Fossil fragments in bed 17 decrease in abundance and become finer grained upward. Stylolites and dark gray mottling are common in the lower half of this bed. The upper surface of this unit is stained orange and appears corroded, bored, and/or burrowed. Occurring on the upper surface are articulated (in-situ?) Neospirifer and Composita, along with fusulinids, crinoid columnals (up to 5 cm in length), and fine skeletal debris.

Bed 18, a wackestone to packstone (20 to 50 cm thick), is the uppermost bed of the Worland limestone in this quarry. Throughout most of the quarry bed 18 is overlain by a soil. The lower third of this unit is a packstone consisting of predominantly fine sand-sized algal-coated skeletal grains and occasional crinoid, bryozoan, and brachiopod fragments. The upper two thirds grades into a skeletal wackestone, consisting of algal coated phylloid algal fragments and sand-sized skeletal debris.

Bed 19, the uppermost bed at this locality, is a discontinuous noncalcareous mudstone. It occurs only in channel-like structures or depressions in the upper surface of bed 18 (see fig 5), and contains some plant remains. It is the lowermost part of the Nowata Shale.

Stratigraphy at Locality 692

Introduction--Locality 692 is an active quarry approximately 1.4 km southeast of locality 729 (see fig. 1), operated by Harry Keith and Sons Crushed Rock of Coffyville, Kansas, and is equivalent to locality CM-1 of Mathewson (1978). Within the quarry, nearly all of the Amoret Limestone, the entire Lake Neosho Shale, and the lower 2 meters of the Worland limestone are exposed. The lower part of the Amoret limestone and the uppermost part of the Bandera Shale were studied in a core taken by Mathewson (1978).

Figure 9 is a map of the quarry as it appeared in the summer of 1988. Unlike locality 729, there was no preferential quarrying of the units present. Active quarrying at this locality made detailed examination difficult, and no vertical profiles where drawn. Five sections were measured (labelled 692-S3, 692-S4, 692-S5, 692-S7, and 692-S10) and described in detail (see Appendix B). A core of the lower Amoret limestone and the upper Bandera Shale (collected by Mathewson, 1978) from this locality was used to supplement the measured sections.

Figure 10 shows the rocks exposed within this quarry; bed numbers correspond to equivalent beds at locality 729,most of which are similar in all aspects. Therefore, the following bed descriptions will be brief and will focus

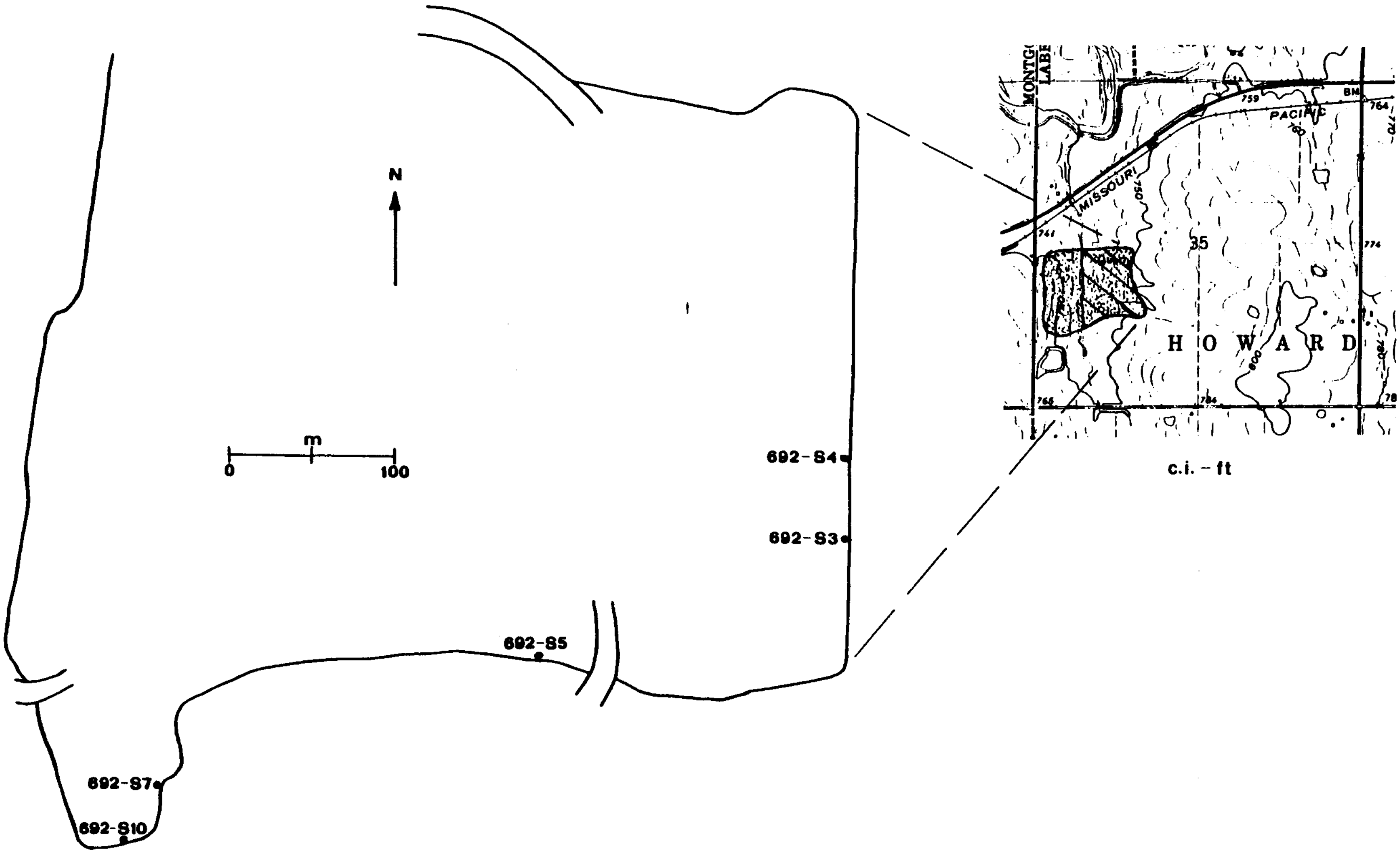


Figure 9. Pace and compass map of locality 692 showing the location of measured stratigraphic sections. Closed area is entire quarry complex. Quarry pit is cross-hatched area. Topographic map is from the USGS 7.5 minute Coffeyville East Quadrangle (1962, revised 1979)

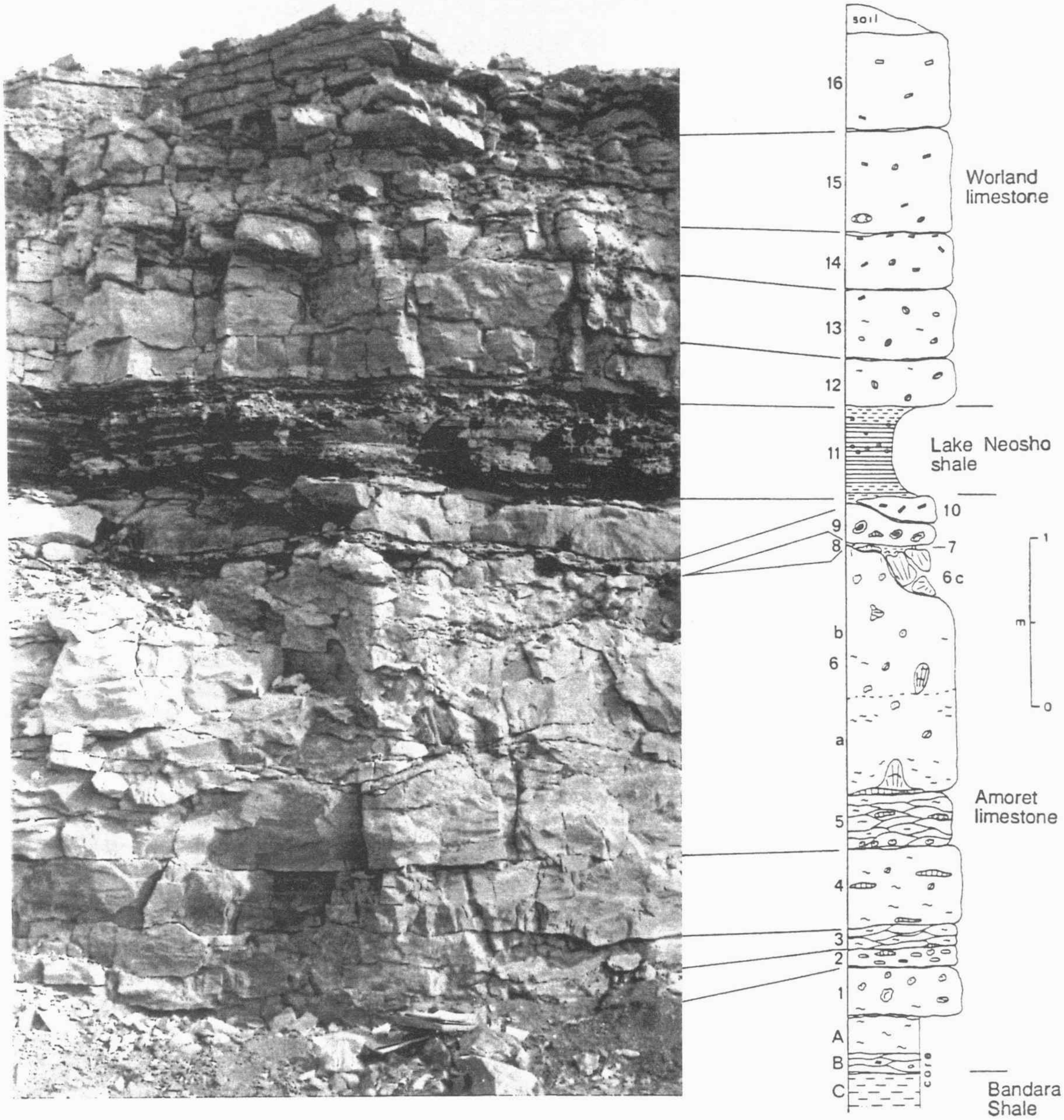


Figure 10. Photograph of the Amoret limestone exposed at section 692-S10, and associated position on composite stratigraphic section of locality 692. Hammer is 30 cm long. See Introduction to Appendices for a description of symbols used.

on differences which were noted between the two localities.

Using the erosional surface at the top of bed 6 as a datum, the strike and dip of these beds is N. 8° W. and 1° SW.

Description of Beds--The following descriptions of beds A-C are modified from Mathewson (1978).

Bed C, a micaceous siltstone, is equivalent to Mathewson's (1978) beds D and C, and differs little from bed C at locality 729. it is 35 cm thick (no lower contact was noted), and contains calcareous clasts.

Bed B, an argillaceous wackestone (10 cm thick) overlies bed C, and represents the lowermost part of the Amoret limestone. This bed is the equivalent of Mathewson's (1978) bed B, and is very similar to Bed B at locality 729, although the thickness here is roughly half that at locality 729. Finely disseminated pyrite is present throughout.

Overlying bed B is a wackestone (bed A), which is 22 cm thick and is the equivalent of Mathewson's (1978) bed A. This wackestone is very similar to bed A at locality 729, although nearly twice as thick.

Bed 1, a wackestone to mudstone (30 to 37 cm thick), is the lowermost bed exposed at locality 692. This bed does not show any major differences from the equivalent bed at locality 729.

The overlying bed (2), a wackestone to packstone (7 to

11 cm thick), is very similar to bed 2 at locality 729, however, some differences were noted. Occasional laminar to low domical chaetetids occur in the upper half of the bed, and these often appear to have been overturned and/or dislocated. Also, fusulinids are less conspicuous than at locality 729.

Bed 3, a phylloid algal wackestone, is 4 to 15 cm thick and similar to bed 3 at locality 729. Unlike locality 729, laminar chaetetids occur infrequently near the lower and upper contacts. Lophophyllidium is also locally abundant within this bed, but are seldom in-situ.

Bed 4, a wackestone, is similar to bed 4 at locality 729, but the thickness is much less at 31 to 42 cm. Also, units a-c noted within bed 4 at locality 729 are not readily distinguishable in the field at this locality.

Above bed 4 is a phylloid algal, brachiopod wackestone (bed 5) which is 32 to 42 cm thick and differs little from bed 5 at locality 729. Chaetetids in the lower part occasionally appear overturned and/or fragmented. Chert nodules also occur in the lower half of this unit.

Bed 6, a chaetetid wackestone to packstone (110 to 164 cm thick), is similar to bed 6 at Locality 729. Three units, a-c, can be distinguished here, although unit c is not as prominent as it is at locality 729. Some graded-bedding and possible cross-bedding was observed at one section (692-S7) in the upper 10 cm of unit b. As at locality 729, the upper contact is an erosional surface where the overlying bed is absent. Figure 11 is a photograph of a large quarried block of bed 6 and shows a plan view of this erosional surface.

Bed 7, a laterally discontinuous skeletal carbonate mudstone, is comparable to bed 7 at locality 729, and ranges in thickness from 0 to 30 cm. It occurs frequently within depressions along the upper surface of bed 6. The upper surface is pitted and potmarked, with chert-filled fractures and zones of in-place brecciation.

Overlying bed 7 (or bed 6 where bed 7 is missing) is a noncalcareous to calcareous clayshale (bed 8), which ranges in thickness from 0 to 10 cm across the quarry. This bed is similar to bed 8 at locality 729, occurring within depressions in the underlying beds, and containing eroded limestone and chaetetid fragments.

Bed 9, an oncolitic wackestone (4 to 35 cm thick), differs little from bed 9 at locality 729. Where this bed thins it often grades laterally to a clay-rich, nodular limestone to a calcareous, nodular clayshale. Brachiopod oncolites are conspicuous throughout, and appear to increase in size near the center of the bed.

The overlying discontinuous wackestone bed (bed 10) is the uppermost bed of the Amoret limestone at this locality, and is comparable to bed 10 at locality 729, ranging in thickness from 0 to 34 cm. Thin discontinuous lenses of a

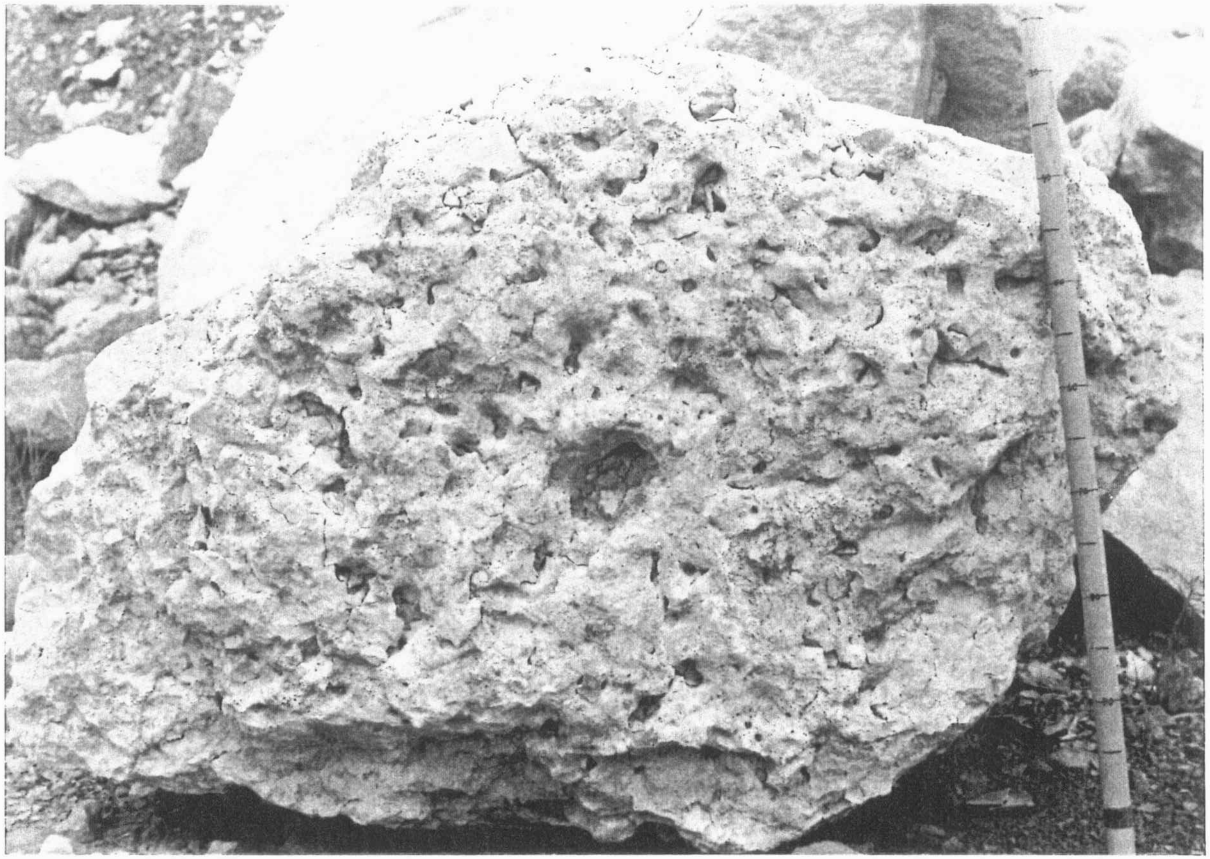


Figure 11. A large quarried block of bed 6 showing the pitted and eroded upper surface of the bed at locality 692. Numbers on pole scale are in cm.

crinoidal-Mesolobus packstone occasionally occur within the upper part. A quarried block of this bed present near section 692-S7 contained a large flattened bifurcating Lepidodendron-like fragment on its upper surface (fig. 12).

Bed 11, a phosphatic, black shale (56 to 70 cm thick), is the stratigraphic equivalent of the Lake Neosho shale. Seven distinct units (a-g) can be delineated within this bed, all of which are similar to the same units at locality 729. Discoidal to spherical phosphate nodules occur in the upper half, but are concentrated near the center of the bed and occur less frequently in the upper part.

Access to beds 12 through 16 (Worland limestone) was limited throughout most of the quarry, but where examined appeared to differ little from the same beds at locality 729. Crinoid debris, brachiopods, and medium to fine sand-sized skeletal grains were conspicuous throughout. A modern soil profile is developed on the upper surface of bed 16, the uppermost bed present within the quarry.

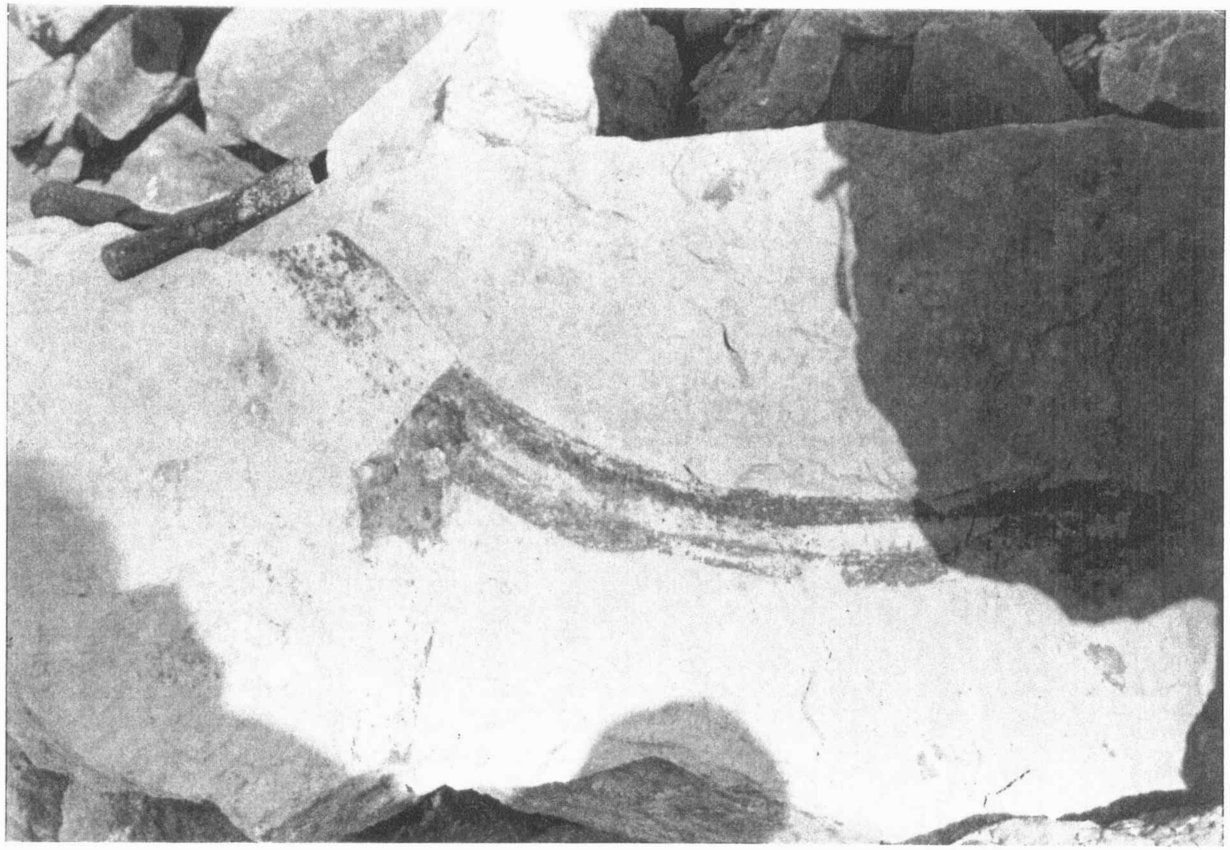


Figure 12. Compacted bifurcating Lepidodendron-like branch present on the upper surface of bed 10 at locality 692. Hammer head is 15 cm across.

Stratigraphy at Locality 693

Introduction--Locality 693, a small inactive quarry owned by Ben Donley of Coffeyville, Kansas, is in the eastern part of the study area (see fig 1). Exposed within this quarry is what appears to be all but the lower few beds of the Amoret limestone. The entire Lake Neosho shale, and the lower part of the Worland limestone were exposed by trenching in the northeastern part of the quarry. This locality is the same as Mathewson's (1978) locality CL-6.

Figure 13 is a pace and compass map of the quarry as it appeared in the summer of 1989. Five detailed stratigraphic sections were measured within the quarry (labelled 693-S1, 693-S2, 693-S5, 693-S6, and 693-S7 on the map); these are described in detail in Appendix C. Two profiles, each 10 meters long, were drawn of the exposed vertical wall to show lateral relationships and chaetetid occurrences within beds exposed in the quarry (labelled as 693-P1 and 693-P2 on the map). The approximate location of a one inch diameter core taken by Mathewson (1978), which was re-described for this study, is also shown on the map (labelled 693-C1).

Using the erosional surface of bed 6 as a datum, the strike and dip of the beds is S. 34° E. and 1.0° SE.

Rocks exposed at section 693-S1 are shown in figure 14, along with a composite stratigraphic profile of locality 693. The lower beds (1-3) were usually under water, and

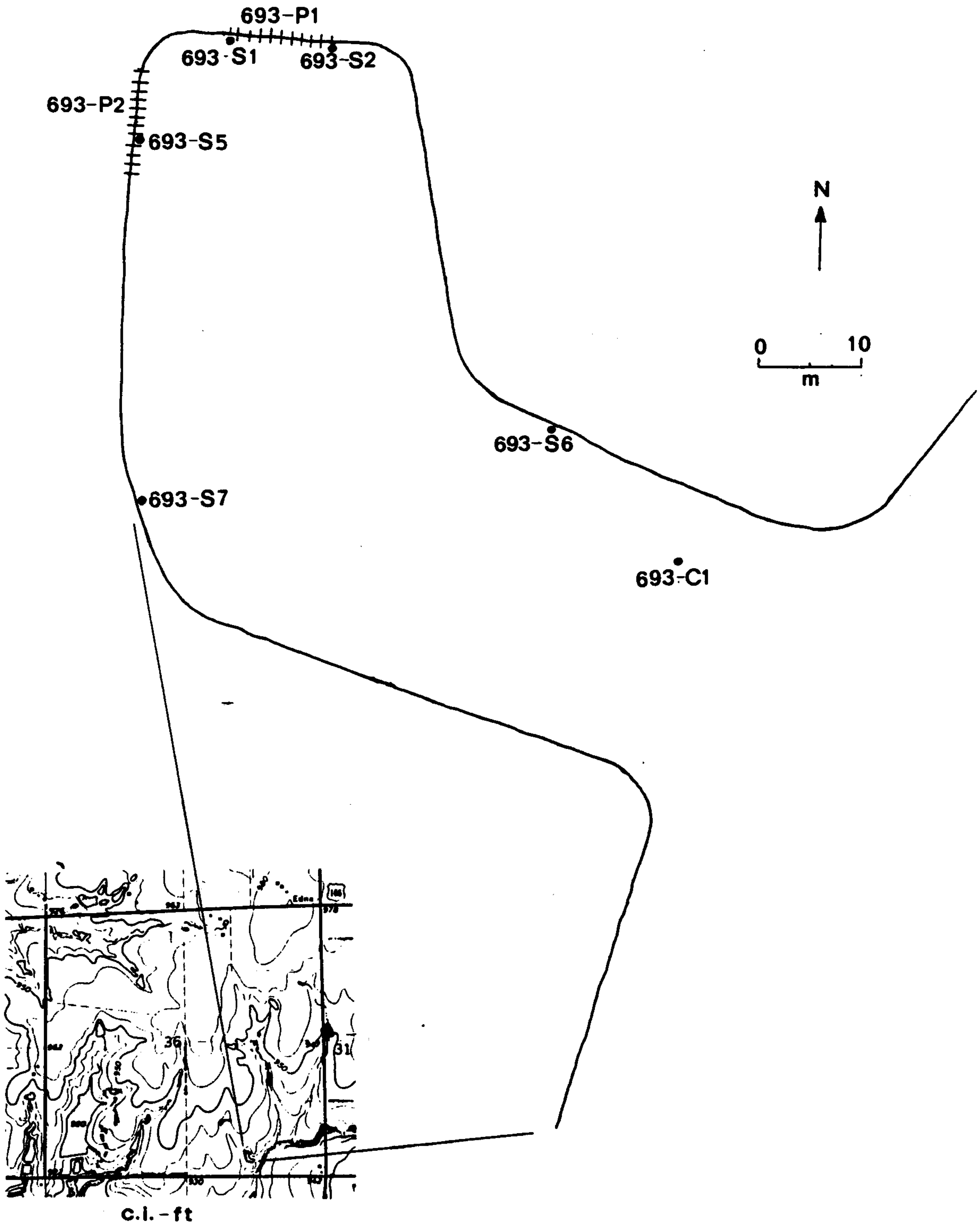


Figure 13. Pace and compass map of locality 693 showing the location of measured stratigraphic sections, profiles, and core. Topographic map is from the USGS 7.5 minute Valeda Quadrangle (1974).

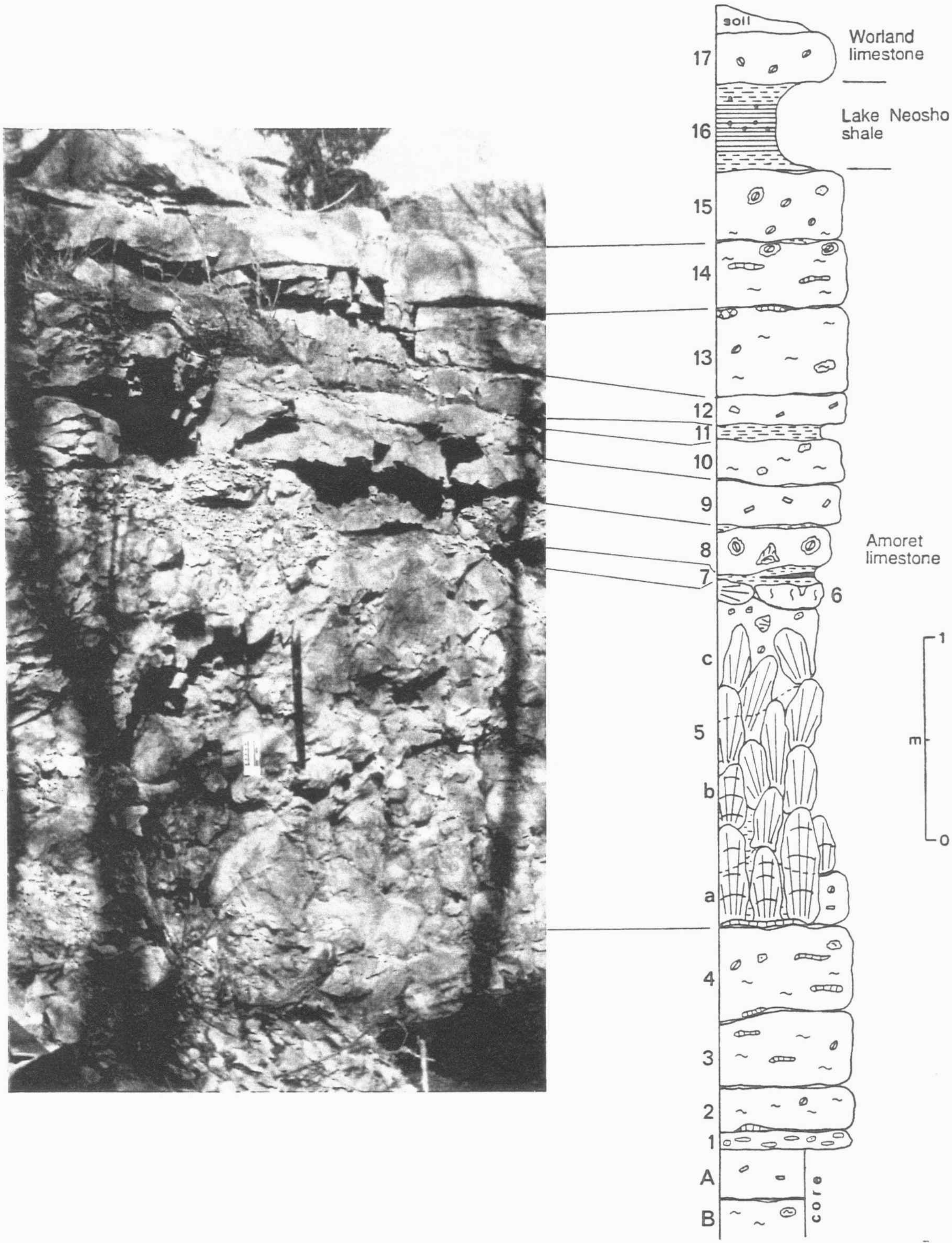


Figure 14. Photograph of the Amoret limestone exposed at section 693-S1, and position on composite stratigraphic section of locality 693. Scale is 10 cm long. See Introduction to Appendices for a description of symbols.

beds A and B were only recognized in the core. The Lake Neosho shale and Worland limestone did not occur at section 693-S1.

Description of Beds--Bed B, a wackestone, is the lowermost bed observed at this locality. The thickness of the bed is unknown; only 17 cm was obtained from coring and no lower contact was evident. Skeletal debris consist predominantly of phylloid algal fragments and unidentifiable skeletal grains. Other fossils present include productid shell fragments, high-spired gastropods, crinoid debris, and bryozoan fragments. Much of this skeletal debris is partially to entirely algal-coated. The upper contact was sharp and marked by thin clay-rich laminae.

Overlying bed B is a wackestone bed (bed A) which is 6 cm thick. Skeletal debris consists primarily of unidentifiable skeletal grains (medium to fine sand-sized) and small crinoid fragments. Other skeletal elements are fusulinids, brachiopod shell fragments, and bryozoan fragments. Algal coatings are conspicuous on many of the skeletal grains, especially in the lower half. The upper contact with the overlying bed is sharp.

Bed 1, a packstone (5 to 7 cm thick), contains skeletal grains consisting predominantly of fusulinids and medium to fine sand-sized skeletal debris. Other fossils include phylloid algal fragments, crinoid debris, brachiopod shell fragments, bryozoans, calcispheres, gastropod shell fragments, ostracodes, and small foraminiferids (including Globivalvulina and Tetrataxis). Skeletal debris is mostly fragmented and abraded, with many grains algal-coated. Wavy bedding occurs throughout, and the upper contact is sharp and marked by black clay-rich laminae.

Bed 2, a wackestone (17 to 28 cm thick), is the lowermost bed exposed at the surface in the quarry. Fossil debris is mostly phylloid algae fragments (up to 3 cm long). Other fossils include crinoid debris, Composita and other brachiopod shell fragments, gastropod shell fragments, calcispheres, small foraminiferids (including Tetrataxis), and unidentifiable skeletal grains. Some skeletal debris is partially "algal"-coated. Spar-filled areas that appear to have been original porosity are present under some phylloid algal fragments. The contact with the overlying bed is sharp and marked by microstylolites and black clay-rich laminae.

The overlying chaetetid-bearing wackestone (bed 3) ranges from 23 to 60 cm thick in the quarry. It is similar to the underlying bed, but contains slightly more skeletal grains. The most conspicuous skeletal elements are phylloid algal fragments, often up to several cm in length. Laminar chaetetids occasionally occur in the upper half of bed 3. Other fossils include gastropod fragments, Composita, ostracodes, foraminiferids (including fusulinids and

Tetrataxis), and unidentifiable skeletal grains that are medium to fine sand-sized. The contact with the overlying bed is sharp and marked by thin clay-rich laminae.

Bed 4, a phylloid algal foraminiferid wackestone, is 23 to 46 cm thick in the quarry. This wackestone is similar to the underlying bed, but phylloid algae appears more fragmented, and laminar chaetetids occur less frequently, usually near the lower contact. Foraminiferids are conspicuous in thin section, consisting of fusulinids, Endothyra, Tetrataxis, Globivalvulina, and others. Rugose corals, Composita, productids, high-spired gastropods, calcispheres, and unidentifiable skeletal grains are also present. "Algal"-coated skeletal debris occurs throughout. The upper contact is sharp and marked by black clay-rich laminae.

Figures 15 and 16 are profiles of the quarry walls at locality 693, and are introduced here to illustrate the lateral thickness variations in beds 5 through 8 at this locality.

As seen in figures 15 and 16, bed 5, a chaetetid wackestone to boundstone (134 to 138 cm thick), can be divided into three units (labelled a, b, and c), each of which varies considerable in thickness across the quarry.

Unit a is a chaetetid wackestone to boundstone, with chaetetids, in places, making up 100% of this interval. Elsewhere this zone contains crinoids, Composita, Mesolobus,

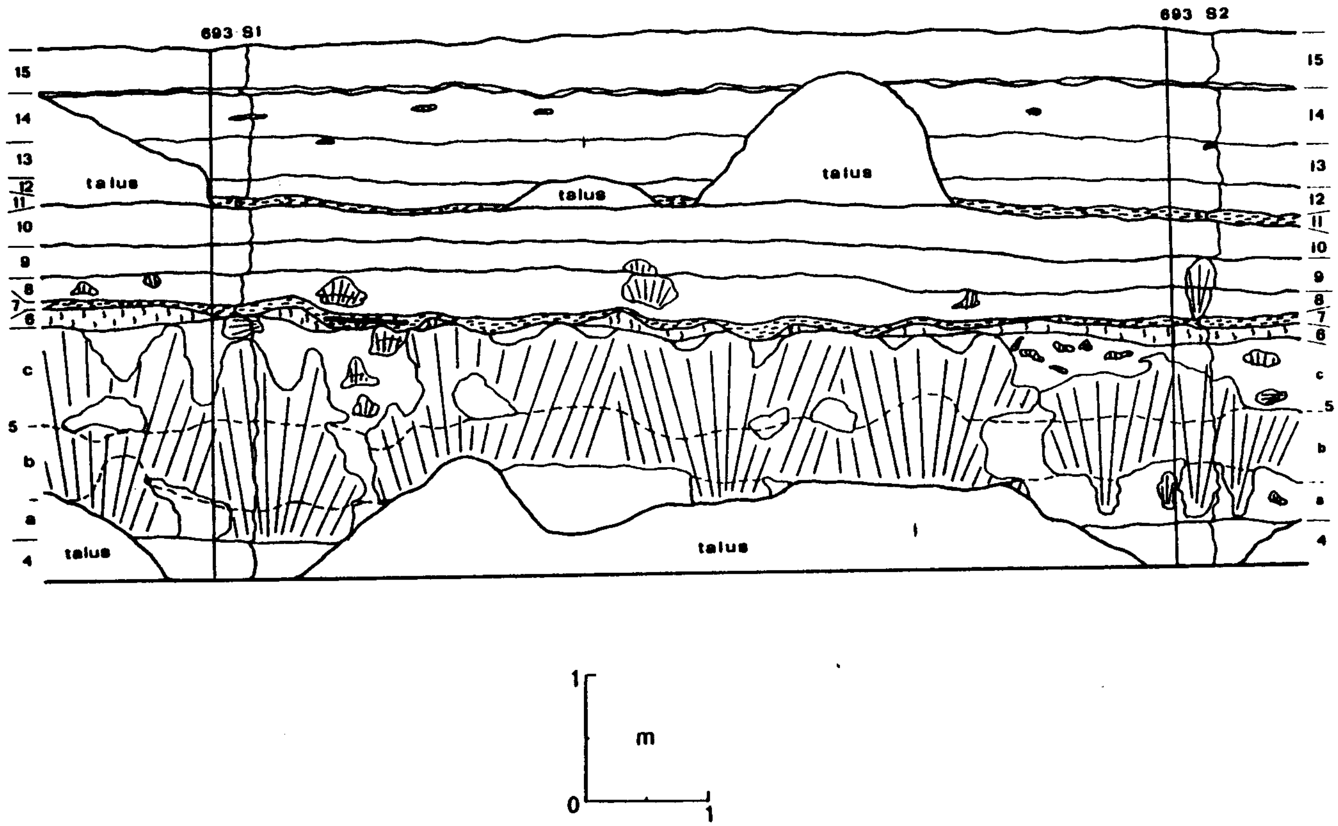


Figure 15. Profile 693-P1 showing chaetetid occurrences and the irregularity of Amoret limestone beds at locality 693. Bed contacts are solid lines; unit contacts are dashed lines (see text). Datum is surface of water in quarry. See figure 13 for location in quarry.

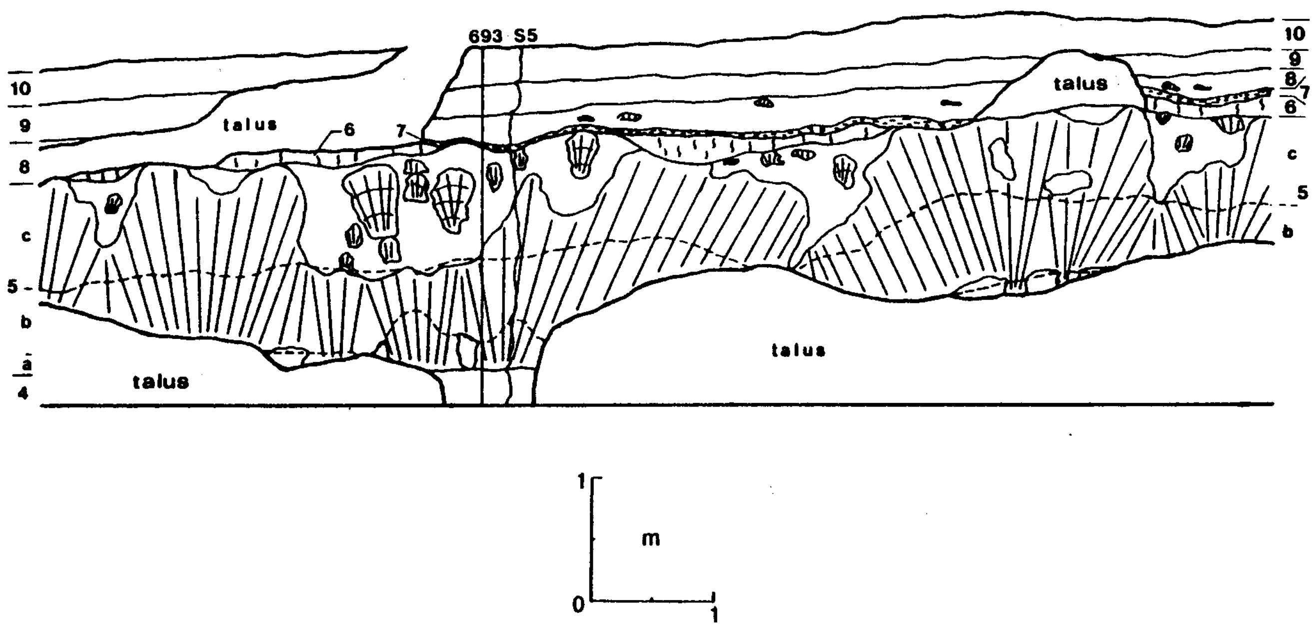


Figure 16. Profile 693-P2 showing chaetetid occurrences and the irregularity of Amoret limestone beds at locality 693. Bed contacts are solid lines; unit contacts are dashed lines (see text). Datum is surface of water in quarry. See figure 13 for location in quarry.

productid shell fragments, fusulinids, bryozoan fragments, small foraminiferids (including Tetrataxis and Endothyra), and unidentifiable skeletal grains that are medium to fine sand-sized. An "algal"-coating occurs on some of the fossil debris and also occasionally on chaetetids. The growth form of chaetetids at the base of this unit is laminar, but becomes low domical in the upper part. These frequently continue upward into the overlying unit. Occasionally the low domical forms are toppled or overturned. Clay-rich laminae mark the sharp upper contact with the overlying unit.

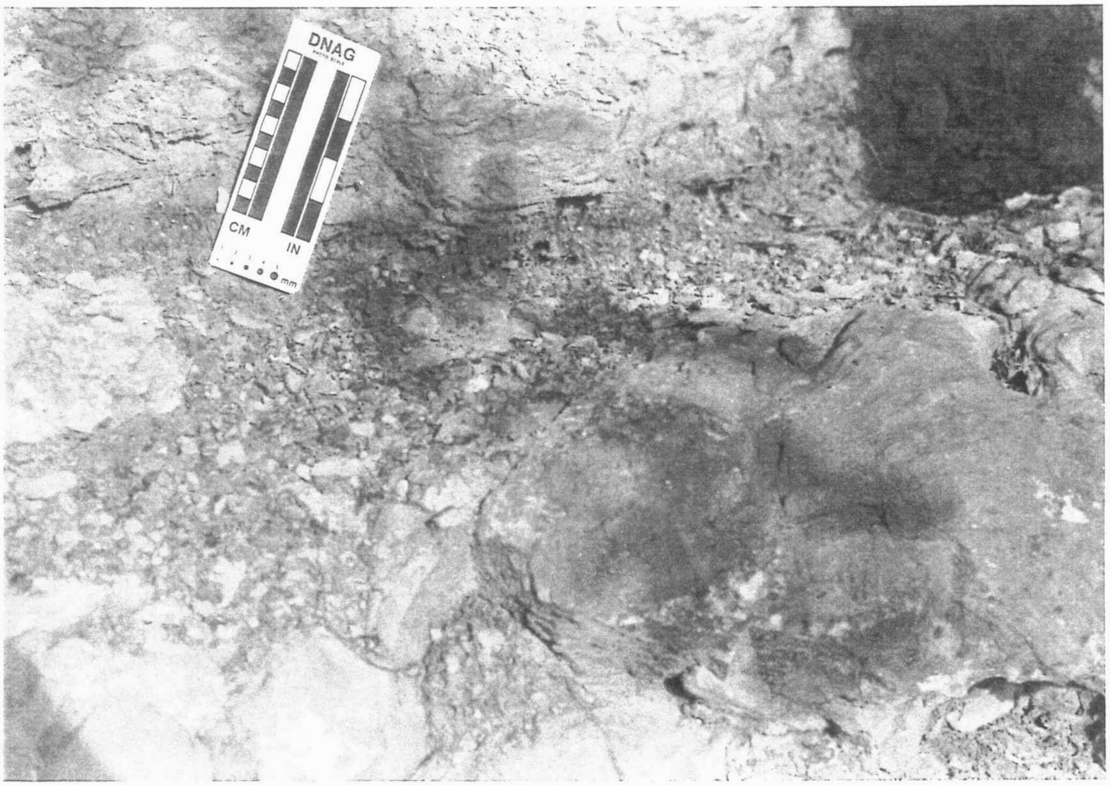
Unit b, a chaetetid boundstone, is comprised almost entirely of columnar chaetetids. Discontinuous lenses of a crinoidal fusulinid wackestone to packstone occur between some of the columnar chaetetids. These lenses frequently contain angular chaetetid fragments. Large open cavities are present between many of the individual chaetetids. Overturned and displaced chaetetids occasionally occur within this zone, often near the contact with the overlying unit. The contact with unit c is marked by black clay-rich laminae.

Unit c is a chaetetid boundstone to skeletal wackestone. Areas of chaetetid boundstone within this zone are a continuation of the columnar chaetetids in the underlying unit. However, some chaetetids also begin at or near the lower contact of unit c. The matrix surrounding the chaetetids is skeletal packstone to grainstone, much of which is unidentifiable skeletal grains and foraminiferids (including fusulinids, Tetrataxis, Endothyra, and Globivalvulina). Composita, bryozoan fragments, high- and low-spired gastropods, Edmonia, crinoid debris, ostracodes, and calcispheres also occur. Chaetetids in the upper part of unit c are often toppled or overturned. Where the overlying bed (6) is missing, the upper surface of unit c appears eroded (fig 17). The upper contact is sharp, although occasionally difficult to recognize when bed 6 is present due to numerous stylolites.

Bed 6, a carbonate mudstone to wackestone, is laterally discontinuous across the quarry (see figures 15 and 16), ranging in thickness up to 15 cm. Skeletal debris is sparse, composed mostly of unidentifiable skeletal grains that are medium to fine sand-sized. Infrequent ostracodes, gastropods, calcispheres, foraminiferids, and pellets also occur. Spar- and carbonate mud-filled rootlet and/or burrow-like structures are conspicuous within this bed. The upper surface is pitted and eroded, with spar- and chert-filled fractures. In-place brecciation is evident in the upper part of this bed, occasionally interfingered with a thin, discontinuous, dark orange siltstone. The contact with the overlying bed is sharp.

The overlying calcareous mudstone to mudshale (bed 7) ranges in thickness from 1 to 6 cm across the quarry,

Figure 17. Eroded upper surface (ES) of beds 5c and 6 at locality 693. Note how bed 6 pinches out against bed 5c in the left half of the photograph, and the large planed-off chaetetid (PCh) in bed 5c in the right half of the photograph.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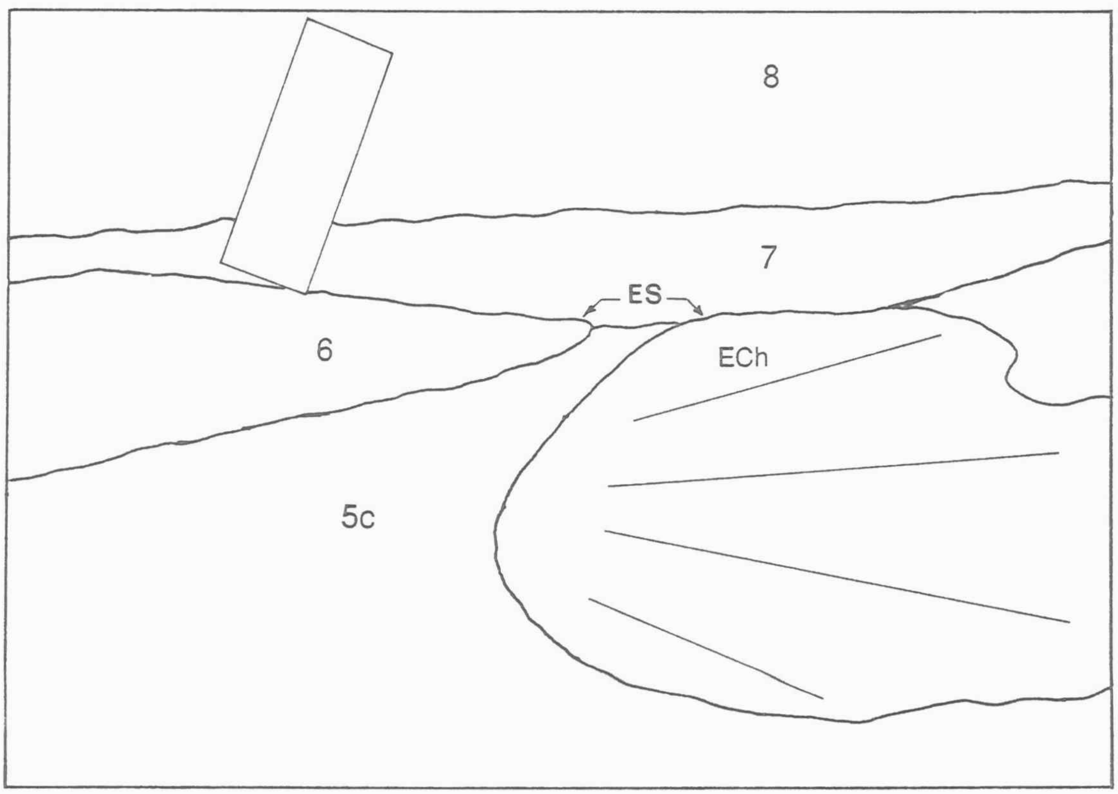

8
7
ES
6
ECh
5c

thickening over depressions in the underlying bed. The lower few centimeters of this bed are non-calcareous, blocky, and contain plant fragments and an occasional thin (<1 cm thick) coal smut. Upward this bed becomes calcareous and platy. A few compacted brachiopod shell fragments were present in the upper part. The contact with the overlying bed is gradational.

Overlying bed 7 is an oncolitic wackestone (bed 8) which is 14 to 26 cm thick. Thin (1 to 2 cm) areas of concentrated black platy laminae occur at both the upper and lower contacts of bed 8. Fossils within this bed are predominantly productids and Composita, which range from fragmented to articulated with geopetal. Articulated brachiopods become more conspicuous in the upper part of this bed. Many brachiopods are partially to completely "algal"-coated, forming large (up to 5 cm) oncolites. Some productids, forming the cores of oncolites, still retain well preserved spines. Other fossils are echinoid spines, ostracodes, gastropods, small foraminiferids (including Tetrataxis, Globivalvulina, Endothyra), and unidentifiable skeletal grains. Many of these fossils are also "algal"-coated. Some oncolites are further encrusted with chaetetids, and often show evidence of overturning. Chaetetids, when present, occur most often in the upper half of the bed. Clay-rich laminae occur throughout, in places becoming very abundant where the bed becomes nodular. The contact with the overlying bed is sharp.

Bed 9, a wackestone, ranges in thickness from 12 to 23 cm in the quarry. Crinoid debris, bryozoan fragments, and unidentifiable skeletal grains (medium to fine sand-sized), are the predominant fossils in this bed. Much of the crinoid debris appears fragmented and abraded, with borings present on many grains. Infrequent productids, Composita, Mesolobus, echinoid spines, low-spired gastropods, and ostracodes also occur. Some skeletal grains are partially to completely "algal"-coated. One low domical chaetetid was noted continuing into this bed from bed 8 below (see area around 693-S2 on fig. 15). Most brachiopods are fragmented but a few are articulated and micrite-filled. Some silt-sized quartz grains were noted in thin section. The upper contact is sharp to gradational.

Overlying bed 9 is a phylloid algal wackestone (bed 10) which is 16 to 30 cm thick. Phylloid algae and unidentifiable skeletal grains (medium to fine sand-sized) are conspicuous throughout. Other, less-frequently occurring fossils include Composita, productids, Mesolobus, gastropods, ostracodes, Derbyia, bellerophontids, crinoid debris, echinoid spines and plates, bryozoans, calcispheres, Tetrataxis, and other small foraminiferids. Occasional small (< 5 cm length) laminar chaetetids were noted at the contact with the overlying bed. "Algal"-coated skeletal debris occurs throughout the bed. Dark colored mottling occurs throughout the bed, and may represent bioturbation. The contact with the overlying bed is sharp throughout the quarry.

Bed 11, 6 to 13 cm thick, varies from a calcareous clayshale to a carbonate wackestone in the quarry. Discontinuous wackestone to packstone lenses occur within the clayshale part, generally where the bed is thickest. There is an abundance of skeletal debris, mostly crinoid ossicles and stems up to several centimeters in length. Mesolobus is frequently noted, occurring as articulated or as whole disarticulated valves. Packstone lenses occur and are made up nearly entirely of crinoids (stems and ossicles) and Mesolobus. Other fossils include Composita, Juresania, Derbyia, Neospirifer, Aviculopecten, Ditomopyge, straight-shelled cephalopods, echinoid spines and plates, ramose bryozoan fragments and loose holdfasts, gastropods, sponge spicules, fish bones, ostracodes, fusulinids, and conodonts. Most of the skeletal debris is fragmented and crushed. The upper 2 to 4 cm grades into a wackestone with a skeletal composition similar to that of the clayshale. The upper contact is sharp.

Bed 12, a wackestone, varies considerable in thickness in the quarry, ranging from 4 to 14 cm. Fossils are predominantly crinoid debris and medium to fine sand-sized skeletal grains. Gastropods, productids, Composita, ramose bryozoan, and foraminiferids (including fusulinids, Tetrataxis, and Endothyra) also occur. The upper contact is sharp and occasionally stylolitic.

The overlying wackestone (bed 13) ranges in thickness from 30 to 40 cm. Skeletal grains are predominantly fragmented phylloid algae (up to several centimeters in length). Crinoid debris and unidentifiable skeletal grains (medium to fine sand-sized) also frequently occur. Other fossils include Composita, Crurithyris, productids, bryozoans, gastropods, ostracodes, calcispheres, and small foraminiferids. "Algal"-coated skeletal grains occur throughout the bed. Infrequent laminar chaetetids occur near the top of the bed. Dark colored mottling occurs, but is most conspicuous near the upper contact which is sharp to gradational and marked by thin clay-rich laminae and chert nodules.

Bed 14, a wackestone, is 34 to 46 cm thick and is similar to bed 13, although laminar chaetetids are more prominent in this bed, and foraminiferids occur in greater numbers (including Globivalvulina, Endothyra, and fusulinids). A Multithecopora coral (20 cm long) was noted at section 693-S2. On the upper surface of bed 14 oncolites, consisting of articulated and disarticulated "algal"-coated productids, Composita, and other brachiopods, were conspicuous. The contact with bed 15 is sharp, and marked by a thin calcareous clayshale laminae.

Bed 15, a carbonate mudstone to wackestone, ranges in thickness from 30 to 43 cm. In most areas within the quarry, this is the uppermost bed exposed, and an overlying modern soil is occasionally present. In places, recent erosion appears to have removed much of bed 15. Unidentifiable skeletal grains that are medium to fine sand-sized predominate. Larger fossils are not overly conspicuous, but a diverse brachiopod assemblage is present, predominately Composita and productids, but also Crurithyris, Mesolobus, Derbyia, Hustedia, Wellerella, and Neospirifer. An occasional specimen of Composita occurs articulated and in apparent life position. Crinoid debris appears rounded and abraded. Other fossils include Aviculopecten, fenestrate and ramose bryozoan fragments, gastropods, bellerophontids, phylloid algal fragments, echinoid spines and plates, and small foraminiferids (including Tetrataxis, Globivalvulina, Endothyra). One small chaetetid (<3 cm long) encrusting an articulated Composita was noted near section 693-S1. Most fragments of phylloid algae occur in the lower half of the bed, and overall there is a decrease in the amount of fossil debris upward. Partially to completely "algal"-coated skeletal debris is present throughout. The upper surface is somewhat irregular; depressions on this surface sometimes contain thin lenses of a skeletal wackestone which are composed primarily of broken and abraded skeletal grains. The contact with bed 16 (when present) is sharp.

Bed 16, a calcareous clayshale to a phosphatic black shale, and the overlying bed (17) were only present in the northeast section of the quarry, and had to be exposed by trenching (see section 693-S6). Most of bed 16 is disturbed by the roots of living plants and processes of soil formation, and, along with bed 17, serves as the parent rock for the present-day soil. Bed 16 is the stratigraphic equivalent of the Lake Neosho shale, and can be divided into three units (a,b, and c) based on lithologic and biologic differences.

Unit a is an olive-colored calcareous clayshale which is 8 cm thick. Fossils include ramose bryozoan fragments, *Crurithyris*, productid fragments, scaphopods, gastropods, echinoid spines, crinoid debris, fish bones, foraminiferids, and conodonts. A few discoidal phosphate nodules were also found. The contact with unit b is sharp.

Unit b, a black, non-calcareous, platy to fissile shale, is 22 cm thick. Fossils within this unit are scarce, and consist of scaphopods, bryozoan fragments, dermal denticles (*Petrodus*), fish scales, *Orbiculoidea*, *Crurithyris*, brachiopod spines, *Worthenia*, foraminiferids, echinoid spines, and conodonts. Phosphate nodules are present throughout, but occur most frequently in the upper half. Phosphate nodules have formed around *Orbiculoidea*, *Petrodus*, plant fragments, and other unidentifiable debris. The contact with unit c is sharp.

Unit c is a 9 cm thick, yellowish gray, calcareous clayshale. Fossils include Orbiculoidea, other brachiopod shell fragments (including productids and Neochonetes), ramose bryozoan fragments and loose holdfast, crinoid ossicles and plates, bellerophontids, Donaldina-like gastropods, echinoid spines, low-spired gastropods, scaphopods, foraminiferids, and conodonts. Phosphate nodules are also present in this unit, with Orbiculoidea, fish bones, plant debris, Petrodus, and unidentifiable debris as nuclei. The contact with the overlying bed is gradational.

Only 33 cm of bed 17, a wackestone, is present at section 693-S6, on top of which a modern soil is developed. This bed is the lowermost part of the Worland limestone in this area. Composita, Crurithyris, and medium to fine sand-sized skeletal grains are conspicuous. Brachiopods occur as shell fragments and whole disarticulated valves, or as articulated and spar-filled shells exhibiting geopetal structure. Productids, Hustedia, gastropods, crinoid debris, bryozoan fragments, fusulinids, Tetrataxis, and other small foraminiferids, were also noted.

Stratigraphy at Locality 782

Introduction--Locality 782, a road cut on highway 166 approximately 1.2 km east of Edna, Kansas, is the eastern most locality studied (see fig 1). The uppermost part of the Bandera Shale and the lower and middle beds of the Amoret limestone are exposed along the north side, and the middle and upper beds of the Amoret limestone are exposed along the south side at this locality.

Figure 18 is a map of locality 782 as it looked in the summer of 1990. Four detailed stratigraphic sections were measured along the exposure (labelled 782-S1 through 782-S5 on the map); these are described in detail in Appendix D. Two horizontal profiles, one 34 meters long (782-P1) and one 41 meters long (782-P2), were drawn to show lateral relationships and chaetetid occurrences within the exposed beds.

Rock exposed at section 782-S1 are shown in figure 19, along with the composite stratigraphic profile of locality 782. Beds 11 through 15, shown on the composite section, occur only on the south side of the exposure, and are not present at section 782-S1.

Using the upper surface of bed 6 as a datum, the strike and dip of the beds is N. 16° E. and 0.23° NW.

Figures 20 and 21 are the horizontal profiles noted above. These can be referred to visualize thickness changes

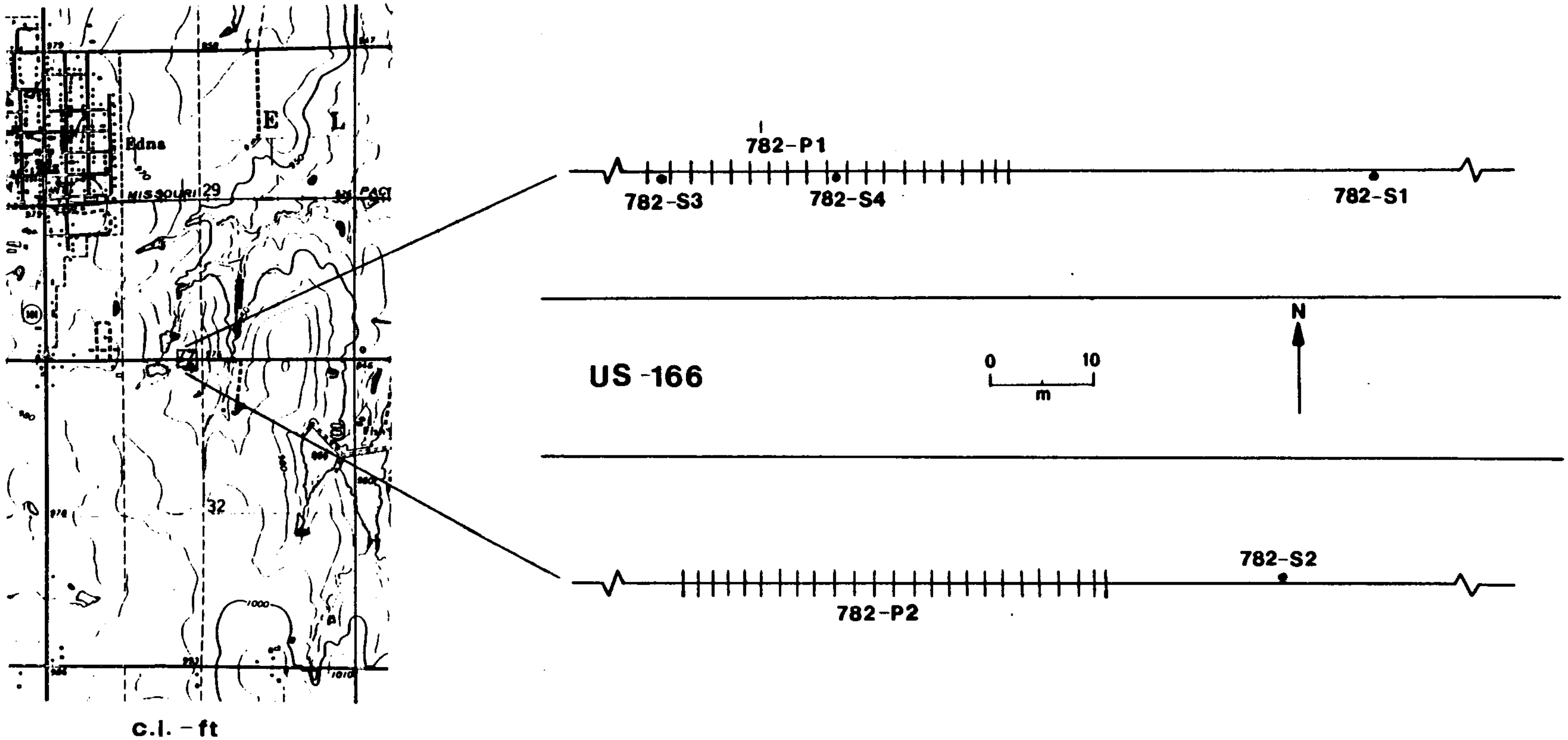


Figure 18. Pace and compass map of locality 782 showing the location of measured stratigraphic sections and profiles. Topographic map is from the USGS 7.5 minute Edna Quadrangle (1974).

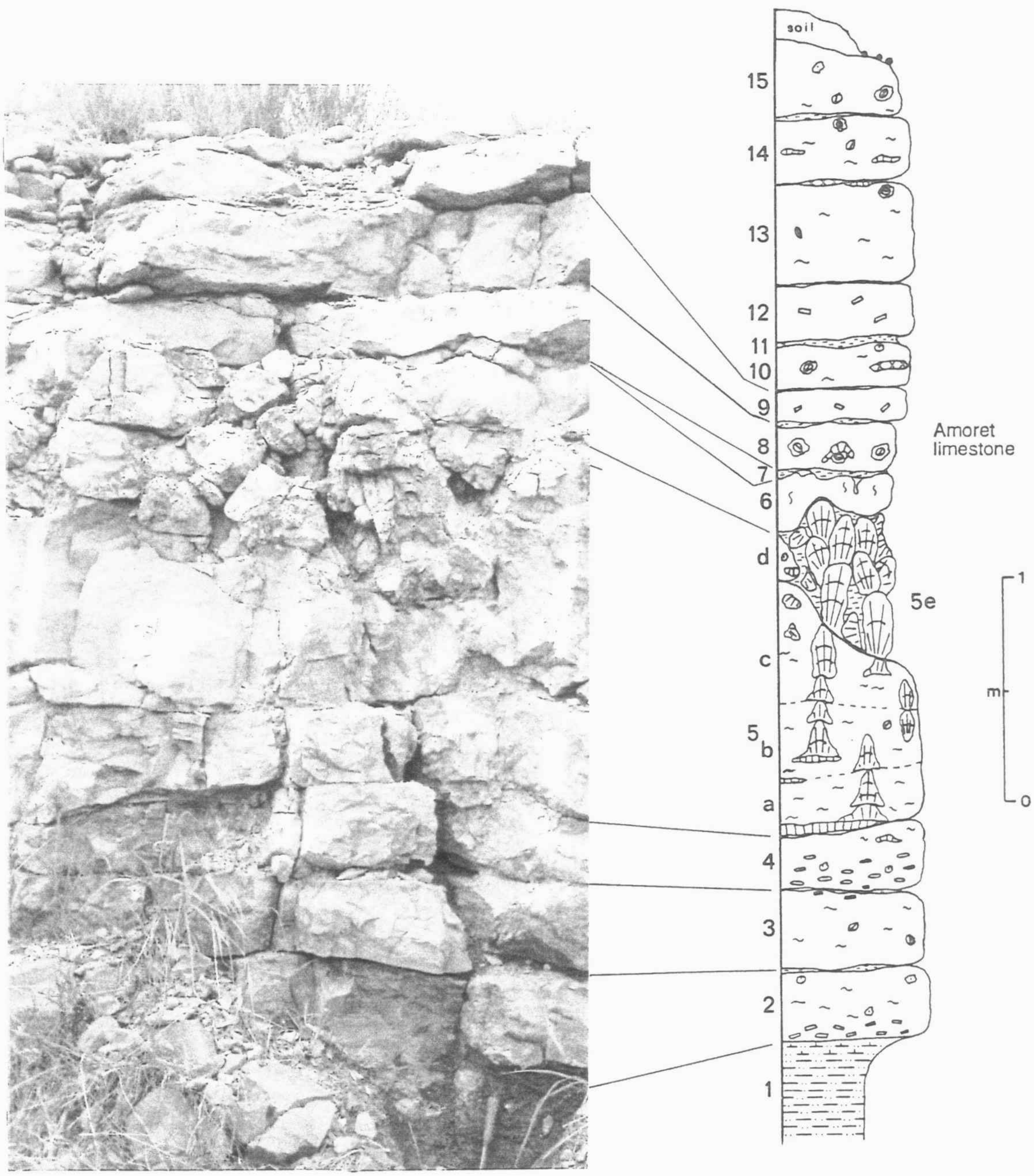
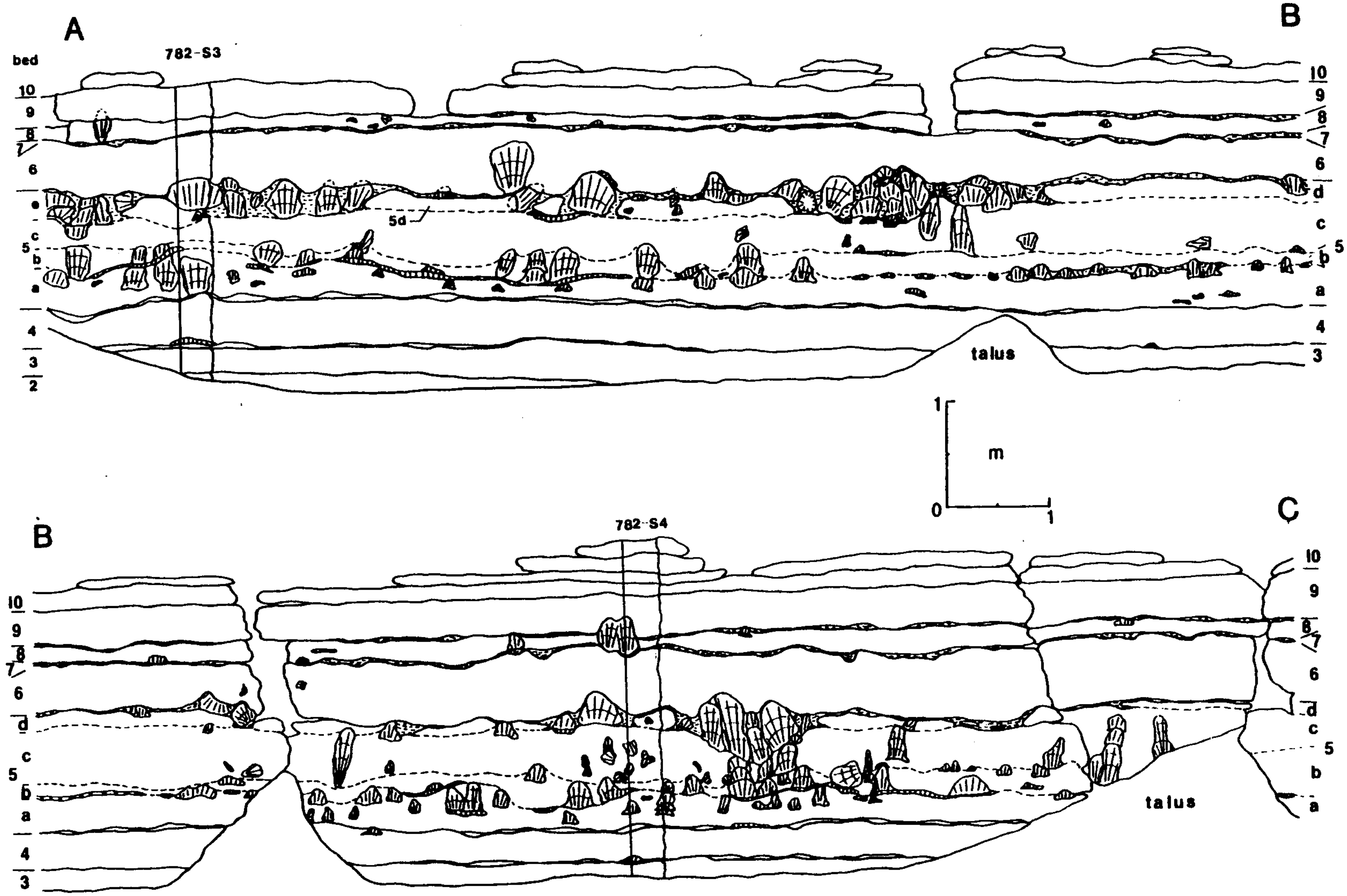


Figure 19. Photograph of the rocks exposed at section 782-S1, and the position on composite stratigraphic section of locality 782. Hammer handle in lower right corner is 25 cm long. See Introduction to Appendices for a description of symbols used.

Figure 20. Profile 782-P1 showing chaetetid occurrences and the irregularity of Amoret limestone beds at locality 782. Bed contacts are solid lines; unit contacts are dashed lines (see text). Beds traced from photographic profile, details added in the field. See figure 18 for location along roadcut.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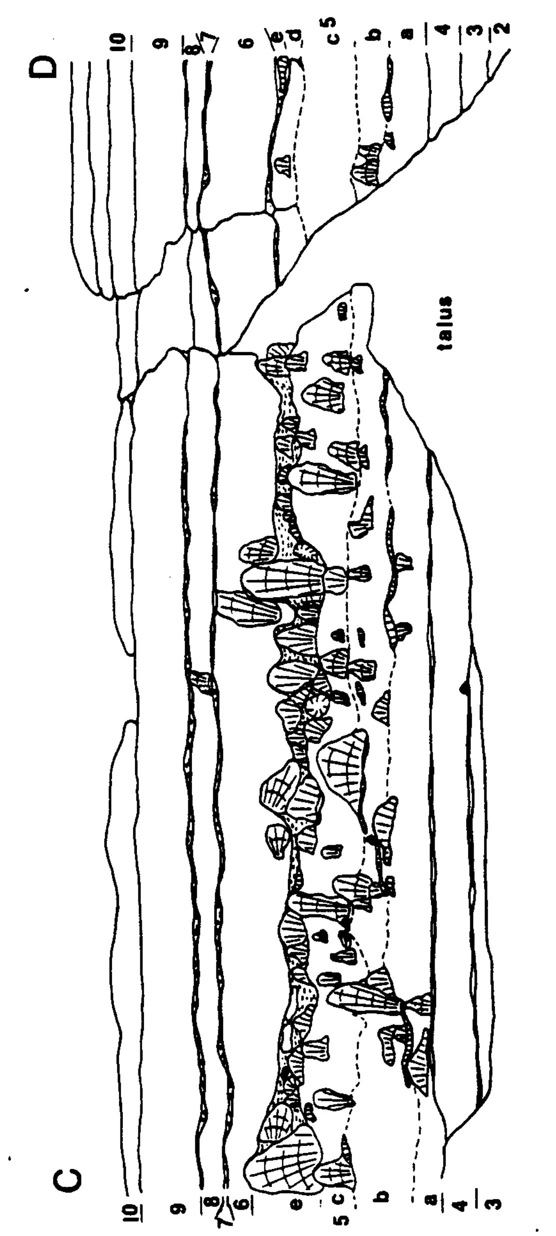
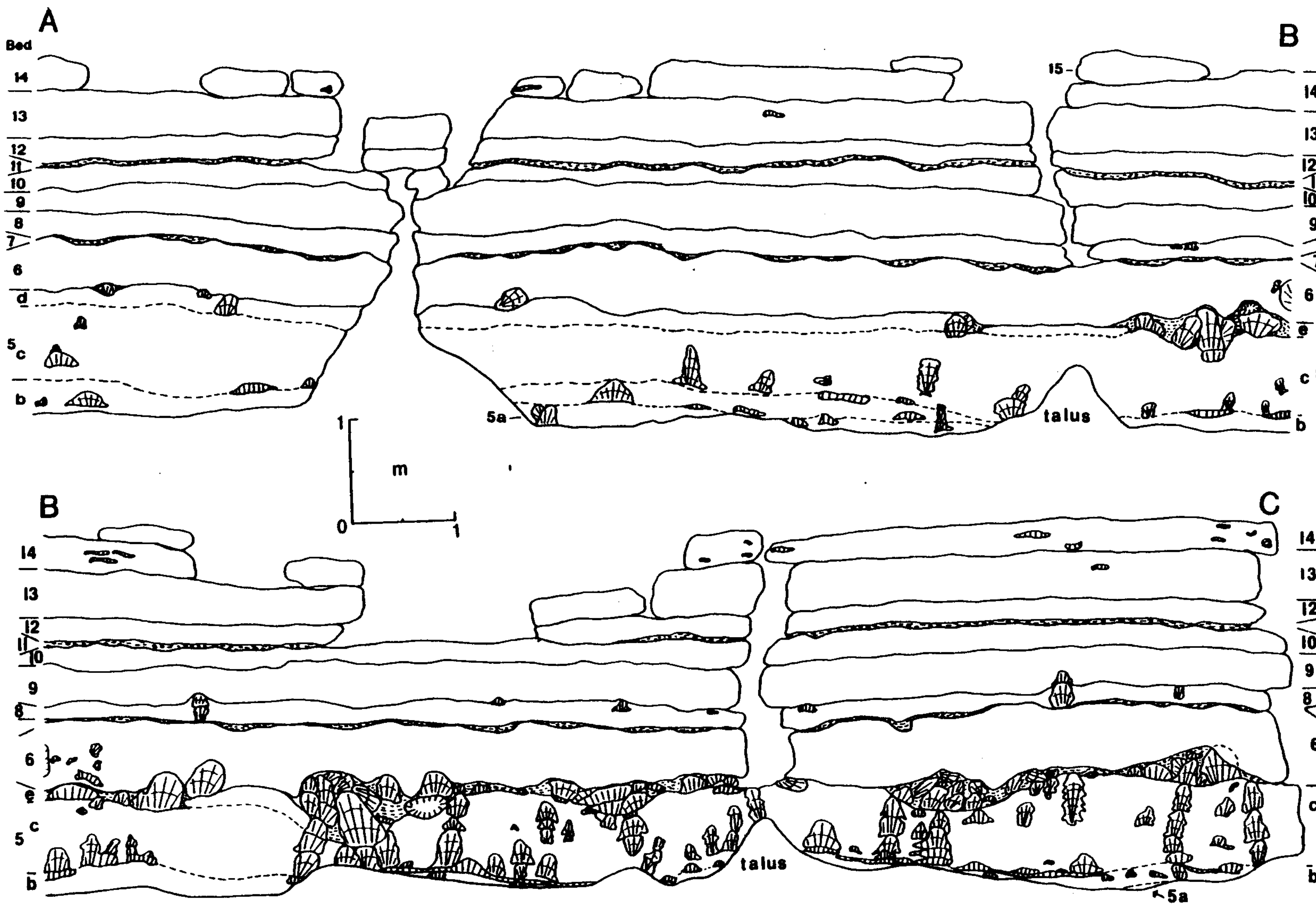


Figure 20. cont.

Figure 21. Profile 782-P2 showing chaetetid occurrences and the irregularity of Amoret limestone beds at locality 782. Bed contacts are solid lines; unit contacts are dashed lines (see text). Beds traced from photographic profile, details added in the field. See figure 18 for location along roadcut.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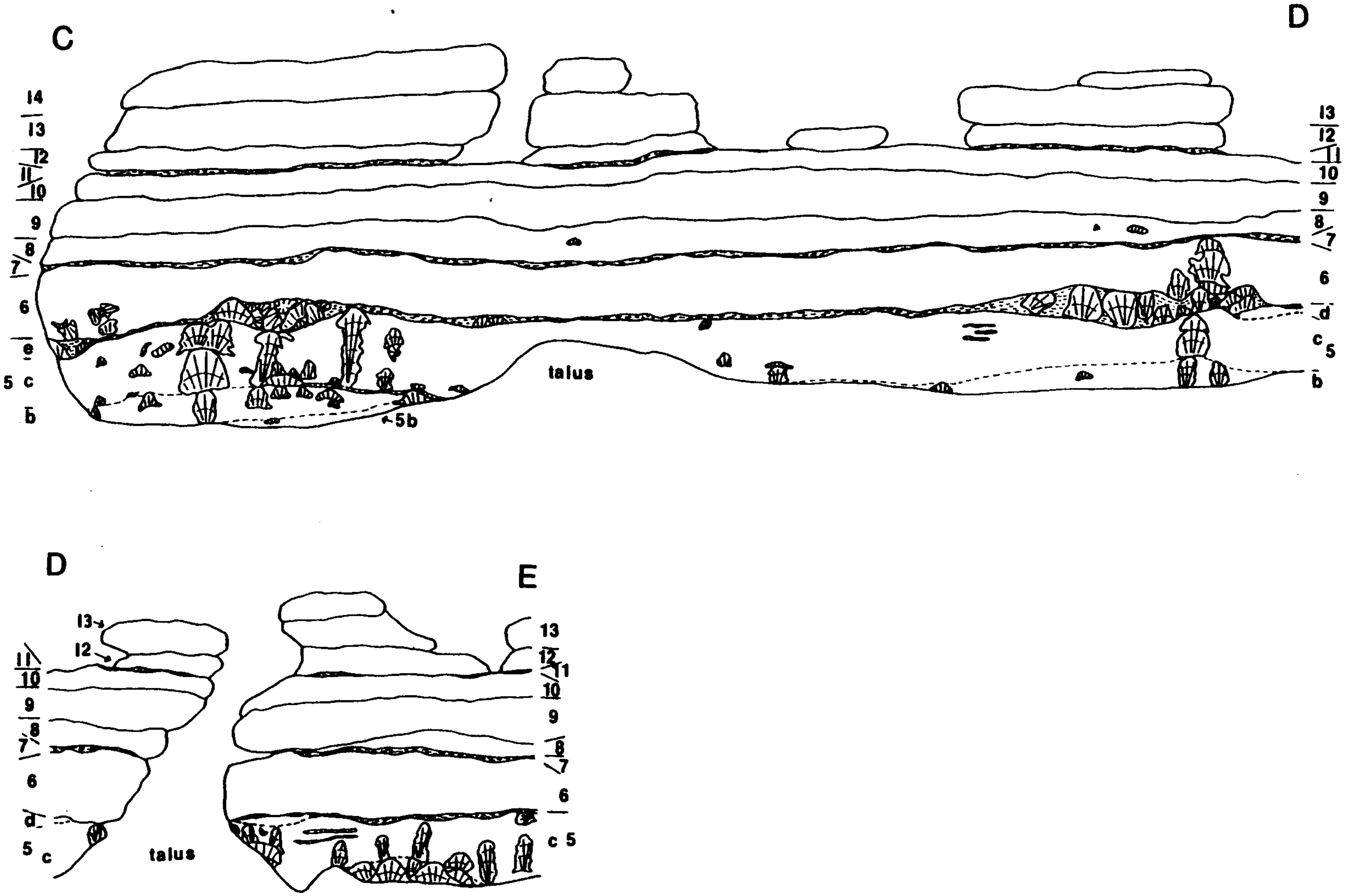


Figure 21. cont.

and lateral interrelationships within and between beds discussed below.

Description of Beds--Bed 1, a micaceous siltstone, is the stratigraphic equivalent of the uppermost part of the Bandera Shale; by trenching, 46 cm was exposed at section 782-S1. The lower 35 cm was noncalcareous and contained plant fragments and root-like traces. The upper 10 cm of the bed becomes calcareous and contains unidentifiable skeletal debris that is medium to fine sand-sized. The contact with the overlying Amoret limestone is gradational.

The lowermost part of the Amoret limestone (bed 2) is a packstone to wackestone which is 30 to 35 cm thick. The lower 8 cm is a crinoidal wackestone to crinoidal packstone with abundant medium sand- to silt-sized quartz grains. This grades upward into a wackestone dominated by phylloid algal fragments, calcispheres, and unidentifiable skeletal grains. Other fossils include Composita, productids, bivalve fragments, and gastropods. "Algal"-coated skeletal grains are conspicuous throughout. The contact with bed 3 is sharp and marked by fossiliferous clayshale partings. These partings contain mostly fine grained, fragmented skeletal debris, and occasional Lophophyllidium, Crurithyris, and fenestrate bryozoan fragments.

The packstone to wackestone (bed 3) which overlies bed 2 ranges from 20 to 33 cm thick along the outcrop. The lower 6 to 8 cm is a skeletal packstone made up almost entirely of unidentifiable skeletal grains that are medium to fine sand-sized. Upward the bed becomes a wackestone dominated by exceptionally large phylloid algal fragments (up to 10 cm long) and medium to fine sand-sized skeletal grains. Other fossils, which occur less frequently include <u>Composita</u>, <u>Crurithyris</u>, crinoid debris, gastropods, sponges (<u>Heliospongia</u>), bryozoan fragments, ostracodes, and foraminiferids (including <u>Tetrataxis</u>). "Algal"-coated fossils are conspicuous. Two large cephalopods (<u>Owenocerous</u>?) were collected from this bed, the exteriors of which were partially "algal"-coated. The contact with bed 4 is sharp and marked by a thin fossiliferous clayshale parting, which grades laterally into thin black clay-rich laminae. This parting contains crinoid debris, <u>Composita</u> shell fragments, and unidentifiable medium to fine sand-sized skeletal grains.

Overlying bed 3 is a wackestone to packstone (bed 4) which is 15 to 40 cm thick. Most of the bed is a wackestone to packstone comprised predominantly of fusulinids and unidentifiable, sand-sized skeletal grains. Bed 4 is similar in composition to bed 1 at locality 693, but considerable thicker. Where the bed 4 thickens it grades upward into a wackestone with conspicuous phylloid algal fragments (up to 4 cm long) and medium to fine sand-sized skeletal grains. In these thicker areas laminar to low domical chaetetids occasionally occur in the upper half, but these chaetetids do not continue into the overlying bed. The upper contact is sharp and undulatory, and marked by a thin fossiliferous clayshale which contains crinoid debris, bryozoan fragments, Composita shell fragments, fusulinids and unidentifiable skeletal grains.

As seen in figures 20 and 21, bed 5, a wackestone to boundstone, varies considerable in thickness along the outcrop, ranging from 90 to 150 cm. Five distinct chaetetid-bearing units (a through e) can be recognized.

Unit a is a wackestone to packstone which is 20 to 50 cm thick. Chaetetid growth forms in this unit are predominately laminar in the lower part and mostly low domical in the upper part, some of which continue into the overlying unit. Fossils in the matrix around the chaetetids are mostly phylloid algal fragments, which, in places, form a packstone (fig 22). Other fossils are Composita, Crurithyris, gastropods, crinoid debris, Lophophyllidium, and unidentifiable medium to fine sand-sized skeletal grains. Some fossils are partially to entirely "algal"-coated. The contact with unit b is sharp and highly irregular, and marked by thin black clay-rich laminae.

Unit b, a wackestone (2 to 60 cm thick), is somewhat similar to zone a, but with less conspicuous phylloid algal fragments and more conspicuous chaetetids. Medium to fine sand-sized, skeletal grains are also prominent. Chaetetids

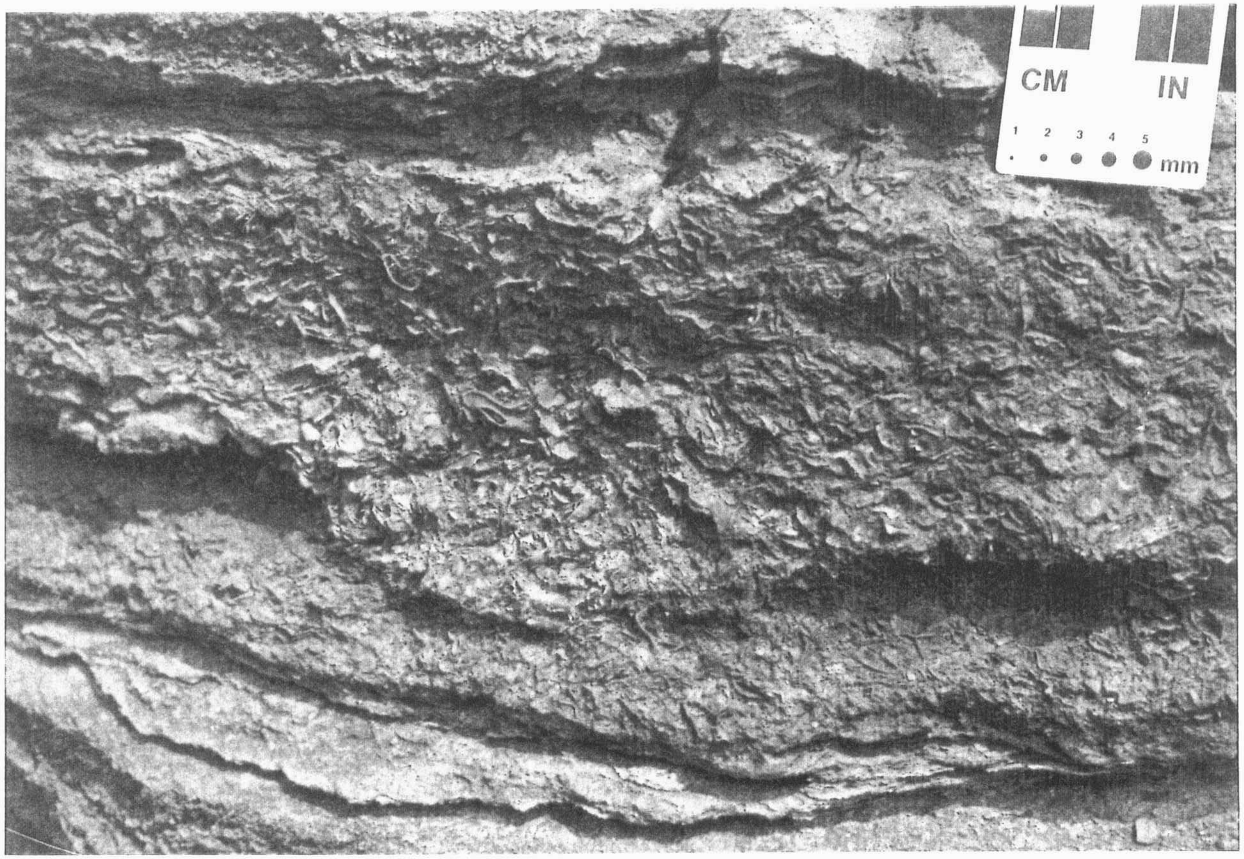


Figure 22. Phylloid algal packstone of bed 5a at locality 782.

usually begin as laminar forms at the base, and grade upward into low domical to columnar forms which occasionally continue into the overlying unit. In places across the outcrop unit b nearly pinches out, grading laterally into thin black clay rich laminae. The contact with unit c is highly irregular and sharp, marked by thin, black, clay-rich laminae.

Unit c is a wackestone to packstone ranging from 20 to 90 cm thick. Chaetetids are less conspicuous than in unit b, and occur as laminar to columnar forms. When present, chaetetids usually begin near the lower contact of unit c, or continue upward from the underlying unit. Those that occur in the upper part frequently are toppled and/or overturned. Laterally discontinuous lenses of phylloid algal fragments occur throughout. Other fossils are crinoid debris, bryozoan fragments, fusulinids, gastropods, and small foraminiferids. In areas devoid of chaetetids, this unit is a packstone made up nearly entirely of unidentifiable skeletal grains (sand-sized), often "algal"-coated. The contact with unit d (or e) is sharp and irregular.

Unit d is laterally discontinuous along the outcrop, ranging in thickness from 0 to 30 cm. It is a wackestone composed predominantly of small crinoid fragments and unidentifiable skeletal grains. "Algal"-coated grains occur throughout. Infrequent small laminar and low domical chaetetids are also present. The overlying contact with unit e (or bed 6 where unit e is missing) is sharp, and marked by a thin clayshale parting.

Unit e is also laterally discontinuous, and generally does not occur where unit d is present. It is a chaetetid boundstone to chaetetid rudstone, inter-bedded with a fossiliferous clayshale, and ranges from 0 to 100 cm thick. Chaetetids within zone e are low domical to columnar forms which occasionally form small buildups. Some of the buildups apparently began entirely within unit e, while other are formed around chaetetids which have continued into unit e from unit c. In places, unit c appears scoured out around these buildups (see area just to the right of section 782-S4 on figure 20). Chaetetids frequently appear toppled, overturned, or rolled about. A calcareous clayshale fills the voids around the chaetetids. Fossils within the clayshale are <u>Composita</u>, productids, gastropods, ramose bryozoan fragments, crinoid columnals, ostracodes, echinoid spines, and small angular chaetetid fragments. The upper contact is sharp, although a few chaetetids do continue through this contact into bed 6.

Overlying bed 5 is a carbonate mudstone to wackestone (bed 6), which varies considerable in thickness at this outcrop from 4 to 90 cm. Thickness variations are mostly due to a highly irregular lower surface which closely follows irregularities on the upper surface of bed 5 (see fig 20 and 21). Fossils occur sporadically, and when present consist primarily of endothyroid foraminiferids, high-spired Donaldina-like gastropods, and unidentifiable skeletal grains (sand-sized). Other fossils include Composita, Crurithyris, bellerophontids, and crinoid debris. Chaetetids occasionally occur in the lower half of the bed, and virtually always appear abraded and displaced. Chaetetids which do occur in life position are continuations of chaetetids from the underlying bed. Small (2-3 cm in length) burrow and/or rootlet-like structures are extremely abundant within this bed, occasionally bifurcating downward (fig 23). The upper surface is irregular and contains prominent micrite-, spar-, or clay-filled solution features (fig. 24) which often extend downward 30 cm or more. The contact with the overlying bed is sharp.

Bed 7, a non-calcareous to calcareous mudshale (1 to 5 cm thick), fills in many of the erosional features on the surface of the underlying bed. Where thickest, the lower part occasionally contains discontinuous black clayshale lenses with plant debris. Most fossils in bed 7 are fragmented and abraded fossils, and include crinoid ossicles, echinoid spines and plates, brachiopod shell fragments, ramose bryozoan fragments, and ostracodes. The contact with the overlying bed is gradational.

Beds 8 through 15 are very similar to the corresponding beds (8-15) at locality 693. Therefore the following bed

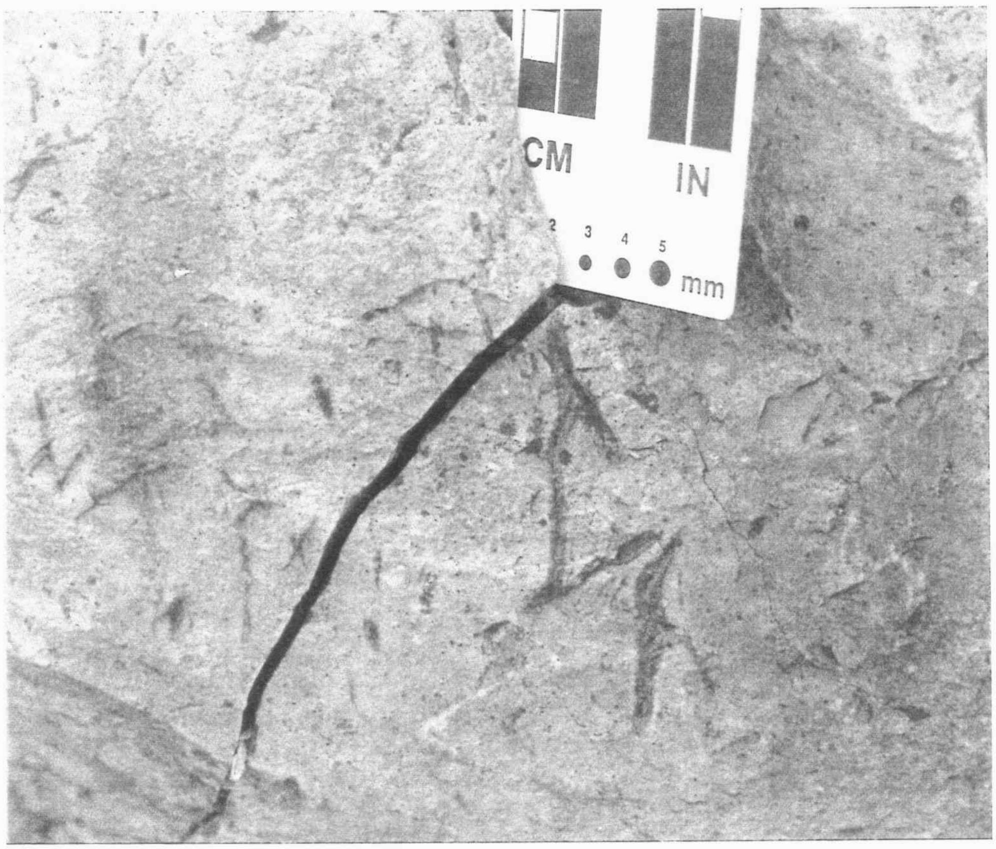


Figure 23. Bifurcating rootlet-like structures in bed 6 at locality 782.

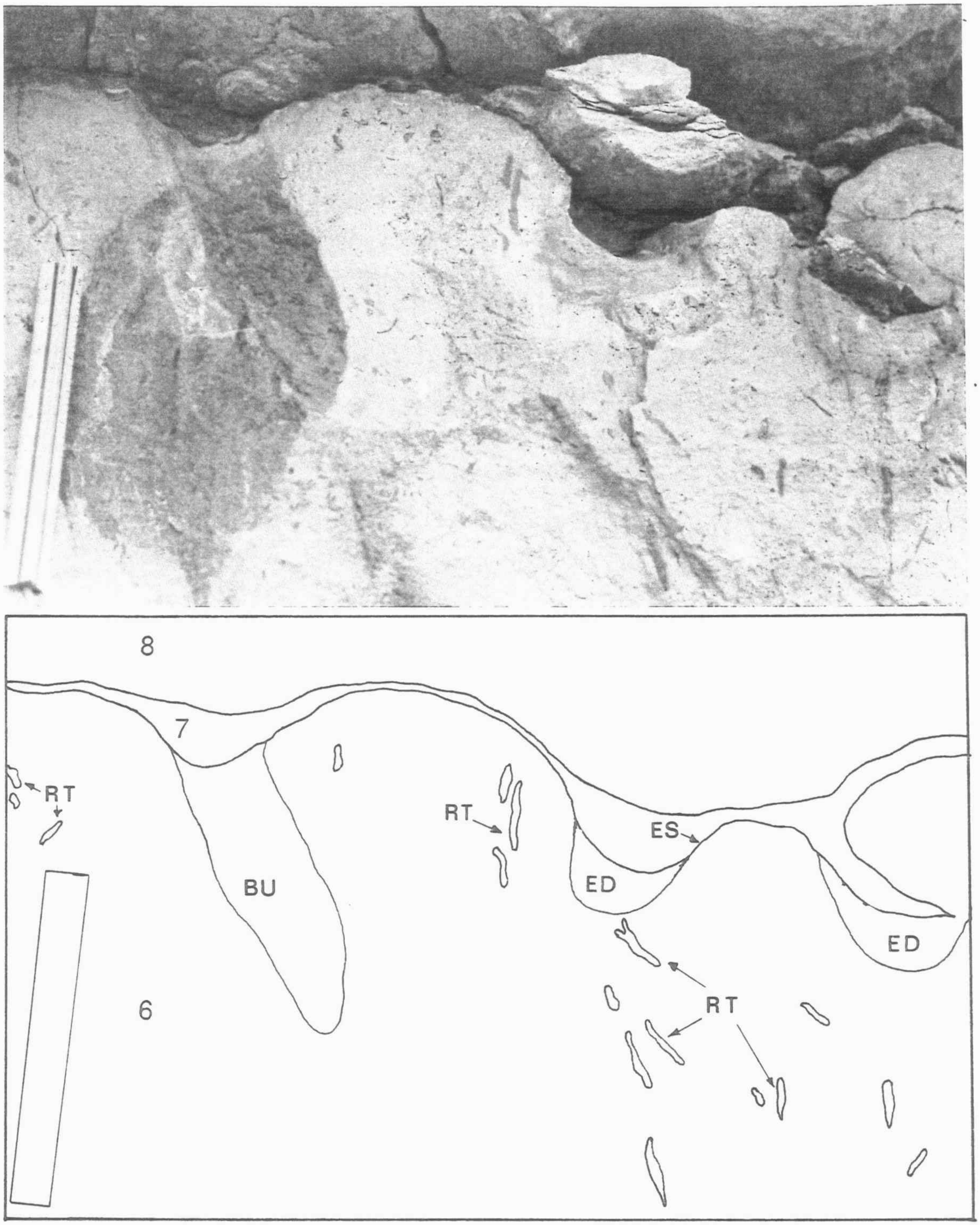


Figure 24. Erosional surface (ES) and associated features on the upper surface of bed 6 at locality 782. Note large erosional pits and depression (ED), burrow-like structure (BU), and rootlet-like structures (RT). Ruler is 15.24 cm long.

description will be brief and focus on differences noted between the two localities.

Bed 8, an oncolitic wackestone (5 to 30 cm thick), is very similar to bed 8 at locality 693, and also to bed 9 at localities 729 and 692. As at the other localities, laminar to low domical chaetetids encrust oncolites within the bed. Where bed 8 thins it grades laterally into a platy, nodular, limestone to clayshale. The contact with bed 9 is gradational.

Bed 9, a wackestone (25 to 30 cm thick), is essentially the same as bed 9 at locality 693. At this locality (782) mottling is more conspicuous, and is occasionally preferentially silicified. One chaetetid from the underlying bed (8) was noted extending upward into bed 9, but elsewhere bed 9 appears to have smothered out the chaetetids present in bed 8. The upper contact is relatively sharp and marked by thin, clay-rich laminae.

The overlying wackestone (bed 10) ranges from 20 to 25 cm thick and is nearly identical to bed 10 at locality 693, although no chaetetids were found here. The contact with the overlying bed is sharp.

Bed 11, 4-14 cm thick, varies from a calcareous clayshale to wackestone. Fossils are essentially the same as those seen in bed 11 at locality 693, but here (locality 782) the bed is somewhat thicker, more calcareous, and more indurated. The upper contact is sharp.

Bed 12, a wackestone, ranges from 10 to 14 cm thick and is similar to bed 12 at locality 693. Mottling is conspicuous and occasionally preferentially silicified. The contact with bed 13 is sharp.

The overlying wackestone (bed 13) ranges from 40 to 45 cm thick and is essentially the same as bed 13 at locality 693. Mottling is conspicuous throughout, but concentrated in the upper half. Occasionally, small laminar chaetetids occur near the upper contact, which is sharp to gradational and marked by a discontinuous nodular chert zone.

Bed 14, a wackestone, is usually the uppermost bed exposed at this locality, and is overlain by a modern day soil profile. Where the overlying bed is present (soil absent), bed 14 is 30 to 40 cm thick. This wackestone is essentially the same as bed 14 at locality 693. Periodically, small laminar chaetetids occur, some of which are overturned and show multiple generations of growth. The contact with bed 15 (when present) is sharp and marked by thin clayshale parting.

Bed 15, a carbonate mudstone to wackestone, is the uppermost bed exposed at this locality. In most areas the bed is absent, apparently due to weathering associated with modern soil formation. The maximum thickness is 50 cm, and the bed is very similar to bed 15 at locality 693. One small (<3 cm long) laminar chaetetid was noted. Where the bed is thickest, phosphate nodules, like those in the Lake

Neosho shale at the other localities (693, 692, and 729), occur on the upper surface.

DIAGENESIS

Introduction

A detailed and critical study of the diagenetic history of these rocks was not feasible for this study, but some observations can be made and the general diagenetic history suggested.

Diagenetic Features

For most beds within the study area, micrite appears to have been deposited along with skeletal grains. Some inter-particle porosity apparently was present in a few beds such as the skeletal grainstone noted in unit c of bed 5 at locality 693. Intra-particle porosity was prevalent in many beds as evidenced by frequently occurring spar-filled fossils and geopetal structures. Shelter porosity appears to have been restricted to beds with abundant phylloid algae fragments (such as bed 3 at locality 729). Nearly all this porosity has been occluded by coarse spar. Fringes of bladed Mg-calcite occur on the internal surface of several articulated brachiopods (such as in thin section A13). This cement apparently formed very early after the death of the organism, perhaps even prior to burial (Scoffin, 1987). Some inter-particle equant calcite cement was present as void-filling cement in some of the grainstone beds in the upper part of bed 6 at locality 729 and 692, and the upper part of bed 5 at locality 693 and 792. Such cement generally forms in the meteoric phreatic zone (Longman 1980). Other void-filling cement is generally blocky ferroan to non-ferroan calcite, with an overall predominance of ferroan calcite. The presence of multiple generations of ferroan and non ferroan calcite indicates a complex history of fluctuating aeration of pore waters.

Evidence of compaction and dissolution of skeletal debris was noted frequently in the clay-rich laminae which are common throughout the area (such as in thin section A1). Macro- and micro-stylolites also often occur along these laminae (see fig. 25 and thin section A5). Clay-rich laminae similar to these have been produced from the compaction of recent carbonate sediments by Shinn and Robbin (1983) and Knight (1988). Shinn and Robbins (1983) believed the laminae they observed would, over time, stimulate carbonate dissolution, and subsequently concentrate clays and other insolubles along their boundaries. These concentrated zones would then serve to enhance pressure solution and the formation of stylolites. This sequence of events would produce features not unlike those observed in the Amoret limestone.

Some crushed non-"algal" coated brachiopods were also present in the oncolitic zone throughout the area. This crushing appeared to have resulted upon contact with other skeletal grains.

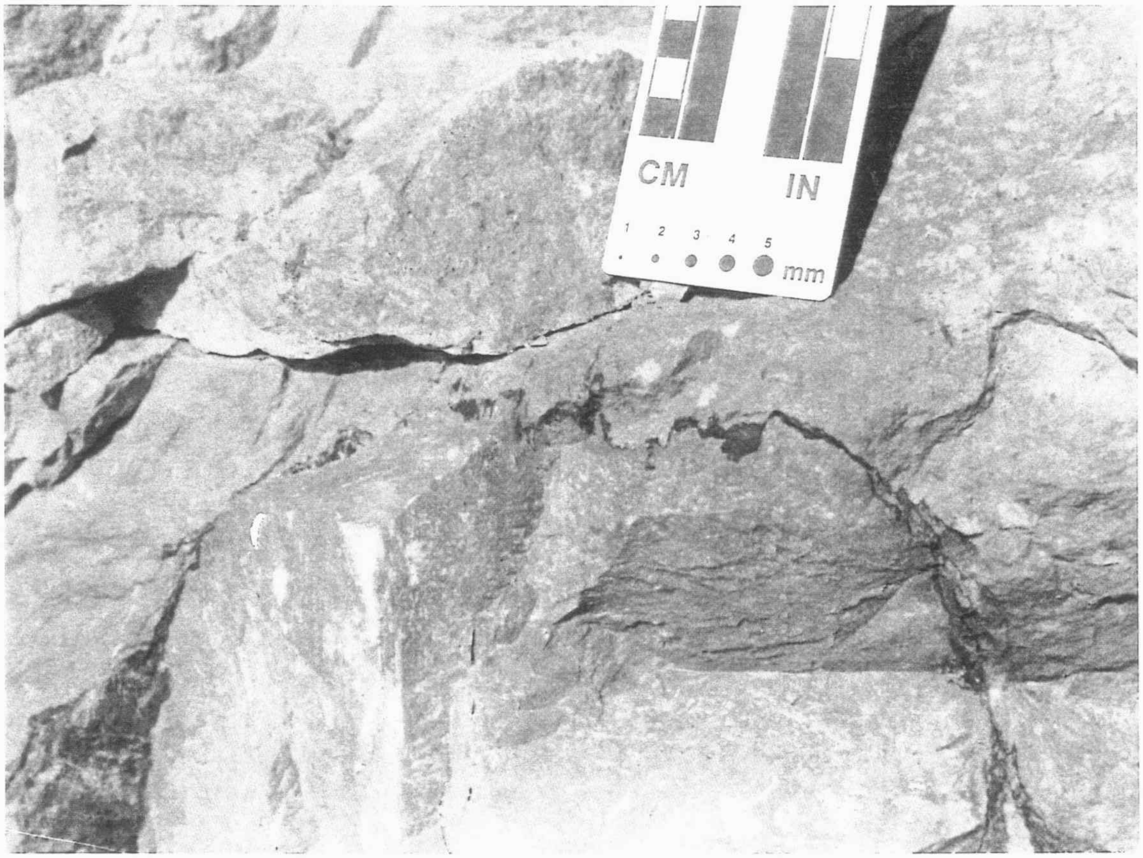


Figure 25. Stylolites along clay-rich laminae in bed 5, locality 692. Stylolites outline the upper surface of a high domical (smooth) chaetetid.

Aggrading neomorphism was very pervasive throughout the area in most beds. Most noticeable was the replacement of micrite by patchy spar and the replacement of unstable grains by crystalline sparite. Scoffin (1987) stated that aggrading neomorphism is usually caused by freshwater interaction with the sediment, although it may rarely occur in marine water settings. Neomorphic sparite in this study ranged from ferroan to non-ferroan calcite, but was predominantly ferroan calcite. Recrystallized skeletal debris occurred as both ferroan and non-ferroan calcite, again with an overall predominance of ferroan calcite.

Most phylloid algal and molluscan fragments lack any internal structure and were probably dissolved prior to replacement by coarse sparite.

Syntaxial overgrowths were very rare, and observed only in thin section A14. Such overgrowths are believed to have formed in the freshwater phreatic zone (Longman, 1980).

Micrite envelopes were present in several thin sections, most noticeably from those low in the section. Micrite envelopes are believed to form early during diagenesis in a stagnant marine phreatic environment (Longman 1980). They are apparently produced by boring of skeletal debris by micro-organisms. Such boring produces a stable micrite rind around the particle (Flugel, 1982). This rind preserves the outline of the particle during subsequent dissolution and recrystallization events.

Dolomite only occurs in any abundance in units a and b of bed 6 at localities 729 and 692. X-ray diffraction of samples from units a and b showed that bed 6 is composed of nearly equal amounts of calcite and ferroan dolomite. The dolomite appears to be restricted to dark mottled areas present in this bed. Some skeletal grains in the mottled areas are not dolomitized (see thin section A13). The dolomite occurs as closely packed euhedral to subhedral crystals. This dolomite texture is referred to by Sibley and Gregg (1987) as unimodal, planar-s texture. They believed that the presence of non-dolomitized skeletal debris in a dolomite matrix would require formation in waters which were not highly supersaturated with respect to dolomite, and would require the dolomitizing solution to be in contact with the rock over an extensive amount of time. Such a scenario would be possible in the deep burial environment suggested for the formation of ferroan dolomite (Scoffin, 1987). Mottled areas in this bed, possibly the result of bioturbation, may have served as porous avenues for dolomitizing solutions, which in turn led to the formation of dolomite within these areas.

Chert nodules and areas of partial silicification occur at all localities, but were not overly abundant. Chert formation does not appear to have been the result of evaporite replacement, as none of the chert-bearing beds show any evidence of having formed in such an environment.

Silicious spicules have been reported from some fossil chaetetids (Wood, 1990). It is possible that silicious spicules from chaetetids may have contributed to the formation of the chert and silicious nodules seen in these rocks. As pore waters undersaturated with respect to silica moved through chaetetid-bearing zones, silicious spicules may have dissolved. These then silica-rich waters may have moved through other sediments, where barriers to fluid flow, such as bed boundaries or areas of biologically disturbed sediment, may have concentrated the silica-rich waters and led to the precipitation of SiO_2. Depending on how far the silica- rich waters moved, beds with chaetetids would not necessarily be expected to contain chert (or vice-versa). This type of scenario for chert formation in chaetetid-bearing rocks has been proposed by Connolly (1985) and Suchy (1987), and seems probable for rocks in this area also.

Coarse spar-filled fractures which cut across the matrix, allochems, and other diagenetic features occur in many of the beds examined. These apparently formed during the late diagenetic history of these rocks. The fracture-filling sparry calcite is ferroan calcite which stains dark blue, indicating late stage formation during deep burial (Kershaw, 1987, personal communications).

Large spar-filled fractures occur on chaetetids in the buildups in unit b of bed 5 at locality 693 and unit e of bed 5 at locality 792. These fractures taper downward internally from the upper surface of the chaetetids. These fractures may be the result of compaction of the chaetetids during burial. As sedimentation continued and thus compaction increased, it is possible that the lateral expansion of the chaetetids into the large open cavities around them resulted in surface fracturing of this type. Later, pore fluids moving through these areas may have brought about the precipitation of coarse sparry calcite in the fractures.

Diagenetic History

The depositional history of these rocks appears to be one of fluctuating sea level, ranging from subaerial exposure to normal marine conditions. Such widely fluctuating environments have led to a complex diagenetic overprint on these rocks.

Initially, sediment was deposited with a micrite matrix and some inter-particle porosity. Some early intra-particle cements formed during this early stage of deposition. As these sediment were buried, further development of intra-particle cement continued, along with micritization of skeletal grains as marine pore waters became stagnated. Subsequent lowering of sea level would have exposed previously deposited sediments to meteoric conditions where inter-particle cement, silicification, and syntaxial overgrowths formed, and aggrading neomorphism began to occur. Fluctuations of pore waters caused the formation of several generations of cement within the sediments. These rocks may have been subjected to many more episodes of marine and fresh water diagenesis as sea level fluctuated over time.

Continued accumulation of overlying sediments caused the formation of compaction features and subjected the rocks to deep burial conditions. Dolomite formed under these conditions, along with late stage fracturing and the precipitation of ferroan calcite. The overall abundance of ferroan calcite suggest that much of what is now seen is the result of late-stage diagenesis during deep burial conditions.

DEPOSITIONAL FRAMEWORK

Genetic Stratigraphy Overview

Before describing the depositional framework, some clarification of the methods used in correlating these rocks is warranted.

As previously stated (p. 6), the Altamont Limestone has been interpreted as representing one overall deepening-shallowing event (Schenk, 1963,1967). At present, the "Kansas Cyclothem " model of Heckel (1977), is used to interpret these rocks as having been deposited during a single transgressive-regressive event, with the Amoret limestone representing the transgressive phase. In this study an attempt was made to recognize genetic/event surfaces that delineate smaller scale events or genetic units. Such smaller scale events would provide a more detailed understanding of the depositional environment of the Amoret Limestone Member.

The "Kansas Cyclothem" model of Heckel (1977) relies on the correlation and interpretation of rocks based on lithologic analysis of specific facies types (see fig. 3). Deposition is one of a gradual deepening-shallowing event, generally considered to be on the order of 400,000 years (Heckel, 1980). Heckel (1984) recognized that smaller cycles sometimes occur within the larger "Kansas Cyclothem", these he termed intermediate and minor cycles. This approach does give an overall picture of the depositional sequence, but is often too generalized and can gloss over geologically important smaller scale events and genetic units.

In this study, the method used is based on one proposed by Anderson and Goodwin (1980), Goodwin and Anderson (1985), and Goodwin et al. (1986). They stated that the geologic record consists of meter scale, basin wide, shallowing upward cycles, bounded by surfaces of relatively instantaneous base-level rises. These they termed Punctuated Aggradational Cycles, or PAC's. Each PAC represents tens of thousands of years, an order of magnitude smaller than the "Kansas Cyclothem". Correlation of individual PAC's is accomplished using marker beds and marker horizons common to all sections. Anderson and Goodwin (1980) grouped PAC's into larger "Shallowing PAC Sequences", roughly equivalent in scale to the "Kansas Cyclothem" (Busch and Rollins, 1984).

Busch and Rollins (1984), Busch et al. (1985), and Busch and West (1986), believed that different scales of transgressive-regressive units (T-R units) could be grouped into a nested hierarchy. Their 6th order T-R units are equivalent in scale to Anderson and Goodwin's (1980) PAC's and Heckel's (1984) minor cycles. Fifth order T-R units are equivalent to "Shallowing PAC Sequences" and "Kansas Cyclothems". All T-R units may be either allocyclic or autocyclic (Busch et al., 1985). Allocyclic units are correlative across the basin of deposition at all localities, where as autocyclic units are only present at some localities.

Brett et al. (1990) were also able to delineate a nesting of different scales of cycles in the Silurian of the Appalachian Basin. Their smallest scale widespread correlative cycles they termed 5th and 6th-order cycles. These are 0.2 to 5 m thick, and are equivalent to 5th and 6th order T-R units.

Control of both 5th and 6th-order cycles (and equivalent units) has generally been considered to be the result of glacial eustacy caused by Milankovitch orbital cycles (Heckel, 1977, 1980; Busch and West, 1986; Goodwin and Anderson, 1985), although Klein (1988, 1990) favors tectonic control.

More recent work has focused on climate and climate change as a driving force for such rock cycles (Archer et al., 1990; Cecil, 1989, 1990). Cecil (1989, 1990) related the formation of different rock types to alternating wet and dry periods, with siliciclastic rocks forming in wet periods and chemical rocks more characteristic of dry periods. It is possible that many of the cycles seen in the rock record are simply the result of climatic change, with little or no change in water depth (West, 1990).

The fact that small scale cycles (PAC's, 6th order cycles, or minor cycles) do exist has been well established for Pre-Cambrian, Ordovician, Silurian, Devonian, Permian, Triassic, and Cretaceous rocks (Anderson and Goodwin, 1990). In Pennsylvanian rocks of the midcontinent, studies by Roth (1991), Leonard (1990), Suchy (1987), West and Busch (1985), and Heckel (1985, 1988) have substantiated the existence of 6th order (or equivalent) cycles.

In this report I will use the terminology of Brett et al. (1990). Within the area of this study, cycles identified will be shown to be allocyclic, with the understanding that a larger basin wide study may show some of these to be autocyclic. Although changes in water depth will be assumed to be the overriding controlling mechanism for these cycles, it is possible that climate change alone may account for some or all of what is seen. Deciding which of these was the overriding factor controlling the deposition of rock types would be difficult at best. It is very probable that a combination of factors acted in this area to produce the variations seen.

Regional Geologic Setting

The potential influence of the regional structural features must be taken into account in any reconstruction of the depositional environment. Figure 1 shows the location of the outcrops studied relative to known midcontinent structural elements which were present during the Middle

Pennsylvanian. The study area is located within the Cherokee Platform, bounded to the north by the Bourbon Arch, to the east by the Ozark Uplift, to the south by the Shelf Edge Rise and the Arkoma Basin, and to the west by the Nemaha Uplift.

The Cherokee Platform (or Basin) apparently developed from the pre-Mississippian Chautauqua Arch, a westward extension of the Ozark Uplift (Price, 1984). By Pennsylvanian time, the southern part of this arch was depressed, forming the Cherokee Platform (Price 1981). During the Pennsylvanian, the Cherokee Platform tilted slightly southward and underwent slow subsidence (Moore, 1979). It is considered to have been a shallow feature (Merriam, 1963), with water depths probably never greatly exceeding 100 ft at any time (Steward, 1975).

The Bourbon Arch is also considered to be a remnant of the Chautauqua Arch; as the southern area became depressed to form the Cherokee Platform, the northern part remained a positive feature that became the Bourbon Arch (Price, 1981). Lee (1943, p. 85) described the Bourbon Arch as " a broad low structural divide of Mississippian rocks that separated the Forest City and Cherokee Basins ...(in) Kansas." Several smaller structural features existed to the north and south of the Bourbon Arch proper, these are summarized by Price (1981), who recommended using the name "Bourbon Arch Complex" to describe this area. The arch was apparently sub-aerially exposed during the early Pennsylvanian, but became submerged during the Middle and Late Pennsylvanian (Jewett, 1951). Although submerged during Marmaton times, its effect as a structural high on rocks deposited during this time has been well documented (Suchy, 1987; Roth, 1991; Price, 1981; Knight, 1985; Gamble, 1967). Schenk (1963) noted that the Amoret limestone pinches out, and the Lake Neosho shale and Worland limestone thin considerable over the Bourbon Arch. Mathewson (1978) believed that the Bourbon Arch influenced the deposition of the Amoret limestone in southeast Kansas.

To the east, the Ozark Uplift (or Dome) was a landmass of low relief and low elevation during most of the Desmoinesian, and at times, probably served as a source for clay size sediment (Wanless, 1975). Schmidt (1959), and Price (1981, 1984), believed that the relief on the Ozark Dome was enough to supply clastic sediment during the deposition of the Bandera Shale. The westward extension of the Ozark Uplift into southeast Kansas is generally placed at the present day surface outcrop boundary of Mississippian and Pennsylvanian age rocks (extreme southeast Kansas), but it most likely affected deposition in areas further west (Jewett, 1951).

The Shelf Edge Rise was recognized by Price (1981, 1984) based on the presence of algal buildups in the Pawnee Limestone in northern Oklahoma. He believed that it represented a slight topographic high which separated the Cherokee Platform to the north from the tectonically active Arkoma Basin to the south. It apparently influenced sedimentation in the area until it was covered by deltaic clastics in the Missourian (Price, 1984). The Amoret limestone pinches out over the Shelf Edge Rise (Price 1981), and the Lake Neosho shale and Worland limestone thin considerable (Krumme, 1981). The Arkoma Basin further to the south consisted of a geosynclinal trough adjacent to the Ouachita Uplift (Schenk, 1963). During the Middle Pennsylvanian it was an area of strong subsidence which during the Desmoinesian expanded northward (Rascoe and Adler, 1983). The Ouachita uplift contributed sediment to the Arkoma basin throughout the Atokan and Desmoinesian, and by the late Pennsylvanian (Mississippian-Virgilian) the Arkoma Basin was filled and inactive (Branson, 1962).

The Nemaha Ridge separates the Cherokee Basin from the Sedgwick Basin in Central Kansas. During the early Pennsylvanian, it existed as an uplifted area of granite hills, which were inundated and buried by early Pennsylvanian beds as the sea eventually covered them (Merriam, 1963). It apparently continued as a positive feature on the sea floor, and exerted some influence on the deposition of Desmoinesian rocks, as evidenced by their thinning over this feature (Krumme, 1981).

Depositional Environment

Introduction--Localities 729, 692, 693, and 782 essentially represent a strike section in the southern part of the Cherokee Platform (fig. 1). Plate 1 shows the correlation of identified genetic/event surfaces (labelled G-1 to G-7) at these localities. Each surface bounds small scale cycles. The genetic/event surfaces and corresponding cycles are discussed below.

Genetic/Event Surfaces--Surface G-1 represents a relatively rapid transition from the underlying non-fossiliferous siltstone to the overlying skeletal wackestone. The underlying siltstone (uppermost Bandera Shale) has been interpreted as having formed from an influx of sediment from an easterly source (Schenk, 1963; Price, 1981). Wanless et. al. (1963) stated that large migrating deltas existed on the northern flank of the Ozark Uplift, but they could not find any evidence that these contributed to Marmaton rocks in the Cherokee Basin. Schmidt (1959), Schenk (1963, 1967), Gamble (1967), and Price (1981) believed that deltas from the Ozark region did supply sediment to the Cherokee Basin area during Marmaton time, and that much of the Bandera Shale in the Cherokee Basin is a deltaic deposit.

Beds above surface G-1 represent deposition in a marine environment as sea level rose and deltaic environments retreated eastward. Some reworking of deltaic deposits may have supplied sediment for the clay-rich laminae in bed B at locality 729 and 692, and clay-rich laminae and silt-sized quartz seen in the lower part of bed 2 at locality 782. An increase in fossil diversity above these beds may indicate a more offshore environment and/or decreased turbidity. Although no phylloid algae were noted in-situ in this study, they have rarely been documented as occurring in-situ in the literature (Baars and Torres, 1991). Connolly (1985) noted that phylloid algal blades rarely occur as isolated individuals, but occur in abundance when present. This he attributed to a supposed similarity to modern day calcareous codiacian green algae, which quickly disarticulate and fragments upon death. Where phylloid algae blades occur in abundance, they are generally assumed to have undergone little transport because of the suspected fragility of the fronds (Connolly, 1985). The occurrence of an abundance of phylloid algae in these beds suggest low energy environments. Overall, fossil diversity is higher at the easternmost locality, perhaps indicating a more stable (further offshore or less turbid, or both) environment in this area. Very large fragments of phylloid algae in bed 3 at locality 782 would suggest that these have undergone less transport, perhaps due to less turbulent conditions and/or rapid burial. Above the phylloid algal wackestone beds fossils are more fragmented, and fossil diversity decreases upward to surface G-2. Calcispheres are believed to be indicative of restricted, shallow water deposits (Wray, 1977; Flugel, 1982; Scholle, 1978); their presence in the beds underlying surface G-2 may indicate deposition of these rocks in a restricted shallow water environment. Tetrataxis attached to skeletal grains, as seen in thin section D2, indicate occasional rapid burial events (Cossey and Mundy, 1990). "Algal"-coated grains suggest that waters were clear enough, at least at times, to permit algal growth. Rounded and abraded grains suggest frequent reworking.

Surface G-2 is a very sharp surface separating the underlying skeletal mudstone from the overlying packstone bed. This overlying packstone bed is similar at all localities, and is a prominent marker bed due to its distinct fossil content and silicious nodules. Common abraded and algal-coated fusulinids indicate frequent reworking prior to final deposition. Highly fragmented skeletal debris is also indicative of a high energy environment. This bed marks the first occurrence of chaetetids at all localities. An increase in micrite above this bed may indicate a transition to lower energy, quieter conditions. Furthest offshore conditions for this cycle may be represented by the diverse open marine assemblage in the phylloid algal wackestone (bed 4, localities 729, 692; bed 3 at locality 692; the upper part of bed 4 at locality 782).

Laminar chaetetids in these beds became established on algal blades or possibly directly on the loose muddy substrate (further discussed in the following section on chaetetids). Movement to higher energy, less stable, conditions upward to surface G-3 may have occurred, indicated by increased fragmentation of skeletal debris and a decrease in fossil diversity.

Surface G-3 is sharp, and occasionally marked by a thin skeletal "lag" deposit. Above surface G-3 fossil diversity is initially high, but decreases upward. Fragmentation of fossils increases upward at all localities. Beds with the best developed and most numerous chaetetids in the study area occur above surface G-3. At locality 693, conditions appear to have been optimal for chaetetid growth, with chaetetids forming an extensive reef-like buildup. Tall columnar chaetetids in this buildup may have formed in relatively low-energy, "deep" water (further offshore) conditions, as suggested by West and Kershaw (1991) for columnar growth forms. The chaetetids in bed 5 at locality 782 also show increased growth over those to the west, but not as intense as at locality 693. Shallower (higher energy) conditions may have existed to the west, where chaetetids are generally smaller and occur less frequently. Although Mathewson (1978) believed that the reefal buildup at locality 693 pinched out laterally at this outcrop, its extent could not be established from field observation for this study.

Conditions at all localities apparently began to slowly shallow upward, with evidence of increased energy present in the form of displaced chaetetids and an overall decrease in the abundance of chaetetid and other organism. Black clay-rich laminae and shale partings may be the result of storm events superimposed on an overall upward shallowing environment.

Bed 5e at locality 782 and bed 6c at localities 729 and 692 represent extremely shallow conditions of strong to intense energy levels. Small chaetetid buildups occur, not unlike small "patch reefs" seen in modern day nearshore environments. Storms and strong wave energy frequently knocked over and displaced large chaetetid heads and scoured areas around these small buildups. Most sediment bypassed this area, with little being deposited except in areas protected by chaetetid buildups. At locality 693, fine skeletal debris was deposited and most of the mud was winnowed away.

As sea level continued to shallow, high energy conditions were replaced by a low energy lagoonal environment (bed 7 at localities 729, 692; bed 6 at localities 693,782). Sediment was frequently rooted and burrowed, with storm events occasionally washing in broken and abraded skeletal debris. This environment appears to have existed in the eastern localities longer, as suggested by the increased thickness and lateral persistence of bed 7 at the eastern localities (especially at locality 782).

Eventually all localities were exposed to subaerial exposure. Features noted in field observations and thin sections throughout the study area at the upper surface of this cycle (surface G-4), such as irregular to planar sharp upper surfaces, in place brecciation, leached and vuggy porosity, lithoclast in the overlying bed, laminar micrite crust, circum-granular cracking, clotted micrite, root molds, and surficial karstification, are all good indications of subaerial exposure (Estaban and Klappa 1983). In addition, void-filling inter-particle equant calcite cement and micrite envelopes in rocks directly underlying this surface indicate early exposure to the fresh water phreatic zone (Longman, 1980). The green clayshale filling in pits and depressions on this surface (G-4) at localities 729 and 692 may be the remains of a paleosol, similar to a clayshale described from a Silurian subaerial exposure surface by Carlson (1990). Carew (1990) noted that soil and associated debris can penetrate downward through karstic features for some distance, possibly explaining the inter-fingering of clay- rich sediment with the in-place brecciation present at Surface G-4.

Surface G-4 is a knife-sharp contact separating the underlying subaerial exposure surface from the overlying marine beds. Transgression may have began with a change to more humid conditions (increased rainfall), causing intense micro-karsting of the subaerial surface at all localities, and the establishment of localized peat swamps (suggested by the thin coal smuts present at locality 693). High energy conditions during sea level rise would probably have removed most soil that may have formed. Initially, clay-rich sediment was deposited, eventually being replaced by the carbonate oncolitic bed present at all localities (bed 9 at localities 692 and 729, and bed 8 at localities 693 and 782). Although Mathewson (1978) believed this bed represented deposition in very shallow high energy conditions ranging from low intertidal to high subtidal, the presence of a large number of articulated brachiopods and the abundance of clay and silt- sized sediment does not suggest high energy conditions. Also, some brachiopods appear to have been alive during some of the initial "algal" encrustation, suggested by encrustations which do not continue over the commissure (thin section D3). Recently, Pragger and Ginsburg (1989) have found concentrically laminated foraminiferal-algal nodules on Florida's outer shelf in low energy settings of water depths of 35 to 65 meters. These nodules have formed around skeletal grains and rock fragments, not unlike those seen in this study. They found that foraminiferids and algae encrusting these nodules are able to grow on all surfaces of the nodule at one time. Because of this, complete overturning is not required for concentric growth, and nodule growth is facilitated by slight repositioning due to biological activity (burrowers, grazers, etc) and possible infrequent storm and surge events. Dullo and Hecht (1990) found that growth of concentrically banded coralliths was caused by bioturbation by fishes and not storm or other high energy events. An environment similar to those discussed above can be inferred for the oncolitic zone in this study. Nodule formation would have been enhanced by biological activity and possible rare storm and/or surge events. Infrequent overturning is suggested by chaetetids within this bed. Although some do show evidence of overturning, several centimeters of upward growth is evident on many chaetetids between overturning events. Wood (1990) suggest that, based on the mechanical strength of the skeletons, extant calcified demosponges grow at a slower rate than modern corals (1 to 15 mm/year, Fagerstrom, 1987). If chaetetid growth rates were similar to that of modern calcareous demosponges, a considerable amount of time would have occurred between overturning episodes. Influxes of sediment appears to have occasionally buried and smothered chaetetids and "algae"-encrustations. These may in turn have been later re-exposed and served as nucleating sites for new "algal"-encrustations and/or chaetetid growth, similar to organism recolonization episodes noted by Seilacher (1984) in recent sediments in the straits of

Malacca, Malaysia.

An increase in clay-rich sediment in the upper part of the oncolitic bed may indicate a return to more shoreward, higher energy conditions where "algal"-coated grains were frequently buried before well defined oncolites could form. Most chaetetids do not continue into the overlying bed; these may have been killed off by increased turbidity and/or sedimentation. The presence of overturned productids in hydrodynamically stable positions at the top of the oncolitic zone is also indicative of frequent high energy conditions.

Continued upward shallowing created conditions unfavorable for nearly all organisms. Abundant abraded, bored, and fragmented skeletal grains indicates frequent reworking and bioerosion. Wavy bedding and cross-bedding may also indicate deposition in higher energy, shallower conditions, not unlike what would be expected in an intertidal environment. Silt-sized quartz (thin sections A16, C10, D8) below surface G-5 suggest the influx of siliciclastic debris from land sources.

Bed 11 at localities 693 and 782, and the discontinuous crinoidal packstone lenses near the top of bed 10 at localities 729 and 692 may represent a storm event, that deposited both fragmented and whole skeletal grains, along with micrite.

At the western end of the transect (localities 729, 692), surface G-5 marks the transition from carbonate to black mud deposition. In the east (localities 693, 782), the transition across surface G-5 is (initially) not as dramatic, going from a crinoidal mudstone to phylloid algal-rich carbonates. This transgression may have caused some erosion of the underlying beds, thus accounting for the discontinuity of bed 10 at localities 729 and 692, and sharp undulatory upper surface of bed 12 at locality 693. Black organic-rich mud was deposited in the west, whereas in the east an optimum environment existed for phylloid algae.

Lack of a true modern analog has historically caused problems in the environmental interpretation of black phosphatic shales such as the Lake Neosho shale. Interpretations have centered around two widely opposing ideas, either formation in a shallow, nearshore environment (tidal flat or restricted lagoonal deposit), or in a deep water anoxic environment.

Shallow water interpretations were prevalent early in studies of the midcontinent Pennsylvanian. Udden (1912) believed that black shales were the result of the flooding of coal swamps during a marine transgression and the subsequent reworking of the peat. Moore (1929), and Zangerl and Richardson (1963) believed that black shales formed in shallow, lagoonal waters where large floating algal mats prevented the agitation and oxygenation of the underlying waters, and also served as the source for organic carbon.

One of the earlier workers to suggest a deep water environment for black phosphatic shales was Schenk (1963, 1967). He believed that the Lake Neosho shale formed during maximum transgression when upwelling from deep oceanic waters brought nutrients and phosphatic rich waters onto the shelf. This in turn caused planktonic blooms and a subsequent anoxic environment due to the loss of oxygen brought about by the decomposition of phytoplankton. This idea was later used by Heckel and Baesemann (1975), and Heckel (1977), to explain all phosphatic black shales. Heckel (1977) believed that at maximum transgression (water depths of 80-100 meters) a strong thermocline developed that prevented the mixing of top and bottom waters. Prevalent trade winds setup a "quasi-estuarine circulation cell", which caused upwelling of nutrient and phosphorous-rich waters onto the shelf, which in turn brought about abundant planktonic growth. This further caused depletion of the oxygen in these bottom waters as these organism sank and decayed.

Recently, some workers have began to look at the coal swamp flooding model of Udden (1912) more closely. Wenger and Baker (1986) believed that during a regressive phase, the craton would have contained extremely widespread brackish marine peat swamps. Subsequent flooding of these areas during a eustatic sea level rise would have brought about the influx of nutrients and organic debris, causing high algal production, anoxic conditions, and subsequent black organic-rich mud deposition in relatively shallow nearshore environments. Coveney et al. (1991) suggested that black shales may have formed under different environments and recognized two, a shallow nearshore and a deeper offshore environment. They believed that in both cases, black shale formation was brought about by the flooding of peat swamps during transgression and the subsequent influx of organic debris into the marine environment.

Pederson and Calvert (1990) have shown that oxygen minima (i.e. anoxic condition) is not the controlling factor for the accumulation of organic matter, and that in fact organic-rich muds in the Black Sea were deposited during oxygenated times. They believed the primary control for black shale deposition was the influx of organic matter and high primary productivity.

The Lake Neosho shale has been interpreted as both a shallow water deposit (Schmidt 1959; Gamble 1967; Mathewson 1977) and as a deep water deposit (Schenk 1963, 1967; Price, 1981, 1984; Heckel 1984). Shallow water deposition is suggested for the Lake Neosho shale by physical evidence found in this study. Plant debris was ubiquitous throughout the bed at all localities. Commonly occurring Petrodus-like dermal denticles have been interpreted as a shallow water, low energy, nearshore component (Zangerl and Richardson, 1963). Sedimentation rates must have been high enough at times to preserve plant debris and fragile Listrocanthus spines found within the Lake Neosho shale. Lateral continuity is often given as evidence for black shales representing the deepest water facies, but within the area studied the Lake Neosho shale is not even laterally continuous over a distance of approximately 10 km.

It appears that the ideas of Wenger and Baker (1986), and Coveney et al. (1991), best describe the deposition of the Lake Neosho shale. Gamble (1967) recognized the presence of deltaic sediments near the western localities (729, 692) which are laterally equivalent to Lake Neosho shale sediments elsewhere. During the transgression suggested by surface G-5, streams which produced these deltas would have deposited organic matter in the western area; areas to the east would have been less affected and existed as more open marine areas. Climatic change may have been an overriding factor at this time. As suggested by Cecil (1989, 1990), increased rainfall would have resulted in an increase of terrestrial runoff into streams and subsequently into marine environments. Evidence of an influx of organic debris includes the large Lepidodendron fragment noted on the upper surface of bed 10 at locality 692, and other plant debris noted in the Lake Neosho shale at localities 729 and 692. To the east more open marine conditions existed where phylloid algae flourished, and moderate energy condition occasionally reworked and buried skeletal debris. Chaetetids in the east above surface G-5 are limited to small laminar forms, possibly due to high sedimentation rates, and/or competition with phylloid algae. The abundance of photosynthetic phylloid and encrusting algae indicates that turbidity was probably not very high, and light penetration good. Initially in the west a restricted marine assemblage existed, but conditions were harsh enough to keep these organisms small, and eventually even these were wiped out as conditions worsened, shutting off carbonate production and depositing a sparsely fossiliferous black shale.

Another genetic surface may be present at localities 693 and 782 at the oncolitic zone at the top of bed 14 at and the clayshale parting above this. Some of the lower units (a-c) within bed 11 may correspond to this event in the western exposures. Bed 15 at localities 693 and 782 may represent increased turbidity, suggested by the decrease in phylloid algae and increase in micritic mud. Deposition of black organic-rich mud began at the top of bed 11c in the western area. A continued wet (high rainfall) environment eventually resulted in the encroachment of organic-rich sediment plumes from the west into the eastern area, resulting in the clayshale at the base of bed 16. Eventually these organic-rich sediments shut off carbonate production in the eastern area, causing black organic-rich shale deposition over the entire study area. Organisms during this time were generally restricted to pelagic forms, possibly as the bottom became anoxic or near anoxic. Periods of bottom water oxygenation may have occurred, as suggested by Maples (1986), allowing for some bottom dwelling organisms to exist, such as Orbiculoidea, and Chondrites and Planolites producing organisms.

Phosphate nodules in the middle and upper part of the Lake Neosho shale have generally been interpreted as the result of precipitation from phosphate rich upwelling waters in a deep water environment (Heckel 1977; Kidder 1983, 1985), although others have suggested environments for phosphate formation that do not require deep water upwelling conditions. Soudry and Levy (1988) believed that phosphate nodules in the late Cretaceous Mishash formation are parts of algal mats formed in lagoonal environments. Shaffer et al. (1988) and Leonard (1990) also suggested a possible algal origin for phosphate nodules, but did not observe any microbial structures. Although no evidence for or against shallow water origin of phosphate nodules was found in this study, what is important is that their presence alone does not demonstrate deep water formation.

It appears that the black fissile part of the Lake Neosho Shale represents deposition in relatively quiet water (nearshore) conditions where marine and nonmarine sediments were mixed together. High productivity kept oxygenation low, and some, more tolerant, benthic organisms occurred. Nektic organisms (such as sharks and conodonts) existed, and upon death settled to the bottom, disarticulated, and were incorporated into the sediment.

The upper part of the Lake Neosho shale may represent more offshore conditions and/or a decrease in terrestrial organic influx (due to decreased rainfall), allowing for the establishment of more normal marine fauna and a return to a carbonate producing environment.

Eventually full open marine conditions existed throughout the area, as represented by bed 12 at localities 692 and 729, and bed 17 at locality 693. This is the last bed present at the eastern localities, and may represent deposition in more offshore conditions than previous beds. Algal-coated grains ubiquitous in the beds below are absent, and robust fusulinids and a diverse brachiopod assemblage occur. Photosynthesis may have been restricted by turbidity and/or water depth, accounting for the near absence of phylloid algae. Highly fragmented phylloid algae present may, as suggested by Schenk (1963) and Mathewson (1978), have been carried into this area from shallower phylloid algae producing zones higher up on the southern flank of the bourbon arch.

Bed 12 at localities 692 and 729, and bed 17 at locality 693 is the least variable of the beds studied, being nearly identical wherever present. This also supports a more stable (further offshore) environment of formation, where slight topographical differences would have had little effect on deposition.

Observations above this bed are based on limited outcrop data at the western localities. As such these bed were less well studied and interpretations based on only one or two localities. Some general observations follow.

A return to higher energy, less turbid conditions began to occur in the upper part of bed 12 and continued through beds 13 and 14, as suggested by an increase in phylloid algae, fragmented skeletal debris and decrease in fossil diversity. Organic partings may be the result of storm events which washed in silt and clay-rich sediment.

The sharp upper contact with the crinoidal packstone at the top of bed 14 (surface G-6), may indicate a move to more offshore (stable) conditions, suggested by the more skeletal diverse bed 15. Upward, less stable, higher energy conditions occurred through beds 15, 16, and 17, as suggested by increased fragmentation of skeletal debris and a decrease in skeletal diversity. Occasional storm events may account for the crinoidal packstone lenses seen in bed 17. The sharp, pitted, eroded, and iron-stained upper surface of bed 17 (surface G-7) may indicate a subaerial exposure event.

Surface G-7 represents a transition to offshore marine conditions. This surface was probably well lithified after subaerial exposure, creating a stable surface upon which a diverse open marine brachiopod assemblage could exist. In the upper part of bed 18, the "algal"-coated grains and abundant phylloid algae fragments are similar to those seen in beds within the Amoret limestone, suggesting environmental conditions similar to that present during much of Amoret deposition.

In most areas above this bed (18) a modern soil is developed. The Nowata Shale (bed 19) is only present in depressions on the upper surface of bed 18. Schenk (1963), believed that the lower Nowata Shale represented shallowing conditions, where deltas from the Ozark Uplift to the east began to encroach upon the area once again.

In conclusion, the deposition of the Altamont Limestone does not appear to have occurred during a single transgressive-regressive event, but instead has a more complex depositional history. Most of the Amoret limestone (bounded by surfaces G-1 through G-5) appears to have been deposited in relatively shallow (nearshore) water. Besides the evidence presented, regional studies of the Altamont Limestone by Schenk (1963, 1967) showed that along the outcrop belt the Amoret limestone disappears over structural highs. Although Schenk (1963, 1967) believed that the Amoret was not deposited over these structural highs, he did not recognize the subaerial exposure surface noted near the top of the Amoret limestone (surface G-4). It seems probably that the Amoret was deposited across these highs, and subsequently eroded away during subaerial exposure. This is supported by the presence of brecciated beds in the Amoret limestone noted by Schenk (1963) on the flanks of many of the structurally high elements present in this region.

Increased rainfall and/or marine transgression above this subaerial exposure surface eventually led to flooding of peat swamps to the north and subsequent deposition of the Lake Neosho shale. Initially deposition of black fissile shale was confined to the western localities, with open marine carbonates being deposited to the east. Smaller sea level fluctuations (and/or rainfall fluctuations) may have occurred during this time, but eventually all areas were affected by organic-rich terrestrial influx and subsequent black shale deposition. A decrease in organic-rich sediment influx, due to decreased rainfall and/or sea level rise, brought about the return of carbonate producing environments to all localities. This may represent the most offshore environment that existed during deposition of the Altamont Limestone. Schenk (1963, 1967) believed that the Lake Neosho Shale represented maximum transgression (furthest offshore), but he based this interpretation mainly on the presence of phosphate nodules, even though the lithology, in outcrop, of the Lake Neosho shale varies from a black fissile shale to a green mudstone. As suggested earlier, phosphate nodules do not necessarily demonstrate deep water formation. From Schenk's (1963) cross sections it appears that the least variable unit across the outcrop is the Worland limestone, which suggests deposition in a more offshore environment less influenced by structural features. A relatively "deep" water (further offshore) environment may also account for the absence of chaetetids within the Worland limestone at all localities studied. Chaetetids do occur in the Worland limestone to the northeast of this study area in Kansas, Missouri, and Iowa. The occurrence (and absence) of chaetetids in the Worland limestone will be discussed more thoroughly in the chaetetid section.

Overall upward shallowing interrupted by smaller scale genetic events continued above the lower part of the Worland limestone. Eventually the area shallowed to a point where deltas from the east began encroaching upon the area once again, depositing siliciclastic sediment (Nowata Shale).

CHAETETIDS

Introduction

Species--Chaetetids have been linked closely to extant sclerosponges described by Hartman and Goreau (1972). Now considered by many to be extinct coralline demosponges, chaetetids were important framebuilders during much of the Carboniferous. Seven species have been identified from the middle Carboniferous in North America, with speciation based on eleven characteristics, although not all characteristics were examined for each species (West, 1989a; West, in review). Chaetetids in the Altamont Limestone were described as Chaetetes milleporaceus by Schenk (1967). Recent evidence (West, 1989a, 1989b, in press) has shown that many of the speciating characteristics overlap and/or fail to delineate different species, and that a single chaetetid specimen may show characteristics of several supposed individual species. In fact, Wood (1990) has noted that many fossil sponges previously classified as chaetetids are not even all of the same lineage. Thus, it is recommended that the term "chaetetid" should only be used to represent a skeletal grade of organization, without any high systematic value (Wood, 1990). Because the classification of chaetetids is in a state of flux, no attempt will be made to recognize the species of chaetetids observed in this study.

Structure--Chaetetids formed calcareous skeletons consisting of numerous polygonal ceroid to meandroid tubes (tubules) which are horizontally partitioned by irregular spaced tabula and pseudo-septa (West and Clark, 1984). An X-ray diffraction of a well preserved chaetetid specimen from locality 692 (well preserved tubules and tabula; hollow, un-mineralized tubules) showed it to be composed of nearly pure low-Mg calcite (1 mole % $MgCO_3$), indicating a probable original skeleton of low-Mg calcite or possible aragonite.

Chaetetid growth was apparently by longitudinal fission, peripheral expansion, and inter-calicle budding (West and Clark, 1984). The living tissue of the organism was probably similar to that of modern sclerosponges in which the living tissue forms a thin veneer over the outer surface of the calcareous skeleton (Hartman and Goreau, 1970). Astrorhizae were noticed on several specimens throughout the study area, both external and internal. Mathewson (1978) and West and Clark (1984) have also reported the presence of astrorhizae on chaetetids from this area. In modern sclerosponges these structures represent part of the exhalent system for fluid flow through the organism.

Growth Forms--Previous workers have noted the highly variable growth forms of chaetetids. West and Clark (1984) recognized three distinct growth forms; laminar, ragged low domical, and columnar. Kershaw (1979) noted four distinct forms of stromatoporoids, which have growth forms nearly identical to chaetetids; laminar, domical, bulbous, and dendroid. Connolly (1985) recognized four distinct growth forms; 1) hemispherical, 2) digitate, columnar, and club-shaped, 3) lamellar, tubular, and plate-like; and 4) anastomosing lamellar. West and Kershaw (1991) stated that there are only three basic growth forms, (tabular, domical, and columnar), and that the basic building block of all forms is a thin, laminar sheet. Other more complex forms are simply variations of these basic types. Kershaw and West (1991) recognized eleven different chaetetid growth forms (figure 26). Many of the growth forms described by different workers are one in the same, and those described by Kershaw and West (1991) appear to encompass most recognized growth forms. Chaetetid growth forms observed in this study will be described using the growth form names suggested in figure 26.

Growth forms have often been related to different environmental conditions. Spaw (1977) believed that laminar forms were an adaption to prevent overturning in high energy conditions, where as club forms (columnar) may have been restricted to less turbulent, more stable, deeper water conditions. Rich (1969) stated that water depth, turbidity and nutrient supply were the most critical factors affecting

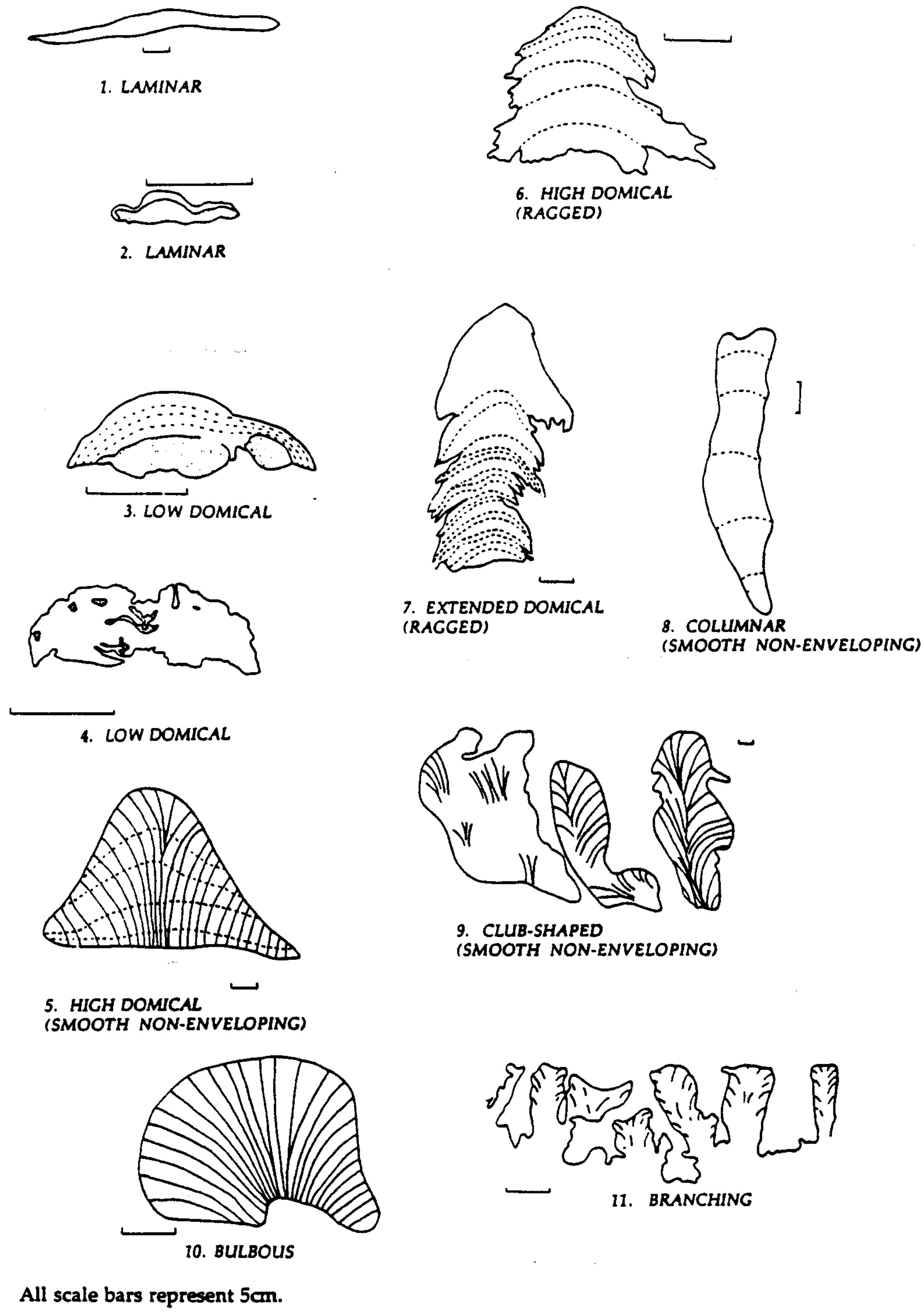


Figure 26. Growth forms observed in North American Pennsylvanian-age chaetetids (from Kershaw and West, 1991).

chaetetid growth, more so than the degree of agitation the chaetetids were subjected to. Kershaw (1981) suggested that the growth forms of stromatoporoids (similar to those in chaetetids) may be genetic differences and thus different species. Nelson (1973) recognized two species of chaetetids based on different growth forms, laminar and domical, but suggested that these may in fact be ecophenotypic adaptations to different environmental conditions. Sutherland (1984) concluded that within the Marble Falls Limestone of Texas, chaetetids with globular growth forms (low domical) were deposited in areas of low sediment influx, where as cylindrical growth forms (columnar) were the result of increased carbonate mud influx. Mathewson (1978) felt that shingle (laminar) growth was a response to an unstable, high energy, "fluidy" substrate, whereas columnar growth may have been the result of: a) crowding of chaetetids in a limited area, or b) growth on a more stable, lower energy, firm substrate. He believed hemispherical forms occurred somewhere between these two growth forms in moderate energy stable environments. West and Clark (1984), noted that laminar to low domical forms frequently occur in mudstones and may reflect the firmness of the substrate and sedimentation rates, where as domical to high domical forms occur in cleaner carbonates which suggest both firmer substrate and less sedimentation. Fagerstrom (1987, fig 13.3) depicted laminar chaetetids occupying high energy reef crest and hemispherical forms occupying lower energy back-reef lagoonal areas. Kershaw and West (1991, pg. 333) suggest that "columnar and branching forms grew in quiet water, while laminar and domical (growth forms) were better adapted to environments of high energy", although they did recognize that laminar forms are found in both high and low energy facies.

Apparently many factors, both genetic and environmental, could have influenced growth forms, and that relating chaetetid growth forms to a particular depositional environments is somewhat arbitrary. How the chaetetid growth forms and related environmental interpretations discussed above relate to those seen in this study will be covered in the following sections.

Paleoenvironment--It is important to note that most interpretations of the growth environment of chaetetids differ to a greater extent than those for modern coralline demosponges. Modern relatives (sclerosponges?) are generally confined to cryptic habitats, with an optimum distribution of 20-100 meters (Fagerstrom, 1984). Chaetetids have generally been interpreted as occurring in a wide range of shallow subtidal conditions. Connolly et al. (1989, pg. 139), believed "...the optimum environment for chaetetids was in the shallowest water, approaching intertidal depth..., favoring at least moderate water energy." Suchy (1987, pg. 122) stated that chaetetids thrived from "depths not far below wave base to well within normal wave base." Evidence of wave action or other high energy events acting on chaetetids has suggested by Mathewson (1978), and West and Clark (1984). Randolph (1974), Soar (1984), and Suchy (1987), noted that chaetetids were highly sensitive to topographical changes, and that they favored the flanks of structurally positive features. Suneson (1984) suggested chaetetids grew both within and below wave base, but believed they thrived in subtidal environments free from harsh wave action. Connolly et al. (1989) summarize numerous reported paleo-environmental occurrences of chaetetids, ranging from brackish environments to areas well below wave base. It is apparent from the above discussion that chaetetids were highly adaptive to different environmental conditions.

Fagerstrom (1984) believed that the apparent shift of modern related organisms to cryptic habitats may have been due to competition from hermatypic scleractinian corals, forcing previous shallow water non-hermatypic coralline demosponges to cryptic habitats. Some have suggested algal symbiosis for chaetetids (Connolly et al. 1989; West, in review). If this was indeed the case, then the reason for the shift in habitat may be due to some other factor(s) not based on algal symbiosis. Wood (1990) surmised that corals employ a trade-off between structural integrity and rate of growth, and as such were able to colonize substrates faster than more structural sound (but slower growing) calcareous demosponges.

Most authors have stated that chaetetids needed some firm or stable substrate for initial growth. Chaetetids encrusted oncolites, shell fragments, intraclast, and other chaetetids (Mathewson 1978; West and Clark, 1984; Suchy, 1987; this study). Others have suggested the sediment was initially lithified by sediment binding organisms (Lustig, 1971), or encrusting foraminiferids (Spaw, 1977). Connolly (1985) recognized chaetetids colonizing non-mobile oolitic bars in the Magdelena Limestone of Texas.

Occurrences

Introduction--At localities 729 and 692 chaetetids occur within beds 2, 3, 4, 5, 6, 8, and 9, and are most conspicuous in bed 6. At locality 693, chaetetids occur in beds 3, 4, 5, 8, 9, 13, 14, and 15, and are the most conspicuous in bed 5. Beds below 1 (seen only in core) may contain chaetetids, but none were observed. At locality 782, chaetetids occur in beds 4, 5, 6, 8, 9, 13, 14, and 15, and were the most conspicuous in bed 5.

Lateral Relationships--Laterally, chaetetids tend to occur closely associated with other chaetetids in all beds; chaetetids are seldom observed that do not have other chaetetids in close proximity (more apparent among domical to columnar forms). Large lateral areas exist which are devoid of chaetetids in chaetetid-bearing beds (see figures 6, 7, 15, 16, 20, and 21). At locality 693, chaetetids in bed 5 form a nearly continuous lateral buildup, and are so crowded together that it is nearly impossible to delineate individuals in this bed (see figures 16 and 17).

Growth Forms and Attachments--Chaetetids in the lowermost beds of the Amoret (beds 2-5, localities 729, 692; beds 3-4, locality 693; bed 4, locality 782) generally consist of laminar growth forms, although a few low domical forms also occur.

Laminar chaetetids in bed 2 at localities 729 and 692 range in size up to 15 cm long and 4-5 cm high, and the few low domical forms seen range in size up to 15 cm long (at the base) and 15 cm high. Chaetetids often appear attached to silicious nodules which occur in the bed. The nodules have the identical composition as the surrounding matrix and may represent areas of sediment originally bound together by encrusting algae, suggested by the abundance of algal coated grains within bed 2. Some evidence of the mobility of the surrounding sediment during chaetetid growth is suggested by what appears to be shifting during growth and a piling up of sediment around chaetetids (fig. 27).

Chaetetids in beds 3-4 (localities 729, 692, 693) and

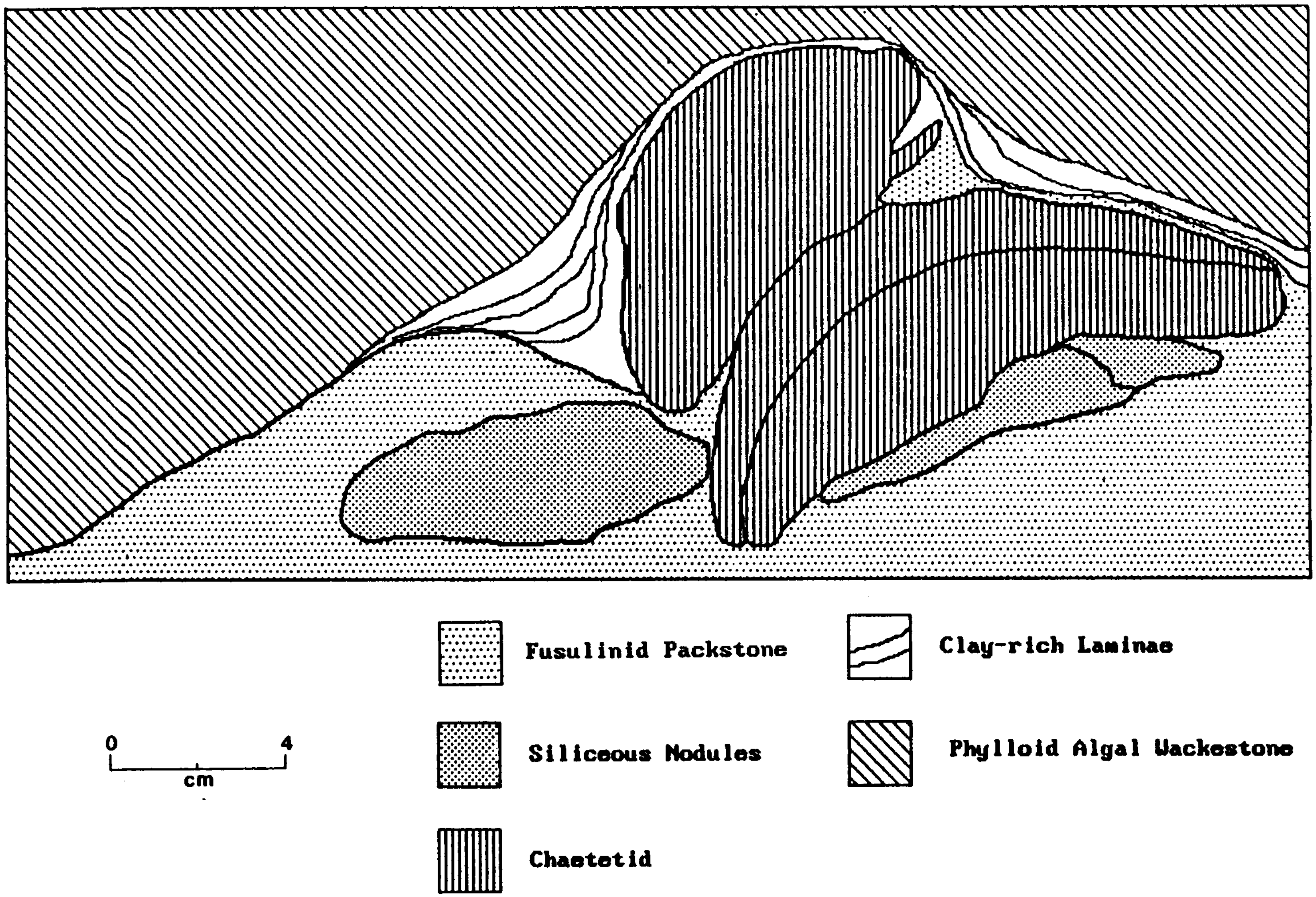


Figure 27. Tracing of a low domical chaetetid observed in bed 2, locality 729. Note how sediment appears to have "piled-up" immediately to the left of the chaetetid. Chaetetid also appears to have been slightly displaced early in growth.

bed 4 (locality 782) are frequently attached to phylloid algal fragments, but also are attached to fossil debris, or occur directly on clay-rich laminae within these beds. Laminar forms are occasionally one meter or more long (see figure 7), but are generally much smaller (less than 25 cm long). A few low domical forms occur in bed 4 (localities 729, 692, and 782), these are up to 20 cm long and 15 cm high.

Chaetetids in bed 5 at localities 729 and 692 are predominantly laminar, although a few low to high domical forms are also present (see figures 6 and 7). Laminar chaetetids are up to 1 meter long and 15 cm high, and domical forms are up to 30 cm wide and occasional continue upward through the entire thickness of this bed (30-40 cm). Chaetetids within bed 5 are frequently attached to phylloid algal fragments, fossil debris, or occur directly on clay-rich laminae.

Within those beds where chaetetids are the most conspicuous (bed 6, localities 729, 692; bed 5, localities 693, 782), a variety of growth forms occur. Within bed 6 at localities 729 and 692 growth forms include laminar, low domical, high domical (both smooth and ragged), extended domical (ragged), columnar (smooth), and bulbous (see figures 6 and 7). Laminar forms occur infrequently, generally near the lower contact of the bed, and range in size up to 25 cm long and 5-10 cm high. Low and high domical forms (both smooth and ragged) are conspicuous and occur throughout the bed, although more frequently in unit a. These are up to 40 cm across and 40 cm high. Extended domical forms are also prominent, and generally begin in unit a and occasionally continue into unit b. These are up to 45 cm wide and 1.2 meters high. As seen in figure 26, extended domical forms consist of stacked laminar to ragged, domical forms, and may represent one or more colonization events. Columnar forms (smooth) occur infrequently, and are up to 30 cm wide by 50 cm high. Bulbous growth forms are uncommon, and are generally confined to unit c. Figure 28 shows a large bulbous form in unit c (bed 6) at locality 729. Bulbous forms are up to 75 cm in diameter.

In bed 6 (localities 729, 693), laminar forms are often attached to phylloid algal fragments. Low to high domical forms may attach to phylloid algal fragments, but were also found attached to belerophontids and brachiopods (<u>Composita</u>, productids, others). Extended domical forms initially begin as laminar or low domical chaetetids. Columnar forms are attached to skeletal fragments (brachiopods, bellerophontids). Bulbous forms are frequently overturned or toppled; what they initially attached to (if anything) could not be determined.

In bed 5 at locality 693, chaetetids make up the entire bed in places. In unit a, chaetetids range from laminar to low and high domical forms. Laminar forms, up to 30 cm

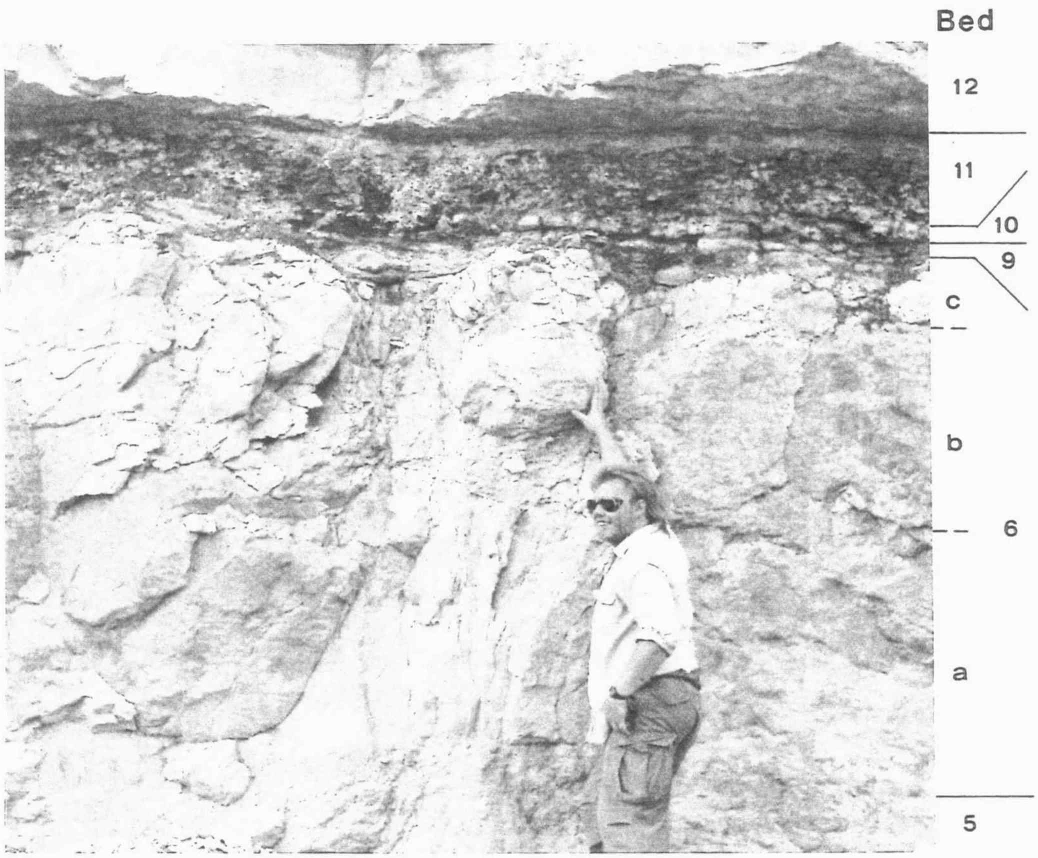
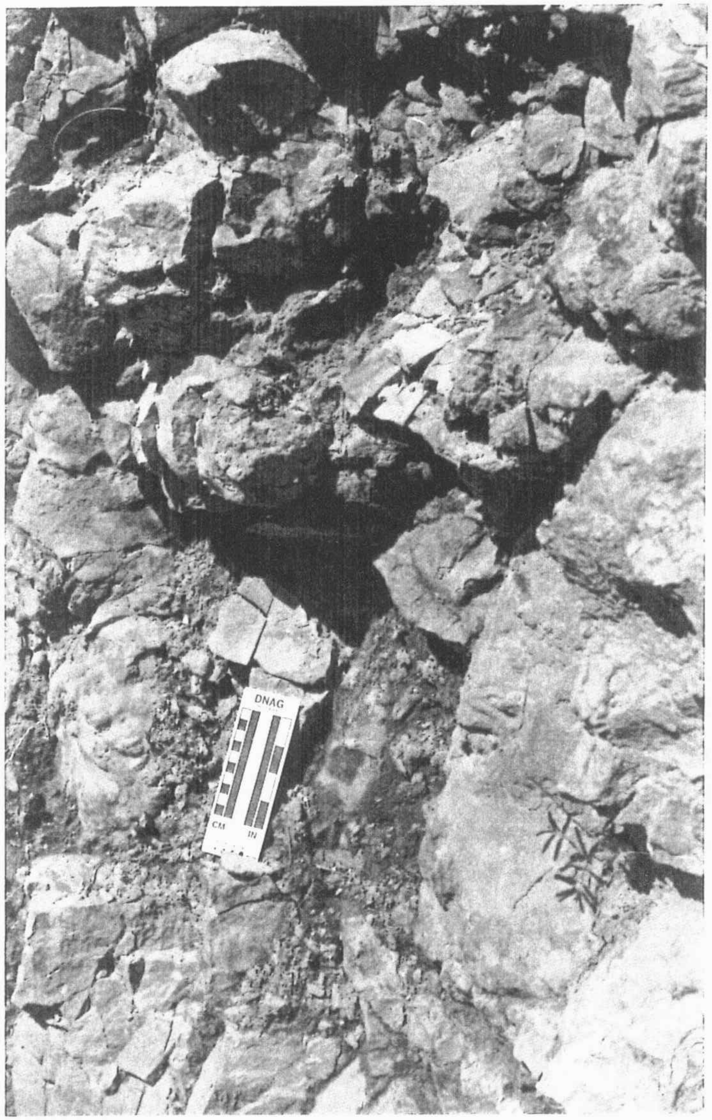


Figure 28. Hand is resting on large bulbous chaetetid in unit c, bed 6, at locality 729.

long and 5 cm high, often form the base of domical forms, which are up to 40 cm wide and 30 cm in height (entire thickness of this unit). In places chaetetids make up the entire bed, and individual heads are difficult to distinguish (Fig. 29). Laminar forms appear to have attached directly to the upper surface of bed 4, suggesting this surface was stable at this time. Domical forms (all ragged) are up to 30 cm high and 40 cm wide, and often continue into the overlying unit (b). Unit b contains low domical (ragged), high domical (ragged), extended domical (ragged), and columnar forms, in most areas making up the entire unit (see figures 15 and 16). Chaetetids are frequently continuations of domical forms from unit a, although some do originate at the base of unit b (attached directly to the upper surface of unit a). Unit c contains laminar, low domical (ragged), high domical (ragged), bulbous, extended domical (ragged), and columnar forms. Columnar forms all originate within unit b or unit a, and are clumped together making individual chaetetids difficult to distinguish. Some of the columnar forms which begin in unit a are up to 1.2 meters high. Laminar forms are up to 20 cm long and 5 cm high, and are restricted to the upper half of unit c. Low and high domical forms are up to 25 cm wide and 30 cm high, and occur mostly in the upper half of unit c. Extended domical forms begin near the lower surface of unit c and continue upward. Bulbous forms are restricted

Figure 29. Chaetetid buildup in part of bed 5 at locality 693. Unit b is made up entirely of chaetetids, many of which appear to have grown at angles less than 90 degrees. Dashed line is approximate contact between units a and b of bed 5. Up is to the left of the page.



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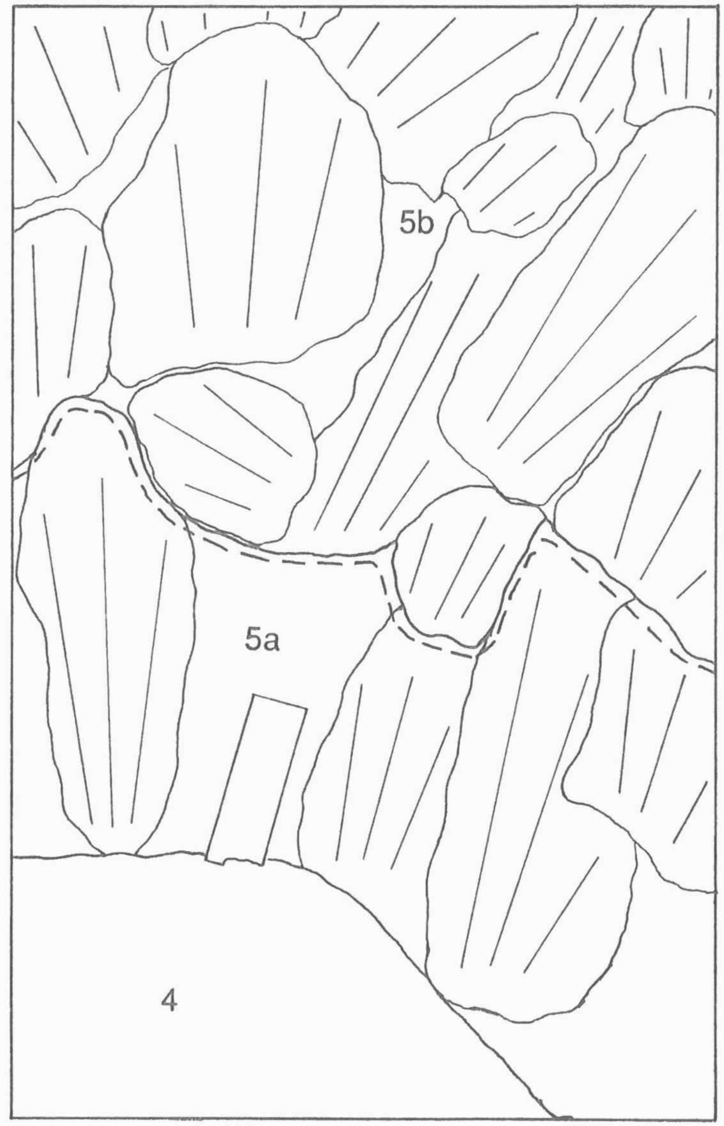


to the lower half of bed 5c, and are up to 50 cm in diameter. Substrates for laminar and domical forms are skeletal fragments and/or algal coated grains. Bulbous forms are all attached directly to the upper surface of unit b, suggesting a stable substrate at the time of initial attachment. A few expanding-upward, extended-domical forms occur, entirely within unit c, and are attached to skeletal grains (including <u>Composita</u>).

In bed 5 at locality 782, chaetetids occur as laminar, low domical, high domical (both ragged and smooth), columnar, extended domical, and bulbous forms. Laminar chaetetids (up to several meters long and up to 10 cm high) occur predominately at the contacts of beds 4 and 5, units a and b (bed 5), and units b and c (bed 5). Attachment appears to have been to chaetetids in the underlying units or directly to the contact surface. Laminar chaetetids serve as the base for other growth forms (see profiles, figures 20 and 21). Laminar chaetetids also occur in the upper part of unit c, and are attached to phylloid algal fragments or other fossil debris. Domical chaetetids (low and high) occur most frequently in units a and c, but are also present in units b, d, and e. They are up to 50 cm wide and 40 cm high, but are generally much smaller. Domical chaetetids are often attached to laminar or low domical forms. They also occur attached to phylloid algal fragments, bellerophontids, or other fossil debris. To the right of 782-S3 on profile 782-P1 (Figure 20), two unusually large high domical forms occur, one in unit b and one in unit c (bed 5). These are approximately 50 cm long and 40-60 cm high. Extended domical chaetetids occur in units a, c, and e. These are up to 30 cm wide and 1.5 meters high. Extended domical forms are made up of laminar and domical (high and low) forms which have grown upon each other (see Figure 30). In unit e columnar chaetetids occur (figure 31), and appear to have been free standing. Columnar forms are attached to laminar or domical chaetetids, or less frequently to other fossil debris. Bulbous chaetetids up to 30 cm in diameter occur in unit e. The attachment site for the bulbous forms was not evident from field observations; many appeared to have been toppled and/or rolled around.

Chaetetids above these beds (bed 6, localities 729, 693; bed 5, localities 782, 693) occur infrequently, and are predominantly laminar to domical forms.

In bed 6 at locality 782, chaetetids are generally low domical and high (ragged) domical forms, with a few bulbous forms present. Domical chaetetids range in size up to 35 cm long and 25 cm high, although most are much smaller. Bulbous chaetetids range in size up to 40 cm in diameter. All chaetetids in the bed begin in the lower half, and only two continue into the upper part of the bed. The chaetetids are attached to fossil debris or more frequently are a continuation of chaetetids from bed 5 (the contact between

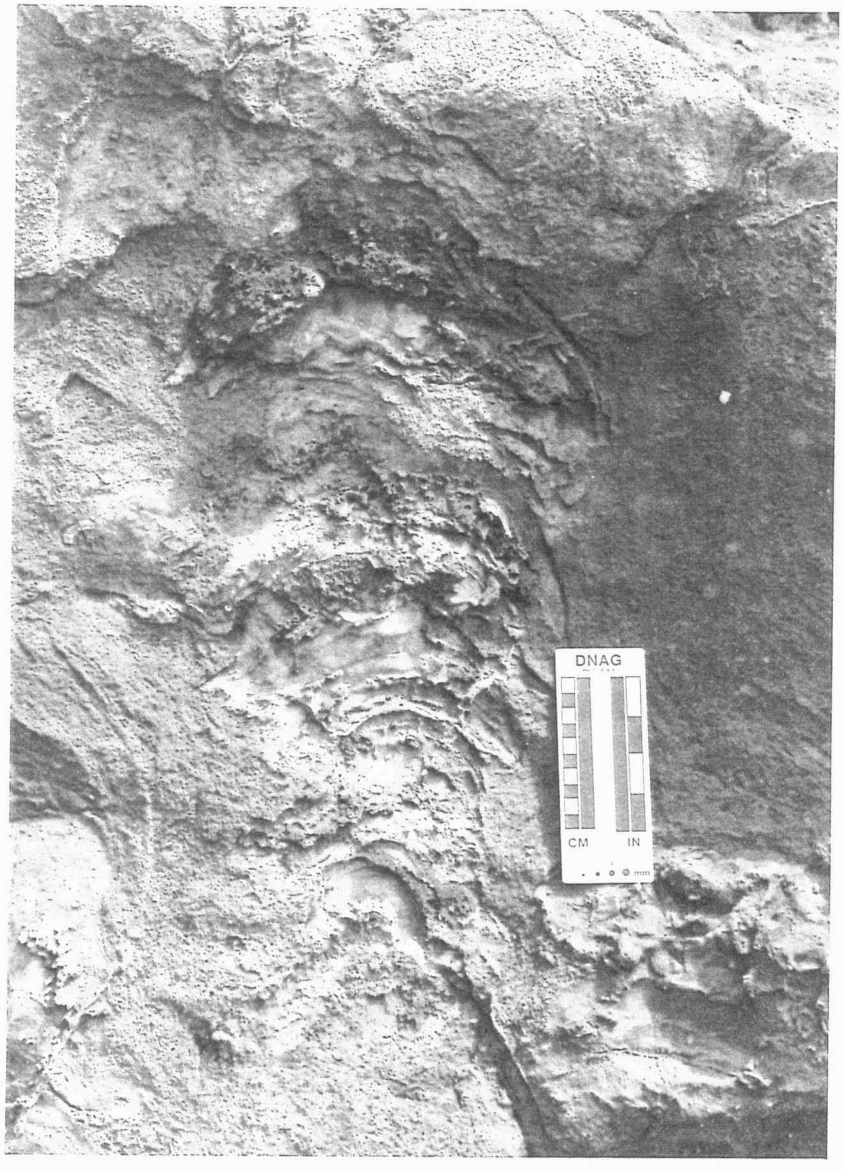
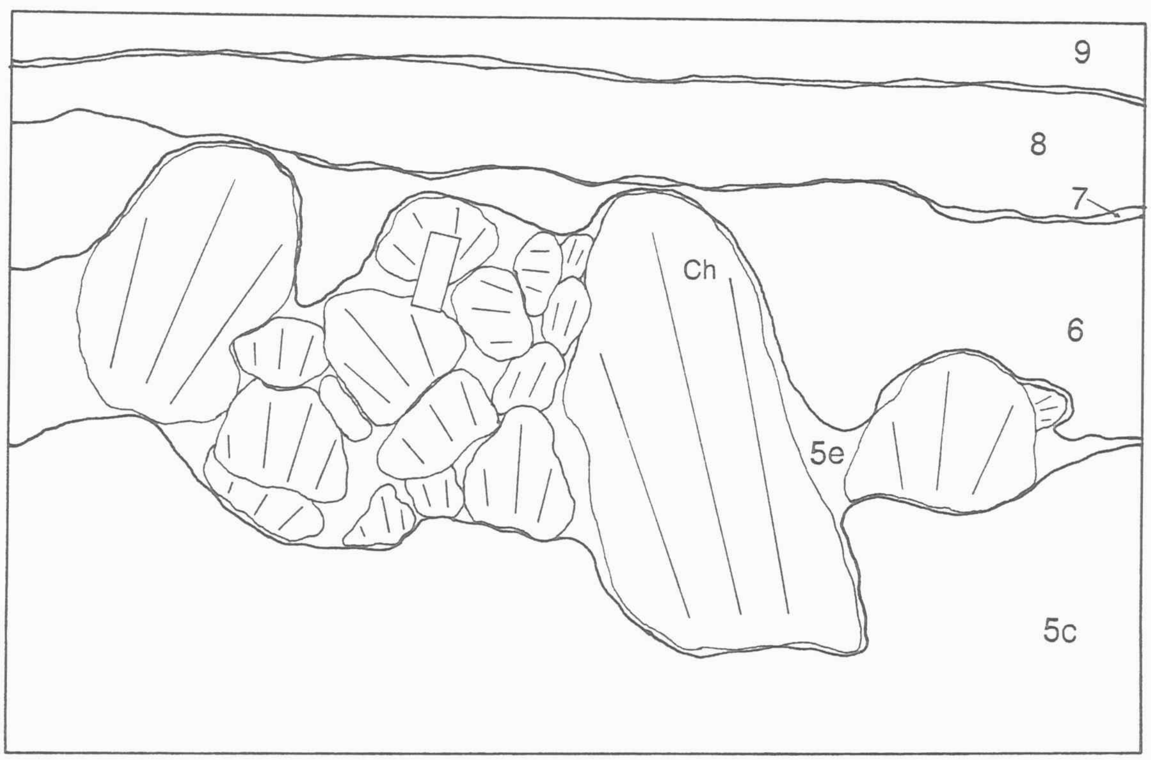


Figure 30. Expanding-upward, extended-domical chaetetid in bed 5, locality 782. Note how this growth form is made up of stacked laminar to ragged domical forms.

Figure 31. Chaetetid buildup in unit e, bed 5 at locality 782. Cross-hatched objects are chaetetids. Note columnar chaetetid (Ch) near center of photograph. Small black squares on left of scale are 1 cm long.


9
8
7
Ch
6
5e
5c

beds 5 and 6 passes through these chaetetids).

Chaetetids in bed 8 at localities 729 and 692 were fragmented, eroded, and abraded. Fragments were up to 20 cm long, and appear to be the result of weathering of chaetetids from bed 6 during subaerial exposures.

Chaetetids in bed 9 at localities 729, 782 and bed 8 at localities 693 and 782 occur as small laminar to low to high domical (ragged, smooth) forms. Laminar forms are up to 20 cm long and up to 5 cm high. Domical forms range up to 30 cm across and 30 cm in height. Substrates for all chaetetids in these beds are "algal"-coated productids and Composita (frequently articulated), and other skeletal debris. Occasionally several oncolites served as a substrate for chaetetid growth (Fig. 32). Figure 33 shows a tracing of a high domical (ragged) chaetetid from bed 8 which began on an oncolite and which shows evidence of overturning during growth. Occasionally chaetetids occur that were initially two (or more) individual organisms that subsequently were joined together, perhaps by recolonization (see section 782-S4).

A large exposed area 30 x 50 meters was mapped of the upper surface of beds 9 and 10 at locality 729 (plate 2). Where the surface of bed 9 was exposed (area inside dashed line) chaetetids were mapped directly (black objects on map). Where bed 10 occurred, irregular positive surface features that suggested the presence of chaetetids in the

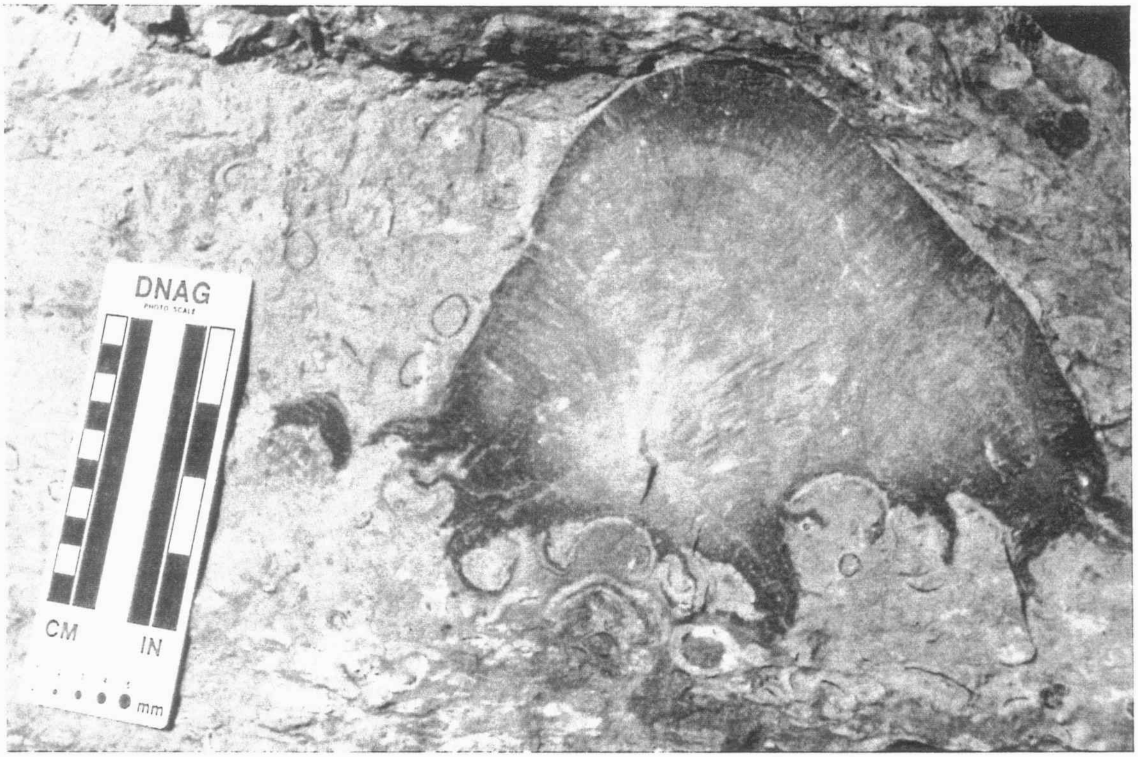


Figure 32. High-domical (smooth) chaetetid growing on several "algal"-coated productids and Composita in bed 9, locality 729.

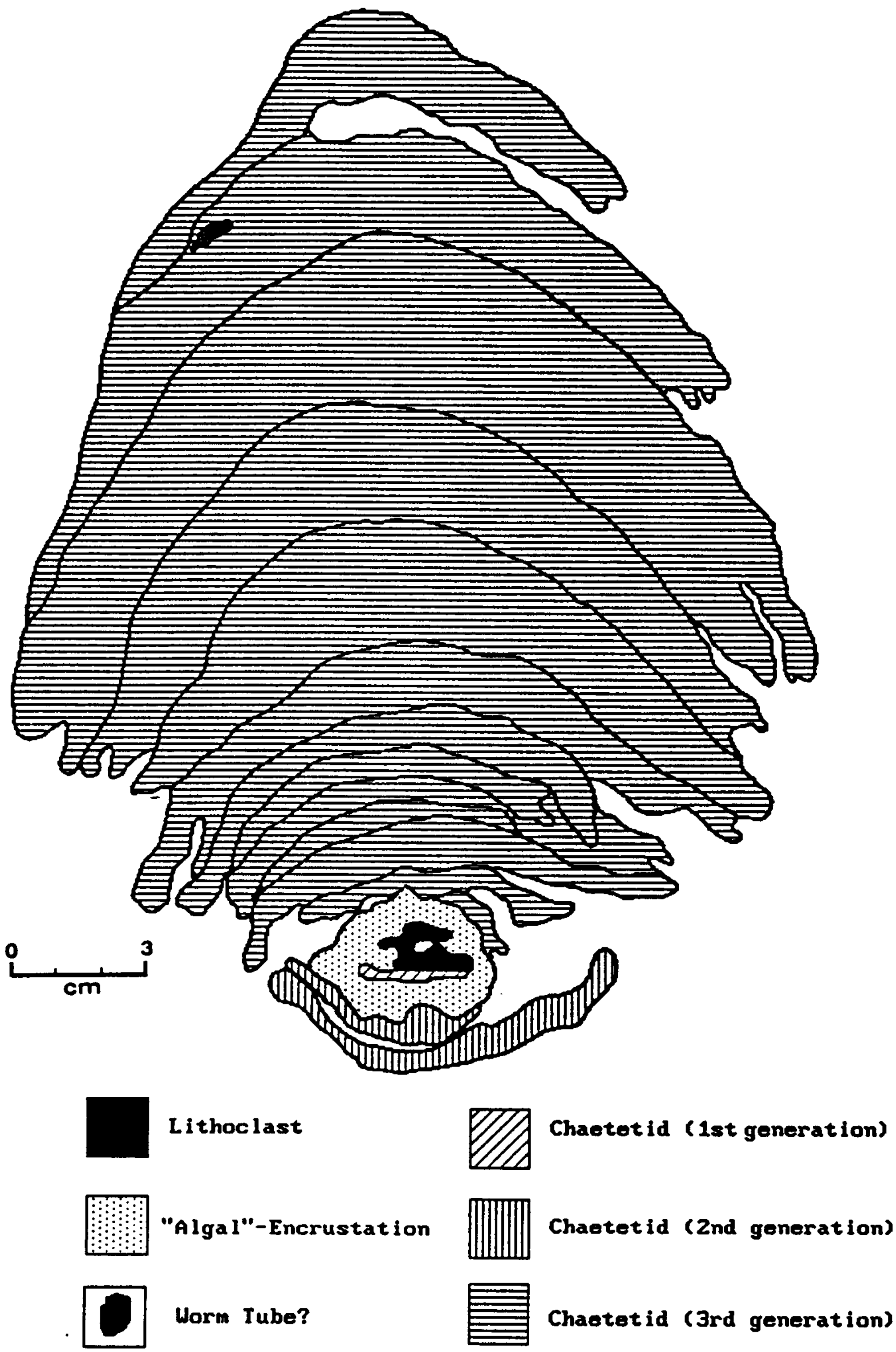


Figure 33. Tracing of cut and polished high domical (ragged) chaetetid from bed 8 at locality 693. Note how this form is composed of numerous individual laminar forms.

underlying bed (fig. 34) were also mapped (unfilled closed objects on map). Some areas within the mapped area (cross-hatched area) were covered by remnants of black phosphatic shale (bed 11).

Only a few chaetetids occur in bed 9 at localities 693 and 782, and all are continuations of high domical chaetetids from bed 8. The contact between beds 8 and 9 passes directly through the chaetetids, suggesting that the transition from bed 8 to bed 9 was gradual, and that they were growing during bed 9 deposition and not simple smothered out by a rapid influx of sediment at the contact.

In beds 13 and 14 at localities 693 and 782 chaetetids are uncommon, and are small (up to 15 cm long and 5 cm high) laminar forms. These initially attached to phylloid algal fragments or less frequently "algal"-coated skeletal grains.

One small chaetetid was found in bed 15 at locality 693; it consisted of a laminar encrustation around the entire outer surface an oncolite approximately 2.5 cm in diameter. This chaetetid encrusted oncolite was in turn algal-coated.

<u>Toppling, Overturning, and Growth Interruptions</u>--Chaetetids throughout the study area frequently show evidence of displacement at some point in their growth.

In bed 2 at localities 729 and 692, chaetetids

Figure 34. Chaetetids which occur under positive feature on the surface of bed 10, locality 782 (exposed during removal of overlying beds). Hammer is 28 cm. long.

frequently appear moved (see fig. 27) or overturned. Growth interruptions commonly occur on low domical forms where the surrounding sediment was washed over the chaetetid, smothering out much, and many times all, of the chaetetid (see fig. 27).

Chaetetids in beds 3 and 4, localities 729, 692, and 693, and bed 4, locality 782, generally do not show evidence of overturning or toppling. A few small (<5 cm long) laminar forms at Locality 729 in Bed 4 (see sections 729-S1, 729-S2) were noted that appeared overturned. Several laminar chaetetids were fragmented, but this may be due to compaction because they did not appear displaced or overturned, and all fragments appeared to be present.

Chaetetids in bed 5 at localities 729 and 692 rarely appear toppled or overturned, although some appear fragmented (in-place), apparently due to compaction. Growth interruptions are common on low domical forms, defined by a thin clay layer or dark lines which may be breaks in tubule growth.

At localities 729 and 692, toppled or overturned chaetetids occur throughout bed 6, but are the most prevalent in the upper half. These are mostly high domical (smooth) forms to columnar (smooth) forms with an expanding upward growth form. Toppled chaetetids often served as a firm substrate upon which other chaetetids grew (fig. 35). Most bulbous forms in bed 6, unit c, are toppled, lying on

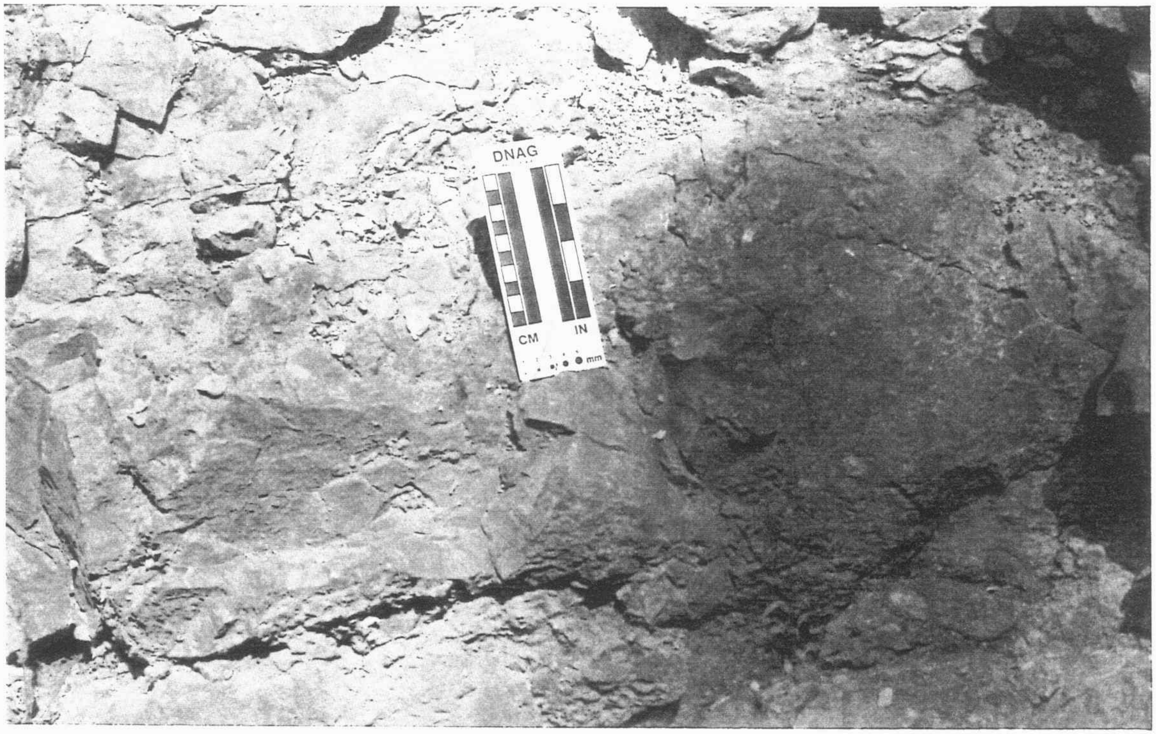
Figure 35. Toppled chaetetid in bed 6 at locality 692 (lower third of photograph). Note other chaetetids which utilized the toppled chaetetid as a firm substrate upon which to grow (chaetetids outlined using permanent marker). Up is towards top of page. Scale is 30.5 cm long.

their side. Some overturned or toppled chaetetids appear to have survived overturning and apparently continued growing in an upward direction after the disturbance. Growth interruptions are common throughout the bed, similar to those seen in bed 5.

At locality 693, laminar chaetetids in unit a, Bed 5, appear in-situ, as do most domical (low, high, and extended) and columnar forms. One small low domical chaetetid appeared toppled over within unit a. Columnar chaetetids in unit a, as well as in units b and c, often occur at angles of less than 90 degrees but appear to be in-situ. This may be the result of competition of space with other chaetetids during growth and/or compaction. Some columnar chaetetids in unit b, appear toppled and or overturned. In much of unit b chaetetids are so tightly packed together it is difficult to distinguish individual orientations. A few columnar chaetetids were noted on their sides at the contact of units b and c (figure 36). Laminar and domical chaetetids in the upper part of unit c frequently appear toppled and/or overturned. Growth interruptions marked by clay-rich laminae and interruptions in tubule growth are common throughout all units.

At locality 782, some chaetetids in units c and e, bed 5, appear toppled or overturned. Low domical chaetetids are often overturned in the upper half of unit c, and on some of these upward growth continued after disruption. Toppled

Figure 36. Toppled columnar chaetetid (Ch) at the contact of units b and c, bed 5, locality 693. The relatively smooth sides of the chaetetid suggest substantial relief above the sea floor during growth.


DNAG
CM
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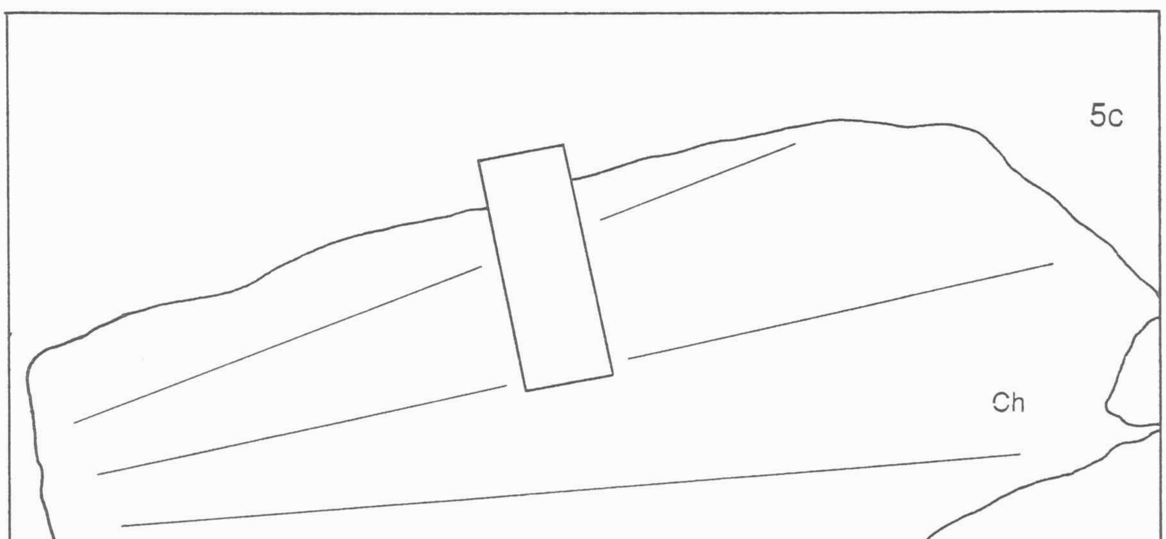
mm


5c
Ch
5b

and overturned chaetetids frequently occur in unit e; in some areas nearly all chaetetids appear disrupted. Over the entire outcrop, perhaps 15-20% of all chaetetids within unit e appear to have been toppled and rolled around. The density of chaetetids in some areas of the unit makes it difficult to determine whether chaetetids were actually displaced or growing at some odd angle in response to crowding. Some overturned or toppled chaetetids appear to be the broken off tops of in-place columnar forms. Growth interruption on chaetetids are very noticeable throughout bed 5, and consist of clay-rich laminae, "algal"-coatings, or breaks in tubule growth suggested by dark lines.

In bed 6 at locality 728, most chaetetids are fragmented, abraded, toppled, and/or overturned.

Nearly all domical chaetetids in bed 9 (localities 729, 692) and bed 8 (localities 693, 782) show evidence of toppling and/or overturning, but laminar forms are seldom overturned. Often domical forms appear to have been overturned several times, coating all sides of the encrusted oncolite. At some point a critical size was apparently reached, at which point the chaetetid stabilized and upward growth prevailed. Growth interruptions are prevalent throughout, generally marked by thin clay-rich layers or "algal"-coatings, but also simply by dark lines on the chaetetid. In a few cases the chaetetids became entirely "algal"-coated and became oncolites themselves. Figure 37 is a tracing of a cut and polished chaetetid from this bed 9 at locality 729 which shows many of the relationships discussed above. The upper surfaces of chaetetids are often bored, but borings also occur internally.

At localities 693 and 782, most chaetetids in beds 13 and 14 appear in-situ, although some fragmented and/or overturned laminar forms were observed.

The one small chaetetid noted in bed 15 at locality 693 was obviously overturned several times for growth to have occurred on all surfaces of the oncolite.

Associated Organisms--A wide variety of organisms are associated with chaetetids throughout beds in the area, but they do not all occur together or in the same way. Table 1 list the organisms that occur with chaetetids at the localities studied. Associated organisms at localities 729 and 693 are combined on the chart due to the similarities of beds at these two localities.

In bed 2 at localities 729 and 692 and bed 4 at locality 782, the most conspicuous organisms present were fusulinids (Fusulina sp.) and encrusting "algae". Most organisms are fragmented, abraded, and/or "algal-coated, and do not appear in situ (except for chaetetids). Ostracodes and smaller foraminiferids in these beds are not "algal"-coated. Phylloid algae are also predominate in the upper third of bed 4 at locality 782.

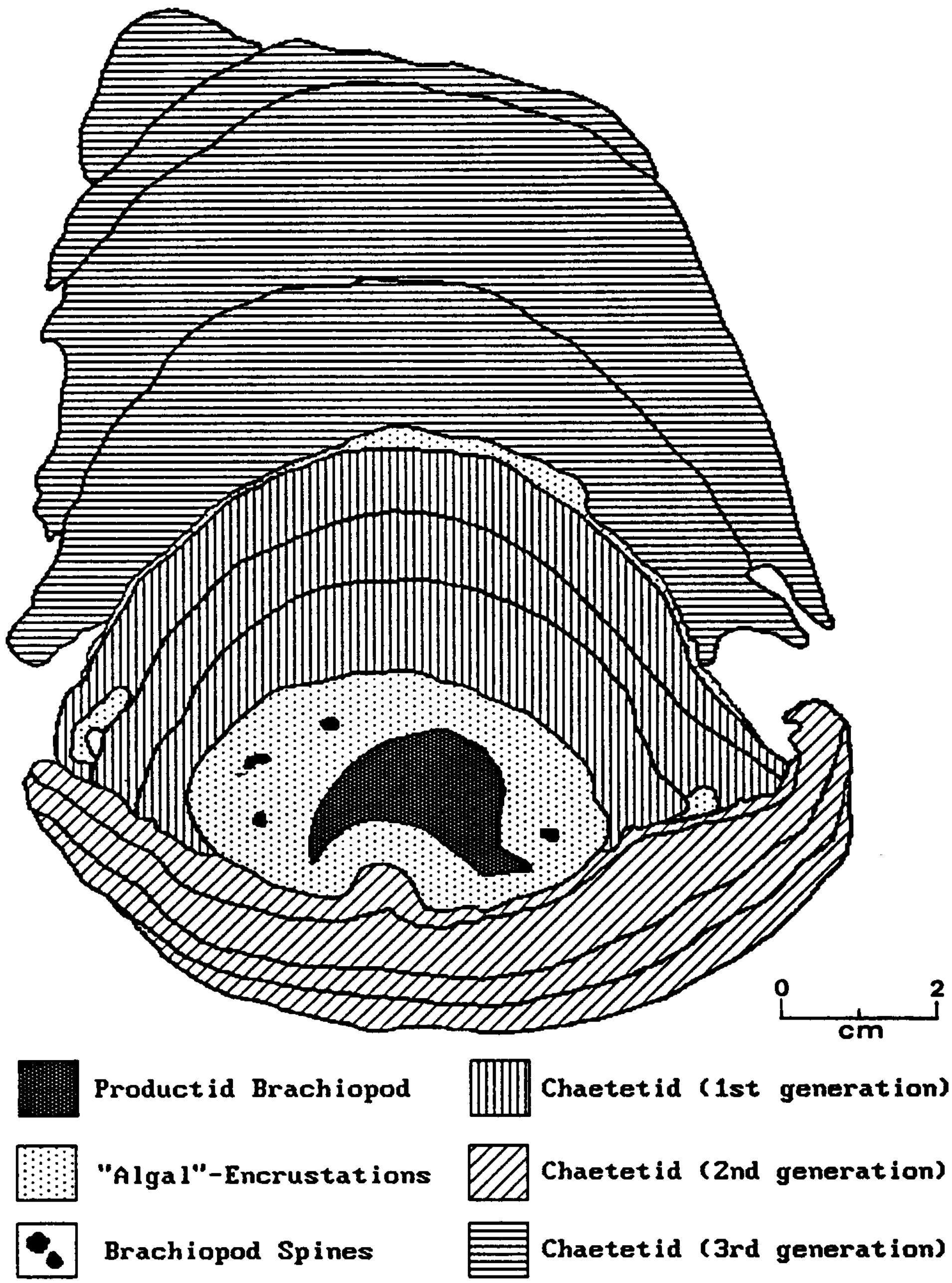


Figure 37. Tracing of cut and polished chaetetid from bed 9, locality 729. Note "algal"-coated productid at center, multiple generations of chaetetid growth, and "algal"-coated growth interruption.

Table 1. Organisms which occur with chaetetids in beds at all localities (X = conspicuous; o = noted).

	LOCALITIES 729, 692						LOCALITY 693						LOCALITY 782					
	2	3	4	5	6	9	3	4	5	8	13	14	4	5	6	8	13	14
BRACHIOPODS	o	o	o	X	X	X	o	o	X	X	o	o	o	X	o	X	X	X
Composita		o	o	X	X	X	o	o	X	X	o	o	o	X	o	X	X	X
Crurithyris	o	o	o	o	o				X		o	o		o			o	o
productids		o	o	o	o	X		o	o	X	o	o		o		X	o	o
Neospirifer			o							o							o	
Hustedia						o										o		
Neochonetes															o			
Mesolobus												o						
Lingula										o								
PHYLLOID ALGAE	o	X	X	X	X		X	X			X	X	X	X			X	X
GASTROPODS	o	o	o	o	X		o	o	o	o	o	o	o	o	X	o		
low-spired	o				X						o	o		o	o	o		
high-spired	o	o	o	o	X			o						o	X	o		
Omphalotrocus			o						o			o				o		
Straparollus														o				
BELLEROPHONTIDS			o	o	X									o	o	o		
BIVAVLES			o						o									
Edmondia									o									
Aviculopecten			o															
ECHINOIDS				o	o				o	o	o	o		o		o		
CRINOIDS		o	o	o	X	o	o	o	X	o	o	o	o	o	o	o	o	o
BRYOZOANS		o	o	o	o	o		o	o		o	o	o	o		o		o
CEPHALOPODS					o									o				
SPONGES		o	o	o												o		
Girtyocoelia		o	o	o														
CORALS		o	o	o				o	o			o		o		o		
Lophophyllidium		o	o	o				o	o					o		o		
Multithecopora												o						
"ALGAL"-ENCRUSTATIONS	X	o	o	o	o	X	o	o	o	X	o	o	X	o	o	X	o	o
FORAMINIFERIDS	X	o	o	o	o	o	o	o	X	o	o	o	X	X	o	o	o	o
fusulinids	X			o		o	o	o	X			o	X	X				
Tetrataxis					o	o	o	o	X	o		o	o				o	o
Globivalvulina	o				o	o		o	X	o		o	o	o	o			
Endothyra	o				o	o		o	X	o		o			o	o	o	o
OSTRACODES	o	o	o	o	X	o	o		X	o	o	o	o	X	X	o	o	o
TRILOBITES			o		o													
CALCISPHERES					o	o		o	o		o	o		o		o	o	o
BARNACLE BORINGS						X			o	X				o		X		
WORM TUBES					o	o			o	o				o		o		

In bed 3-5 at localities 729 and 692, and bed 3-4 at locality 693, phylloid algal fragments are conspicuous, frequently up to several cm long (see thin section C-4). Some phylloid algal fragments are incorporated into chaetetid skeletons (see thin section C-4). Brachiopods frequently are articulated with spar-filling, but usually are not in-situ. In bed 3 at locality 729, Lophophyllidium occasionally occurs in-situ, and some specimens were attached to, and overgrown by, chaetetids (see section 692-S3). Crinoids and bryozoans are fragmented and do not occur in- situ.

A diverse assemblage of organisms is associated with chaetetids in bed 6 at localities 729 and 692. In places phylloid algal fragments dominate, but these areas are discontinuous and pinch out laterally along the quarry walls. Chaetetids are generally not as common or robust where phylloid algae is present in large quantities. Most larger skeletal fragments occur near in-situ chaetetids; away from chaetetids the matrix is mostly medium to fine sand sized skeletal debris. Crinoids, although disarticulated, generally occur clumped together around in-situ chaetetids.

Associated organisms in bed 5 at locality 693 are numerous and diverse. In the lower part of the bed fusulinids, crinoids, Composita, and Crurithyris are dominant. Fusulinids range from intact to fragmented.

Crinoids are disarticulated but clumped around chaetetids. Composita and Crurithyris are frequently articulated, and several appeared to be attached to the upper surface of the chaetetids. In unit c, the dominant fossils are small foraminiferids (Globivalvulina, Endothyra, and Tetrataxis) and ostracodes. In unit c, as is true throughout the bed, articulated and robust fossils occur near and around chaetetids, whereas away from the chaetetids the skeletal debris is mostly small foraminiferids and other fragmented medium to fine sand-sized skeletal debris.

In bed 5 at locality 782, organisms closely associated with chaetetids vary upward through the different units. Predominant in unit a are phylloid algal fragments, in places making up to 90% of the lower half of this unit (see figure 22). Chaetetids generally occur in the upper half of unit a where phylloid algae are less prominent, but phylloid algal fragments usually are the substrate for chaetetids. An occasional articulated Composita and masses of crinoid debris occur near some domical chaetetids. In unit b the associated organisms are primarily crinoids, phylloid algae, and fusulinids. Most larger, recognizable fossils occur in close proximity to chaetetids, whereas in areas with no chaetetids the skeletal debris is mostly unidentifiable medium to fine sand-sized fragments (often "algal"-coated), calcispheres, ostracodes, and lens-shaped masses of phylloid algal fragments. Crinoids, although disarticulated, are mostly clumped together in areas near in-situ chaetetids. Articulated Composita and Crurithyris occur around, and occasionally attached to, chaetetids. Bryozoans fragments also occur in close proximity to chaetetids. Organisms in unit c show the same relationships to chaetetids as noted in unit b. Some areas of concentrated phylloid algal fragments (up to 80 percent of the skeletal grains) which occur are not closely associated with chaetetids. In unit d, recognizable fossils occur infrequently (crinoid debris and fusulinids); most fossil debris is fragmented and "algal"-coated. In unit e, articulated and whole disarticulated valves of Composita are conspicuous, as are articulated ostracodes.

In bed 6 at locality 782, prominent organisms are high spired gastropods (Donaldina?) and ostracodes, but these are not closely associated with chaetetids.

In bed 9 at localities 729 and 692, and bed 8 at localities 693 and 782, brachiopods and encrusting "algae" are the most conspicuous organisms present. Approximately 70-80% of the fossil debris is "algal"-coated; these oncolites served as the substrate for most chaetetids, although some chaetetids attached to brachiopods which did not exhibit "algal"-coatings. Brachiopods, as previously discussed (pg. 103), appear to have been living in this environment along with the chaetetids. Chaetetids frequently encrust brachiopods, and Composita (and some other brachiopods) are often attached to the surface of chaetetids. Figure 38 shows an apparently in-situ Composita (no "algal"-coating) occupying a niche under an overhanging growth of a chaetetid. Small pit (up to 1 cm across) were observed on the outer surfaces of some chaetetids, and small holes (up to 0.5 cm across) were seen on cut and polished internal surfaces of chaetetids. Calicles did not appear deformed around surface pits, but were deformed around some internal holes.

In beds 13 and 14 at localities 693 and 782, the most conspicuous organisms are phylloid algae. "Algal"-coated fossil debris is also prominent and, along with phylloid algal fragments, served as nucleating sites for the occasional laminar chaetetids observed.

Relief--The height of the chaetetids above the sea floor can be roughly estimated for some specimens observed in the study area. In Bed 2 at locality 693, sediment draping over the chaetetid in figure 27 indicates a possible relief of approximately 6 cm above the sea floor. This was probably unusual for most chaetetids in this bed, because most growth forms are laminar and could only have had a few centimeters of relief. Laminar chaetetids observed in other beds throughout the area (i.e. beds 3-5, localities 729, 782; beds 3-4, 13-14, localities 693, 782) most likely had similar relief of only a few centimeters. Domical

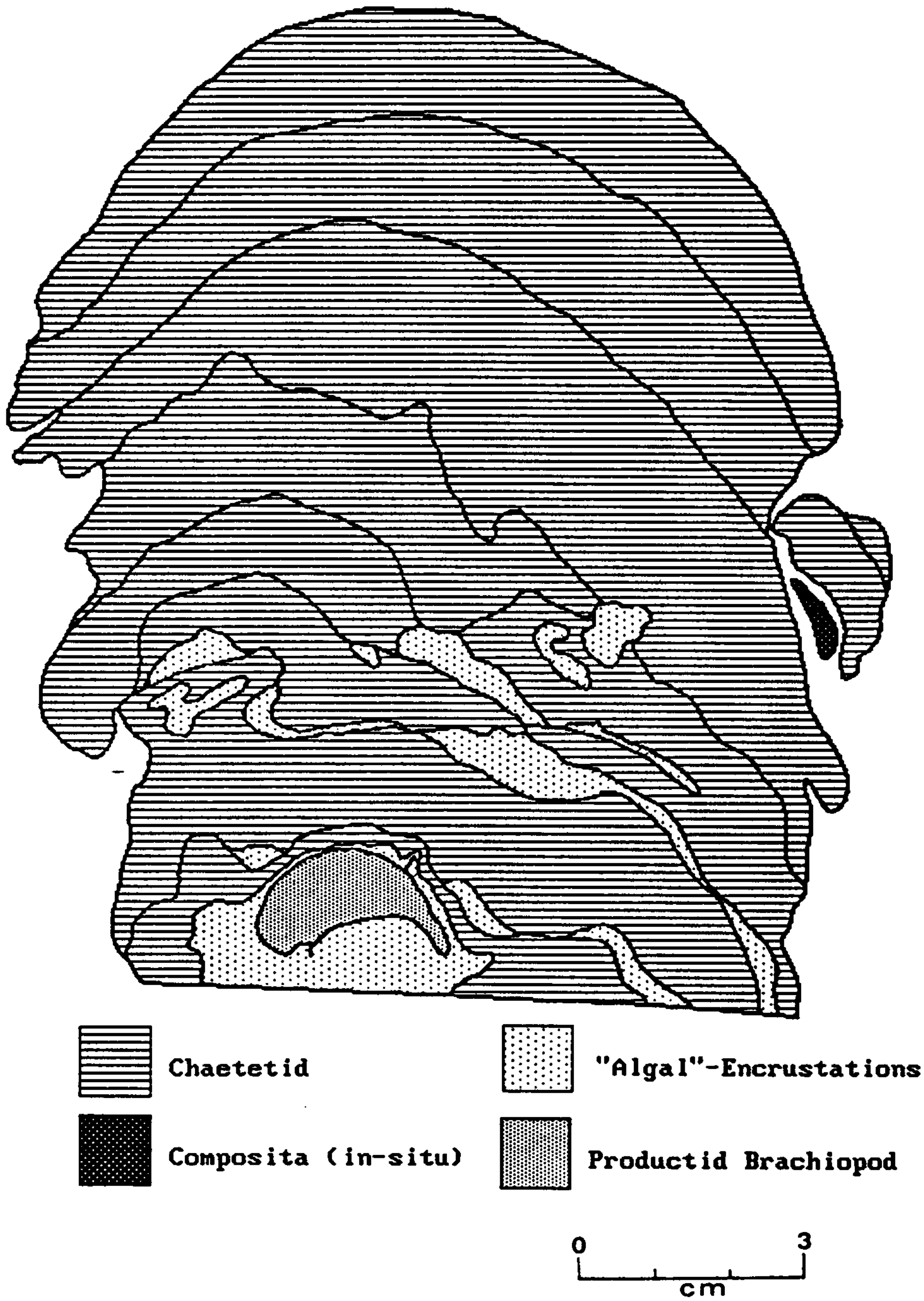


Figure 38. Tracing of cut and polished chaetetid from bed 9, locality 692 showing Composita occupying niche under a ragged extension. Note "algal"-encrusted productid and "algal"-encrustations on chaetetid growth partings.

chaetetids in bed 5 at localities 729 and 692 appear to have had a maximum of 15 cm of relief above the sea floor based on sediment draping over the upper surface.

Relief apparently varied significantly in bed 6 at localities 729 and 692. Laminar to low domical forms show little evidence of relief greater than 10 cm or so. Some columnar forms, such as the toppled one in figure 35, appear to have been nearly entirely exposed above the sea floor prior to displacement, suggesting relief of approximately 40 cm. Evidence includes the smooth sides, which would indicate little interference from sediment during growth. In addition, the fact that it fell over suggest that it was not buried very deeply by sediment as it grew. No evidence of scouring was observed that suggest this chaetetid was uncovered and then toppled. Upward- expanding, columnar forms probably did not have relief of over 10 cm or so, as their form would not be stable unless well secured by sediment. These also typically have ragged margins (and growth interruptions) suggesting interruption by sedimentation during growth.

In bed 5 at locality 693, evidence points to significant relief above the sea floor for many of the chaetetids observed. In unit a, sediment draping over chaetetids indicate relief of 10-15 cm. In unit b sediment draping over the upper surface of chaetetids and toppled columnar forms suggest relief on the order of 50-75 cm. The toppled columnar chaetetid noted previously (see fig. 36) at the contact of unit b and c is 75 cm long; it would seem most likely that in order to fall over most of it would have had to be exposed above the sea floor. In most of unit c sediment draping over chaetetids suggests relief on the order of 30 cm or less.

In bed 5 at locality 782, relief seems to have varied considerable. Some chaetetids in unit a were noted with the surrounding matrix draping over the upper surface, suggesting a potential relief of 8-11 cm (fig. 39). In unit b some chaetetids appear to have had a relief of 20-30 cm based on relatively smooth sides and the amount of sediment draping. The relief in unit c appears to have been similar to that in unit a. Chaetetids in unit e appear to have had the greatest relief, with some columnar forms suggesting relief of up to 75 cm. (see fig. 31).

Chaetetids in bed 6 at locality 782 do not appear to have had relief of more than 5-10 cm (based on ragged growth forms), although some bulbous chaetetids may have exceeded this.

In bed 9 at localities 729 and 693, and bed 8 at localities 692 and 782, relief of chaetetids was probably a maximum of 5-10 cm (in a few high domical forms it may have been as much as 15 cm, see fig. 32, 33), based on the ragged margins of most chaetetids and the numerous interruption partings. Some of the low domical forms in bed 9

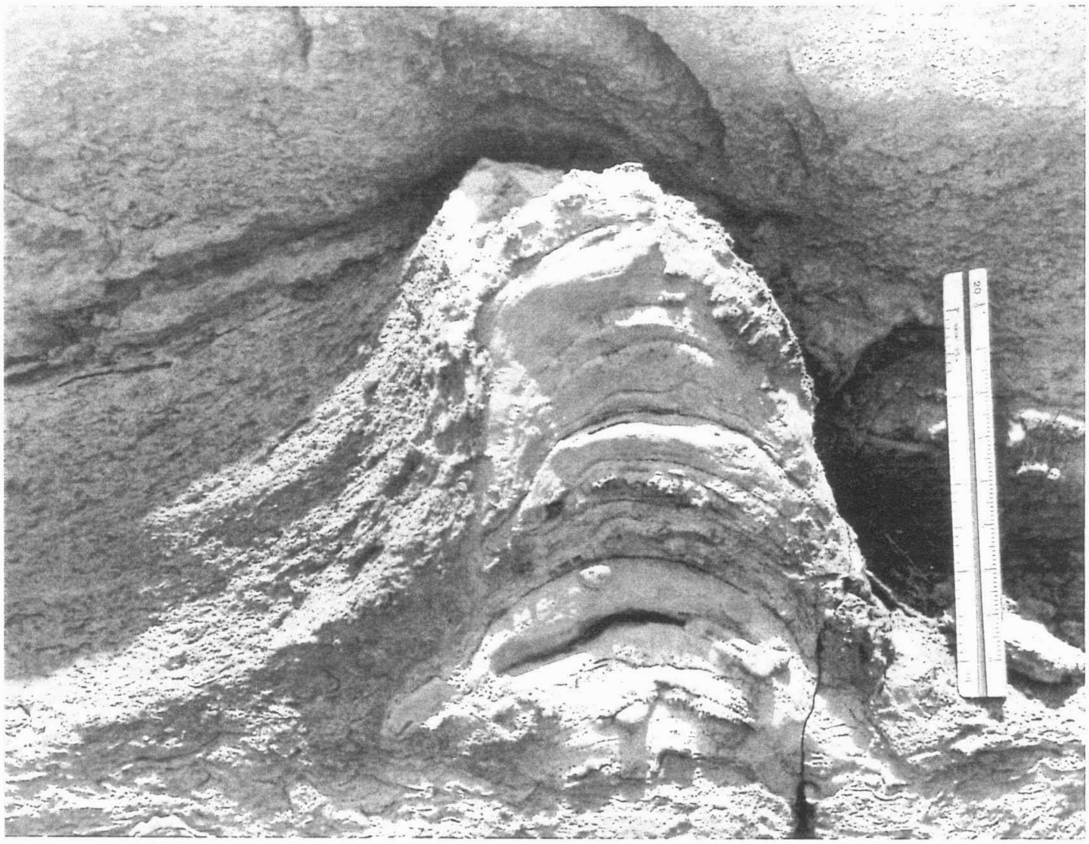


Figure 39. Sediment draping over high domical (smooth) chaetetid in unit a, bed 5, at locality 782. Draping of sediment suggest a relief above the sea floor during growth of 8-11 cm. Scale is 11 cm long.

(localities 729, 692) protrude up to 5-10 cm into bed 10, and probably represent the relief prior to being covered by bed 11 (see fig. 34).

At locality 782, bed 9 drapes over some chaetetids in the upper part of bed 8, suggesting up to 15 cm of relief.

In bed 9 at locality 693, (at section 693-S2) a chaetetid was noted over which bed 10 draped approximately 7 cm, suggesting this was probably very near the actual relief above the sea floor prior to inundation by the sediments now comprising bed 10.

Paleoecology

Introduction--Chaetetids were extremely rugged organisms, able to tolerate a wide variety of environments, and able to coexist with numerous types of organisms. Once established, chaetetids appear to have adapted well to gradually changing conditions, being only wiped out during major influxes of sediment.

Relationship to Other Chaetetids--Chaetetids at all localities displayed a noticeable close relationship to each other. Isolated individuals are rare; most chaetetids have at least one, and generally several, other chaetetids within 20-30 cm of themselves. This is especially true for columnar, and domical (extended, high, and low) forms. Rigby (1987) noted modern sponges occur in a similar fashion, tending to group together in isolated patches on the sea floor. The close association among chaetetids may be due to several factors. Reproduction was most likely by free swimming larvae, which would have settled on hard substrates and began growing. A large number of larvae would most likely have settled in areas close to living chaetetids because the substrate was obviously acceptable for growth. Larger chaetetids, such as columnar and high domical (smooth) forms, may have had enough relief above the sea floor to create microenviroments of reduced current where larger sedimentary particles (fossil debris, etc.) would have accumulated. These large sedimentary particles would have provided more stable surfaces for larvae attachment. Regeneration is common among many modern sponges; if chaetetids also had this ability, broken fragments of live chaetetids could have settled close to the "parent" with a new chaetetid forming from the fragment. Fragments of chaetetids are common in many of the beds studied, but conclusive evidence of regeneration was not observed.

Chaetetids are seen at all localities growing directly on toppled chaetetids. Frequently the sequence of toppling and renewed upward growth is evident in a single specimen. New upward growth may be the same genetic individual, or the result of settling of new genetic individuals. Overturned and toppled chaetetids could have served as large, stable substrates for larvae attachment. The merging of two individual chaetetids into a single complex is also of some interest. In samples of these that were slabbed, it appears that one of the individuals died (possible from an influx of sediment, or biological activity), and the skeleton served as a stable substrate for lateral expansion of the remaining live chaetetid. Why one chaetetid died off and the other was able to survive was not evident.

<u>Association With Other Organisms</u>--Chaetetids occur with a wide variety of stenohaline and (possible) euryhaline organisms. There appears to be a high probability of finding phylloid algae, <u>Composita</u>, fusulinids, and "algal"-encrustations with chaetetids.

Phylloid algae is one of the most pervasive fossils in the rocks studied. Throughout the study area, phylloid algae abundance was generally inversely proportional to the number of chaetetids observed. This inverse relationship was seen in beds 3, 4, and 5 at localities 692 and 729, and beds 4, 13, and 14 at locality 693, where small laminar chaetetids are inconspicuous. In other intervals such as bed 6 at localities 692 and 729, lenses of phylloid algal fragments appear to smother out chaetetid growth. Assuming these fragments represent little transport from nearby phylloid algal growth, it appears phylloid algae may have been able to better utilize existing growing space than chaetetids. It is also a possibility that the ability of phylloid algae to trap fine sediment created a surrounding unstable substrate that was not suitable for chaetetid attachment and growth.

In areas of vigorous chaetetid growth, phylloid algal fragments are rare, and fusulinids, crinoid debris, and brachiopods are more conspicuous. Phylloid algal fragments are absent from those units with extensive chaetetid buildups (unit b, bed 5 at locality 729; unit e, bed 5 at locality 782). Toppled and overturned columnar chaetetids in these units suggest high energy conditions and may indicate turbidity levels unsuitable for phylloid algal growth. Suchy (1987) believed that chaetetids were more tolerant of high turbidity than phylloid algae, and in such conditions could better utilize the existing growing space. The chaetetid buildups would have served as sheltered areas where a wide variety of organisms such as brachiopods, crinoids, echinoids, gastropods, and foraminiferids, could thrive.

Chaetetids, in apparent life positions, in bed 6 of locality 782 suggest a tolerance for euryhaline conditions. The contact of bed 6 and the underlying bed passes through the chaetetids (not over the top), indicating that they were alive during (at least) the early stages of bed 6 deposition. Abundant high-spired gastropods, and sedimentological features, such as root-like structures, implies deposition in a restricted bay or lagoon. Salinities in similar modern-day environments often fluctuate from brackish to hypersaline. If similar conditions existed during the deposition of bed 6, then chaetetids could apparently withstand some major salinity changes.

Chaetetids occurring with "algal"-coated oncolites is also indicative of their ability to survive in less than ideal conditions. The inferred depositional environment for bed 8 (all localities) is discussed on pages 104-107. "Algal"-encrustation and clay-rich partings frequently interrupted the growth of chaetetids (evident in the numerous growth interruptions observed), but in most cases chaetetids were able to overcome this disturbance and continue upward growth.

Mathewson (1978) believed that among chaetetids, internal holes with deformed tubules surrounding them were serpulid worm tubes, whereas surface pits were the borings of acrothoracian barnacles. Neither appeared to have much of a detrimental effect on the chaetetids; tubule growth continues over internal worm tubes, and the lack of tubule deformation on surface borings suggest that the chaetetids were probably dead prior to barnacle boring.

<u>Areal Distribution</u>--The surface grid map showing the areal distribution of chaetetids on the surface of bed 9 at

locality 729 (plate 2) indicates that chaetetids tended to grow in close proximity to each other, and were separated by areas devoid of chaetetid growth. Nearest neighbor analysis, based on the method of Clark and Evens (1954), was conducted on the area of the map bounded by J-17 to R-17 and J-30 to R-30. This method is used to determine if individuals are clumped, randomly spaced, or evenly spaced. The null hypothesis is that all chaetetids are randomly distributed. The value of t obtained from the measurement of the nearest neighbor to 105 other chaetetids was such that the null hypothesis could be rejected at the 0.05 level. An R value of 0.9 was calculated from the measurements; R values less than 1 imply that individuals are clumped into discreet areas.

The linear trend of 127 positive surface features on bed 10 was measured and plotted on a rose diagram (see upper right section of plate 2). A distinctive east-west trend is evident from this diagram. If these positive features on bed 10 are the result of underlying chaetetids in bed 9 (as suggested by field observations-see fig. 34), then some preferential horizontal alignment during growth apparently occurred. It is possible that chaetetids may have roughly aligned themselves parallel (or perpendicular) to the prevalent current direction at the time of growth.

<u>Growth Forms</u>--Growth forms in chaetetids, when examined

along with associated lithologies and organisms and relative to the inferred environmental setting, agree with previous interpretations of the relationship of growth forms to depositional environments (see pages 120-124). Laminar growth forms are found in beds which suggest either high energy (such as unit c, bed 5, at localities 693 and 782), or potentially high rates of sedimentation (such as bed 4 at localities 729 and 692). Columnar forms occur in beds which suggest lower energy conditions (bed 5 at locality 729) or crowding (such as unit b, bed 5, at locality 693 and unit e, bed 5, at locality 792). Hemispherical and domical (low, high, and extended) forms occur in areas suggesting intermediate energy conditions (such as the lower part of unit c, bed 5, at locality 693). As stated previously, hemispherical chaetetids often do not appear in-situ; they may have been transported into the area during very high energy events (storms) from another area.

Other Relationships--Chaetetid growth appears to have been favored by moderate to high energy conditions, probably well within wave base. Optimum chaetetid growth (columnar and extended domical forms) occurred in areas with moderate to low sedimentation rates and occasional moderate to high energy conditions. Such growth also appears to have been favored in areas of extremely high energy approaching the intertidal environment.

Beds which contain a high percentage of micrite and mostly fine grained skeletal debris are generally devoid of chaetetids. The abundance of fine sediment may have created conditions too turbid for chaetetid growth. In addition, high sedimentation rates, along with no firm substrate for attachment, may have prevented chaetetids from becoming established.

Chaetetids within the study area occur most frequently in the regressive parts of the small scale cycles discussed previously. West and Clark (1984) also noted that chaetetids seem to occur in the greatest abundance in regressive limestones. This is probably an indication of more stable environmental conditions (and longer time spans) which existed during the relatively slow regressive phases.

The lack of chaetetids above the Lake Neosho shale could be the result of several factors. It is possible that water depths in this area during the deposition of most of the Worland limestone may have been too deep for chaetetids. If this was the case, one would expect to see chaetetids in shallower areas, such as would have existed over topographic highs, and to the northeast in the direction of the paleoshoreline. In fact, chaetetids are present in the Worland limestone near the Bourbon Arch (personal observations) and are a common element of the Worland limestone in Missouri (Gentile, 1976). Water depths may have shallowed too quickly during the deposition of the upper part of the Worland limestone to allow chaetetids to migrate into the study area from the north. High turbidity, which could have restricted chaetetid growth, may also have existed during deposition of the Worland limestone.

ECONOMIC IMPORTANCE

Construction Aggregate

As evident by the active quarrying of rock at two of the localities studied (729 and 692), chaetetid-bearing rocks in this area are important source of industrial limestone. Crushed limestones from these quarries are used as both concrete and asphalt aggregates. Limestones from both of these localities have been tested for durability at the Kansas Department of Transportation, using their extended durability test. This is a six month long process that examines the engineering and geological properties of the limestone. Roughly half of the limestones submitted for this testing fail to pass. Limestones which do pass can be used in all phases of construction in Kansas that require a limestone aggregate. Limestones from the same quarry are submitted as different beds based on major lithological changes. The following is taken from KDOT's unpublished aggregate database, which gives the results of the extended durability test for all limestones submitted.

At locality 729, both the Worland limestone and Amoret limestone were divided into three beds each, labelled 1 - 6 from the top down (beds 1-3 = Worland limestone, beds 4-6 = Amoret limestone). Using KDOT's reported thicknesses for each bed, the corresponding beds from this study would be as follows:

KDOT		this study
6	=	1-4
5	=	5-7
4	=	8-10
3	=	12, 13
2	=	14-16
1	=	17, 18

All beds of the Worland limestone passed, as did the lower two beds of the Amoret limestone (KDOT beds 6 and 5).

At locality 692, the Worland limestone was divided into 2 beds, and the Amoret limestone divided into 3 beds, labelled 1-5 from the top down (beds 1, 2 = Worland limestone, beds 3-5 = Amoret limestone). Corresponding beds from this study are:

KDOT		this study
5	=	1-4
4	=	5-7
3	=	8-10
2	=	12,13
1	=	14-16

All beds of the Worland limestone passed, as did the lower two beds of the Amoret limestone (KDOT beds 5 and 4).

Failure of the upper KDOT bed of the Amoret limestone at both localities can be related to the silt and clay content of the this part of the Amoret Limestone at these localities, specifically beds 8, 9, and 10 from this study. Acid insoluble residue is a key component of the durability test, and this failed upper bed had very high insoluble residues at both localities (approx. 13%, compared to 7% or less for acceptable beds).

The high amount of dolomite that was present in bed 6 at localities 729 and 692 (approx. half) did not seem to be a factor, even though dolomitic rocks often have poor performance records as aggregates. Dubberki and Marks (1990) found that shifts in the d-spacing of dolomite could be related to the expected durability, and that rocks with lower d-spacings gave better performance. X-ray diffraction of bed 6 showed a dolomite d-spacing indicating that good durability could be expected from this rock (Dubberki and Marks, 1990).

One might expect that chaetetid buildups such as the one in unit b of bed 5 at locality 692 would also produce durable aggregates, but the large cavities between chaetetid heads are often filled with clay-rich sediment that would most likely give this interval a high insoluble residue content and other undesirable engineering properties.

Petroleum Potential

One of the more interesting discoveries in the study was the presence of oil stained chaetetids throughout the area. These were most noticeable in recently quarried surfaces of bed 6 at locality 692. Some of these chaetetids were saturated to the point that oil was dripping out of the fresh surface. Figure 40 shows how this staining usually occurred in chaetetids within the quarry. Oil stained chaetetids have a partially to completely un-calcified open tubule network (honey-comb like) in which the oil has collected. Some joint surfaces in the rock were also coated with oil. West (1991) stated that oil production from chaetetid bearing rocks has been reported from the subsurface of Texas, Oklahoma, eastern Colorado, and perhaps eastern Kansas. Caldwell (1983) reported on the production of oil from the Altamont limestone in the subsurface of western Kansas. Oil in chaetetids in this study area may have originated in-place, or possible migrated up-dip from the Altamont limestone in the subsurface of western Kansas.

Although the rocks exposed at localities 729 and 692 would probably not make good reservoir rocks, this same interval in the subsurface may have undergone more diagenetic alteration, creating more porous rocks. The chaetetid buildup at locality 693 could potentially be a major producing zone in the subsurface; large open inter-chaetetid cavities would make the buildup a good reservoir rock. The overlying Lake Neosho shale may have served as a source rock, and, along with the underlying Bandera Shale, would help to prevent oil migration out of the Amoret limestone interval. Karstification associated with

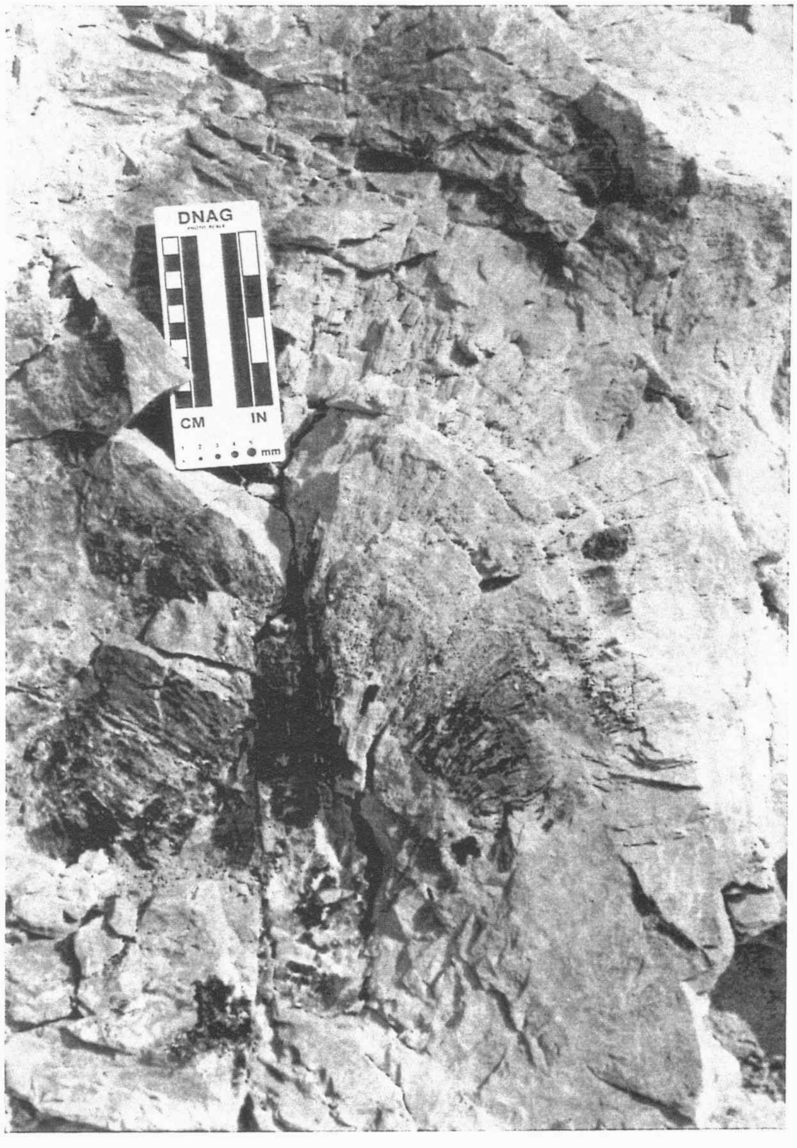


Figure 43. Oil-stained chaetetid in bed 5, locality 692. Dark areas in lower center of photograph are oil-staining. Note how the oil-staining outlines the tubules of the chaetetid in the right half of the photograph.

subaerial exposure could also serve to increase the porosity of these rocks. It seems likely that some, if not all, of these features may occur within the Amoret limestone in the subsurface.

CONCLUSIONS

The Altamont Limestone Formation, generally regarded as representing deposition during a single transgressive-regressive event, was deposited in a more complex environment than previously envisioned. The application of genetic/event stratigraphy suggests that the Altamont limestone in southeast Kansas contains at least seven genetic surfaces bounding small-scale cycles.

Cycles bounded by genetic surfaces G-1 to G-4 comprise most of the Amoret limestone, and record an overall transition from a deltaic environment to normal open marine conditions, followed by upward shallowing to non-marine conditions and subaerial exposure. The marine part of this sequence appears to have formed entirely under relatively shallow water conditions throughout the area of study.

Cycles bounded by genetic surfaces G-4 to G-7 record an overall transition from subaerial exposure to normal marine, and back to nonmarine conditions. The cycle bounded by genetic surfaces G-4 and G-5 is comprised of the uppermost Amoret limestone beds. The small scale cycle above surface G-5 begins with the deposition of a black phosphatic shale (Lake Neosho shale) in the western part of the study area and phylloid algal limestones in the east. The black shale appears to represent the influx of organic debris from coal swamps to the north into a shallow marine setting during a major transgressive event. The over-abundance of organic debris led to high primary production and anoxic conditions. Eventually these conditions spread over the entire study area. As the transgression continued and/or organic influx decreased, normal marine conditions were re-established.

Structural elements affecting the deposition of these rocks were the Ozark Uplift, Bourbon Arch, Nemaha Uplift, and Cherokee Basin.

Chaetetids occur frequently throughout the area within the Amoret Limestone Member. Numerous growth forms are present; these are most likely related to environmental and sedimentological conditions present at the time of growth. Laminar growth forms apparently were favored during high energy conditions, or on poorly consolidated sediments. Columnar forms apparently were favored in lower energy conditions or where crowding with other chaetetids occurred. Domical forms favored environments somewhere between laminar and columnar forms. Bulbous forms occur in intermediate environments and also in high energy conditions. Smooth-sided chaetetids appear to have had greater relief above the sea floor during growth than did forms with ragged margins.

Chaetetids occur most frequently in the regressive part of small scale cycles, implying more stable conditions during this interval. Once started, chaetetids often continued growing upward through units which suggest varying depositional environments. Although initial growth began under normal marine conditions, evidence suggest that some chaetetids were able to survive in environments of fluctuating seawater salinity.

Chaetetids were often able to regenerate upward growth after toppling or overturning, and toppled or overturned chaetetids served as a stable substrate for the attachment of new chaetetids.

Numerous organisms occur with chaetetids and utilized them as firm substrates or as sheltered areas. Although chaetetids and phylloid algae often occur together, chaetetids are the most numerous and robust in areas devoid, or nearly so, of phylloid algae.

Chaetetid buildups occur to the east in the form of: 1) an extensive reefal buildup formed in moderate energy conditions, and 2) as small clumps which formed in very high energy conditions. Chaetetids in these buildups may have had 1 meter or more of relief above the sea floor during growth.

Sediments of the Amoret limestone were exposed to a complex diagenetic history over time due to fluctuations of sea level. Ferroan calcite predominate over non-ferroan calcite, suggesting an overriding late-stage diagenetic imprint. Late stage deep burial caused the formation of ferroan dolomite.

Altamont limestone beds in the western localities are good sources of high quality construction aggregates; rocks deposited in similar environments elsewhere should also produce good quality aggregates. The Amoret limestone has the potential to be a competent petroleum-producing zone if reefal buildups, subaerial exposure surfaces, and dolomitization seen in surface outcrops in the study area also occur down-dip in the subsurface.

Additional work which could be done to test and refine the findings of this study include:

(1) Attempt to trace and correlate the genetic/event surfaces recognized in this study over a larger regional area to better understand the depositional environment of the Altamont Limestone. In particular, the subaerial exposure surface in the upper part of the Amoret Limestone Member has important implications for depositional models now being employed to interpret cyclic repetitions of rock types.

(2) Conduct a detailed lithological and geochemical study of the Lake Neosho Shale Member over a broad regional area in order to better understand it's environment of formation, and it's relationship to surrounding limestone members.

(3) Examine chaetetids within the Amoret limestone more closely, especially their relationship to the genetic/event surfaces and small scale cycles recognized in this study. This should include a detailed petrographic and insoluble residue analyses of the surrounding rocks.

(4) Closely examine growth forms and surrounding rocks in an attempt to determine whether growth forms are the result of different species or a response to changing environments.

(5) Further refine the relationships of chaetetids to each other and to other organisms using the profiles and surface map of chaetetids which were generated during this study.

REFERENCES

Adams, G. I., 1896. A geologic section from Galena to Wellington. Kansas University Geological Survey, v. 1, pp. 16-30.

Adams, G. I., 1903. Stratigraphy and paleontology of the Upper Carboniferous rocks of the Kansas Section. U. States Geological Survey Bulletin, no. 211, pp. 32

Ager, D. V., 1963, Principles of Paleoecology: McGraw Hill, New York, 371 p.

Anderson, E. J., and Goodwin, P. W., 1980, Application of the PAC hypothesis to limestones of the Helderberg Group: Society of Economic Paleontologist and Mineralogist, Eastern Section Guidebook, 32 p.

Anderson, E. J., and Goodwin, P. W., 1990, The significance of metre-scale allocycles in the quest for a fundamental stratigraphic unit: Journal of the Geological Society, London, v. 147, pp. 507-518.

Archer, A. W., West, R. R., and Maples, C. G., 1990, Relationship between climate change and cyclicity in the Upper Paleozoic (Carboniferous and Permian): Geological Society of America, Abstracts with Programs, v. 22, p. 1.

Baars, D. L., and Torres, A. M., 1991, Late Paleozoic phylloid algae - a pragmatic review: Palaios, v.6, no. 5, pp. 513-516.

Branson, C. C., 1962, Pennsylvanian system of the Mid-Continent, in Branson, C. C., ed., Pennsylvanian Systems in the United States: American Association of Petroleum Geologist, Tulsa, Oklahoma, pp. 431-460.

Brett, C. E., Goodman, W. M., and LoDuca, S. T., 1990, Sequences, cycles, and basin dynamics in the Silurian of the Appalachian Foreland Basin: Sedimentary Geology, v. 69, pp. 191-244.

Busch, R. M., and Rollins, H. B., 1984, Correlation of Carboniferous stratigraphy using a hierarchy of transgressive-regressive units: Geology, v. 12, pp. 471-474.

Busch, R. M., and West, R. R., 1987, Hierarchal genetic stratigraphy, a framework for paleoceanography: Paleoceanography, v. 2, pp. 141-164.

Busch, R. M., West, R. R., Barrett, F. J., and Barrett, T. R., 1985, Cyclothems verses a hierarchy of transgressive-regressive units, in Watney, W. L., Kaesler, R. L., and Newel, K. D., eds., Recent Interpretations of Late Paleozoic Cyclothems: Conference Symposium, Society of Economic Paleontologist and Mineralogist, Mid-Continent Section, pp. 141-153.

Caldwell, C. D., 1983, Kansas-type cyclothems and porosity development in Middle Pennsylvanian Marmaton group, Dirks Field, Logan County Kansas: American Association of Petroleum Geologist Bulletin, v. 67, no. 8, p. 1323.

Carew, J. L., 1990, Potential difficulties in the use of paleosols for stratigraphic interpretation of carbonate sequences: Geological Society of America, Abstract with Programs, Annual Meeting, p. A334.

Carlson, E. H., 1990, Subaerial features associated with the Silurian-Devonian unconformity, western Lake Erie: Geological Society of America, Abstracts with Programs, Annual Meeting, p. A334.

Cecil, C. B., 1989, A climate change model for the origin of Carboniferous coal-bearing strata in the eastern United States: Geological Society of America, Abstracts with Programs, Annual Meeting, p. A25.

Cecil, C. B., 1990, Paleoclimate controls on stratigraphic repetition of chemical and siliciclastic rocks: Geology, v. 18, pp. 533-536.

Clark, P. J. and Evens, F. C., 1954. Distance to nearest neighbor as a measure of spacial relationships in populations: Ecology, v. 35, pp. 445-453.

Cline, L. M., 1941, Traverse of upper DesMoines and lower Missourian series from Jackson County, Missouri, to Appanoose County, Iowa: American Association of Petroleum Geologist Bulletin, v. 25, pp 23-72.

Cline, L. M., and Greene, F. C., 1950, A stratigraphic study of the Marmaton and Lowermost Pleasanton Groups, Pennsylvanian , of Missouri: Missouri Geological Survey and Water Resources, Report of Investigation, no. 12, 74 p.

Connolly, W. M., 1985, Microfacies analysis, paleoecology, and environment of deposition of Morrowan shelf carbonates, Magdalena Limestone (lower division), Hueco

Mountains, El Paso County, West Texas: unpublished M.S. Thesis, Texas A & M University, 437 p.

Connolly, W. M., Lambert, L. L., and Stanton, R. J., 1989, Paleoecology of Lower and Middle Pennsylvanian (Middle Carboniferous) Chaetetes in North America: Facies, v. 20, pp. 139-168.

Cossey, P. J., and Mundy, D. J., 1990, Tetrataxis: a loosely attached limpet-like foraminifer from the Upper Paleozoic: Lethaia, v. 23, pp. 311-322.

Coveney, R. M., Watney, W. L., and Maples, C. G., 1991, Contrasting depositional models for Pennsylvanian black shales discerned from molybdenum abundances: Geology, v. 19, pp. 147-150.

DeVries, D. A., 1955, Paleoecology and paleontology of a Chaetetes biostrome in Madison County, Iowa: Ph. D. Dissertation, University of Wisconsin, 69 p.

Dubberki, W. D., and Marks, V. J., 1990, Evaluation of carbonate aggregate using X-ray analysis: Transportation Research Record, no. 1250, pp. 17-24.

Dullo, W.-Chr., and Hecht, C., 1990, Corrallith growth on submarine alluvial fans: Senckenbergiana marit., v. 21, pp. 77-86.

Estaban, M., and Klappe, C. F., 1983, Subaerial exposure environment, in Scolle, P. E., Bebout, D. G., and Moore, C. H., eds., Carbonate Depositional Environments: American Association of Petroleum Geologists, Memoir 33, pp. 1-54.

Fagerstrom, J. A., 1984, The ecology and paleoecology of the Sclerospongiae and Sphinctozoa (senso stricto): a review: Palaeontographica Americana, no. 54, pp. 370-381.

Fagerstrom, J. A., 1987, The Evolution of Reef Communities: Wiley Interscience, New York, 600 p.

Flugel, E., 1982, Microfacies Analysis of Limestones: Springer Verlag, New York, 633 p.

Gamble, J. C., 1967, Paleo-environmental of a portion of Upper Desmoinsesian (Pennsylvanian) strata of the Mid-Continent region: M.S. Thesis, University of Illinois, 98 p.

Gentile, R. J., 1976, The geology of Bates County, Missouri:

Missouri Geological Survey, Report of Investigations, no. 59, 89 p.

Goodwin, P. W., and Anderson, E. J., 1985, Punctuated aggredational cycles, a general hypothesis of episodic stratigraphic accumulation: The Journal of Geology, v.93, pp. 515-533.

Goodwin, P. W., Anderson, E. J., Goodman, W. M., and Saraka, L. J., 1986, Punctuated aggradational cycles: implications for stratigraphic analysis: Paleoceanography, v. 1, no. 4, pp. 417-429

Hartman, W. D., and Goreau, T. F., 1970, Jamaican coralline sponges: their morphology, ecology, and fossil relatives: Symposium Zoological Society London, no. 25, pp. 205-243.

Hartman, W. D., and Goreau, T. F., 1972, Ceratoporella (Porifera: Sclerospongiae) and the chaetetid "corals": Connecticut Acad. Art. Sci. Trans., vol. 44, pp. 133-148.

Heckel, P. H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothems of Mid-Continent North America: American Association of Petroleum Geologists Bulletin, v. 61, pp. 1045-1068.

Heckel, P. H., 1980, Paleogeography of eustatic model for deposition of Mid-Continent Upper Pennsylvanian cyclothems. in Fouch, T. D., and Magathan, E. R., eds., Paleozoic Paleogeography of West-Central United States: Paleogeography Symposium 1, Society of Economic Paleontologist and Mineralogist, Rocky Mountain Section, p. 197-215.

Heckel, P. H., 1984, Factors in Mid-Continent Pennsylvanian limestone deposition. in Hyne, N. J., ed., Limestones of the Mid-Continent. Tulsa Geological Society Special Publication No. 2, pp. 25-50

Heckel, P. H., 1985, Current views of Mid-Continent Pennsylvanian Cyclothems, in Watney, W. L., and others, eds., Recent Interpretations of Late Paleozoic Cyclothems: Society of Economic Paleontologist and Mineralogists, Proceeding of the Third Annual Meeting and Field Conference, Mid-Continent Section, pp. 1-22.

Heckel, P. H., 1988, Classic "Kansas" cyclothems: Geological Society of America, Centennial Field Guide, v. 4, South Central Section, pp. 43-55.

Heckel, P. H., and Baesemann, J. E., 1975, Environmental interpretation of conodont distribution in Upper Pennsylvanian (Missourian) Megacyclothems in Eastern Kansas: American Association of Petroleum Geologist Bulletin, v. 59, pp. 486-509.

Henbest, L. G., 1963, Biology, mineralogy, and diagenesis of some typical Late Paleozoic sedimentary foraminifera and algal-foraminiferal colonies: Cushman Foundation for Foraminiferal Research Special Publication no. 6, 44 p.

Hill, D., 1981, Rugosa and Tabulata,in Teichert, C., ed, Treatise on Invertebrate Paleontology, part F, Coelenterata, Supplement 1, 2 vol.: University of Kansas Press, Lawrence, Kansas, 762 p.

Jewett, J. M., 1941, Classification of the Marmaton Group, Pennsylvanian, in Kansas: Kansas Geological Survey Bulletin 38, pp. 285-344.

Jewett, J. M., 1945, Stratigraphy of the Marmaton Group, Pennsylvanian, in Kansas: State Geological Survey of Kansas Bulletin 58, 148 p.

Jewett, J. M., 1951, Geologic structures of Kansas: Kansas Geological Survey Bulletin 40, Report of Studies, pt. 6, pp. 105-172.

Johansson, F. C., 1959, Paleoecology of the Worland Limestone, Upper Desmoinesian, of Iowa, Missouri, and Kansas: M.S. Thesis, University of Wisconsin, 49 p.

Johnson, J. H., 1946, Lime-secreting algae from the Pennsylvanian and Permian of Kansas: Geological Survey of America Bulletin, no. 57, pp. 1087-1120.

Kershaw, S., 1979, Functional and environmental significance of skeletal morphology in stromatoporoids: Ph. D. Dissertation, University of Wales, 430 p.

Kershaw, S., 1981, Stromatoporoid growth form and taxonomy in a Silurian biostrome, Gotland: Journal of Paleontology, v. 55, pp. 1284-1295

Kershaw, S., and West, R. R., 1991, Chaetetid growth form and its controlling factors: Lethaia, v. 24, pp. 333-346.

Kidder, D. L., 1983, Petrology and origin of midcontinent Pennsylvanian phosphate nodules: Geological Society of America, Abstracts with Programs, Annual Metting, v.

15, no. 6, p. 612.

Kidder, D. L., 1985, Petrology and origin of phosphate nodules from midcontinent Pennsylvanian epicontinental seas: Journal of Sedimentary Petrology, v. 55, pp. 809-816.

Klein, G. deV., 1988, Origin of the coal-bearing Pennsylvanian cyclothems of North America: product of combined tectonic and eustatic processes: Geological Society of America, Abstracts with Programs, Annual Meeting, p. A219.

Klein, G. deV., 1990, Pennsylvanian time scales and cycle periods: Geology, v. 18, pp. 455-457.

Knight, C. D., 1988, Mechanical compaction of recent carbonate sediments in Florida Bay: Sigma Gamma Epsilon Compass, v. 65, no. 2, pp. 111-115.

Knight, K. L., 1985, Stratigraphy, depositional and diagenetic history of three Middle Pennsylvanian cyclothems (Breezy Hill and Fort Scott Limestones), Mid-Continent North America: Unpublished Ph. D. Dissertation, The University of Iowa, Iowa City, Iowa, 340 p.

Krumme, G. W., 1981, Stratigraphic significance of limestones of the Marmaton Group (Pennsylvanian, Desmoinesian) in eastern Oklahoma: Oklahoma Geological Survey Bulletin, no. 131, 68 p.

Lee, W., 1943, The stratigraphy and structural development of the Forest City Basin in Kansas: Kansas Geological Survey Bulletin, no. 51, 142 p.

Leonard, K., 1990, Conodont distribution and paleoecology within genetic units of the Iola Limestone (Missourian, Upper Pennsylvanian) of Northeastern Kansas: Kansas State University, unpublished M.S. Thesis, 235 p.

Longman, M. W., 1980, Carbonate diagenetic textures from nearsurface diagenetic environments: American Association of Petroleum Geologists Bulletin, v. 64, no. 4, pp. 461-487.

Lustig, L. D., 1971, Middle Pennsylvanian Chaetetes (Tabulata) from the Bird Spring Formation of southern Nevada: M.S. Thesis, University of California, Los Angeles, 148 p.

Maples, C. G., 1986, Enhanced paleoecological and paleoenvironmental interpretations result from analysis of early diagenetic concretions in Pennsylvanian shales: Palaios, v. 1, p. 512-516.

Mathewson, J. E., 1978, Chaetetids and their paleoenvironment in the Amoret Limestone Member (Desmoinesian) of Labette County, Kansas: Kansas State University, unpublished M.S. thesis, 148 p.

Merriam, D. F., 1963, The geologic history of Kansas: Kansas Geological Survey Bulletin no. 161, 317 p.

Moore, G. E., 1979, Pennsylvanian paleogeography of the southern Mid-Continent, in Hyne, N. J., ed., Pennsylvanian Sandstones of the Mid-Continent: Tulsa Geological Society, Special Publication no. 1, 360 p.

Moore, R. C., 1929, Environment of Pennsylvanian life in North America: American Association of Petroleum Geologist Bulletin, v. 13, no. 5, pp. 459-487.

Moore, R. C., 1936, Stratigraphic classification of the Pennsylvanian rocks in Kansas: Kansas Geological Survey Bulletin, v. 22, 256 p.

Nelson, W. J., 1973, Paleoenvironmental analysis of Chaetetes biostromes (Pennsylvanian) of the Arrow Canyon Quadrangle, Clark County, Nevada: Unpublished M.S. Thesis, University of Illinois at Urbana-Champaign, 93 p.

Pederson, T. F., and Calvert, S. E., 1990, Anoxia vs. productivity: what controls the formation of organic-carbon-rich sediments and sedimentary rocks?: American Association of Petroleum Geologists Bulletin, v. 74, no. 4, pp. 454-456

Pragger, E. J., and Ginsburg, R. N., 1989, Carbonate nodule growth on Florida's outer shelf and its implication for fossil interpretations: Palaios, v. 4, no. 4, pp. 310-317.

Price, R. C., 1981, Stratigraphy, petrology, and depositional environments of the Pawnee Limestone, Middle Pennsylvanian (Desmoinesian), Mid-Continent North America: University of Iowa, Ph. D. Dissertation, 115 p.

Price, R. C., 1984, Stratigraphy and depositional environment of the Pawnee Limestone, Middle Pennsylvanian (Desmoinesian), in Mid-continent North

America and equivalent Strata (Oologah Limestone) in northern Oklahoma, in Hyne, J. H., ed., Limestones of the Mid-Continent: Tulsa Geological Society Special Publication No. 2, pp. 377-392.

Randolph, E., 1974, Lithostratigraphy and subsurface study of the Chaetetes bearing lower Strawn formation (Pennsylvanian) Gaines County, Texas: M.S. Thesis, University of Oklahoma, 66 p.

Rascoe, B. R., and Adler, F. J., 1983, Permo-Carboniferous hydrocarbon accumulations, Mid-Continent, U.S.A.: American Association of Petroleum Geologists, v. 67, no. 6, pp. 979-1001.

Reitner, J., 1986, "Chaetetids", a problematic sponge group: North American Paleontological Convention 4, Abstracts with Programs, p. A38.

Rich, M., 1969, Petrographic analysis of Atokan carbonate rocks in central and southern Great Basin: American Association of Petroleum Geologist Bulletin, v. 53, no.2, pp. 340-366.

Rigby, J. K., 1987, Phylum Porifera, in Boardman, R. S., Cheetham, A. H., and Rowell, A. J., eds., Fossil Invertebrates: Blackwell Scientific Publications, California, pp. 116-139.

Roth, S. J., 1991, Regional stratigraphic analysis of the Blackjack Creek limestone (Desmoinesian, Middle Pennsylvanian) in southeast Kansas and northeast Oklahoma: unpublished M. S. Thesis, Kansas State University, 243 p.

Schenk, P. E., 1963, The environment of cyclic sedimentation and the paleoecology of the Altamont Formation (Desmoinesian) of Iowa, Missouri, Kansas, and northeastern Oklahoma: University of Wisconsin Ph. D. Dissertation, 115 p.

Schenk, P. E., 1967, Facies and phases of the Altamont Limestone and Megacyclothem (Pennsylvanian), Iowa to Oklahoma: Geological Society of America Bulletin 78, pp. 1369-1383.

Schmidt, H. A., 1959, The convergence of the Altamont and Pawnee Limestones in northeast Oklahoma: M.S. Thesis, University of Kansas, 115 p.

Scholle, P. A., 1978, A Color Illustrated Guide to Carbonate Rock Constituents, Textures, Cements, and Porosities:

American Association of Petroleum Geologist, Memoir 27, 241 p.

Scoffin, T. P., 1987, An Introduction to Carbonate Sediments and Rocks: Blackie USA, Chapman and Hall, New York, 274 p.

Seilacher, A., 1984, Storm beds: their significance in event stratigraphy, in Seibold, E., and Meulenkamp, J. D., eds., Stratigraphy Quo Vadis: American Association of Petroleum Geologists, Studies in Geology, no. 16, pp. 49-54.

Shaffer, N. R., Chou, C. L., Frost, J. K., and Coveney, R. M., 1988, Geochemical and petrologic features of phosphate nodules in Paleozoic midwestern black shales: Geological Society of America, Abstracts with Programs, Annual Meeting, Denver, p. A212.

Shinn, E. A., and Robbins, D. M., 1983, Mechanical and chemical compaction in fine-grained shallow-water limestones: Journal of Sedimentary Petrology, v. 53, no. 2, pp. 595-618.

Sibley, D. F., and Gregg, J. M., 1987, Classification of dolomite rock textures: Journal of Sedimentary Petrology, v. 57, no. 6, pp. 967-975.

Soar, L. K., 1984, Paleoecology of phylloid algal mud mounds, Honaker Trail Formation (Pennsylvanian), southwest Colorado: M.A. Thesis, University of Texas at Austin, 69 p.

Soudry, D., and Levy, Z., 1988, Microbially influenced formation of phosphate nodules and megafossil moulds (Negev, Southern Israel): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 64, pp. 15-34.

Spaw, J. M., 1977, Paleo-environments of Middle Pennsylvanian Chaetetes lithotypes, Texas and New Mexico: M. S. Thesis, Rice University, 80 p.

Steward, G. F., 1975, Kansas, in McKee, E. D., and Crosby, E. J., eds., Paleotectonic Investigation of the Pennsylvanian System in the United States, part 1, Introduction and Regional Analysis of the Pennsylvanian System: United States Geological Survey, Professional Paper no. 853, part 1 of 3, pp. 127-156.

Suchy, D. R., 1987, Regional stratigraphic setting and paleoecology of a chaetetid "reef" in the Houx-Higgensville Limestone (Pennsylvanian) of Southeast

Kansas: unpublished M.S. Thesis, Kansas State University, 181 p.

Suneson, M. A., 1984, Reconstruction of paleo-environments and assemblages in a Pennsylvanian (Desmoinesian) Chaetetes-bearing limestone from southwestern Colorado: unpublished M.A. Thesis, University of Texas at Austin, 94 p.

Sutherland, P. K., 1984, Chaetetes reefs of exceptional size in Marble Falls Limestone (Pennsylvanian), central Texas: Fourth International Symposium of Fossil Cnidaria, Paleontographica Americana, no. 54, pp. 543-547.

Swade, J. W., 1985, Conodont distribution, paleoecology, and preliminary biostratigraphy of the Upper Cherokee and Marmaton Groups (Upper Desmoinesian, Middle Pennsylvanian) from two cores in south central Iowa: Iowa Geological Survey Technical Information series No. 14, 71 p.

Twenhofel, W. H., 1919, Pre-Cambrian and Carboniferous algal deposits: American Journal of Science, article 22, Fourth Series, no. 48, pp. 339-352.

Udden, J. A., 1912, Geology and mineral resources of the Peoria Quadrangle, Illinois: United States Geological Survey Bulletin 506, 103 p.

Voegeli, V. J., 1989, Lateral variations within the Altamont Limestone formation (Middle Desmoinesian), southeastern Kansas: Geological Society of America, Abstracts with Program, v.21, p. 42.

Wanless, H. R., 1975, Missouri and Iowa, in McKee, E. D., and Crosby, E. J., eds., Paleotectonic Investigation of the Pennsylvanian System in the United States, part 1, Introduction and Regional Analysis of the Pennsylvanian System: United States Geological Survey, Professional Paper no. 853, part 1 of 3, pp. 127-156.

Wanless, H. R., Tubb, J. B., Gednetz, D. E., and Weiner, J. L., 1963, Mapping sedimentary environments of Pennsylvanian shales: Geological Society of America Bulletin, v. 74, pp. 437-486.

Wanless, H. R., and Weller, J. M., 1932. Correlation and extent of Pennsylvanian cyclothems. Geological Society of America Bull., v. 43, pp. 1003-1016

Wenger, L. M., and Baker, D. R., 1986, Variations in organic geochemistry of anoxic-oxic black shale-carbonate sequences in the Pennsylvanian of the Mid-Continent, USA: Organic Geochemistry, v. 10, p. 85-92.

West, R. R., 1988, Temporal changes in Carboniferous reef mound communities: Palaios, v. 3, no. 2, pp. 152-169.

West, R. R., 1989a, Carboniferous species of Chaetetes in North America: Geological Society of America, Abstracts with Programs, South Central Section, p. 43.

West, R. R., 1989b, Variability in Chaetetes (Carboniferous of North America), is it environmental?: Geological Society of America, Abstracts with Programs, Annual Meeting.

West, R. R., 1990, Thoughts on the upper Paleozoic history of Kansas, in Cunningham, C. R. and Maples, C. G., eds., 1990 Society of Vertebrate Paleontology Upper Paleozoic of eastern Kansas Excursion Guidebook, Kansas Geological Survey Open-File Report 90-24, pp. 5-15.

West, R. R., 1992, Chaetetes (Demospongiae): Its occurrence and biostratigraphic utility: Oklahoma Geological Survey Circular no. 94, pp. 163-169.

West, R. R., IN REVIEW, Species in coralline demosponges: Chaetetida: Proceedings of the VI International Symposium on Fossil Cnidaria including Archaeocyatha and Porifera.

West, R. R., and Busch, R. M., 1985, Sixth-order transgressive-regressive units in the Wewoka Formation (Anne Shale Member) of Oklahoma, in Watney, W. L., Kaesler, R. K., and Newell, K. D., eds., Recent interpretations of Late Paleozoic Cyclothems: Proceedings and Field Trip Guidebook of Third Annual Meeting Mid-Continent Section, Society of Economic Paleontologists and Mineralogists, pp. 155-170.

West, R. R., and Busch, R. M., 1986, Paleoceanography as revealed by sixth-order T-R units and the understanding of chaetetid reefs in Middle Carboniferous strata of Kansas: Geological Society of America, Abstracts with Programs, v. 18, p.330.

West, R. R., and Clark, G. R. II, 1984, Paleobiology and biological affinities of Paleozoic chaetetids: Palaeontographica Americana, no. 54, pp. 337-348.

West, R. R., and Kershaw, S., 1991, Chaetetid Habitats, in Reitner, J., and Keupp, H., eds., Fossil and Recent

Sponges: Springer-Verlag, pp. 445-455.

Wood, R., 1990, Reef-building sponges: American Scientist, v. 78, pp. 224-235.

Wray, J. L., 1977, Calcareous Algae: Elsevier, New York, 185 p.

Zangerl, R., and Richardson, E. S., 1963, The paleoecological history of two Pennsylvanian black shales: Fieldiana-Geology Memoirs, v. 4, pp. 213-239.

Zeller, D. E., 1968, The stratigraphic succession in Kansas: Kansas Geological Survey Bulletin 189, 81 p.

INTRODUCTION TO APPENDICES

Notes on the term "algal"- as used in section desciptions and text

Osagia was first described by Twenhofel in 1919 as an algal encrustation. Subsequent work by Johnson (1946) suggested that *Osagia* was an encrustation composed of algae and foraminiferids. Henbest (1963) identified the algae *Girvanella* and several foraminiferids in *Osagia*. Thus, *Osagia*, an association between algae and foraminiferids, is not a valid taxonomic name. In this study all encrustations that would have been identified as *Osagia* are referred to as "algal"-coatings or "algal"-encrustations. Quotation marks are used to differentiate *Osagia* coatings from other unidentifiable algal coatings. The latter are noted as algal-coatings or encrustations, without quotation marks.

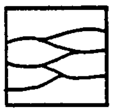
Section Notes --

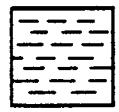
Samples shown on weathering profiles are only those thin sections and washed residues described in appendices E and F. Thin sections are denoted by the prefix TS; washed residues are listed by sample number. For a list of all samples collected at a particular section, see the second page of the appendix for that particular locality.

LEGEND OF SYMBOLS

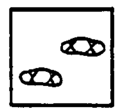
 Micaceous Siltstone

 Coal Smut

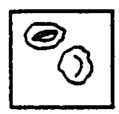
 Clay-rich Laminae

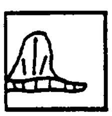
 Clayshale

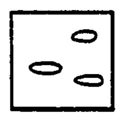
 Phosphatic Black Shale

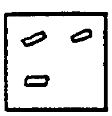
 Chert Nodules

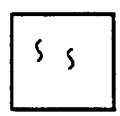
 Phylloid Algae

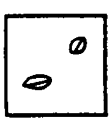
 Oncolites

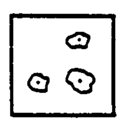
 Chaetetids

 Fusulinids

 Crinoids

 Burrows, Rooting?

 Brachiopods

 Coated Grains

APPENDIX A

MEASURED SECTION DESCRIPTIONS

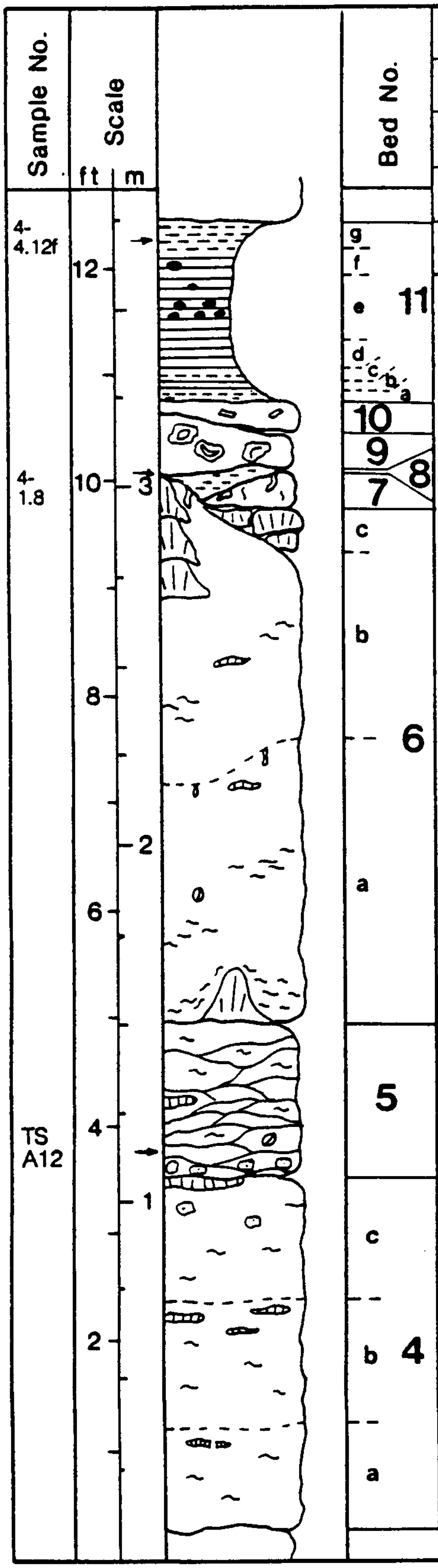
LOCALITY 729

Active quarry operated by Midwest Minerals,
Pittsburg, Kansas

Samples collected at locality 729

Sample no.	Level
729-S1	
S-1.	
1a	lower contact, bed 1
1b	upper contact, bed 1
2	middle part, bed 2
3	upper half, bed 3
4a	lower 15 cm, bed 4
4b	upper 20 cm, bed 4
5	lower contact, bed 5
6a	middle part, bed 6a
6b	middle part, bed 6b
7	middle part, bed 6c
8	grab sample, bed 8
9	upper contact, bed 7
10	upper contact, bed 9
11	entire thickness, bed 10
12c	unit d, bed 11
12d	unit e, bed 11
12e	unit f, bed 11
12f	unit g, bed 11
729-S2	
S-2.	
1a	lower contact, bed 1
1b	upper contact, bed 1
2	lower contact, bed 2
3	middle part, bed 3
4a	lower contact, bed 4a
4b	lower contact, bed 4b
4c	lower contact, bed 4c
4d	upper contact, bed 4c
5a	lower third, bed 5
6a	middle part, bed 6a
6b	middle part, bed 6b
8a	lower part, bed 7
8b	upper contact, bed 7
10a	middle part, bed 9
11b	lower half, bed 10
12a	lower 5 cm, bed 11
12b	unit d, bed 10

Sample no.	Level
729-S3	
S-3.	
12b	unit e, bed 11
12c	unit g, bed 11
12d	upper contact, unit g, bed11
13	entire thickness, bed 12
14a	lower contact, bed 13
14b	upper third, bed 13
15	lower contact, bed 14
16	middle part, bed 15
17	lower third, bed 16
18a	upper third, bed 17
18b	upper contact, bed 17
18c	lower third, bed 17
19a	lower contact, bed 18
19b	middle part, bed 19
729-S4	
S-4.	
3	entire thickness, bed 3
6a	lower half, bed 6a
6b	lower half, bed 6b
8	upper part, bed 7
10	entire thickness, bed 9
12a	lower 8 cm, bed 11
12b	unit d, bed 11
12c	unit g, bed 11



DESCRIPTION: Section 729-S1, Locality 729

13 meters south of NE corner

LOCATION: SW 1/4, NE 1/4, sec 34, T.34S, R.17 E, Montgomery Co., Kansas

MEASURED BY: Vincent Voegeli 1988

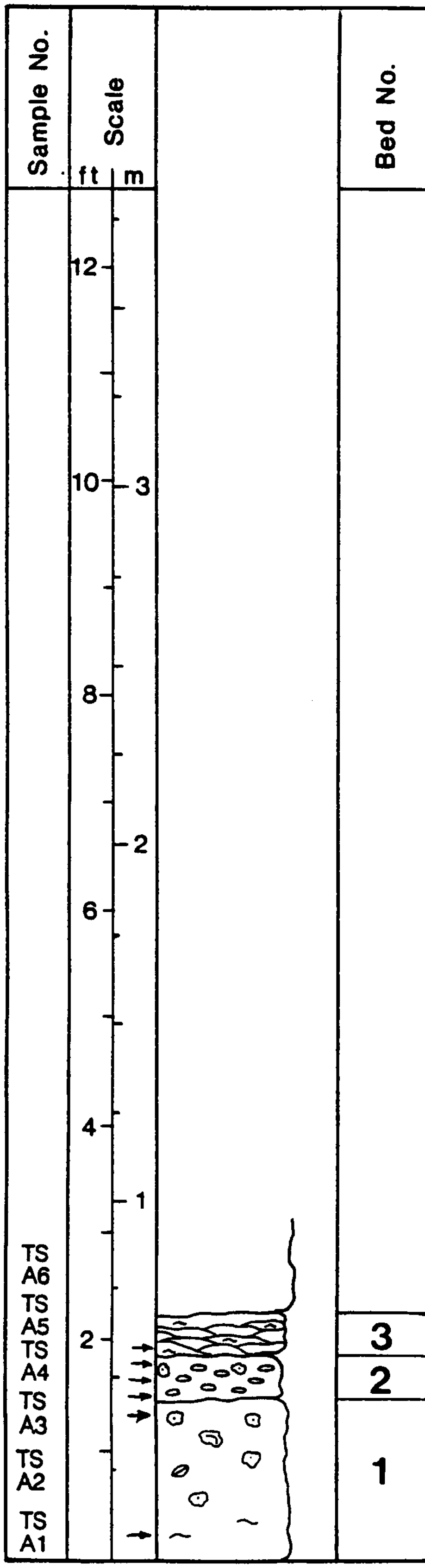
SECTION 729-S1

bed

Lake Neosho Shale Member

11. Shale: (50 cm) divisible into seven units, a-g.
 Unit a: Calcareous Clayshale, 3 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1), 25-30% fossils, including 20-25% brachiopod shell fragments (mostly Composita, and Crurithyris) and crinoid ossicles; flaggy partings; contact with overlying unit gradational.
 Unit b: Slightly Calcareous Shale, 4-5 cm thick; grayish black (N2), weathers dark gray (N3); 8-10% fossils, including Mesolobus (3-4%), Crurithyris (1-2%), Orbiculoidea, other unidentifiable medium- to fine sand-sized skeletal grains; platy partings; contact with overlying unit sharp to gradational.
 Unit c: Calcareous Clayshale, 3-4 cm thick; olive black (5Y 2/1), weathers olive gray (5Y4/1); 15-20% fossils, including Crurithyris (8-10%), Mesolobus (2-3%), unidentifiable medium to fine sand-sized skeletal grains; flaggy partings; contact with overlying unit sharp to gradational.
 Unit d: Non-calcareous Shale, 11-12 cm thick; grayish black (N2), weathers dark gray (N3); 1% fossils, including Orbiculoidea, fish scales, horizontal Planolites-like traces; fissile to platy partings; contact with overlying unit gradational.
 Unit e: Non-calcareous Phosphatic Shale, 18-20 cm thick; black (N1), weathers dark gray (N3); <1% fossils, including Orbiculoidea, horizontal trace fossils; discoidal to spherical phosphate nodules throughout, concentrated in upper half in distinct band, compaction slickensides on some nodules; fissile partings; contact with overlying unit gradational.
 Unit f: Phosphatic Shale, 10 cm thick; grayish black (N2), weathers medium dark gray (N4); 1% fossils (1%), mostly Orbiculoidea and horizontal Planolites-like traces, few fish? scales; discoidal to spherical phosphate nodules, appear randomly oriented and less common than in underlying unit; platy to fissile partings; contact with overlying unit sharp to gradational.
 Unit g: Calcareous Clayshale, 5-7 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1); 5-10% fossils, including Crurithyris (3-7%, frequently articulated), productid shell fragments, crinoid ossicles, and dermal denticles; some calcified, horizontal burrows up to 2 cm in dia.; few spherical phosphate nodules; platy partings; contact with overlying bed gradational with some articulated (up to 3 cm long) crinoid stems near contact.

(cont.)



DESCRIPTION: Section 729-S1, Locality 729

13 meters south of NE corner

LOCATION: (cont.)

MEASURED BY:

Amoret Limestone Member

10. Crinoidal Wackestone: 3-9 cm thick; olive gray (5Y4/1), weathers medium light gray (N6); moderately well-sorted; medium- to fine-grained; 15-20% fossils, including crinoid debris (2-3%, most <5 mm in size, fragmented), productids, Composita, and other brachiopod shell fragments, and unidentifiable medium to fine sand-sized skeletal grains (10-12%); few skeletal grains algal-coated; contact with overlying bed sharp to gradational; somewhat wavy bedded; discontinuous laterally.

9. Brachiopod Oncolitic Wackestone: 10-28 cm thick; light gray (N7), weathers very light gray (N8); poorly-sorted; coarse- to fine-grained; 40-50% fossils, including Composita (25-30%, a third articulated and mud-filled), productids (10-15%, few articulated), Neospirifer, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; articulated brachiopods more common upward; one algal-coated micrite lithoclast; 20-25% of fossil debris algal-coated, half coated equally on all sides; olive black (5Y2/1) shale partings at upper and lower contacts; contact with overlying bed gradational.

8. Non-calcareous to Calcareous Mudshale: 0-14 cm thick; greenish gray (5G6/1), upper 5 mm olive gray (5Y4/1), weathers light greenish gray (5G8/1); becomes more calcareous upward; lower half sparsely fossiliferous, few plant fragments; upper half 5-10% fossils, including few Crurithyris, Composita shell fragments, mostly unidentifiable medium to fine sand-sized skeletal grains (4-8%); flaggy bedding; discontinuous laterally, filling in irregularities on surface of underlying beds; contact with overlying bed sharp to gradational.

7. Skeletal Wackestone: 0-10 cm thick; very light gray (N8), weathers yellowish gray (5Y8/1); moderately well-sorted; fine-grained; 5-10% fossils, including small-sized crinoid debris (1-2%), high and low-spired gastropods, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils randomly oriented; small vertical rootlet-like structures (5 mm wide, up to 4 cm long) occur near upper contact, most filled with medium dark gray (N4) to dark gray (N3) mudstone; olive black (5Y2/1) clay-rich stylolitic laminae throughout, concentrated near upper contact; uppermost part somewhat brecciated, inter-fingering with overlying mudshale; discontinuous laterally away from this section; contact with overlying bed sharp.

6. Wackestone to Rudstone: 138-156 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); divisible into three units, a-c.
Unit a: Chaetetid Phylloid Algal Wackestone, 60-80
(cont.)

cm thick; poorly-sorted; fine- to coarse-grained; 25-30% fossils, including phylloid algae (10-12%, lens-shaped occurrences upward), Composita (1-2%, few articulated and mud-filled), crinoid debris (1-2%), bellerophontids, low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%); one low domical chaetetid at lower contact (20 cm high), 2 small laminar chaetetids near upper contact (<10 cm long, one encrusting spar-filled bellerophontid); skeletal grains randomly oriented, coarser grained near low domical chaetetid; some olive gray (5Y3/2) mottling present throughout; bedding indistinct; contact with overlying unit b sharp, marked by small vertical burrow-like structures (up to 8 cm in length, 1 cm wide).

Unit b: Chaetetid Skeletal Wackestone, 55-60 cm thick; 20-25% fossils, similar to unit a, phylloid algae less common (occurs in lenses), more unidentifiable medium to fine sand-sized skeletal grains; mottling more common; one small laminar chaetetid in middle part; one columnar chaetetid, lower surface covered, continues to upper surface; fossils randomly oriented; skeletal grains fines upward; bedding indistinct; contact with overlying unit c sharp, very irregular; upper surface is pitted, eroded where overlying unit or bed 7 missing;

Unit c: Chaetetid Rudstone, 0-14 cm thick; mostly jumbled and fragmented chaetetids; inter-bedded argillaceous wackestone lenses, containing 20-25% unidentifiable medium to fine sand-sized skeletal grains; laterally discontinuous away from this section; contact with overlying bed sharp; bed 7 absent where unit c present.

5. Phylloid Algal Wackestone: 35-40 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted; coarse to fine-grained; 40-50% fossils, including phylloid algae (20-30%), Composita (3-4%, quarter articulated), crinoid debris, echinoid fragments, high-spired gastropods, Omphalotrochus, unidentifiable medium to fine sand-sized skeletal grains (10-15%, 2-3% algal-coated); one small laminar chaetetid in middle part; fossils randomly oriented; lower 5 cm skeletal hash consisting of unidentifiable medium to fine sand-sized algal-coated skeletal grains, small crinoid fragments, and fusulinids; olive black (5Y2/1) clay-rich laminae throughout; possible brecciation; large chert nodule (30 cm long) just to the right of this section with same skeletal composition as surrounding bed; contact with overlying bed irregular, gradational and marked by disappearance of clay-rich laminae.

4. Phylloid Algal Wackestone: 85-90 cm thick; very light gray (N8) to medium light gray (N6), weathers yellowish-gray (5Y7/2); poorly-sorted; fine- to coarse-grained; roughly divisible into three units, a-c, separated by gradational contacts.

Unit a: 35-38 cm thick; 25-30% fossils, including phylloid algae fragments(15-20%), Composita (1-2%, few articulated, mud-filled, show evidence of compaction), ostracodes, ramose bryozoan fragments, Lophophyllidium, Neospirifer, unidentifiable medium to fine sand-sized skeletal grains (2-4%, few algal-coated); one small laminar chaetetid in upper part, fragmented in place (compaction?);

Unit b: similar to unit a; also high-spired gastropods, several laminar chaetetids in upper 10 cm (up to 6 cm high, 20 cm long);

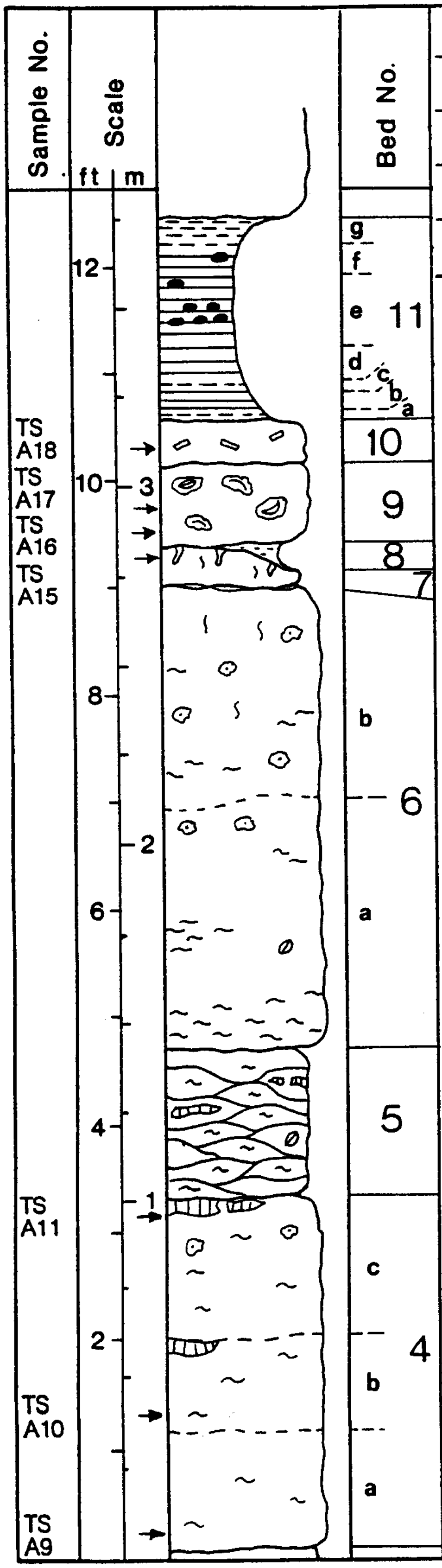
Unit c: similar to units a and b, with less phylloid algae fragments(10-15%), more unidentifiable medium to fine sand-sized algal-coated skeletal grains; laminar chaetetid at upper contact (20 cm long, 5 cm high). Fossils randomly oriented throughout bed 4 (except for chaetetids in life position); indistinct bedding; contact with overlying bed sharp, marked by olive black (5Y2/1) clay-rich laminae.

3. Phylloid Algal Wackestone: 11 cm thick; medium gray (N5), no weathered surface; poorly-sorted; coarse-grained; 15-20% fossils, including phylloid algae fragments (8-12%), Composita (1-2%, few articulated, most mud-filled, some spar-filled), rugose corals, high-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains; wavy bedded; olive black (5Y2/1) clay-rich laminae throughout; contact with overlying bed sharp to gradational.

(cont.)

2. Fusulinid Skeletal Packstone: 13 cm thick; light gray (N7), no weathered surface; poorly-sorted; coarse- to fine-grained; 70-80% fossils, including fusulinids (50-60%), phylloid algae (3-6%), unidentifiable medium to fine sand-sized skeletal grains (10-20%); 30% of fusulinids and 30-40% of other fossil grains algal-coated; phylloid algae more common upward, fusulinids and other fossil grains less common upward; sorting decreases upward; wavy bedded; contact with overlying bed gradational.

1. Fusulinid Brachiopod Wackestone: 41-42 cm thick; medium dark gray (N4), no weathered surface; moderately-sorted; medium- to fine-grained; 20-30% fossils, including fusulinids (4-8%, more common upward), productids (1-4%, few articulated and mud-filled, randomly oriented), , Composita, crinoid fragments, phylloid algae fragments, small (<4 mm) gastropods, unidentifiable medium to fine sand-sized skeletal grains (8-14%); 30-40% of fossils algal-coated; articulated brachiopods compaction fractured; indistinct bedding; lower contact sharp, marked by grayish black (N2) shale partings with fusulinids and fine sand-sized skeletal grains; upper contact sharp with thin grayish black (N2) clay-rich laminae.



DESCRIPTION: Section 729-S2, Locality 729

72 meters north of south edge of west wall

LOCATION: SW 1/4, NE 1/4, sec 34, T.34S, R.17 E, Montgomery Co., Kansas

MEASURED BY: Vincent Voegeli 1988

Section 729-S2

bed

Lake Neosho Shale Member

11. Shale: (54-55 cm) divisible into seven units, a-g.

<u>Unit a</u>: Calcareous Clayshale, 1-3 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1); 15-20% fossils, including brachiopod shell fragments (10-15%, mostly <u>Composita</u>, <u>Crurithyris</u>, also productids), crinoid ossicles, <u>Mesolobus</u>, and ramose bryozoan fragments; fossil debris compacted, parallel alignment; upper contact gradational.

<u>Unit b</u>: Slightly Calcareous Shale, 6 cm thick; grayish black (N2), weathers dark gray (N3); 8-10% fossils, including <u>Mesolobus</u> (3-4%), <u>Crurithyris</u> (1-2%), <u>Orbiculoidea</u>, <u>Lingula</u>, <u>Straparolus</u>, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; fossils small (<1 cm long); several brachiopods articulated, crushed and compacted; platy partings; upper contact sharp to gradational.

<u>Unit c</u>: Calcareous Clayshale, 2-3 cm thick; olive black (5Y2/1), weathers olive gray (5Y4/1); 15% fossils, including <u>Crurithyris</u> (8-10%), <u>Mesolobus</u> (2-3%), unidentifiable medium to fine sand-sized skeletal grains; flaggy partings; upper contact sharp to gradational.

<u>Unit d</u>: Non-calcareous Shale, 13-14 cm thick; grayish black (N2), weathers dark gray (N3); 1% fossils, including <u>Orbiculoidea</u>, fish scales, horizontal <u>Planolites</u>-like traces; fissile to platy partings; upper contact gradational.

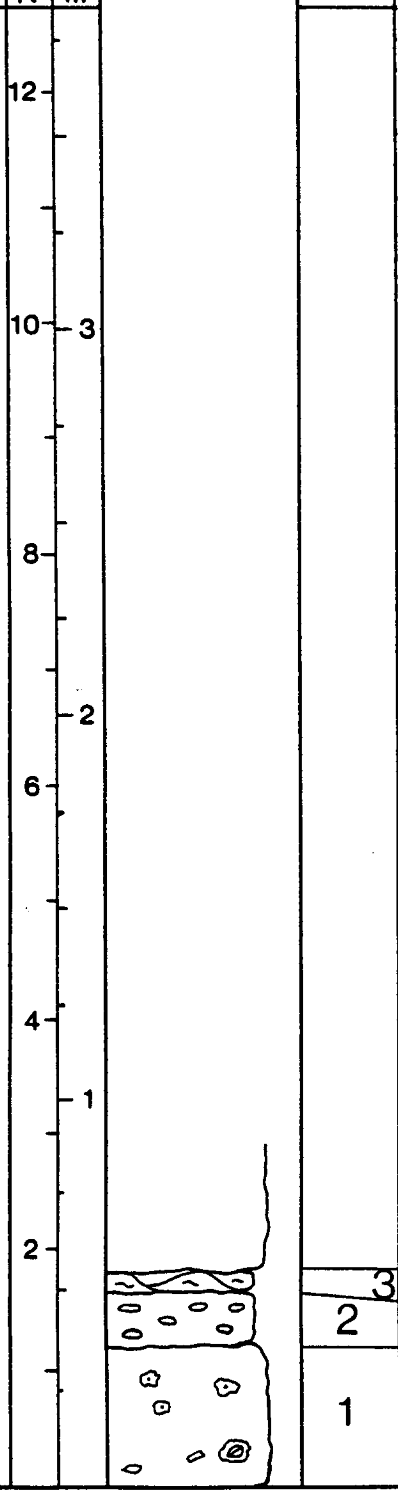
<u>Unit e</u>: Non-calcareous Phosphatic Shale, 20-23 cm thick; black (N1), weathers dark gray (N3); <1% fossils, including <u>Orbiculoidea</u>, horizontal trace fossils; discoidal to spherical phosphate nodules throughout, concentrated in center in distinct band; compaction slickensides on some nodules; fissile partings; upper contact gradational.

<u>Unit f</u>: Phosphatic Shale, 11-12 cm thick; grayish black (N2), weathers medium dark gray (N4); 1% fossils (1%), mostly <u>Orbiculoidea</u> and horizontal <u>Planolites</u>-like traces, few fish? scales; discoidal to spherical phosphate nodules, appear randomly oriented and less common than in underlying unit; platy to fissile partings; upper contact sharp to gradational.

<u>Unit g</u>: Calcareous Clayshale, 6 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1); 15-20% fossils, including <u>Crurithyris</u> (3-7%, frequently articulated), productid shell fragments, crinoid ossicles (3-4%), dermal denticles, unidentifiable medium to fine sand-sized skeletal grains; some calcified, horizontal burrows up to 2 cm in diameter; few spherical phosphate nodules; platy partings; contact with overlying bed gradational with some articulated (up to 3 cm long) crinoid stems near contact.

(cont.)

Sample No.	Scale (ft / m)		Bed No.	DESCRIPTION: Section 729-S2, Locality 729
				72 meters north of south edge of west wall
				LOCATION: (cont.)
				MEASURED BY:



Amoret Limestone Member

10. Crinoidal Wackestone, 14-16 cm thick, olive gray (5Y4/1), weathers medium light gray (N6); moderately well-sorted, medium- to fine-grained; 20-25% fossils, including crinoid debris (5-7%), unidentifiable medium to fine sand-sized skeletal grains (15-20%, half algal-coated); fossils somewhat preferentially aligned horizontally; two brownish black (5YR2/1) lithoclast (up to 3 cm long, angular) noted; wavy bedded; upper contact sharp.

9. Brachiopod Oncolitic Wackestone, 24 cm thick; light gray (N7), weathers very light gray (N8); poorly-sorted, fine- to coarse-grained; lower 0.5-2.5cm calcareous brownish black (5YR2/1) shale with packstone stringers, grades upward into oncolitic wackestone; lower 6-7 cm 50% fossils, including fragmented Composita and productids (30-35%), brachiopod spines, crinoid debris (5%), unidentifiable medium to fine sand-sized skeletal grains (10-15%); all fossils algal-coated, most equally coated on all sides; above this fossil grains become coarser, 35-40% fossils, including Composita (15-20%, frequently articulated, random orientation), productids (10-15%, frequently articulated, random orientation), brachiopod spines, unidentifiable medium to fine sand-sized skeletal grains (10-15%); articulated brachiopods mostly mud-filled, 5% spar-filled or with internal void space; most fossils algal-coated, half with thicker encrustations on one side; fossil debris in lower part somewhat wavy bedded, randomly oriented throughout rest of bed; few small (0.7 cm wide, 4 cm long) vertical burrow-like structures at upper contact; upper contact sharp to gradational with brownish black (5YR2/1) shale partings.

8. Non-calcareous to Calcareous Mudshale: 0-8 cm thick; greenish gray (5G6/1), weathers light greenish gray (5G8/1); becomes more calcareous upward; lower half sparsely fossiliferous, few plant fragments; upper half 5-10% fossils, including few Crurithyris, Composita shell fragments, chaetetid fragments (worn, abraded), mostly unidentifiable medium to fine sand-sized skeletal grains (4-8%); flaggy bedding; few angular to rounded clast of underlying bed; discontinuous laterally, filling in irregularities on surface of underlying beds; contact with overlying bed sharp to gradational.

7. Skeletal Wackestone: 5-10 cm thick; very light gray (N8), weathers yellowish gray (5Y8/1); moderately well-sorted; fine-grained; 10-15% fossils, including small-sized crinoid debris (4-5%), high and low-spired gastropods, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils randomly oriented; small vertical rootlet-like structures (5 mm wide, up to 4 cm long) occur near upper contact, most filled with medium dark gray (N4)
(cont.)

to dark gray (N3) mudstone; medium gray (N5) mottling throughout, weathers olive gray (5Y3/2); olive black (5Y2/1) clay-rich stylolitic laminae throughout, concentrated near upper contact; uppermost part somewhat brecciated, inter-fingering with overlying mudshale; upper surface irregular, pitted, eroded; chert-filled fractures extending downward from upper surface; discontinuous laterally away from this section; contact with overlying bed sharp.

6. Wackestone: 130-135 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2): divisible into two units, a and b.

Unit a: Phylloid Algal Skeletal Wackestone, 70-78 cm thick; moderately-sorted, medium- to fine-grained; lower 26 cm 25-30% fossils, including phylloid algae (15-20%), crinoid debris, Composita shell fragments, Omphalotrochus, unidentifiable medium to fine sand-sized skeletal grains (8-10%); upper part more well-sorted; 40-45% fossils, including crinoid debris (15-20%), echinoid spines, low-spired gastropods, brachiopod shell fragments, phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); fossils randomly oriented; frequent medium gray (N5) mottling throughout; gradational upper contact with unit b, marked by presence of small (<2 cm long, <1 cm wide) spar lined vertical burrow-like structures.

Unit b: Skeletal Wackestone, 52-67 cm thick; similar to upper part of unit a, fossils more fine-grained, less recognizable skeletal grains; mottling decreases upward; few spar lined burrow-like structures throughout, more common upward; indistinct bedding; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

5. Phylloid Algal Brachiopod Wackestone, 46-47 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 30% fossils, including phylloid algae (20-25%), Composita (2-3%, fifth articulated, 2 noted in apparent life position), high-spired gastropods, Euphemites, unidentifiable medium to fine sand-sized skeletal debris (5-8%); two small laminar chaetetids (up to 10 cm long, 3 cm high) in upper half (fragmented in place); olive black (5Y2/1) clay-rich laminae throughout, gives bed a brecciated and wavy appearance; upper contact gradational.

4. Phylloid Algal Wackestone: 94-97 cm thick; very light gray (N8) to medium light gray (N6), weathers yellowish-gray (5Y7/2); poorly-sorted; fine- to coarse-grained; roughly divisible into three units, a-c, separated by gradational contacts.

Unit a: 36-39 cm thick; 30% fossils, including phylloid algae (15-20%), Composita fragments, unidentifiable medium to fine sand-sized skeletal grains (8-10%).

Unit b: 21-24 cm thick; 30-35% fossils, including phylloid algae (15-20%), Composita (3-4%, few articulated near upper contact of unit), productids (1%, rarely articulated), Lophophyllidium (random orientation), Aviculopecten, unidentifiable medium to fine sand-sized skeletal grains (10%, fifth algal-coated); one laminar chaetetid at upper contact (10 cm long, 4 cm high); coarser grained than unit a.

Unit c: 31-34 cm thick; 25-30% fossils, including phylloid algae (8-10%), Composita (1-2%, quarter articulated, spar-filled with geopetal), Lophophyllidium, unidentifiable medium to fine sand-sized skeletal grains (12-15%, half algal-coated); laminar chaetetid at upper contact, fragmented in place.

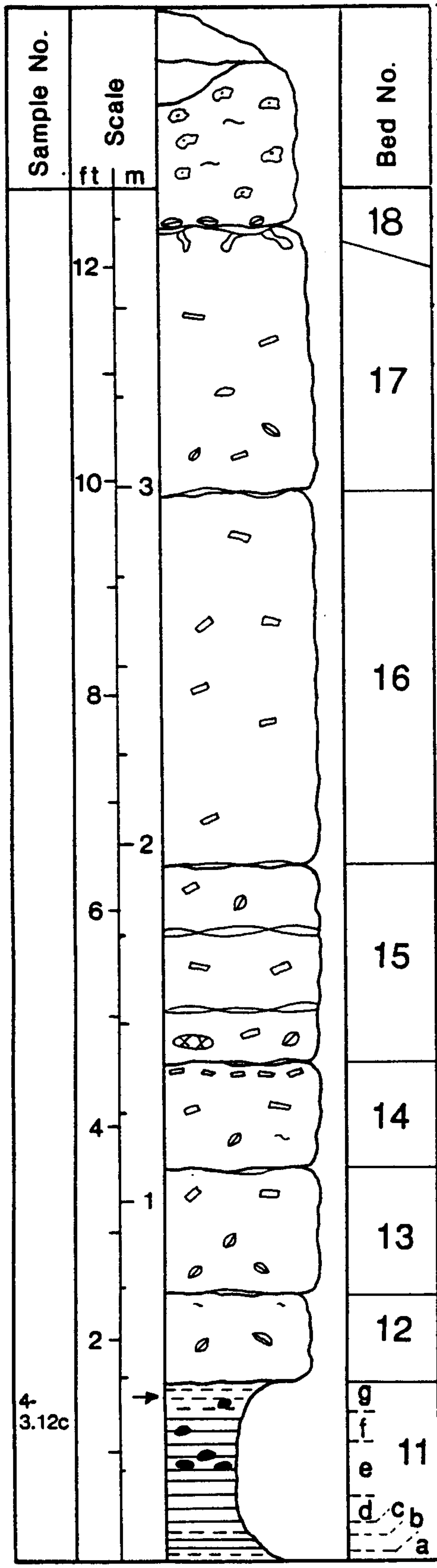
Fossils randomly oriented throughout bed 4 (except chaetetids); medium gray (N5) mottling throughout; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

3. Phylloid Algal Wackestone, 5 cm thick; medium gray (N5), weathers light gray (N7); poorly-sorted, coarse- to fine-grained; 20% fossils, including phylloid algae (12-15%), crinoid debris, Composita fragments, unidentifiable medium to fine sand-sized skeletal grains (4-5%, sixth algal-coated); fossils randomly oriented; somewhat wavy bedding; numerous olive black (5Y2/1) clay-rich laminae throughout, gives bed brecciated appearance; upper contact gradational, marked by disappearance of clay-rich laminae.

(cont.)

2. Fusulinid Wackestone to Packstone, 15-16 cm thick; light gray (N7), no weathered surface; poorly-sorted, coarse- to fine-grained; 70-80% fossils, including fusulinids (40-50%, half algal-coated), crinoid debris (3-4%), productid fragments, Reticulatia (one articulated, but overturned), unidentifiable medium to fine sand-sized skeletal grains (20-30%, third algal-coated); fossils partially aligned horizontally; wavy bedded; upper contact gradational.

1. Skeletal Wackestone, 33 cm; medium dark gray (N4), no weathered surface; moderately well-sorted, medium- to fine-grained; 5-15% fossils; lower half 15% fossils, including crinoid debris (5%), fusulinids (1%), low-spired gastropods, Composita (few articulated, some partially algal-coated), productids (few articulated, partially to entirely algal-coated), bellerophontids, unidentifiable medium to fine sand-sized skeletal grains (8-10%, two-thirds algal-coated); fossils randomly oriented; fossils decrease to 5% in upper part, mostly unidentifiable medium to fine sand-sized skeletal grains (3-4%, most algal-coated), also fusulinids, brachiopod shell fragments (occasionally algal-coated), crinoid debris; randomly orientated; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae with fusulinids and crinoid fragments.



DESCRIPTION: Section 729-S3, Locality 729

29 meters south of 729-S1

LOCATION: SW 1/4, NE 1/4, sec 34, T.34S,

R.17 E, Montgomery Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 729-S3

bed

Worland Limestone Member

18. Skeletal Wackestone to Packstone, 43 cm thick; very pale orange (10YR8/2), weathers pale yellowish orange (10YR8/6); moderately well-sorted, medium- to fine-grained; lower third skeletal packstone; 70-80% fossils, including crinoid debris (5%), brachiopod shell fragments, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (60-70%, nearly all algal-coated); bedding indistinct; grades to a skeletal wackestone in upper two-thirds; 25-30% fossils, including phylloid algal fragments (10-15%, highly fragmented), crinoid debris, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (10-15%); indistinct bedding; light gray (N7) mottling throughout, weathers medium light gray (N6); upper contact removed by bulldozing; away from this section depressions on the upper surface contain a greenish gray (5GY6/1) mudshale with plant fossils;

17. Skeletal Calcareous Mudstone, 70 cm thick; very light gray (N8), weathers very pale orange (10YR8/2; well-sorted, fine-grained; 5-10% fossils, including crinoid debris, bryozoan fragments, Composita (mostly fragments, one articulated), unidentifiable medium to fine sand-size skeletal grains (4-9%); few discontinuous lenses of crinoidal-bryozoan packstone near lower contact; fossils randomly oriented, decreases in abundance and finer grained upward; bedding indistinct; light gray (N7) horizontal mottling in lower half; clay-rich laminae with stylolitic boundaries in lower half; upper contact irregular, sharp, iron stained (dark yellowish orange, 10YR6/6), pitted, corroded; fossils common on upper surface (20-30%), including in-situ Neospirifer (10-15%) and Composita (2-3%), crinoid ossicles and stems (up to 5 cm long), fusulinids, unidentifiable medium to fine sand-sized skeletal grains.

16. Crinoidal Bryozoan Skeletal Wackestone, 100 cm thick; very light gray (N8), weathers very pale orange (10YR8/2; moderately well-sorted, medium- to fine-grained; 10-15% fossils, including crinoid debris (5%), bryozoan fragments (2-3%), Composita and other brachiopod shell fragments, unidentifiable medium to fine sand- sized skeletal grains (8-10%); one small Multithecopora colony (15 cm across) left of this section; fossils randomly oriented; occasional light gray (N7) horizontal mottling throughout; bedding indistinct; few olive black (5Y2/1) laminae throughout, concentrated at sharp upper contact.

15. Crinoidal Bryozoan Wackestone, 60 cm thick; white (N9) to

(cont.)

very light gray (N8), weathers very pale orange (10YR8/2); moderately well-sorted, medium- to fine-grained; 15-20% fossils, including crinoid debris (8-10%), ramose bryozoan fragments (5%), Composita (mostly fragments, one articulated with geopetal), productids, Neospirifer, brachiopod shell fragments, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (5%); fossils randomly oriented; occasional medium gray (N5) mottling throughout; olive black (5Y2/1) clay-rich laminae with stylolitic boundaries throughout, concentrated at center and upper, lower contacts; indistinct bedding; chert nodules (up to 20 cm long) at upper, lower contacts, and near center; upper contact gradational, marked by decrease in clay-rich laminae.

14. Skeletal Wackestone, 31 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including crinoid debris (10-12%), Crurithyris (2-3%, few articulated), productids, Composita, ramose bryozoan fragments, phylloid algae (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils show some preferential horizontal orientation; occasional medium gray (N5) mottling throughout; crinoid ossicles and stems (up to 4 cm long) concentrated at upper contact; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

13. Brachiopod Skeletal Wackestone, 38 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2; poorly-sorted, coarse to fine-grained; 30-40% fossils, including Mesolobus (3-4%), productids (2-3%), Crurithyris (2-3%), Composita (2-3%), crinoid debris (1-2%), phylloid algae (1-2%, highly fragmented), Lophophyllidium (random orientation), gastropods, bryozoan fragments, fusulinids (1-2%), unidentifiable medium to fine sand-sized skeletal grains (10-20%); few brachiopods articulated, spar-filled; becomes less fossiliferous, finer grained upward; fossils randomly oriented; occasional medium gray (N5) mottling throughout; indistinct bedding; upper contact gradational, marked by olive gray (5Y2/1) clay-rich laminae.

12. Brachiopod Wackestone, 24 cm thick; light olive gray (5Y6/1), weathers medium gray (N5); poorly-sorted, coarse- to fine-grained; 40% fossils, including Composita (5-10%, sixth articulated, few in life position), productids, Mesolobus, crinoid debris (3-4%), bryozoan fragments, gastropods, bivalve fragments, Aviculopecten, medium to fine sand-sized skeletal grains (20-30%); most fossils randomly oriented; medium gray (N5) mottling throughout; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Lake Neosho Shale Member

11. Shale: (55 cm) divisible into seven units, a-g.

Unit a: Calcareous Clayshale, 3 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1), 25-30% fossils, including 20-25% brachiopod shell fragments (mostly Composita, and Crurithyris) and crinoid ossicles; flaggy partings; contact with overlying unit gradational.

Unit b: Slightly Calcareous Shale, 4 cm thick; grayish black (N2), weathers dark gray (N3); 8-10% fossils, including Mesolobus (3-4%), Crurithyris (1-2%), Orbiculoidea, other unidentifiable medium to fine sand-sized skeletal grains; platy partings; contact with overlying unit sharp to gradational.

Unit c: Calcareous Clayshale, 3 cm thick; olive black (5Y2/1), weathers olive gray (5Y4/1); 15-20% fossils, including Crurithyris (8-10%), Mesolobus (2-3%), unidentifiable medium to fine sand-sized skeletal grains; flaggy partings; contact with overlying unit sharp to gradational.

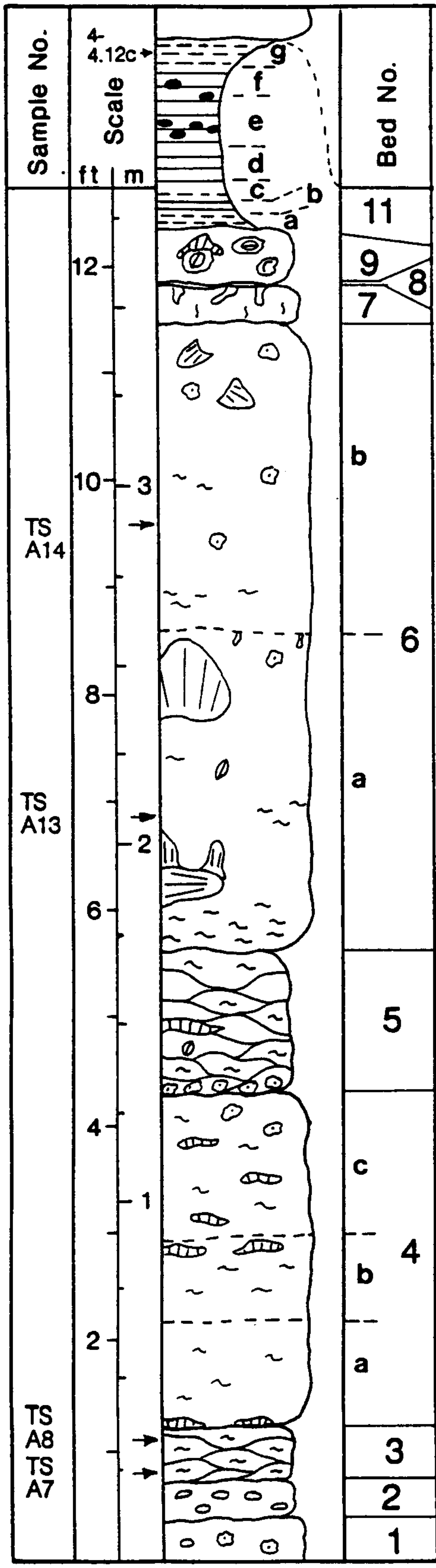
Unit d: Non-calcareous Shale, 9 cm thick; grayish black (N2), weathers dark gray (N3); 1% fossils, including Orbiculoidea, fish scales, horizontal Planolites-like traces; (cont.)

fissile to platy partings; contact with overlying unit gradational.

Unit e: Non-calcareous Phosphatic Shale, 16 cm thick; black (N1), weathers dark gray (N3); <1% fossils, including Orbiculoidea, Calamites fragments, Petrodus, horizontal trace fossils; discoidal to spherical phosphate nodules throughout, concentrated in upper half in distinct band, compaction slickensides on some nodules; fissile partings; contact with overlying unit gradational.

Unit f: Phosphatic Shale, 12 cm; grayish black (N2), weathers medium dark gray (N4); 1% fossils (1%), mostly Orbiculoidea and horizontal Planolites-like traces, few fish? scales; discoidal to spherical phosphate nodules, appear randomly oriented and less common than in underlying unit; platy to fissile partings; contact with overlying unit sharp to gradational.

Unit g: Calcareous Clayshale, 8 cm, olive gray (5Y3/2), weathers light olive gray (5Y6/1); 5-10% fossils, including Crurithyris (3-7%, frequently articulated), Composita, Mesolobus, productid shell fragments, crinoid ossicles, Petrodus; some calcified, horizontal burrows up to 2 cm in dia.; few spherical phosphate nodules; platy partings; contact with overlying bed gradational with some articulated (up to 3 cm long) crinoid stems near contact.



DESCRIPTION: Section 729-S4, Locality 729

45 meters west of NE corner

LOCATION: SW 1/4, NE 1/4, sec 34, T.34S,

R.17 E, Montgomery Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 729-S4

bed

Lake Neosho Shale Member

11. Shale: (60 cm) divisible into seven units, a-g.
Unit a: Calcareous Clayshale, 3-4 cm thick; olive gray (5Y3/2), weathers light olive gray (5Y6/1), 25-30% fossils, including 20-25% brachiopod shell fragments (mostly Composita, and Crurithyris), crinoid ossicles, Straparolus, Aviculopecten, and bryozoan fragments; flaggy partings; contact with overlying unit gradational.
Unit b: Slightly Calcareous Shale, 3-4 cm thick; grayish black (N2), weathers dark gray (N3); 8-10% fossils, including Mesolobus (3-4%), Crurithyris (1-2%), Orbiculoidea, other unidentifiable medium to fine sand-sized skeletal grains; platy partings; contact with overlying unit sharp to gradational.
Unit c: Calcareous Clayshale, 3-4 cm thick; olive black (5Y2/1), weathers olive gray (5Y4/1); 15-20% fossils, including Crurithyris (8-10%), Mesolobus (2-3%), unidentifiable medium to fine sand-sized skeletal grains; flaggy partings; contact with overlying unit sharp to gradational.
Unit d: Non-calcareous Shale, 10 cm thick; grayish black (N2), weathers dark gray (N3); 1% fossils, including Orbiculoidea, fish scales, horizontal Planolites-like traces; fissile to platy partings; contact with overlying unit gradational.
Unit e: Non-calcareous Phosphatic Shale, 18 cm thick; black (N1), weathers dark gray (N3); <1% fossils, including Orbiculoidea, horizontal trace fossils; discoidal to spherical phosphate nodules throughout, concentrated in upper half in distinct band, compaction slickensides on some nodules; fissile partings; contact with overlying unit gradational.
Unit f: Phosphatic Shale, 14 cm; grayish black (N2), weathers medium dark gray (N4); 1% fossils (1%), mostly Orbiculoidea and horizontal Planolites-like traces, few fish? scales; discoidal to spherical phosphate nodules, appear randomly oriented and less common than in underlying unit; platy to fissile partings; contact with overlying unit sharp to gradational.
Unit g: Calcareous Clayshale, 8 cm, olive gray (5Y3/2), weathers light olive gray (5Y6/1); 5-10% fossils, including Crurithyris (3-7%, frequently articulated), productid shell fragments, crinoid ossicles, Mesolobus, plant fragments?, and dermal denticles; some calcified, horizontal burrows up to 2 cm in dia.; few spherical phosphate nodules; platy partings; contact with overlying bed gradational.

(cont.)

Amoret Limestone Member

10. Laterally discontinuous, not present at this section.

9. Brachiopod Oncolitic Wackestone: 17 cm thick; light gray (N7), weathers very light gray (N8); poorly-sorted; coarse- to fine-grained; 30-40% fossils, including Composita (25-30%, a third articulated and mud-filled), productids (10-15%, few articulated), Neospirifer, crinoid debris, laminar chaetetid (one noted in upper half, growing on brachiopod oncolite), unidentifiable medium to fine sand-sized skeletal grains; articulated brachiopods more common upward; 20-25% of fossil debris algal-coated, half coated equally on all sides; olive black (5Y2/1) shale partings at upper and lower contacts; bed thins to right of section, becomes nodular shaly wackestone; contact with overlying bed gradational.

8. Calcareous Mudshale: 0.5 cm thick; olive gray (5Y4/1), weathers light greenish gray (5G8/1); 5-10% fossils, including few Crurithyris, Composita shell fragments, mostly unidentifiable medium to fine sand-sized skeletal grains (4-8%); flaggy bedding; discontinuous laterally, fillingin irregularities on surface of underlying beds; contact with overlying bed sharp.

7. Skeletal Carbonate Mudstone to Wackestone, 5-10 cm; very light gray (N8), weathers yellowish gray (5Y8/1); moderately well-sorted, medium- to fine-grained; 5-10% fossils, including high-spired gastropods (1-2%), brachiopod fragments, unidentifiable medium to fine sand-size skeletal grains (4-8%); upper surface irregular, pitted, eroded, and brecciated in-place; chert-filled fractures on upper surface; upper contact sharp; brecciated areas bed inter-fingered with overlying mudshale.

6. Wackestone: 170 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); divisible into two units, and b.

Unit a: Chaetetid Phylloid Algal Wackestone, 80 cm thick; poorly-sorted; fine- to coarse-grained; 30% fossils, including phylloid algal fragments (8-10%, laterally continuous in lower 10-15 cm, lensatic upward), Composita (1-2%, few articulated and mud-filled), crinoid debris (7-8%), Euphemites, low-spired gastropods, fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (10-15%); toppled high domical (ragged) chaetetid with two low domical chaetetids growing upward from the upper surface; extended domical chaetetid in upper half, ends near upper contact; fossils randomly oriented (except for most chaetetids), coarser grained near chaetetids; no chaetetids and fewer other fossils in areas with phylloid algae; some olive gray (5Y3/2) mottling present throughout; bedding indistinct; contact with overlying unit gradational.

Unit b: Chaetetid Skeletal Wackestone, 90 cm thick; 20-25% fossils, similar to unit a, fossil debris better sorted, finer grained; few fusulinids noted; two toppled low domical chaetetids in upper half; upper contact sharp, stylolitic.

5. Phylloid Algal Wackestone: 35-40 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted; coarse to fine-grained; 35-40% fossils, including phylloid algae (20-30%), Composita (1-2%, quarter articulated), crinoid debris, high-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%, 2-3% algal-coated); one small laminar chaetetid in middle part (fragmented in place); fossils randomly oriented; lower 5 cm skeletal hash consisting of unidentifiable medium to fine sand-sized algal-coated skeletal grains, small crinoid fragments, and fusulinids; olive black (5Y2/1) clay-rich laminae throughout; possible brecciation; contact with overlying bed irregular, gradational and marked by disappearance of clay-rich laminae.

4. Phylloid Algal Wackestone: 100 cm thick; very light gray (N8) to medium light gray (N6), (cont.)

weathers yellowish-gray (5Y7/2); poorly-sorted; fine- to coarse-grained; roughly divisible into three units, a-c, separated by gradational contacts.

Unit a: 30 cm thick; 25-30% fossils, including phylloid algae fragments(15-20%), Composita (1-2%, few articulated, mud-filled, show evidence of compaction), ostracodes, ramose bryozoan fragments, Lophophyllidium, Neospirifer, unidentifiable medium to fine sand-sized skeletal grains (2-4%, few algal-coated); two small (5 cm long) laminar chaetetids at lower contact;

Unit b: 25 cm thick; similar to unit a; also high-spired gastropods, Lophophyllidium, small sponges; two laminar chaetetids (up to 6 cm high, 20 cm long) in upper part.

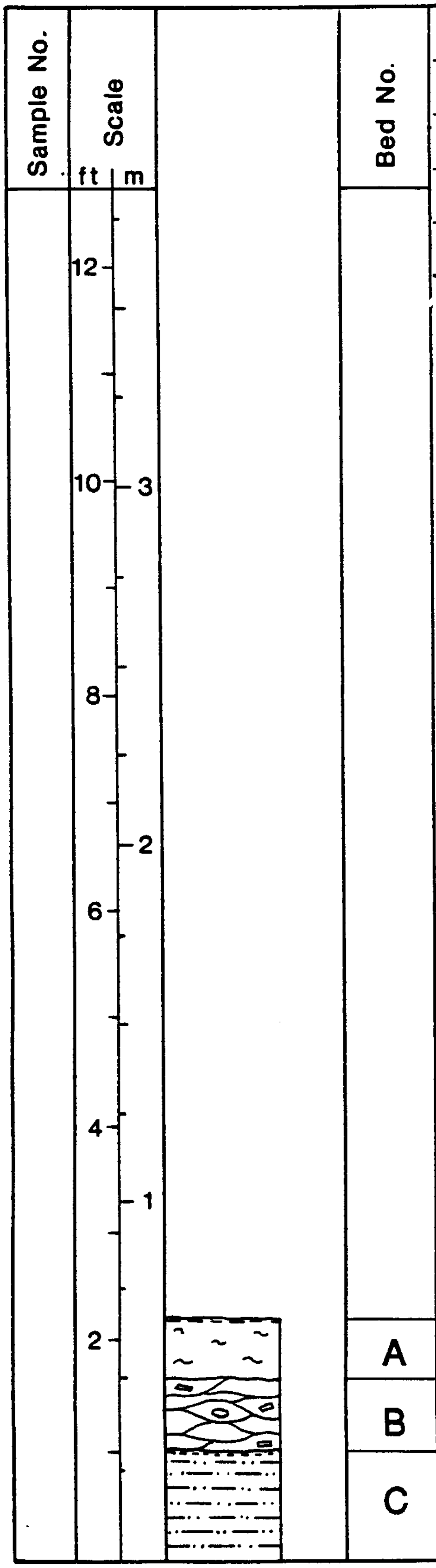
Unit c: 45 cm thick; similar to units a and b, with less phylloid algal fragments(10-15%), more unidentifiable medium to fine sand-sized algal-coated skeletal grains; several small (< 10 cm long) laminar chaetetids throughout.

Fossils randomly oriented throughout bed 4 (except for chaetetids in life position); chaetetids begin on phylloid algal fragments; indistinct bedding; contact with overlying bed sharp, marked by olive black (5Y2/1) clay-rich laminae.

3. Phylloid Algal Wackestone: 16 cm thick; medium gray (N5), no weathered surface; poorly-sorted; coarse-grained; 15-20% fossils, including phylloid algae fragments (8-12%), Composita (1-2%, few articulated, most mud-filled but some spar-filled), rugose corals, high-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains; wavy bedded; olive black (5Y2/1) clay-rich laminae throughout; contact with overlying bed sharp to gradational.

2. Fusulinid Skeletal Packstone: 10 cm thick; light gray (N7), no weathered surface; poorly-sorted; coarse- to fine-grained; 70-80% fossils, including fusulinids (40%), phylloid algae (3-6%), high-spired gastropods, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (20-35%); 30% of fusulinids and 30-40% of other fossil grains algal-coated; phylloid algae more common upward, fusulinids and other fossil grains less common upward; sorting decreases upward; wavy bedded; contact with overlying bed gradational.

1. Fusulinid Skeletal Carbonate Mudstone, 10 cm exposed, lower contact covered: medium dark gray (N4), no weathered surface; moderately well-sorted, medium- to fine-grained; 5% fossils, including fusulinids (1%), crinoid debris (1%), brachiopod shell fragments, one small articulated Composita, unidentifiable medium to fine sand-sized skeletal grains (2-3%, most algal-coated); fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.



DESCRIPTION: Section 729-C1, Locality 729

34 meters N 63 E of 729-S1

LOCATION: SW 1/4, NE 1/4, sec 34, T.34S,

R.17 E, Montgomery Co., Kansas

MEASURED BY: Vincent Voegeli 1989

SECTION 729-C1

bed

Amoret Limestone Member

A. Phylloid Algal Wackestone, 14 cm thick; medium gray (N5); poorly-sorted, coarse- to fine-grained; 30% fossils, including phylloid algal fragments (20%, up to 1 cm in length), brachiopod shell fragments, fusulinids, bryozoan fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (8%); few fossils algal-coated; fossils randomly oriented; bedding indistinct; dark gray (N3) mottling throughout; upper 1 cm medium- to fine-grained crinoidal skeletal packstone with numerous olive black (5Y2/1) clay-rich laminae; upper contact gradational, with 0.5 cm thick sparsely fossiliferous olive black (5YR2/1) shale at contact.

B. Crinoidal Wackestone, 24 cm thick; medium dark gray (N4); moderately well-sorted, medium- to fine-grained; 30% fossils, including small crinoid debris (15%, < 0.3 cm), fusulinids, bryozoan fragments, unidentifiable fine sand-sized skeletal grains (10-12%); coarsens upward; wavy bedded; numerous olive black (5Y2/1) clay-rich laminae throughout, more common downward; upper contact sharp.

Bandara Shale Formation

C. Micaceous Mudshale, 33 cm recovered; medium gray (N5); becomes calcareous in upper 3 cm; Planolites-like horizontal traces, vertical escape structures, small skeletal fragments (<1%), plant fragments?; upper contact sharp, marked by thin (.5 cm) claystone parting.

APPENDIX B

MEASURED SECTION DESCRIPTIONS

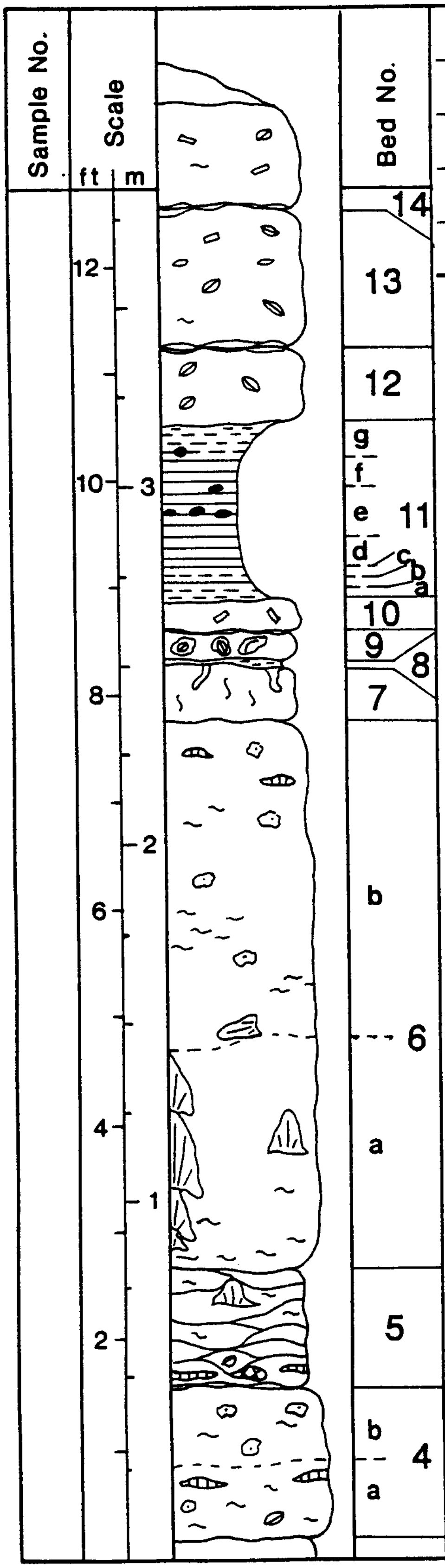
LOCALITY 692

Active quarry operated by Harry Keith and Sons, Coffeyville, Kansas

Samples collected at locality 692

Sample no.	Level
692-S3	
S-3.	
1	middle part, bed 1
4	lower half bed 4
5	middle part, bed 5
6a	lower half, bed 6a
6b	middle part, bed 6b
6c	middle part, bed 6c
7	upper part, bed 7
9	middle part, bed 10
692-S4	
S-4.	
2	middle part, bed 2
4	lower part, bed 4
6a	middle part, bed 6a
6b	middle part, bed 6b
6c	upper part, bed 6b
692-S5	
S-5.	
1a	lower contact, bed 1
1b	upper contact, bed 1
2	middle part, bed 2
4a	lower contact, bed 4
4b	middle part, bed 4
4c	upper part, bed 4
6a	lower third, bed 6a
6b	upper part, bed 6a
7a	lower part, bed 6b
7b	upper part, bed 6b
7c	lower part, bed 7
7d	upper contact, bed 7
9a	lower part, bed 10
9b	upper contact, bed 10

Sample no.	Level
692-S7	
S-7.	
1	middle part, bed 1
2	entire thickness, bed 2
3	upper part, bed 3
4	middle part, bed 4
5	upper contact, bed 5
6	lower third, bed 6a
7	upper part, bed 6b
8	entire thickness, bed 9
692-S10	entire thickness, bed 3
S-10.	
7	composite sample, bed 8
9a	lower contact, bed 10
9b	upper third, bed 10
10a	unit a, bed 11
10b	unit b, bed 11
10c	unit c, bed 11
10d	unit d, bed 11
10eL	lower half, unit e, bed 11
10eU	upper half, unit e, bed 11
10f	unit f, bed 11
10g	unit g, bed 11



DESCRIPTION: Section 692-S3, Locality 692

79 meters north of east SE corner

LOCATION: SW1/4, NW 1/4, sec 35, T.34S, R.17 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 692-S3

bed

Worland Limestone Member

14. Skeletal Wackestone, 32 cm thick, modern soil developed on upper surface; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including crinoid debris (8-10%), Composita, productids, and other brachiopod shell fragments, bryozoan fragments, phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains (10-12%); fossils show some preferential horizontal alignment; medium gray (N5) mottling throughout;

13. Brachiopod Skeletal Wackestone; 44 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (2-3%, few articulated), Crurithyris (1-2%, occasionally articulated, few with geopetal), crinoid debris (2-3%, few stems up to 1 cm long), gastropods, Lophophyllidium, fusulinids (1-2%), phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossil randomly oriented; indistinct bedding; upper contact gradational, marked by olive black (5Y2/1) clay-rich laminae.

12. Brachiopod Wackestone, 23 cm thick; light olive gray (5Y6/1), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 35-40 % fossils, including Crurithyris (2-3%, frequently articulated), Composita (1-2%, occasionally articulated), productid shell fragments and spines, Mesolobus, crinoid debris (1-2%), gastropods, bivalve shell fragments, unidentifiable medium to fine sand-sized skeletal grains (20%); fossils randomly oriented; bedding indistinct; medium gray (N5) mottling throughout; olive gray (5Y6/1) claystone stringers concentrated in lower 3 cm; olive black (5Y6/1) clay-rich laminae at gradational upper contact.

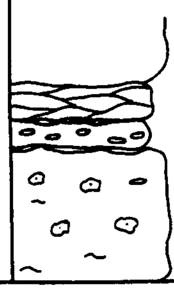
Lake Neosho Shale Member

11. Shale: 56 cm thick; divisible into seven units, a-g.
Unit a: Calcareous Clayshale, 6 cm thick; olive gray (5Y3/2); 25-30% fossils, including Crurithyris (2-3%, few articulated), productids (3-4%, shell fragments and spines), other brachiopod shell fragments, ramose bryozoan fragments, crinoid ossicles (5-7%), unidentifiable medium to fine sand-sized skeletal grains (8-12%); fossils compacted and fractured; flaggy partings; gradational upper contact.
Unit b: Slightly Calcareous Shale, 3 cm thick; grayish black (N2), weather dark gray (N3); 5% fossils,

(cont.)

Sample No.	Scale (ft / m)		Bed No.	DESCRIPTION: Section 692-S3, Locality 692
				79 meters north of east SE corner
				LOCATION: (cont.)
				MEASURED BY:

Scale: ft 12, 10, 8, 6, 4, 2; m 3, 2, 1



Bed No.: 3, 2, 1

including Mesolobus shell fragments, productid shell fragments, Crurithyris, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; micaceous in lower part; platy partings; gradational upper contact.

Unit c: Calcareous Clayshale, 4 cm thick; olive black, weathers olive gray (5Y4/1); 10-15% fossils, including Crurithyris (2-3%), Mesolobus, Orbiculoidea, other brachiopod shell fragments, conodonts, unidentifiable medium to fine sand-sized skeletal grains (5%); flaggy partings; upper contact gradational.

Unit d: Non-calcareous Shale, 8 cm thick; grayish black (N2), weathers dark gray (N3); rare fossils (<1%), including Orbiculoidea, fish scale, plant fragments (Calamites?); fissile to platy partings; upper contact gradational.

Unit e: Non-calcareous Phosphatic Shale, 18 cm thick; black (N1), weathers dark gray (N3); very rare fossils, (<<1%), including conodonts, Orbiculoidea; discoidal to spherical phosphate nodules concentrated in band near center, occur randomly above this; nodules contain Orbiculoidea, Petrodus, plant fragments, unidentifiable debris; rare Planolites-like traces in upper third; fissile partings; upper contact gradational.

Unit f: Non-calcareous Phosphatic Shale, 9 cm thick; grayish black (N2), weathers medium dark gray (N4); rare fossils (<1%), including Orbiculoidea, conodonts, fish scales; Planolites-like traces common throughout (occasionally pyritized); few phosphate nodules throughout, contain Orbiculoidea, unidentifiable debris; fissile to platy partings; upper contact sharp.

Unit g: Calcareous Clayshale, 8 cm thick; olive gray (5Y4/1), weathers yellowish gray (5Y7/2); 15-20% fossils, including Crurithyris (4-7%, several articulated), Mesolobus (1-2%, few whole valves), Petrodus, Orbiculoidea, Juresania shell fragments and spines, crinoid ossicle and stems (few up to 3 cm long in upper part), unidentifiable medium to fine sand-sized skeletal grains; few spherical phosphate nodules, contain Petrodus, Orbiculoidea, unidentifiable debris; platy partings; upper contact gradational.

Amoret Limestone Member

10. Crinoidal Bryozoan Wackestone, 12 cm thick; light olive gray (5Y6/1), weathers greenish gray (5GY6/1); moderately well-sorted, medium- to fine-grained; 5-8% fossils, including crinoid debris (1%), bryozoan fragments (1%), brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils aligned horizontally, parallel to wavy bedded; few dark gray (N3) micritic lithoclast; discontinuous laterally, pinches out left of section; upper contact sharp.

(cont.)

9. Brachiopod Oncolitic Wackestone, 10 cm thick; light olive gray (5Y6/1), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (5%, frequently articulated, all mud-filled, few with preserved brachidia), productids (5%, Juresania, Linoproductus, occasionally articulated, most whole valves overturned), brachiopod spines, crinoid debris, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (15-20%); small (5 cm long, 3 cm high) laminar chaetetid in middle part, appears to have overturned at least once during growth; nearly all fossils "algal"-coated, most completely coated; "algal"-coatings have digitate to concentric growth, digitate growth dominant on larger fragments; some "algal"-coatings appear bored; fossils fragments coarser upward, less "algal"-coated upward; olive black (5Y2/1) clay-rich stylolitic laminae throughout, concentrated at upper, lower contacts; compaction evident along laminae; grayish black (N2) shale parting at upper and lower contacts; upper contact gradational.

8. Slightly Calcareous Mudshale, 2-4 cm thick; greenish gray (5G6/1), weathers light greenish gray (5G8/1); 1-2% fossil, including Crurithyris and other brachiopod shell fragments, high-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains; corroded, abraded limestone fragments (5-7%, up to 1 cm, reworked clast of underlying bed); flaggy bedding; thickens over depressions in underlying bed; discontinuous laterally; sharp upper contact.

7. Skeletal Carbonate Mudstone, 20 cm thick; light gray (N7), weathers yellowish gray (5Y8/1); well-sorted, fine-grained; rare fossils (1-2%), including gastropods, ostracodes, brachiopod? shell fragments, unidentifiable fine sand-sized skeletal grains; fossils randomly oriented; bedding indistinct; numerous mud-filled vertical rootlet- and/or burrow-like structures (up to 1 cm wide, 4 cm long, increase in abundance and size upward, some bifurcate downward); few vertical spar-filled fractures; bird's eye structures; few stylolites at upper contact; discontinuous laterally, pinches out to either side of this section; upper surface irregular, pitted and eroded; in-place brecciation at upper surface, inter-fingered with overlying bed; upper contact sharp.

6. Chaetetid Phylloid Algal Skeletal Wackestone, 156 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; roughly divisible into two units, a and b.

Unit a: 55-60 cm thick; poorly-sorted, coarse- to fine-grained; lower 10 cm 30% fossils, including phylloid algae (15%), Composita (1-2%, few articulated), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10%); above this 40-50% fossils, including phylloid algae (3-5%), crinoid debris (5-7%), Composita (2-3%, few articulated), gastropods, bryozoan fragments (1-2%), unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); one expanding upward extended domical chaetetid, begins at lower contact on bellerophontid, continues upward to upper contact (sediment drapes over surface 5-7 cm); one high domical (smooth) chaetetid at 30 cm (20 cm wide, 15 cm high, begins on phylloid algal fragments); most recognizable fossils near chaetetids, mostly unidentifiable fine-grained fossils debris farther from chaetetids; fossils randomly oriented; bedding indistinct; upper contact gradational;

Unit b: 96 to 101 cm thick; similar to upper portion of unit a; finer grained, less recognizable skeletal debris; one toppled high domical (smooth) chaetetid at lower contact with unit a (lying on side); few small (< 10 cm long) laminar chaetetids in upper 20 cm; medium dark gray (N4) mottling throughout; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

5. Phylloid Algal Brachiopod Wackestone, 39 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 30% fossils, including phylloid algal fragments (10%), Composita (2-3%, few articulated with geopetal), Crurithyris (1%), low-spired gastropods, crinoid debris, unidentifiable medium to fine

(cont.)

sand-sized skeletal grains (12%); laminar chaetetids near lower contact (<20 cm long, up to 4 cm high, fragmented in-place); one low-domical chaetetid in upper third (15 cm high); fossils randomly oriented; numerous olive black (5Y2/1) clay-rich laminae throughout, concentrated near lower contact, some stylolites along these; chert nodules (up to 20 cm long) near lower contact, same fossil composition as surrounding bed; upper contact gradational.

4. Phylloid Algal Wackestone, 46 cm thick, medium light gray (N6), weather yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; can be roughly divided into 2 units, a and b.

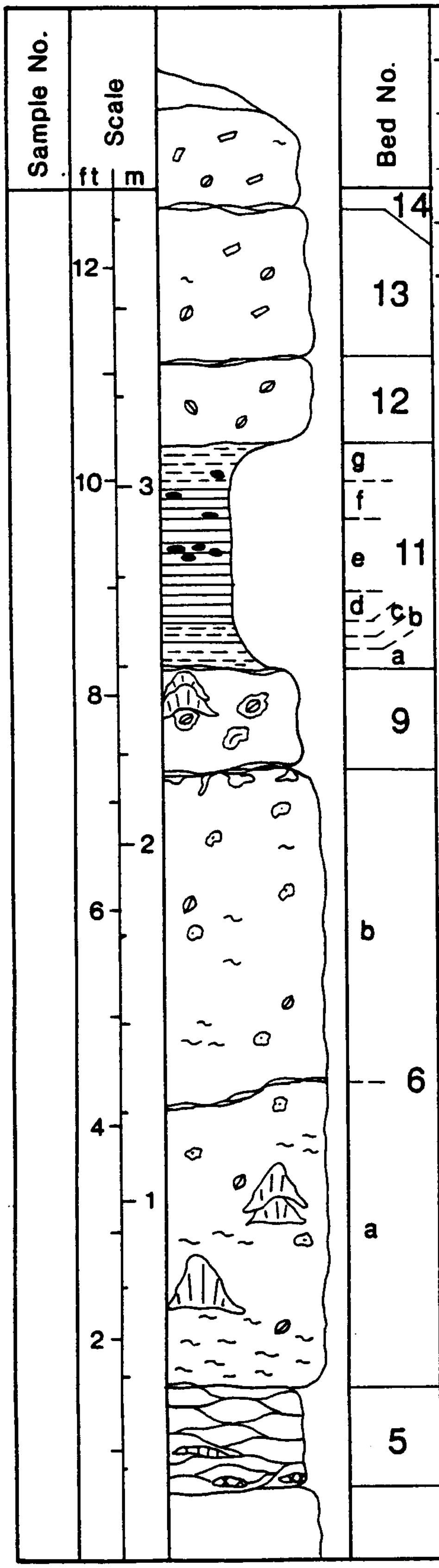
Unit a: 45-50% fossils, including phylloid algal fragments (25-30%), Composita (2-3%, few articulated), Lophophyllidium, Pulchratia, productid spines, unidentifiable medium to fine sand-sized skeletal grains (15%, sixth algal-coated); laminar chaetetids in upper part (up to 15 cm long, 4 cm high); upper contact gradational;

Unit b: similar to unit a, contains less phylloid algae (15-20%), more unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated). Fossils throughout randomly oriented; bedding indistinct; few olive black (5Y2/1) shale stringers at upper contact (1-4 cm thick), contains skeletal packstone lenses consisting mostly of crinoid debris, also bryozoan fragments, brachiopod shell fragments, and unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

3. Phylloid Algal Wackestone, 10 cm thick; medium gray (N5), no weathered surface; poorly-sorted, fine- to coarse-grained; 10-15% fossils, including phylloid algae (1-2%), Lophophyllidium (1-2%, few in apparent life position including one attached to chaetetid), unidentifiable medium to fine sand-sized skeletal grains; one laminar chaetetid at lower contact (15 cm long, begins directly on clay-rich laminae); numerous olive black (5Y2/1) clay-rich laminae throughout (imparts brecciated appearance); some stylolites and evidence of solution and compaction along laminae; upper contact is gradational, marked by disappearance of clay-rich laminae.

2. Fusulinid Skeletal Packstone, 10 cm thick; light olive gray (5Y6/1), no weathered surface; poorly-sorted, coarse- to fine-grained; 70-75% fossils, including fusulinids (60%, some appear worn and abraded, quarter algal-coated), crinoid debris (2-3%), unidentifiable medium to fine sand-sized skeletal grains (5-15%, two-thirds algal-coated); fossil somewhat horizontal aligned; wavy bedding; upper contact gradational, marked by olive black (5Y2/1) clay-rich laminae.

1. Skeletal Carbonate Mudstone, 30 cm thick, lower contact covered; medium gray (N5), no weathered surface; moderately well-sorted, medium- to fine-grained; 5% fossils, including brachiopod shell fragments, phylloid algae? (highly fragmented), fusulinids, unidentifiable medium to fine sand-sized skeletal grains (3%); fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.



DESCRIPTION: Section 692-S4, Locality 692

132 meters north of east SE corner

LOCATION: SW 1/4, NW 1/4, sec 35, T.34S, R.17 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 692-S4

bed

Worland Limestone Member

14. Skeletal Wackestone, 30 cm thick, modern soil on surface; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including crinoid debris (8-10%), Composita, Crurithyris, productids, and other brachiopod shell fragments, bryozoan fragments, phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains (10-12%); fossils show some preferential horizontal alignment; medium gray (N5) mottling throughout.

13. Brachiopod Skeletal Wackestone; 45 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (2-3%, few articulated), Crurithyris (1-2%, occasionally articulated, few with geopetal), crinoid debris (2-3%, few stems up to 1 cm long), gastropods, Lophophyllidium, fusulinids (1-2%), phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossil randomly oriented; indistinct bedding; upper contact gradational, marked by olive black (5Y2/1) clay-rich laminae.

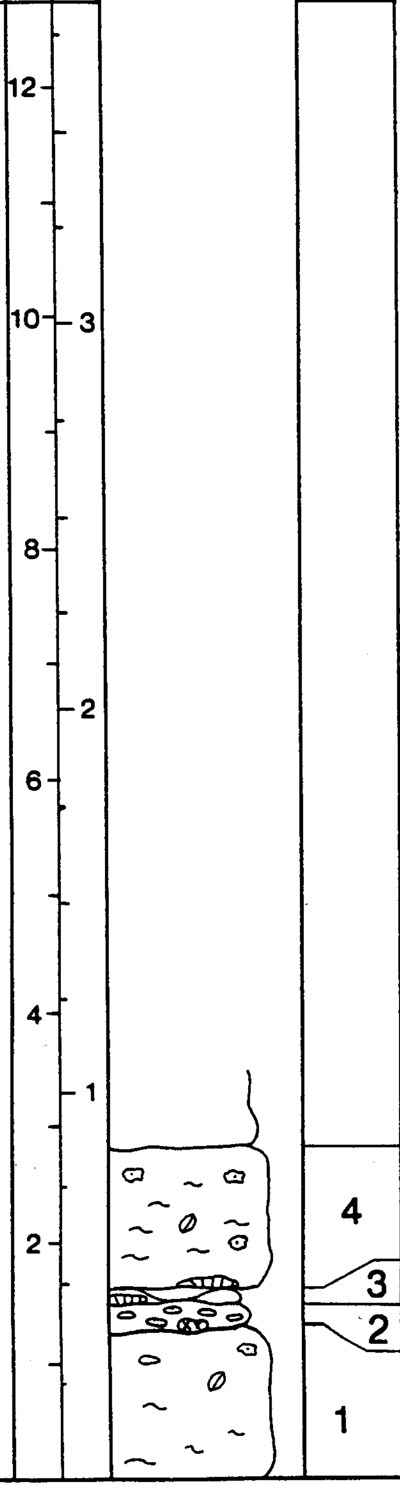
12. Brachiopod Wackestone, 25 cm thick; light olive gray (5Y6/1), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 35-40 % fossils, including Crurithyris (2-3%, frequently articulated), Composita (1-2%, occasionally articulated), productid shell fragments and spines, Mesolobus, crinoid debris (1-2%), gastropods, bivalve shell fragments, unidentifiable medium to fine sand-sized skeletal grains (20%); fossils randomly oriented; bedding indistinct; medium gray (N5) mottling throughout; olive gray (5Y6/1) claystone stringers concentrated in lower 3 cm; olive black (5Y6/1) clay-rich laminae at gradational upper contact.

Lake Neosho Shale Member

11. Shale: 59 cm thick; divisible into seven units, a-g.
Unit a: Calcareous Clayshale, 6 cm thick; olive gray (5Y3/2); 25% fossils, including Crurithyris (2-3%, few whole articulated), productids (3-4%, shell fragments and spines), other brachiopod shell fragments, ramose bryozoan fragments, crinoid ossicles (5-7%), unidentifiable medium to fine sand-sized skeletal grains (8-12%); fossils compacted and fractured; flaggy partings; gradational upper contact.
Unit b: Slightly Calcareous Shale, 3 cm thick; grayish black (N2), weather dark gray (N3); 5% fossils,

(cont.)

Sample No.	Scale ft m		Bed No.	**DESCRIPTION:** Section 692-S4, Locality 692
				132 meters north of east SE corner
				LOCATION: (cont.)
				MEASURED BY:



including Mesolobus shell fragments, productid shell fragments, Crurithyris, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; micaceous in lower part; platy partings; gradational upper contact.

Unit c: Calcareous Clayshale, 4 cm thick; olive black, weathers olive gray (5Y4/1); 10-15% fossils, including Crurithyris (2-3%), Mesolobus, Orbiculoidea, other brachiopod shell fragments, conodonts, unidentifiable medium to fine sand-sized skeletal grains (5%); flaggy partings; upper contact gradational.

Unit d: Non-calcareous Shale, 8 cm thick; grayish black (N2), weathers dark gray (N3); rare fossils (<1%), including Orbiculoidea, plant fragments; fissile to platy partings; upper contact gradational.

Unit e: Non-calcareous Phosphatic Shale, 18 cm thick; black (N1), weathers dark gray (N3); very rare fossils, (<<1%), including conodonts, Orbiculoidea; discoidal to spherical phosphate nodules concentrated in band near center, occur randomly above this; nodules contain Orbiculoidea, Petrodus, unidentifiable debris; fissile partings; upper contact gradational.

Unit f: Non-calcareous Phosphatic Shale, 9 cm thick; grayish black (N2), weathers medium dark gray (N4); rare fossils (<1%), including Orbiculoidea, conodonts, fish scales; Planolites-like traces common throughout (occasionally pyritized); few phosphate nodules throughout, contain Orbiculoidea, unidentifiable debris; fissile to platy partings; upper contact sharp.

Unit g: Calcareous Clayshale, 11 cm thick; olive gray (5Y4/1), weathers yellowish gray (5Y7/2); 15-20% fossils, including Crurithyris (4-7%, several articulated), Mesolobus (1-2%, few whole valves), Petrodus, Juresania shell fragments and spines, crinoid ossicle and stems (few up to 3 cm long in upper part), unidentifiable medium to fine sand-sized skeletal grains; few spherical phosphate nodules, contain Petrodus, Orbiculoidea, unidentifiable debris; platy partings; upper contact gradational.

Amoret Limestone Member

10. Laterally discontinuous, missing at this section

9. Brachiopod Oncolitic Wackestone, 31 cm thick; light olive gray (5Y6/1), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 30-40% fossils, including Composita (10%, frequently articulated, mud-filled), Juresania (8%, frequently articulated), Desmoinesia, Antiquatonia, crinoid debris, Lophophyllidium, unidentifiable medium to fine sand-sized skeletal grains (10-15%); most fossils completely algal-coated (up to 1 cm thick); algal coatings decrease in thickness upward, many grains only partially algal-coated in upper part; (cont.)

one low domical chaetetid in upper half, begins on Composita oncolite, continues to upper surface; fossils randomly oriented (except chaetetid which is in-place); olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper, lower contacts (gives bed a nodular appearance); dark gray (N3) shale partings at upper and lower contacts; upper contact sharp.

8. Laterally discontinuous, missing at this section.

7. Laterally discontinuous, missing at this section.

6. Wackestone: 174 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); divisible into 2 units, a and b.

Unit a: Phylloid Algal Chaetetid Wackestone, 75-80 cm thick; poorly-sorted, coarse- to fine-grained; lower 20 cm 30% fossils, including phylloid algae (15-20%), Composita (1-2%, few articulated), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10%); above this 40-50% fossils, including phylloid algae (3-5%), crinoid debris (5-7%), Composita (2-3%, few articulated), gastropods, bryozoan fragments (1-2%), unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); one high domical (smooth) chaetetid 20 cm above lower contact (20 cm high, 20 cm wide); one high domical (ragged) chaetetid 40 cm above lower contact (20 cm wide, 25 cm high), continues to upper contact with unit b; chaetetids begin on articulated Composita; most recognizable fossils near chaetetids, mostly unidentifiable fine-grained fossil grains further from chaetetids; fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive gray (5Y2/1) clay-rich laminae;

Unit b: Skeletal Wackestone, 94-99 cm thick; moderately well-sorted, medium- to fine-grained; 20-25 % fossil, including phylloid algae (1%), Composita and other brachiopod shell fragments (3-4%), crinoid debris (2-3%), bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (10-15%, quarter algal-coated); fossils randomly oriented; upper surface pitted, eroded; numerous vertical spar- and mud-filled burrow- and/or rootlet-like structures in upper 20 cm (up to 5 cm long, 1 cm wide); few chert-filled fractures on upper surface; upper contact irregular, sharp.

5. Phylloid Algal Wackestone, 30 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (15-25%), Composita (1-2%, few articulated), Lophophyllidium, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10-15%); one laminar chaetetid (10 cm long, 3 cm high) at 10 cm above lower contact; fossils (except chaetetid) randomly oriented; bedding indistinct; olive black (5Y2/1) clay-rich laminae throughout; olive gray (5Y3/2) mottling common in upper half; chert nodules near lower contact; upper contact gradational, marked by disappearance of clay-rich laminae.

4. Phylloid Algal Wackestone, 33 cm thick; medium gray (N5) to light gray (N7), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 35% fossils, including phylloid algal fragments (10-20%, up to several cm in length), gastropods, crinoid debris, Composita (1-2%, few articulated), productid shell fragments, fenestrate bryozoan fragments, Lophophyllidium (in lower half), straight-shelled cephalopod (4 cm long), unidentifiable medium to fine sand-sized skeletal grains (10-15%); one small (10 cm long) laminar chaetetid at lower contact; some skeletal fragments algal-coated (5%); phylloid algal fragments larger, more abundant in lower half, unidentifiable skeletal grains and algal-coated grains more abundant upward; fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

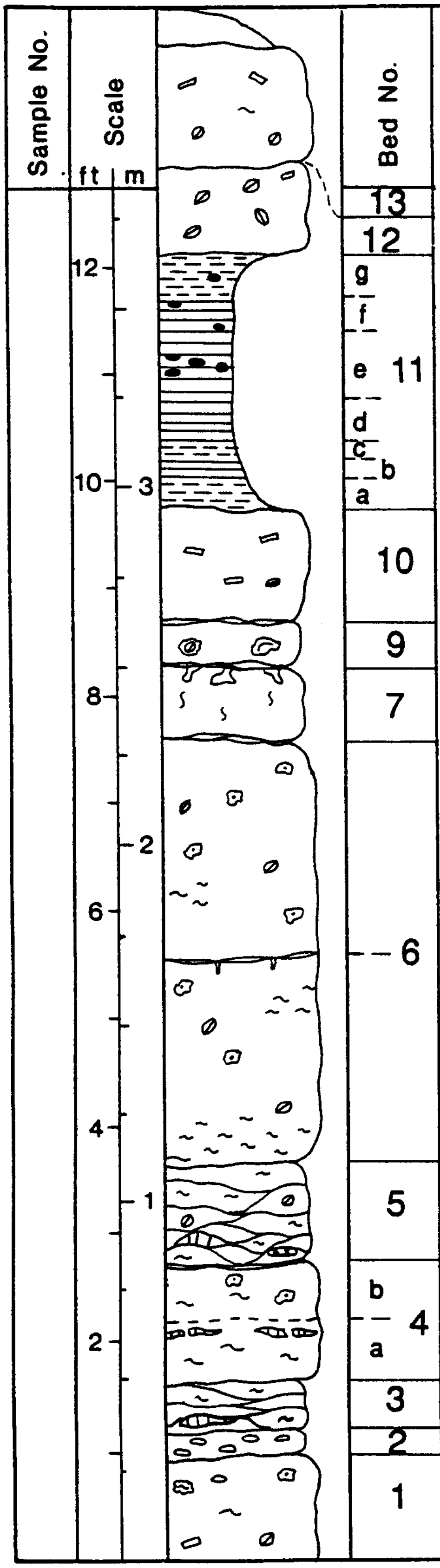
3. Phylloid Algal Wackestone, 4 cm thick; medium gray (N5), no weathered surface; poorly-sorted, fine- to coarse-grained; 10-15% fossils, including phylloid algae (1-2%), Lophophyllidium (1-2%, few in apparent life position), unidentifiable medium to fine sand-

(cont.)

sized skeletal grains; one laminar chaetetid at lower contact (15 cm long, begins directly on clay-rich laminae); numerous olive black (5Y2/1) clay-rich laminae throughout (imparts brecciated appearance); some stylolites and evidence of solution and compaction along laminae; upper contact is gradational, marked by disappearance of clay-rich laminae.

2. Fusulinid Skeletal Packstone, 7 cm thick; light olive gray (5Y6/1), no weathered surface; poorly-sorted, coarse- to fine-grained; 70-80% fossils, including fusulinids (60%, some appear worn and abraded, quarter algal-coated), crinoid debris (2-3%), unidentifiable medium to fine sand-sized skeletal grains (5-15%, two-thirds algal-coated); silicious nodule in lower half (same fossil composition as surrounding sediment); fossil somewhat horizontal aligned; wavy bedding; upper contact sharp to gradational, marked by olive black (5Y2/1) clay-rich laminae.

1. Skeletal Wackestone to Carbonate Mudstone, 37 cm thick; medium gray (N5), no weathered surface; moderately well-sorted, medium- to fine-grained; 5-15% fossils; Lower third 10-15% fossils, including phylloid algae (2-3%), Composita (one articulated), productids (2 articulated, both overturned), crinoid debris, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (8-10%); 5% fossils in upper two-thirds, including brachiopod shell fragments, phylloid algae? (highly fragmented), fusulinids, unidentifiable medium to fine sand-sized skeletal grains (3%); fossils randomly oriented; bedding indistinct; lower contact sharp (quarry floor); upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.



DESCRIPTION: Section 692-S5, Locality 692

33 meters west of road on south side

LOCATION: SW 1/4, NW 1/4, sec 35, T.34S, R.17 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 692-S5

bed

Worland Limestone Member

13. Brachiopod Skeletal Wackestone, 40 cm thick, overlain by modern soil; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (5%, occasionally articulated), productids (1-2%, rarely articulated), Crurithyris (2-3%, occasionally articulated), crinoid debris (3-4%), phylloid algae (2-3%, highly fragmented), fusulinids (1-3%, more abundant upward), unidentifiable medium to fine sand-sized skeletal grains (15-20%); fossils randomly oriented, overall decrease in abundance upward; fines upward; distinct parting at 28 cm, marked by olive black (5YR2/1) clay-rich stylolitic laminae; bedding indistinct.

12. Brachiopod Wackestone, 23 cm thick; light olive gray (5Y6/1), weathers medium gray (N5); poorly-sorted, fine- to coarse-grained; 40-45% fossils, including Composita (10%, fragmented to articulated with geopetal, few in life position), Crurithyris (5%, occasionally articulated), productid shell fragments, Wellerella, Mesolobus, crinoid debris (5%), bivalve fragments, gastropods, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (20-25%); fossils randomly oriented; medium gray (N5) mottling throughout; few olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper contact; upper contact gradational to sharp.

Lake Neosho Shale Member

11. Shale: 70 cm thick; divisible into seven units, a-g.
Unit a: Calcareous Clayshale, 6-8 cm thick; olive gray (5Y3/2); 25-30% fossils, including Crurithyris (2-3%, few whole articulated), productids (3-4%, shell fragments and spines), other brachiopod shell fragments, ramose bryozoan fragments, crinoid ossicles (5-7%), unidentifiable medium to fine sand-sized skeletal grains (8-12%); fossils compacted and fractured; flaggy partings; gradational upper contact.
Unit b: Slightly Calcareous Shale, 3-5 cm thick; grayish black (N2), weather dark gray (N3); 5% fossils, including Mesolobus shell fragments, productid shell fragments, Crurithyris, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; micaceous in lower part; platy partings; gradational upper contact.
Unit c: Calcareous Clayshale, 5 cm thick; olive black, weathers olive gray (5Y4/1); 10-15% fossils, including Crurithyris (2-3%), Mesolobus, Orbiculoidea, other

(cont.)

brachiopod shell fragments, conodonts, unidentifiable medium to fine sand-sized skeletal grains (5%); flaggy partings; upper contact gradational.

Unit d: Non-calcareous Shale, 12 cm thick; grayish black (N2), weathers dark gray (N3); rare fossils (<1%), including Orbiculoidea, fish scale, plant fragments (Calamites?); fissile to platy partings; upper contact gradational.

Unit e: Non-calcareous Phosphatic Shale, 20 cm thick; black (N1), weathers dark gray (N3); very rare fossils, (<<1%), including conodonts, Orbiculoidea; discoidal to spherical phosphate nodules concentrated in band near center, occur randomly above this; nodules contain Orbiculoidea, Petrodus, plant fragments, unidentifiable debris; rare Planolites-like traces in upper third; fissile partings; upper contact gradational.

Unit f: Non-calcareous Phosphatic Shale, 10 cm thick; grayish black (N2), weathers medium dark gray (N4); rare fossils (<1%), including Orbiculoidea, conodonts, fish scales; Planolites-like traces common throughout (occasionally pyritized); few phosphate nodules throughout, contain Orbiculoidea, unidentifiable debris; fissile to platy partings; upper contact sharp.

Unit g: Calcareous Clayshale, 12 cm thick; olive gray (5Y4/1), weathers yellowish gray (5Y7/2); 15-20% fossils, including Crurithyris (4-7%, several articulated), Mesolobus (1-2%, few whole valves), Petrodus, Orbiculoidea, Juresania shell fragments and spines, crinoid ossicle and stems (few up to 3 cm long in upper part), unidentifiable medium to fine sand-sized skeletal grains; few spherical phosphate nodules, contain Petrodus, Orbiculoidea, unidentifiable debris; platy partings; upper contact gradational.

Amoret Limestone Member

10. Crinoidal Bryozoan Wackestone to Carbonate Mudstone, 34 cm thick; light olive gray (5Y6/1), weathers greenish gray (5GY6/1); moderately well-sorted, medium- to fine-grained; 5-10% fossils, including crinoid debris (1%), bryozoan fragments (1%), brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils aligned horizontally, parallel to wavy bedded; discontinuous crinoidal-Mesolobus packstone lenses in upper half; discontinuous laterally, reaches maximum thickness at this section; upper contact sharp.

9. Brachiopod Oncolitic Wackestone, 12 cm thick; light olive gray (5Y6/1), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 30% fossils, including Composita (5%, frequently articulated, all mud-filled, few with preserved brachidia), productids (5%, Juresania, Linoproductus, occasionally articulated, most whole valves overturned), brachiopod spines, crinoid debris, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (15-20%); nearly all fossils "algal"-coated, most completely coated; "algal"-coatings have digitate to concentric growth, digitate growth dominant on larger fragments; some "algal"-coatings appear bored; fossils fragments coarsen upward, less "algal"-coated upward; olive black (5Y2/1) clay-rich stylolitic laminae throughout, concentrated at upper, lower contacts; compaction evident along laminae; 1-2 cm thick grayish black (N2) shale partings at upper, lower contacts; upper contact sharp.

8. Laterally discontinuous, missing at this section

7. Skeletal Carbonate Mudstone, 23 cm thick; light gray (N7), weathers light olive gray (5Y6/1); well-sorted, fine-grained; rare fossils (1-2%), including gastropods, ostracodes, brachiopod? shell fragments, unidentifiable medium to fine sand-sized skeletal grains; fossils randomly oriented; bedding indistinct; numerous mud-filled vertical rootlet- and/or burrow-like structures (up to 1 cm wide, 4 cm long, increase in abundance and size upward, some bifurcate downward); few vertical spar-filled fractures throughout; bird's eye structures throughout; few stylolites at upper contact; discontinuous laterally,

(cont.)

pinches out to either side of this section; upper surface irregular, pitted and eroded; upper contact sharp.

6. Crinoidal Phylloid Algal Skeletal Wackestone, 120-122 cm thick; light gray (N7) to very light gray (N8), weathers yellowish gray (5Y7/2); poorly to moderately-sorted, coarse- to fine-grained; divisible into 2 units, a and b.

Unit a: 55 cm thick; 30-35% fossils, including phylloid algal fragments (5-7%, mostly in lower 20 cm, rare above this), crinoid debris (5-7%), Composita and other brachiopod shell fragments (1-2%), bryozoan fragments, low-spired gastropods, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (15-20%, third algal-coated, more abundant upward); fossils randomly oriented; bedding indistinct; abundant olive gray (5Y3/2) mottling throughout; skeletal debris concentrated in mottled areas; upper contact sharp, marked by vertical spar-filled burrow? structures (3-4 cm long, 1 cm wide) and olive black (5Y2/1) clay-rich laminae.

Unit b: 65-67 cm thick; 20-25% fossils, similar to unit a, less identifiable fossils relative to unidentifiable medium to fine sand-sized skeletal grains; fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich stylolitic laminae.

5. Phylloid Algal Brachiopod Wackestone, 31 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 30% fossils, including phylloid algal fragments (10-20%, more abundant in lower two-thirds), Composita (2-3%, few articulated with geopetal), Crurithyris (1%), low-spired gastropods, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (12%); one low domical chaetetid (20 cm long, 10 cm high) in lower half, clay-rich laminae drape over upper surface 4-5 cm.; fossils randomly oriented; numerous olive black (5Y2/1) clay-rich laminae throughout, concentrated near lower contact, some stylolites along these; chert nodules (up to 15 cm long) near lower contact, same fossil composition as surrounding bed; upper contact gradational.

4. Phylloid Algal Wackestone, 34 cm thick, medium gray (N5), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; can be roughly divided into 2 units, a and b.

Unit a: 45-50% fossils, including phylloid algal fragments (25-30%), Composita (2-3%, few articulated), Lophophyllidium, Pulchratia, productid spines, unidentifiable medium to fine sand-sized skeletal grains (15%, sixth algal-coated); two laminar chaetetids at upper contact (10 and 14 cm long, on fragmented in place); upper contact gradational.

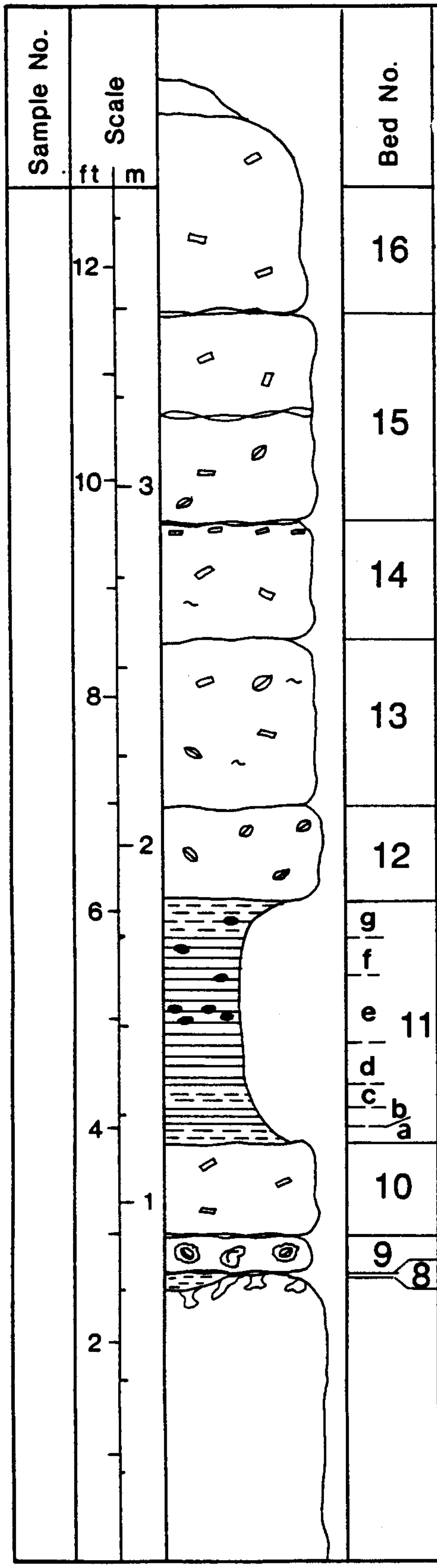
Unit b: similar to unit a, contains less phylloid algae (15-20%), more unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated). Fossils throughout randomly oriented; bedding indistinct; numerous olive black (5Y2/1) shale stringers at upper contact (1-4 cm thick), contains skeletal packstone lenses consisting mostly of crinoid debris, also bryozoan fragments, echinoid spines, brachiopod shell fragments, and unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

3. Phylloid Algal Wackestone, 13 cm thick, medium gray (N5), no weathered surface; poorly-sorted, coarse- to fine-grained; lower half 25-30% fossils, including phylloid algae (5%, highly fragmented), brachiopod shell fragments, fusulinids (1-2%), ramose bryozoan fragments, Lophophyllidium, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (20%, quarter algal-coated); small (5 cm long) laminar chaetetid at lower contact; upper half 20-25% fossils, including phylloid algae (10%, up to several cm in length), Composita (few articulated), Lophophyllidium (2-3%, few in life position, one attached to, and overgrown by, laminar chaetetid), bryozoan, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10%, few algal-coated); laminar (cont.)

chaetetid near lower contact (10 cm long), begin directly on clay-rich laminae; sorting decreases upward; fossils randomly oriented; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper, lower contacts; upper contact gradational.

2. Fusulinids Packstone, 10 cm thick; olive gray (5Y4/1), no weathered surface; poorly-sorted, coarse- to fine-grained; 80% fossils, including fusulinids (60%, third algal-coated), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15%, two-thirds algal-coated); wavy bedded; partially silicified nodule in lower third (7 cm long, same fossil composition as surrounding sediment); upper contact gradational with numerous olive black (5Y2/1) clay-rich laminae.

1. Skeletal Wackestone, 31 cm exposed, lower contact covered; medium gray (N5); moderately well-sorted, medium- to fine-grained; 10-15% fossils; lower half contains crinoid debris (2-3%), Composita (mostly fragments, few articulated, mud-filled), productids (shell fragments and spines, one articulated, overturned), phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains; upper half contains phylloid algal fragments (2-3%, most algal-coated, up to 3 cm long), brachiopod shell fragments, fusulinids, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; fossils randomly oriented throughout; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay rich laminae.



DESCRIPTION: Section 692-S7, Locality 692

50 meters south of inactive south wall

LOCATION: SW 1/4, NW 1/4, sec 35, T.34S, R.17 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 692-S7

bed

Worland Limestone Member

16. Crinoidal Bryozoan Skeletal Wackestone, 53 cm thick (overlain by modern soil); very light gray (N8), weathers pale yellowish orange (10YR8/6); moderately well-sorted, medium- to fine-grained; 10% fossils, including crinoid debris (2-3%), bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (5-7%); fossils randomly oriented; bedding indistinct; few olive black (5Y2/1) clay-rich laminae in upper part.

15. Crinoidal Wackestone, 60 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); moderately well-sorted, medium- to fine-grained; 15-20% fossils, including crinoid debris (5-7%), bryozoan fragments (2-3%), brachiopod shell fragments (2-3%), <u>Composita</u> (three articulated, near lower contact), unidentifiable medium to fine sand-sized skeletal grains (5-7%); fossils randomly oriented; indistinct bedding; medium gray (N5) mottling throughout; olive black (5Y2/1) clay-rich laminae throughout, concentrated near center and upper contact; chert nodules (up to 30 cm long, same fossil composition as surrounding bed) throughout, concentrated near center and upper contact; upper contact gradational.

14. Skeletal Wackestone, 30 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including crinoid debris (8-10%), <u>Composita</u>, productids, and other brachiopod shell fragments, bryozoan fragments, phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains (10-12%); fossils show some preferential horizontal alignment; medium gray (N5) mottling throughout; upper contact sharp, marked by crinoidal packstone lens; olive black (5Y2/1) clay-rich laminae at upper contact.

13. Brachiopod Skeletal Wackestone, 42 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including <u>Composita</u> (5-6%, occasionally articulated), productids (1-2%, rarely articulated), <u>Crurithyris</u> (2-3%, occasionally articulated), <u>Mesolobus</u>, crinoid debris (3-4%), phylloid algae (2-3%, highly fragmented), fusulinids (1-3%, more abundant upward), unidentifiable medium to fine sand-sized skeletal grains (15-20%); fossils randomly oriented, decrease in abundance upward; fines upward; distinct parting at 28 cm, marked by olive black (5YR2/1) clay-rich stylolitic laminae; bedding indistinct; upper contact gradational.

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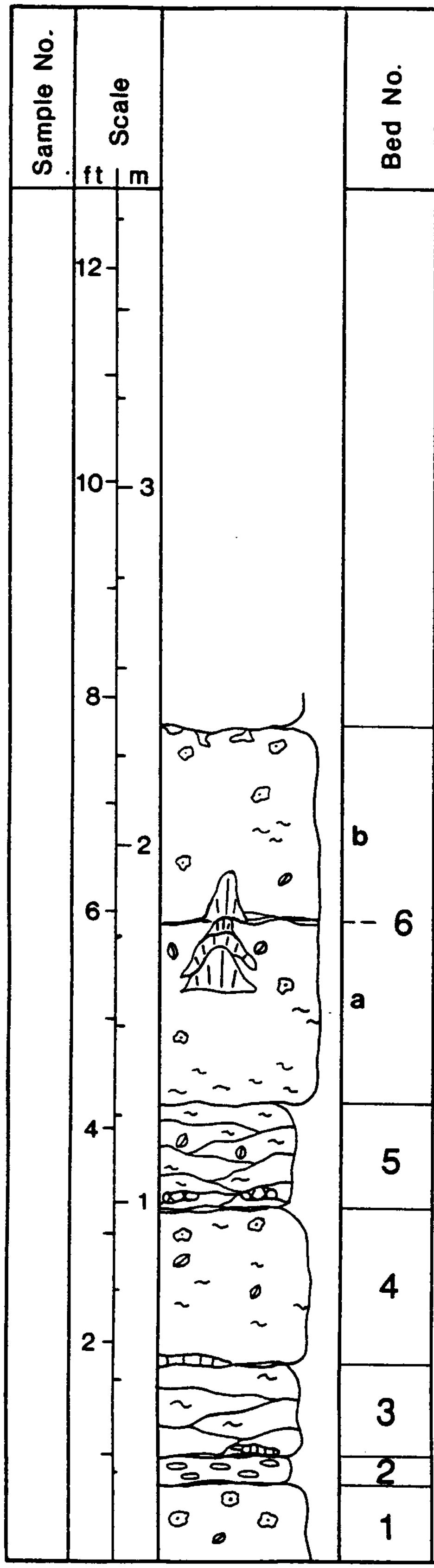


DESCRIPTION: Section 692-S7, Locality 692

50 meters south of inactive south wall

LOCATION: (cont.)

MEASURED BY:

12. Brachiopod Wackestone, 25 cm thick; light olive gray (5Y6/1), weathers medium gray (N5); poorly-sorted, fine- to coarse-grained; 40-45% fossils, including Composita (10%, fragmented to articulated with geopetal, few in life position), Crurithyris (5%, occasionally articulated), productid shell fragments, Wellerella, crinoid debris (5%), bivalve fragments, unidentifiable medium to fine sand-sized skeletal grains (20-25%); fossils randomly oriented; medium gray (N5) mottling throughout; few olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper contact; upper contact sharp.

Lake Neosho Shale Member

11. Shale: (58 cm) divisible into seven units, a-g.

Unit a: Calcareous Clayshale, 3 cm thick, olive gray (5Y3/2), weathers light olive gray (5Y6/1); 20-25% fossils, including productid shell fragments and spines (8-10%), crinoid ossicles (2-3%), Crurithyris shell fragments (2-3%), ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (5-7%); fossils compacted, aligned horizontally; few horizontal grayish black (N2) Planolites-like traces; flaggy partings; upper contact gradational.

Unit b: Slightly Calcareous Shale, 3-cm thick; grayish black (N2), weathers dark gray (N3); 5% fossils, including Crurithyris shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-4%); platy partings; upper contact sharp.

Unit c: Calcareous Clayshale, 4 cm thick; olive black (5Y2/1), weathers olive gray (5Y4/1); 10-15% fossils, including Crurithyris (5%, few articulated), Mesolobus, Orbiculoidea, Myalina, unidentifiable medium to fine sand-sized skeletal grains (5-7%); flaggy partings; upper contact gradational.

Unit d: Non-calcareous Shale, 12 cm thick; grayish black (N2), weathers dark gray (N3); rare fossils (1%), mostly Orbiculoidea, also conodonts, few fish scales, plant fragments, one Listrocanthus spine, one Crurithyris, one Clinopistha-like bivalve, one Dunberella-like bivalve; Planolites-like horizontal traces (occasionally pyritized); fissile to platy partings; gradational upper contact.

Unit e: Non-Calcareous, Phosphatic Shale, 20 cm thick; black (N1), weathers dark gray (N3); very rare fossils (<1%), including Orbiculoidea, conodonts, Listrocanthus spine, rare Planolites-like traces in upper third; abundant discoidal to spherical phosphate nodules, concentrated in layer in middle part, occur less frequently above this; fissile bedding; gradational upper contact.

Unit f: Non-calcareous, Phosphatic Shale, 10 cm thick; grayish black (N2), weathers medium dark gray (N4); rare fossils (1%), including fish? bones and scales, conodonts, few Orbiculoidea, Planolites-like traces throughout

(cont.)

(occasionally pyritized); discontinuous lenses of yellowish gray (5Y7/2) unidentifiable silt-sized material; fissile to platy bedding; upper contact sharp.

Unit g: Calcareous Clayshale, 8 cm thick; olive gray (5Y4/1), weathers yellowish gray (5Y7/2); 10-15% fossils, including Crurithyris (3-4%, frequently articulated), Mesolobus, productid shell fragments and spines (Juresania?), Orbiculoidea, ramose bryozoan fragments, Petrodus (dermal denticles), unidentifiable medium to fine sand-sized skeletal grains (5-7%); few horizontal traces structures noted; few discoidal to spherical phosphate nodules (nucleus Orbiculoidea or unidentifiable debris); platy partings; upper contact gradational.

Amoret Limestone Member

10. Crinoidal Bryozoan Wackestone, 25 cm thick; light olive gray (5Y6/1), weathers greenish gray (5GY6/1); moderately well-sorted, medium- to fine-grained; 5-10% fossils, including crinoid debris (1%), bryozoan fragments (1%), brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils aligned horizontally, parallel to wavy bedded; discontinuous crinoidal-Mesolobus packstone lenses in upper half; few dark gray (N3) micritic lithoclast; discontinuous laterally; upper contact sharp.

9. Brachiopod Oncolitic Wackestone, 12 cm thick; light olive gray (5Y6/1), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (5%, frequently articulated, all mud-filled, few with preserved brachidia), productids (5%, Juresania, Linoproductus, occasionally articulated, most whole valves overturned), brachiopod spines, crinoid debris, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (15-20%); nearly all fossils "algal"-coated, most completely coated; "algal"-coatings have digitate to concentric growth, digitate growth dominant on larger fragments; some "algal"-coatings appear bored; fossils fragments coarsen upward, less "algal"-coated upward; olive black (5Y2/1) clay-rich stylolitic laminae throughout, concentrated at upper, lower contacts; compaction evident along laminae; grayish black (N2) shale parting at upper and lower contacts; upper contact sharp to gradational.

8. Non-calcareous to Calcareous Mudshale, 1-5 cm thick; greenish gray (5G6/1), weathers light greenish gray (5G8/1); 1-2% fossil, including Crurithyris and other brachiopod shell fragments, high-spired gastropods, Myalina shell fragments, chaetetid fragments, plant debris, unidentifiable medium to fine sand-sized skeletal grains; corroded, abraded limestone fragments (5-7%, up to 1 cm, reworked clast of underlying bed); flaggy bedding; thickens over depressions in underlying bed; discontinuous laterally; sharp upper contact.

7. Discontinuous laterally, missing at this section.

6. Wackestone: 110-115 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); divisible into 2 units, a and b.

Unit a: Phylloid Algal Chaetetid Wackestone, 55-60 cm thick; poorly-sorted, coarse- to fine-grained; lower 10 cm 30% fossils, including phylloid algae (15%), Composita (1-2%, few articulated), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10%); above this 40-50% fossils, including phylloid algae (3-5%), crinoid debris (5-7%), Composita (2-3%, few articulated), gastropods, bryozoan fragments (1-2%), unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); one extended domical chaetetid, begins at 35 cm, continues into overlying unit, 5-7 cm of sediment draping over upper surfaces; one small high domical (smooth) chaetetid (25 cm high) toppled over at contact with unit b; most recognizable fossils near chaetetids, mostly unidentifiable fine-grained fossils debris further from chaetetids; fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive gray

(cont.)

(5Y2/1) clay-rich laminae;

Unit b: Chaetetid Skeletal Wackestone, 55-60 cm thick; poorly to moderately well-sorted, coarse- to fine-grained; lower half similar to upper part of unit a, slightly finer grained; columnar chaetetid from unit a below continues 20 cm into this unit; more well-sorted upward, upper 15 cm skeletal packstone to grainstone with endothyroid foraminiferids, ostracodes, gastropods, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains; fossil fragments show graded bedding, possible cross bedding; few lithoclast of green mudstone in upper part; upper surface irregular, pitted, eroded; upper contact sharp.

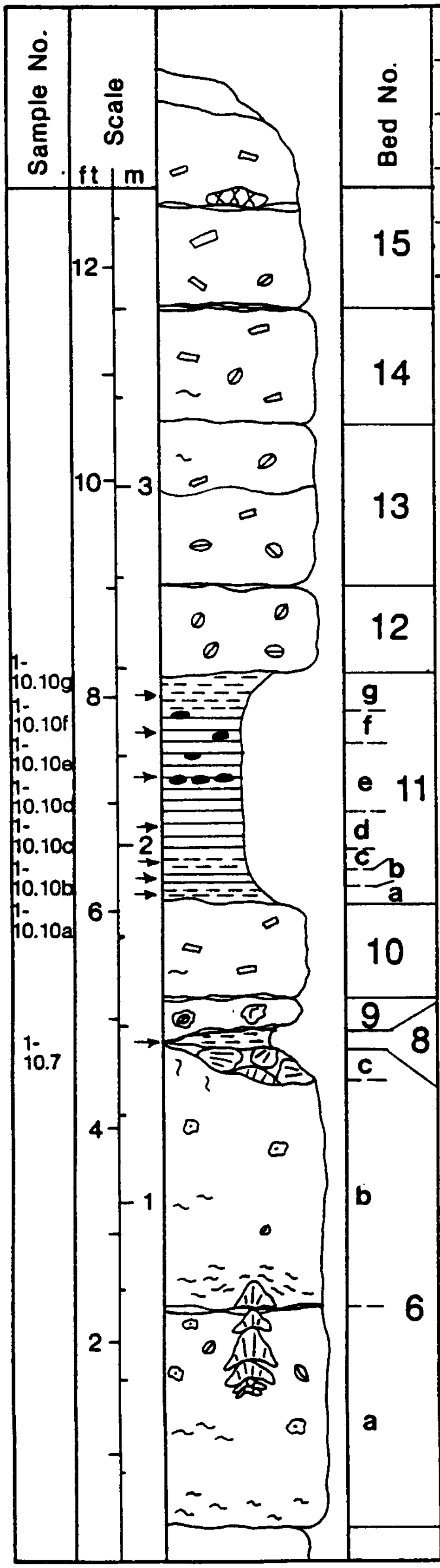
5. Phylloid Algal Brachiopod Wackestone, 32 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 30% fossils, including phylloid algal fragments (10%), Composita (2-3%, few articulated with geopetal), Crurithyris (1%), low-spired gastropods, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (12%); fossils randomly oriented; numerous olive black (5Y2/1) clay-rich laminae throughout, concentrated near lower contact, some stylolites along these; chert nodules (up to 20 cm long) near lower contact, same fossil composition as surrounding bed; upper contact gradational.

4. Phylloid Algal Wackestone, 42 cm thick; medium gray (N5) to light gray (N7), weathers yellowish gray (5Y7/2); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-20%, up to several cm in length), gastropods, crinoid debris, Composita (1-2%, few articulated), productid shell fragments, fenestrate bryozoan fragments, Lophophyllidium (in lower half), unidentifiable medium to fine sand-sized skeletal grains (10-15%); one small (10 cm long) laminar chaetetid at lower contact; some skeletal fragments algal-coated (5%); phylloid algal fragments larger, more abundant in lower half, unidentifiable skeletal grains and algal-coated grains more abundant upward; fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

3. Phylloid Algal Wackestone, 26 cm thick, light gray (N7) to medium gray (N5), no weathered surface; poorly-sorted, coarse- to fine-grained; lower half 25-30% fossils, including phylloid algae (5%, highly fragmented), brachiopod shell fragments, fusulinids (1-2%), ramose bryozoan fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (20%, quarter algal-coated); small (5 cm long) laminar chaetetid at lower contact; upper half 20-25% fossils, including phylloid algae (10%, up to several cm in length), Composita (few articulated), Lophophyllidium (one in life position), bryozoan, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10%, few algal-coated); sorting decreases upward; fossils somewhat aligned horizontally in lower part, randomly oriented in upper part; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper, lower contacts; upper contact gradational.

2. Fusulinid Skeletal Packstone, 7 cm thick; light olive gray (5Y6/1), no weathered surface; poorly-sorted, coarse- to fine-grained; 70-80% fossils, including fusulinids (60%, some appear worn and abraded, quarter algal-coated), crinoid debris (2-3%), unidentifiable medium to fine sand-sized skeletal grains (5-15%, two-thirds algal-coated); fossil somewhat horizontal aligned; wavy bedding; upper contact gradational, marked by olive black (5Y2/1) clay-rich laminae.

1. Skeletal Carbonate Mudstone, 24 cm exposed, lower contact covered; medium gray (N5), no weathered surface; moderately well-sorted; 5% fossils, including productid shell fragments, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (4%, two-thirds algal-coated); fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive black (5Y2/1) clay rich laminae.



DESCRIPTION: Section 692-S10, Locality 692

South wall in active area

LOCATION: SW 1/4, NW 1/4, sec 35, T.34S, R.17 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 692-S10

bed

Worland Limestone Member

15. Crinoidal Wackestone, 60 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); moderately well-sorted, medium- to fine-grained; 15-20% fossils, including crinoid debris (5-7%), bryozoan fragments (2-3%), brachiopod shell fragments (2-3%), Composita, unidentifiable medium to fine sand-sized skeletal grains (5-7%); fossils randomly oriented; indistinct bedding; medium gray (N5) mottling throughout; olive black (5Y2/1) clay-rich laminae throughout, concentrated near center and upper contact; chert nodule (25 cm long same fossil composition as surrounding sediment) near center; upper contact sharp; limestone above this approximately 50 cm (inaccessible), soil developed above.

14. Skeletal Wackestone, 30 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly sorted, coarse- to fine-grained; 20-25% fossils, including crinoid debris (8-10%), Composita, productids, and other brachiopod shell fragments, bryozoan fragments, phylloid algal fragments, unidentifiable medium to fine sand-sized skeletal grains (10-12%); fossils show some preferential horizontal alignment; fines upward, sorting increases upward; medium gray (N5) mottling throughout; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

13. Brachiopod Skeletal Wackestone, 45 cm thick; very light gray (N8) to light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (5-6%, occasionally articulated), Crurithyris (2-3%, occasionally articulated), Mesolobus, crinoid debris (3-4%), phylloid algae? (2-3%, highly fragmented), fusulinids (1-3%, more abundant upward), unidentifiable medium to fine sand-sized skeletal grains (15-20%); fossils randomly oriented, overall decrease in abundance upward; fines upward; distinct parting at 30 cm, marked by olive black (5YR2/1) clay-rich stylolitic laminae; bedding indistinct; upper contact gradational.

12. Brachiopod Wackestone, 26 cm thick; light olive gray (5Y6/1), weathers medium gray (N5); poorly-sorted, fine- to coarse-grained; 40-45% fossils, including Composita (10%, fragmented to articulated with geopetal, few in life position), Crurithyris (5%, occasionally articulated), productid shell fragments, Wellerella, crinoid debris (5%), bivalve fragments, unidentifiable medium to fine sand-sized skeletal grains (20-25%); fossils randomly oriented; medium gray (N5) mottling throughout; upper contact sharp, marked by olive black

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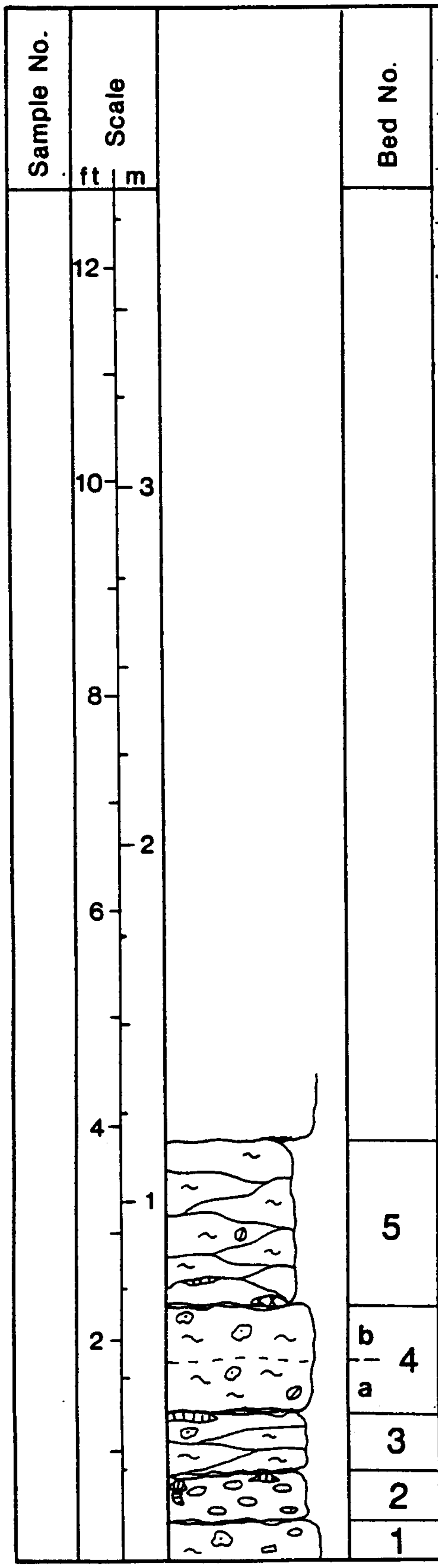


DESCRIPTION: Section 692-S10, Locality 692

South wall in active area

LOCATION: (cont.)

MEASURED BY:

(5Y2/1) clay-rich laminae.

Lake Neosho Shale

11. Shale: (65 cm) divisible into seven units, a-g.
Unit a: Calcareous Clayshale, 5 cm thick, olive gray (5Y3/2), weathers light olive gray (5Y6/1); 20-25% fossils, including productid shell fragments and spines (8-10%), crinoid ossicles (2-3%), Crurithyris shell fragments (2-3%), ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (5-7%); fossils compacted, aligned horizontally; few horizontal grayish black (N2) Planolites-like traces; flaggy partings; upper contact gradational.
Unit b: Slightly Calcareous Shale, 4 cm thick; grayish black (N2), weathers dark gray (N3); 5% fossils, including Crurithyris shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-4%); platy partings; upper contact sharp.
Unit c: Calcareous Clayshale, 5 cm thick; olive black (5Y2/1), weathers olive gray (5Y4/1); 10-15% fossils, including Crurithyris (5%, few articulated), Mesolobus, Orbiculoidea, unidentifiable medium to fine sand-sized skeletal grains (5-7%); flaggy partings; upper contact gradational.
Unit d: Non-calcareous Shale, 12 cm thick; grayish black (N2), weathers dark gray (N3); rare fossils (1%), Orbiculoidea, conodonts, fish scales; fissile to platy partings; gradational upper contact.
Unit e: Non-Calcareous, Phosphatic Shale, 22 cm thick; black (N1), weathers dark gray (N3); very rare fossils (<1%), including Orbiculoidea, conodonts, Listrocanthus spine, rare Planolites-like traces in upper third; abundant discoidal to spherical phosphate nodules, concentrated in continuous layer in middle part, occur less frequently above this; fissile bedding; gradational upper contact.
Unit f: Non-calcareous, Phosphatic Shale, 10 cm thick; grayish black (N2), weathers medium dark gray (N4); rare fossils (1%), including fish scales, conodonts, few Orbiculoidea, Planolites-like traces throughout (occasionally pyritized); discontinuous lenses of yellowish gray (5Y7/2) unidentifiable silt-sized material; fissile to platy bedding; upper contact sharp.
Unit g: Calcareous Clayshale, 10 cm thick; olive gray (5Y4/1), weathers yellowish gray (5Y7/2); 10-15% fossils, including Crurithyris (3-4%, frequently articulated), Mesolobus, productid shell fragments and spines (Juresania?), Orbiculoidea, ramose bryozoan fragments, Petrodus (dermal denticles), unidentifiable medium to fine sand-sized skeletal grains (5-7%); few discoidal phosphate nodules (nucleus Orbiculoidea); platy partings; upper contact gradational.

(cont.)

Amoret Limestone Member

10. Crinoidal Bryozoan Wackestone, 28-33 cm thick; light olive gray (5Y6/1), weathers greenish gray (5GY6/1); moderately well-sorted, medium- to fine-grained; 5-10% fossils, including crinoid debris (1%), bryozoan fragments (1%), brachiopod shell fragments, Heliospongia, phylloid algal fragments (in upper 2 cm) ostracodes, unidentifiable medium to fine sand-sized skeletal grains (3-7%); few "algal" coated skeletal grains; fossil fragments sub-angular to rounded; fossils randomly oriented; parallel to wavy bedding; discontinuous crinoidal-Mesolobus packstone lenses in upper quarter; frequent medium dark gray (N4) mottling in lower two-thirds; discontinuous laterally; upper contact sharp.

9. Brachiopod Oncolitic Wackestone, 4-11 cm thick; light olive gray (5Y6/1), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (5%, frequently articulated, all mud-filled, few with preserved brachidia), productids (5%, Juresania, Linoproductus, occasionally articulated, most whole valves overturned), brachiopod spines, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15-20%); nearly all fossils "algal"-coated, most completely coated; "algal"-coatings have digitate to concentric growth, digitate growth dominant on larger fragments; some "algal"-coatings appear bored; fossils fragments coarsen upward, less "algal"-coated upward; olive black (5Y2/1) clay-rich laminae throughout (imparts a nodular appearance where bed thins), concentrated at upper, lower contacts; compaction evident along laminae; grayish black (N2) shale parting at upper and lower contacts; upper contact gradational.

8. Non-calcareous to Calcareous Mudshale, 0-4 cm thick; greenish gray (5G6/1), weathers light greenish gray (5G8/1); 1% fossil, including brachiopod shell fragments, high-spired gastropods, shell fragments, plant debris, unidentifiable medium to fine sand-sized skeletal grains; corroded, abraded limestone fragments (up to 1 cm, reworked clast of underlying bed); flaggy bedding; thickens over depressions in underlying bed; discontinuous laterally; sharp upper contact.

7. Discontinuous laterally, missing at this section.

6. Wackestone: 130 cm thick; very light gray (N8), weathers yellowish gray (5Y7/2); divisible into 3 units, a-c.

Unit a: Phylloid Algal Chaetetid Wackestone, 48-50 cm thick; poorly-sorted, coarse- to fine-grained; lower 10 cm 30% fossils, including phylloid algae (15%), Composita (1-2%, few articulated), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10%); above this 40-50% fossils, including phylloid algae (3-5%), crinoid debris (5-7%), Composita (2-3%, few articulated), gastropods, bryozoan fragments (1-2%), unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); one extended domical chaetetid at 25 cm, continues through upper contact with unit b, begins on bellerophontid (sediment drapes over upper surface 5-6 cm); most recognizable fossils near chaetetid, mostly unidentifiable fine-grained fossils debris further from chaetetids; fossils randomly oriented; olive gray (5Y3/2) mottling throughout; bedding indistinct; upper contact sharp, marked by olive gray (5Y2/1) clay-rich laminae.

Unit b: Chaetetid Skeletal Wackestone, 63-73 cm thick; poorly to moderately well-sorted, coarse- to fine-grained; lower half similar to upper part of unit a, slightly finer grained; 20 cm thick laterally discontinuous lens of phylloid algal fragments 10 cm above contact with unit a, drapes over chaetetid (5-7 cm); more well-sorted upward; few lithoclast of green mudstone in upper part; olive gray (5Y3/2) mottling throughout; vertical spar- and mud-filled rootlet-like structures in upper 15 cm; where unit c is missing, upper surface is pitted and eroded; upper contact sharp.

(cont.)

Unit c: Chaetetid Rudstone, 0-20 cm thick; made up nearly entirely of overturned, fragmented chaetetids; matrix is skeletal wackestone with brachiopod shell fragments, unidentifiable fine sand-sized skeletal fragments; chaetetids in the upper part eroded, pitted; discontinuous laterally; upper contact sharp.

5. Phylloid Algal Wackestone, 47-50 cm thick; pale yellowish brown (10YR6/2), no weathered surface; poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (15-25%, more abundant upward), Composita (1-2%, few articulated), Lophophyllidium, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10-15%); one small laminar chaetetid (5 cm long, 3 cm high) near lower contact; fossils (except chaetetid) randomly oriented; bedding indistinct; olive black (5Y2/1) clay-rich laminae throughout; olive gray (5Y3/2) mottling common in upper half; thins laterally, appears to be thickest at this section; upper contact gradational, marked by disappearance of clay-rich laminae.

4. Phylloid Algal Wackestone, 27-30 cm thick, medium dark gray (N4) in lower third, medium gray (N5) in upper two-thirds, no weathered surface; poorly-sorted, coarse- to fine-grained; can be roughly divided into 2 units, a and b.

Unit a: 45-50% fossils, including phylloid algal fragments (25-30%), Composita (2-3%, few articulated), Lophophyllidium, Pulchratia, productid spines, unidentifiable medium to fine sand-sized skeletal grains (15%, sixth algal-coated); upper contact gradational with olive black (5Y2/1) clay-rich laminae.

Unit b: similar to unit a, contains less phylloid algae (15-20%), more unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated). Fossils throughout randomly oriented; bedding indistinct; numerous olive black (5Y2/1) shale stringers at upper contact (1-4 cm thick), contains skeletal packstone lenses consisting mostly of crinoid debris, also bryozoan fragments, echinoid spines, brachiopod shell fragments, and unidentifiable medium to fine sand-sized skeletal grains; very light gray (N8) chert nodules at upper contact; upper contact sharp.

3. Phylloid Algal Wackestone, 16-20 cm thick, very light gray (N8) to olive gray (5Y4/1), no weathered surface; poorly-sorted, coarse- to fine-grained; lower half 25-30% fossils, including phylloid algae (5%, highly fragmented), brachiopod shell fragments, fusulinids, ramose bryozoan fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (20%, quarter algal-coated); laminar chaetetid (10 cm long) at upper contact; upper half 20-25% fossils, including phylloid algae (10%, up to several cm in length), Composita (few articulated), Lophophyllidium, bryozoan, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10%, few algal-coated); sorting decreases upward; fossils randomly oriented; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper, lower contacts; upper contact gradational.

2. Fusulinids Packstone, 15 cm thick; olive gray (5Y4/1), no weathered surface; poorly-sorted, coarse- to fine-grained; 80% fossils, including fusulinids (60%, third algal-coated), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15%, two-thirds algal-coated); two small (up to 10 cm across) low domical chaetetids in upper half, one overturned with continued upward growth, one at upper contact; sediment drapes over chaetetids 3-4 cm; wavy bedded; upper contact gradational with numerous olive black (5Y2/1) clay-rich laminae.

1. Skeletal Wackestone, 16 cm exposed, lower contact covered; medium gray (N5), no weathered surface; moderately well-sorted, medium- to fine-grained; 5-15% fossils, including phylloid algae (up to 2%, highly fragmented), crinoid debris (up to 2%), fusulinids (1-3%), Composita and Crurithyris shell fragments, unidentifiable medium to fine sand-sized skeletal grains (3-13%); algal coatings on quarter of fossils; randomly oriented; bedding indistinct; upper contact sharp, marked by numerous olive black (5Y2/1) clay-rich laminae.

APPENDIX C

MEASURED STRATIGRAPHIC SECTIONS

LOCALITY 693

Abandoned quarry owned by Ben Donley,
Coffeyville, Kansas

Samples collected at locality 693

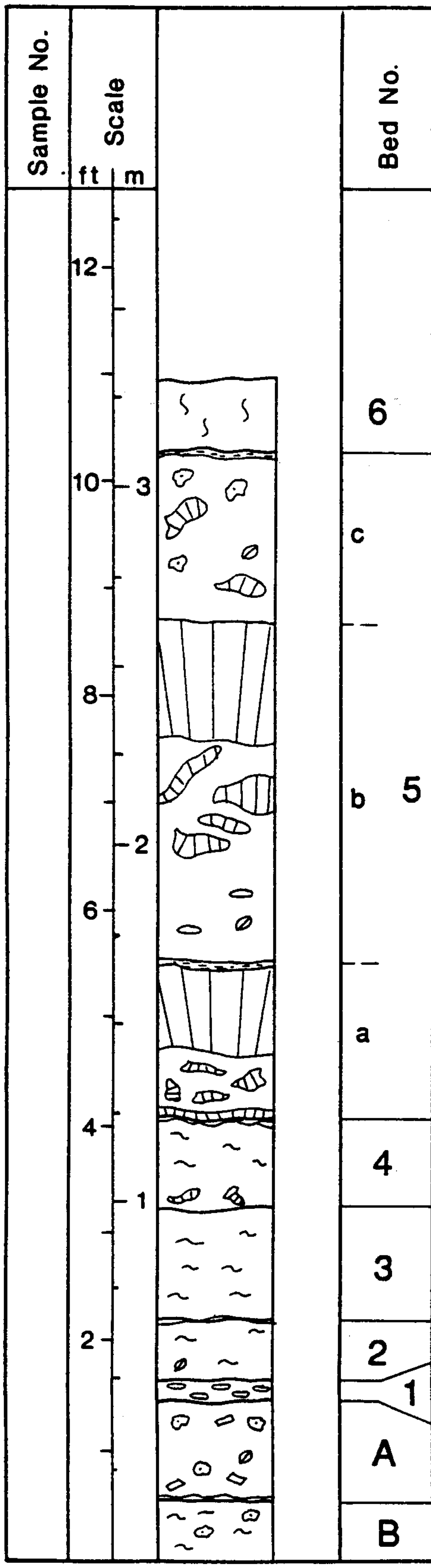
Sample no.	Level
693-S1	
S-1.	
1	upper contact, bed 2
2	lower contact, bed 3
2b	upper half, bed 3
2c	middle part, bed 4
2d	upper contact, bed 4
3a	upper half, bed 5a
3b	lower third, bed 5b
4a	lower third bed 5c
4b	upper contact, bed 5c
5c	upper half, bed 5c
7a	lower contact, bed 9
10a	lower contact, bed 10
8	middle part, bed 10
10b	upper contact, bed 10
11	entire thickness, bed 11
9a	lower half, bed 9
12	upper half, bed 12
13a	lower contact, bed 13
13b	upper half, bed 13
9b	upper contact, bed 13
14a	lower contact, bed 14
14b	upper contact, bed 14
15a	lower contact, bed 15
15b	upper half, bed 15

Sample no.	Level
693-S2	
S-2.	
2	middle part, bed 3
4b	upper part, bed 4
5a	lower half, bed 5a
5b	upper half, bed 5b
5c	upper third, bed 5c
6	upper contact, bed 6
8c	upper contact, bed 8
10a	lower third, bed 10
10	upper contact, bed 10
10c	upper third, bed 10
12	entire thickness, bed 12
13a	lower contact, bed 13
13b	upper third, bed 13
13c	upper contact, bed 13
14a	lower contact, bed 14
14b	upper contact, bed 14
15a	lower contact, bed 15
15b	upper third, bed 15
15c	upper third. bed 15

Sample no.	Level
693-S5	
S-5.	
1a	upper half, bed 1
2b	upper half, bed 2
3	entire thickness, bed 3
4b	upepr half, bed 4
5c1	middle part, bed 5c
5c2	middle part, bed 5c
7	entire thickness, bed 7
8	entire thickness, bed 9
15	lower contact, bed 15

Sample no.	Level
693-S6	entire thickness, bed 3
S-6.	
10a	middle part, bed 10
10b	upper contact, bed 10
12	entire thickness, bed 12
13b	lower third, bed 13
13c	lower half, bed 13
13d	upper contact, bed 13
14b	lower third, bed 14
14c	upper contact, bed 14
15a	lower contact, bed 15
15b	upper contact, bed 15
17a	unit a, bed 16
17b	lower half, unit b, bed 16
17c	upper half, unit b, bed 16
17d	unit c, bed 16
18a	lower contact, bed 17
18b	lower third, bed 17
18c	upper half, bed 17
18d	upper surface, bed 17

Sample no.	Level
693-S7	
S-7.	
5	upper part, bed 5c
6	entire thickness, bed 6
7a	entire thickness, bed 7
7b	lower contact, bed 8
8a	lower third, bed 8
8b	middle part, bed 8
8c	upper. third, bed 8
9	lower contact, bed 9
10	entire thickness, bed 10
11	entire thickness, bed 11
12	contact between beds 12, 13
13a	lower contact, bed 13
13b	lower third, bed 13
13c	middle part, bed 13
14a	lower contact, bed 14
14b	middle part, bed 14
15a	lower contact, bed 15
15b	lower third, bed 15



DESCRIPTION: Section 693-C1, Locality 693 core, 70 meters S46E of 693-S1

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S, R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1990

SECTION 693-C1

bed

Amoret Limestone Member

6. Gastropod Ostracode Carbonate Mudstone to Wackestone, 18 cm thick; yellowish gray (5Y7/2); well-sorted, fine to medium grained; 5-10% fossils, including high-spired gastropods, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (3-7%); fossils randomly oriented; bedding indistinct; small iron-stained mud- or spar-filled burrow- and/or rootlet-like structures throughout; some medium light gray (N6) mottling; upper surface top of core.

5. Rudstone to Wackestone, 181 cm thick; medium gray (N5) to yellowish gray (5Y7/2); divisible into three units, a-c.
Unit a: Chaetetid Rudstone to Boundstone, 40 cm thick; nearly entirely chaetetids; laminar chaetetid at lower contact; above this are fragmented, laminar chaetetids (10 cm thick); matrix unidentifiable medium to fine sand-sized skeletal grains or sparry calcite; rest of unit one solid chaetetid, upper 5 cm of which is highly fractured; upper contact sharp, separated from unit b by 3 cm thick pale yellowish orange (10YR8/6) calcareous clayshale.
Unit b: Chaetetid Boundstone to Skeletal Wackestone, 90 cm thick; lower 28 cm skeletal wackestone to packstone; moderately well-sorted; contains fusulinids, brachiopod spines and shell fragments, Lophophyllidium, unidentifiable medium to fine sand-sized skeletal grains; bedding indistinct; next 34 cm made up nearly entirely of chaetetid fragments; matrix between fragments coarse spar or skeletal packstone containing brachiopod shell fragments, ramose bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; laminar to wavy bedded; rest of unit is one continuous chaetetid to upper contact; upper contact sharp.
Unit c: Chaetetid Skeletal Wackestone to Grainstone, 51 cm thick; well-sorted, medium- to fine-grained; contains few chaetetids, displaced, fragmented; matrix is wackestone to grainstone with gastropods fragments, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (frequently algal-coated); fossils randomly oriented; bedding indistinct; grainstone relative to wackestone increases upward; dark gray (N3) mottling throughout; upper contact sharp, stylolitic.

4. Chaetetid Phylloid Algal Wackestone, 23 cm thick; light olive gray (5Y6/1); poorly-sorted, coarse- to fine-grained; lower 7 cm randomly oriented laminar chaetetid fragments; sparry calcite filling in areas between fragments; above this 30% fossils, including phylloid algal fragments (10%), ramose bryozoan fragments, small chaetetid fragments (< 0.7 cm),
(cont.)

unidentifiable medium to fine sand-sized skeletal grains (15%); fossils more fragmented upward; few micrite lithoclast throughout; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

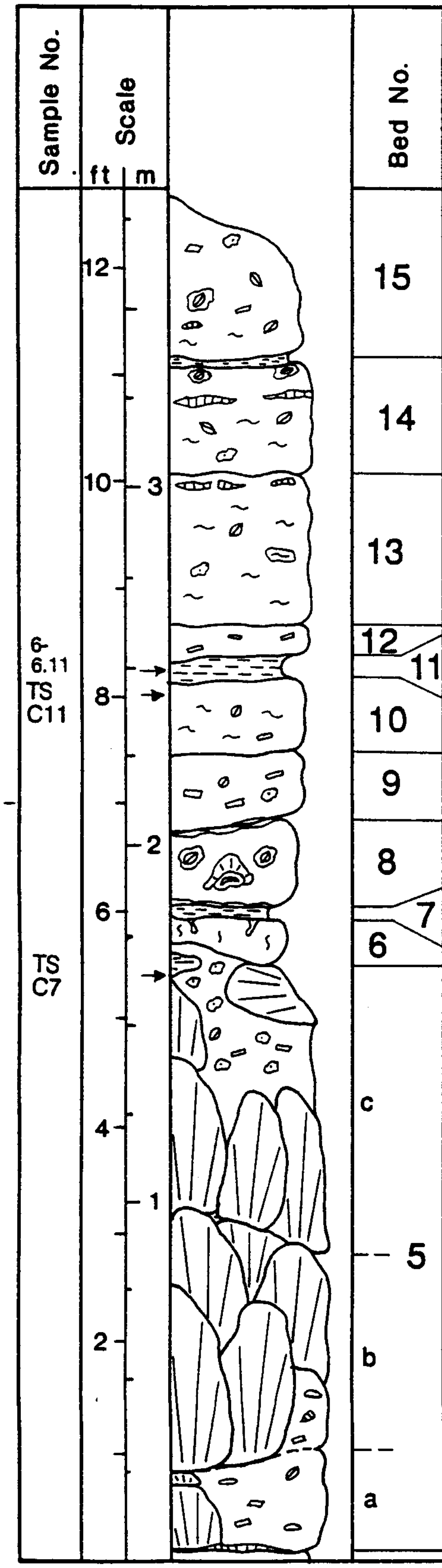
3. Phylloid Algal Wackestone, 30 cm thick; light olive gray (5Y6/1); poorly-sorted, coarse- to fine-grained; 25-30% fossils, similar to bed 2; phylloid algae slightly more abundant, becomes more fragmented, less common upward; one micrite intraclast; fossils randomly oriented; bedding indistinct; olive black (5Y2/1) clay-rich laminae near center and at upper contact; upper contact sharp, stylolitic.

2. Phylloid Algal Wackestone, 15 cm thick; light olive gray (5Y6/1); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including phylloid algae (5-10%, up to 2 cm, more fragmented upward), brachiopod shell fragments (in lower 5 cm), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; bedding indistinct; few micrite clast in upper half; some spar-filled shelter porosity under phylloid algal fragments; sharp upper contact, marked by olive black (5Y2/1) clay-rich laminae.

1. Fusulinid Skeletal Packstone, 6.5 cm thick; light olive gray (5Y6/1); poorly-sorted, coarse- to fine-grained; 75-80% fossils, including fusulinids (30-35%, some fragmented, abraded), phylloid algae? (highly fragmented), brachiopod shell fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (35-40%); fusulinids 10% algal-coated, other fossils 80% algal-coated; wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich stylolitic laminae.

A. Crinoidal Coated Grain Wackestone, 24 cm thick; light olive gray (5Y6/1) to olive gray (5Y4/1); moderately well-sorted, medium- to fine-grained; 25-30% fossils, including crinoid debris (4-8%, more common in lower half), brachiopod shell fragments, bryozoan fragments, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (15-20%); algal-coated fossils throughout, more common in upper third; fossils randomly oriented; bedding indistinct; few lithoclast at upper contact; olive black (5Y2/1) clay-rich laminae 12 cm above lower contact; dark gray (N3) mottling in upper half; spar-filled fractures in upper third; upper contact sharp.

B. Phylloid Algal, Coated Grain Wackestone, 17 cm recovered; olive gray (5Y4/1); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (10-15%, more common upward, most algal-coated), productids (1-2%, mostly shell fragments and spines, one articulated and overturned, algal-coated), high-spired gastropods (uncoated), crinoid debris (uncoated), bryozoan fragments (algal-coated), unidentifiable medium to fine sand-sized skeletal grains (20-25%, two-thirds algal-coated); fossils randomly oriented; bedding indistinct; few spar-filled fractures in upper half; upper contact sharp, marked by abrupt disappearance of phylloid algal fragments; olive black (5Y2/1) clay-rich laminae directly above upper contact; no lower contact.



DESCRIPTION: Section 693-S1, Locality 693

9 meters east of NW corner

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S,

R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 693-S1

bed

Amoret Limestone Member

15. Brachiopod Crinoidal Wackestone, 34-38 cm thick, upper surface top of rock outcrop; very light gray (N8) to light gray (N7), weathers very pale orange (10 YR 8/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (5%, occasionally articulated), productids (1-2%, Desmoinesia, Linoproductus, rarely articulated, overturned), Crurithyris, Mesolobus, crinoid debris (5%), echinoid spines, low-and high-spired gastropods, ramose bryozoan fragments, bellerophontids, phylloid algae (1-2% in lower 10 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%); most brachiopods fragmented; most small fossil debris algal-coated, some larger fossils algal-coated; small (0.5 cm thick, 2 cm long) laminar chaetetid in lower half, encrusting upper surface of articulated Composita; fossils randomly oriented; bedding indistinct; moldic porosity throughout; depressions on upper surface occasionally filled with skeletal wackestone consisting predominantly of unidentifiable fragmented skeletal grains, few brachiopod and crinoid fragments (some grains partially to entirely silicified).

14. Phylloid Algal Brachiopod Wackestone, 32-34 cm thick; light gray (N7), weathers light olive gray (5Y5/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algae (10-15%, up to several cm long, quarter algal-coated), Composita (1-2%, rarely articulated), productids (Linoproductus, rarely articulated), Mesolobus, Crurithyris, crinoid debris (3-4%), echinoid spines and plates, fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); small (10 cm long, 2-3 cm thick) laminar chaetetids 13 cm below upper contact, encrusting phylloid algal fragment; fossils randomly oriented (except chaetetids which occur in place); bedding indistinct; medium light gray (N6) mottling in lower 15 cm and upper 3 cm; on upper surface are numerous articulated and fragmented Composita, Juresania (most algal-coated, few uncoated, some with well-preserved brachidia, randomly oriented, few Juresania with well-preserved spines), also, Mesolobus, echinoid spines, crinoid debris, fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, marked by 2-3 cm thick calcareous clayshale.

13. Phylloid Algal Crinoidal Wackestone, 39-40 cm thick; olive gray (5Y3/2), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algae (10-

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DESCRIPTION: Section 693-S1, Locality 693

9 meters east of NW corner

LOCATION: (cont.)

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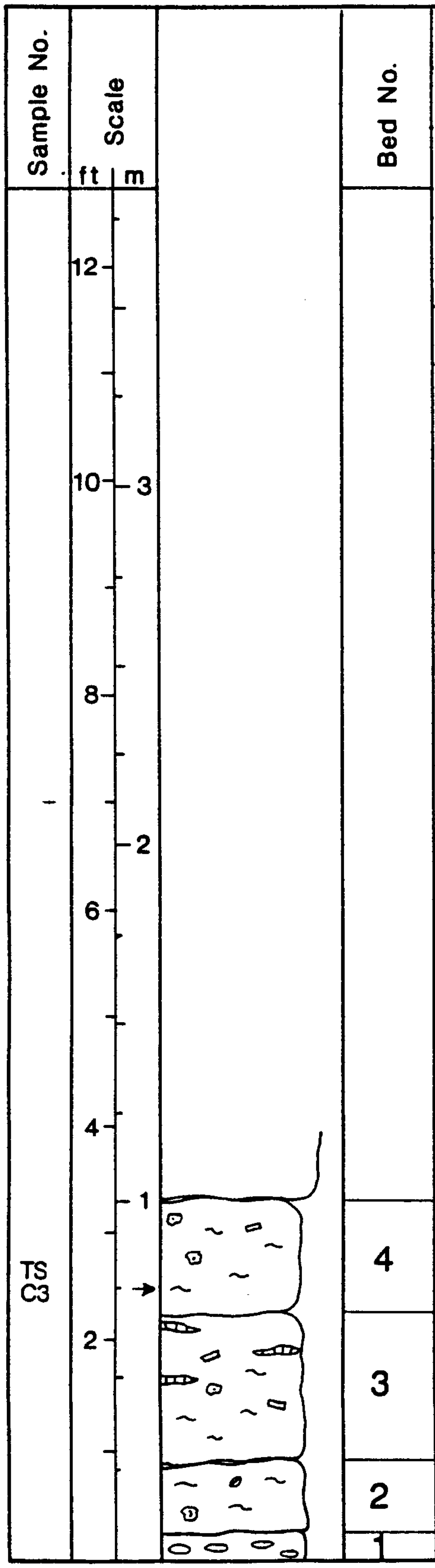

15%, up to several cm long, third algal-coated), crinoid debris (5%, few algal-coated, ossicles and other fragments), Composita (1%, few articulated), low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); laminar chaetetid fragments near upper contact; fossils randomly oriented; bedding indistinct; light gray (N7) to medium light gray (N6) horizontal mottling throughout; upper contact sharp to gradational.

12. Crinoidal Wackestone, 10 cm thick; light gray (N7), weathers pale yellowish orange (10YR8/6) to yellowish gray (5Y7/2); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including crinoid debris (10-15%), Composita (mostly shell fragments, few whole disarticulated valves), brachiopod spines, phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; bedding indistinct; upper contact is sharp.

11. Calcareous Clayshale, 5 cm thick; dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6); 20-25% fossils, including crinoids (10-15%, ossicles, plates), Mesolobus (2-3%, often whole valves, frequently articulated), fenestrate bryozoan fragments, productid fragments and spines, Composita shell fragments, unidentifiable medium to fine sand-sized skeletal grains; few discontinuous wackestone to packstone lenses of crinoid debris and Mesolobus valves; flaggy to platy partings; upper contact sharp.

10. Phylloid Algal Brachiopod Wackestone, 21-24 cm thick; medium light gray (N6), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, most less than 1 cm in length), crinoid debris (2-3%), Composita (1%, few articulated, randomly oriented, mud- or rarely spar-filled), productids (2-3%, Juresania, Desmoinesia, frequently articulated, mud- or spar-filled, rarely in life position, most randomly oriented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); phylloid algae half algal-coated, fifth of other fossils algal-coated; fossils randomly oriented; small (<8 cm long) chert nodules in middle part; bedding indistinct; upper contact sharp, iron stained.

9. Crinoidal Wackestone, 16-20 cm thick; medium light gray (N6), weathers dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained; 20-25% fossils, including crinoid debris (5-10%), Composita shell fragments, Juresania (few noted, mostly shell fragments, one articulated), ramose and fenestrate bryozoan fragments, Mesolobus shell fragments, Cruritbyris shell fragments, low-spired gastropods, phylloid algae (in upper quarter, highly fragmented), ostracodes, unidentifiable medium to fine sand-sized skeletal grains (10-15%); many fossils partially to completely algal-

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coated; fossils randomly oriented; medium light gray (N6) horizontal mottling throughout; bedding indistinct except for platy partings in upper 5 cm; upper contact gradational.

8. Brachiopod Oncolitic Wackestone, 20-28 cm thick; light gray (N7), weathers medium light gray (N6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including productids (Juresania and others, 8-10%, quarter articulated, mud-filled), Composita (2-3%, frequently articulated, mud-filled), brachiopod spines, crinoid debris, small low domical chaetetid (8 cm high, 12 cm wide, begins on productid oncolite), unidentifiable medium to fine sand-sized skeletal grains (30-35%); most fossils entirely algal-coated (up to 2 cm thick, somewhat less well coated upward); articulated brachiopods more common upward; algal-coated lithoclast; olive black (5Y2/1) clay-rich laminae throughout (imparts a nodular appearance); lower 1 cm black (N1) platy calcareous shale with fragmented skeletal debris (productid spines and shell fragments, Lingula?, unidentifiable medium to fine sand-sized skeletal grains); upper 1 cm olive black (5Y2/1) platy shale with articulated algal-coated Composita, productids (biscuit shaped), unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

7. Calcareous Clayshale, 2 cm thick; grayish olive (10Y4/2), weathers pale olive (10YR6/2); contains plant remains, productid spines; this unit thickens to right of this section and contains a thin (0.8 cm thick, 5-6 cm long) coal smut in lower part; upper contact sharp.

6. Skeletal Carbonate Mudstone, 9-13 cm thick; very light gray (N8), weathers same; well-sorted, fine-grained; rare fossils (2-3%), including high- and low- spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (1-2%); fossils randomly oriented; numerous burrow- and/or rootlet-like structures (up to 10 cm long, most 2-3 cm long, up to 1 cm wide, most mud-filled and iron stained, few spar-filled, occasionally bifurcate downward); stylolites throughout, frequently associated with olive black (5Y2/1) clay-rich laminae; upper surface pitted, eroded, with occasional in-place brecciation; discontinuous dark yellowish orange (10YR6/6) mudstone at upper contact, inter-fingered with in-place brecciation; spar-filled fractures on upper surface; upper contact sharp.

5. Wackestone to Boundstone: 159-173 cm thick; divisible into three units, a-c.

Unit a: Skeletal Wackestone to Packstone, 20-25 cm thick; olive gray (5Y4/1), weathers light olive gray (5Y6/1) to grayish black (N2); moderately well-sorted, medium- to fine-grained; 45-60% fossils, including fusulinids (4-5%), crinoid debris (7-8%, somewhat clumped together), Composita (mostly shell fragments, few articulated), other brachiopod shell fragments, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (30-45%, 2/3 algal-coated); laminar chaetetid at lower contact, becomes high domical (ragged) upward, continues into the overlying unit; sediment drapes over upper surface of chaetetid 3-4 cm; vertical burrow-like structure (10 cm long, 1.5 cm wide); wavy bedded; upper surface very irregular away from this section; upper contact sharp, marked by thin black (N1) shale partings with crinoid debris, fusulinids, and unidentifiable medium to fine sand-sized skeletal grains.

Unit b: Chaetetid Boundstone, 58-69 cm thick; light gray (N7), weathers light olive gray (5Y6/1) to olive gray (5Y3/2); nearly entirely high domical (smooth, ragged) to columnar chaetetids (95%); chaetetids begin at lower contact or continue into the unit from unit a; some columnar chaetetids begin in lower unit a, continue through unit b and into unit c (up to 1.5 meters high); some chaetetids at angles less than 90 degrees; few chaetetids toppled; spar-filled fractures extend downward from upper surface of some chaetetids; some open cavities between chaetetids, elsewhere inter-chaetetid areas filled with olive black (5Y2/1) shale or poorly-sorted skeletal wackestone to packstone with crinoid debris, fusulinids, small angular chaetetid fragments, brachiopod shell fragments, echinoid spines and plates, gastropods, few articulated Composita, unidentifiable

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medium to fine sand-sized skeletal grains (most algal-coated); few articulated Crurithyris and Composita (crushed and flattened) attached to outer surface of chaetetids; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper contact; upper contact sharp, few chaetetids continue through contact.

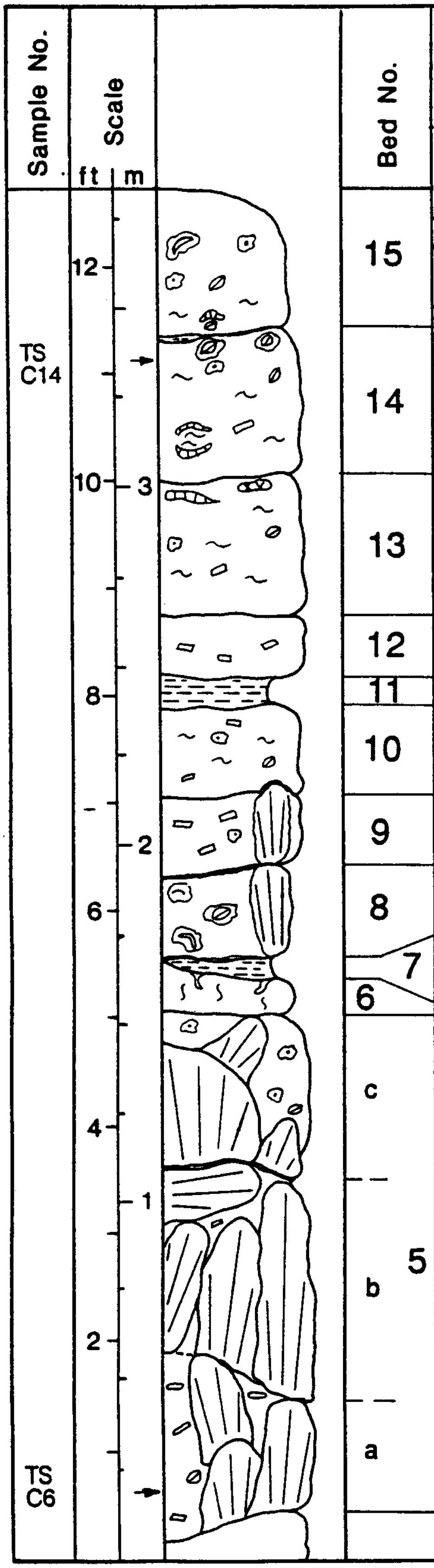
Unit c: Chaetetid Wackestone to Skeletal Grainstone, 70-90 cm thick; very light gray (N8), weathers grayish orange (10YR7/4); 70% chaetetids, have continued into the unit b; few overturned and/or fragmented low domical chaetetids in upper third; toppled chaetetid at upper surface (planed off level with upper surface of bed); matrix skeletal wackestone to grainstone; moderately well-sorted, medium- to fine-grained; 40-80% fossils, including crinoid debris (4-5%), Composita (few articulated with spar-filling, randomly oriented), ostracodes, gastropods, fenestrate bryozoan fragments, Edmondia-like bivalve, Lophophyllidium (one attached to chaetetid, rest in close proximity to chaetetids) unidentifiable medium to fine sand-sized skeletal grains (30-70%, frequently algal-coated); fossils (except chaetetids) randomly oriented; matrix fines upward; bedding indistinct; upper contact irregular, very sharp.

4. Phylloid Algal Wackestone, 30 cm thick; medium gray (N5), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, less abundant upward, third algal-coated), crinoid debris (2-5%, more common upward), brachiopod shell fragments (quarter algal-coated), fusulinids, unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); fossils randomly oriented; bedding indistinct; olive black (5Y2/1) clay-rich laminae common in upper 3 cm; upper contact very sharp, irregular.

3. Phylloid Algal Wackestone, 38 cm thick; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including phylloid algal fragments (15%, up to several cm long, quarter algal-coated, less abundant upward), crinoid debris (1-2%), Composita (few articulated), other brachiopod shell fragments (most algal-coated), unidentifiable medium to fine sand-sized skeletal grains (5-10%, 15% algal-coated); few small (8-10 cm long) laminar chaetetids throughout, concentrated at upper contact; fossils (other than chaetetids that are in-situ) randomly oriented; bedding indistinct; upper contact sharp, marked by olive gray (5Y2/1) clay-rich laminae.

2. Phylloid Algal Wackestone, 17 cm thick; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including phylloid algal fragments (10%, half algal-coated in lower part, less coated upward), productids (few articulated, most algal-coated), other brachiopod shell fragments (most algal-coated), crinoid debris, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (5-10%, most algal-coated); fossils randomly oriented; somewhat wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

1. Fusulinid Skeletal Packstone, 6 cm exposed; medium gray (N5), weathers medium light gray (N7); poorly-sorted, coarse- to fine-grained; 70-75% fossils, including fusulinids (40-45%, some fragmented, abraded), phylloid algae? (2-3%, highly fragmented), brachiopod shell fragments, crinoid debris, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (25-30%); fusulinids 15% algal-coated, other fossils 80% algal-coated; small (6 cm long) laminar chaetetid at upper contact; wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae; lower contact covered.



DESCRIPTION: Section 693-S2, Locality 693

8 meters west of NE corner

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S,

R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1988

SECTION 693-S2

bed

Amoret Limestone Member

15. Brachiopod Crinoidal Wackestone, 32-43 cm thick, upper surface top of rock outcrop; very light gray (N8) to light gray (N7), weathers light olive gray (5Y6/1) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (5%, occasionally articulated, rarely in life position), productids (Desmoinesia, Linoproductus, 1-2%, rarely articulated, overturned), Crurithyris, Derbyia, Mesolobus, crinoid debris (5%), echinoid spines, Aviculopecten, low- and high- spired gastropods, ramose bryozoan fragments, Straporollus, bellerophontids, phylloid algal fragments (1-2% in lower 10 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%); most brachiopods fragmented; much small fossil debris algal-coated, some larger fossils also algal-coated; small (0.5 cm thick, 3 cm long) laminar chaetetid in lower half, entirely encrusting an algal-coated articulated Composita, is in turn encrusted by algae; fossils randomly oriented; bedding indistinct; moldic porosity throughout; depressions on upper surface occasionally filled with skeletal wackestone consisting predominantly of unidentifiable fragmented skeletal grains, few brachiopod and crinoid fragments (some grains partially to entirely silicified).

14. Phylloid Algal Brachiopod Wackestone, 40-46 cm thick; light gray (N7), weathers light olive gray (5Y5/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algae (10-15%, up to several cm long, quarter algal-coated), Composita (1-2%, rarely articulated), productids (Linoproductus, rarely articulated), Mesolobus, Crurithyris, crinoid debris (3-4%), echinoid spines and plates, fenestrate bryozoan fragments, Multithecopora (one, 11 cm long, 2-3 cm thick) unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); small (8 cm long, 1 cm thick) laminar chaetetid in lower half, encrusting phylloid algal fragment, overturned several times during growth; laminar chaetetid near upper contact to the left of section (15 cm long, 10 cm high); fossils randomly oriented (except chaetetids which occur in place); bedding indistinct; light gray (N7) to medium light gray (N6) mottling in lower 5-7 cm and upper 4 cm; on upper surface are numerous articulated and fragmented Composita, Juresania (most algal-coated, few uncoated, randomly oriented, few Juresania with well preserved spines), also Crurithyris, Mesolobus, echinoid spines and plates, crinoid debris, fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, marked by 1-2 cm thick calcareous clayshale.

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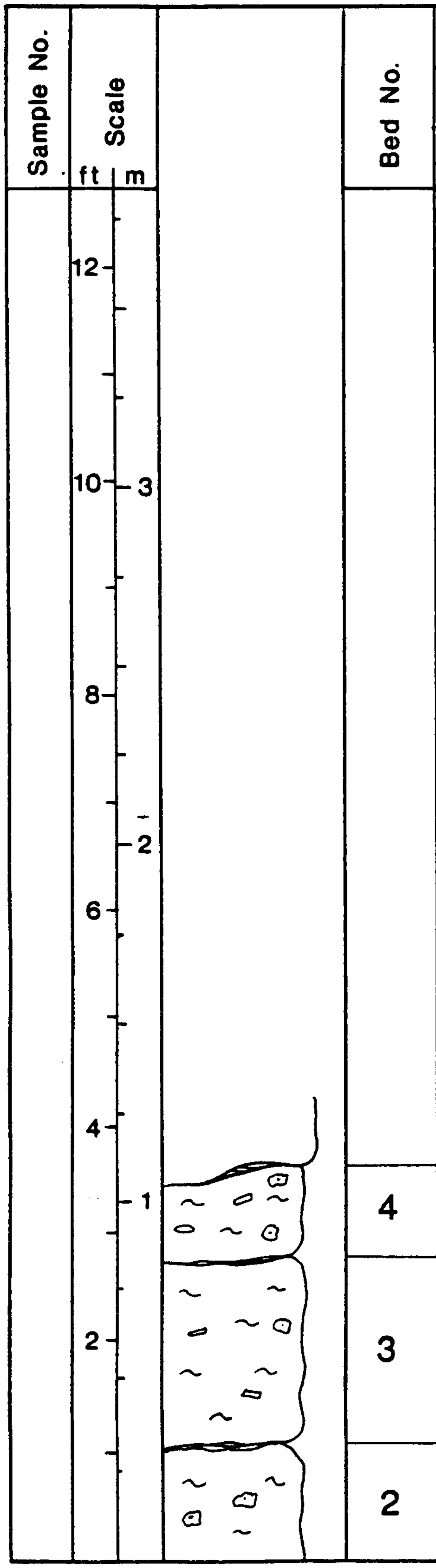

DESCRIPTION: Section 693-S2, Locality 693

8 meters west of NE corner

LOCATION: (cont.)

MEASURED BY:

13. Phylloid Algal Crinoidal Wackestone, 30 cm thick; olive gray (5Y3/2), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algae (10-15%, up to several cm long, third algal-coated), crinoid debris (5%, few algal-coated, ossicles and other fragments), <u>Composita</u> (1%, few articulated), <u>Crurithyris</u> (few articulated), low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); small laminar chaetetid (6 cm long, 4 cm high) just below upper contact; fossils (except for in-situ chaetetid) randomly oriented; bedding indistinct; light gray (N7) to medium light gray (N6) horizontal mottling throughout; discontinuous band of chert nodules at upper contact; upper contact gradational.

12. Crinoidal Wackestone, 14 cm thick; light gray (N7), weathers pale yellowish orange (10YR8/6) to yellowish gray (5Y7/2); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including crinoid debris (10-15%), <u>Composita</u> (mostly shell fragments, few whole disarticulated valves), brachiopod spines, phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; bedding indistinct; upper contact is sharp.

11. Calcareous Clayshale, 9-10 cm thick; dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6); 20-25% fossils, including crinoids (10-15%, ossicles, plates), <u>Mesolobus</u> (2-3%, often whole valves, frequently articulated), fenestrate and ramose bryozoan fragments, productid fragments and spines, <u>Composita</u> shell fragments, unidentifiable medium to fine sand-sized skeletal grains; discontinuous wackestone to packstone lenses of crinoid debris and <u>Mesolobus</u> valves; flaggy to platy partings; upper contact sharp.

10. Phylloid Algal Brachiopod Wackestone, 23-26 cm thick; medium light gray (N6), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, most less than 1 cm in length), crinoid debris (2-3%), <u>Composita</u> (1%, few articulated, randomly oriented, mud- or rarely spar-filled), productids (2-3%, <u>Juresania</u>, <u>Desmoinesia</u>, frequently articulated, mud- or spar-filled, rarely in life position, most randomly oriented), echinoid spines, unidentifiable medium to fine sand-sized skeletal grains (10-15%); phylloid algae half algal-coated, fifth of other fossils algal-coated; most fossils randomly oriented; bedding indistinct; upper contact sharp, iron stained.

9. Crinoidal Wackestone, 19-23 cm thick; medium gray (N5), weathers dark yellowish orange (10YR6/6); moderately well sorted, medium- to fine-grained; 20-25% fossils, including (cont.)

crinoid debris (5-10%), Composita shell fragments, Juresania (mostly shell fragments, one articulated), Echinaria (one articulated, overturned), ramose and fenestrate bryozoan fragments, Mesolobus shell fragments, echinoid spines, phylloid algae (in upper quarter, highly fragmented), columnar chaetetid (tapering downward, begins in underlying bed, continues through bed 9, ends at upper contact, overlying bed drapes over upper surface 3-4 cm), small straight-shelled cephalopod (one), unidentifiable medium to fine sand-sized skeletal grains (10-15%); many fossils partially to completely algal-coated; fossils randomly oriented; medium light gray (N6) horizontal mottling throughout; bedding indistinct; upper contact sharp, marked by 1 cm thick calcareous clayshale parting.

8. Brachiopod Oncolitic Wackestone, 20-25 cm thick; light gray (N7), weathers light gray to very light gray (N8); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including productids (Juresania and others, 8-10%, quarter articulated, mud-filled), Composita (2-3%, frequently articulated, mud-filled), brachiopod spines, columnar chaetetid (tapering downward, begins at lower contact on oncolite, continues into overlying bed), unidentifiable medium to fine sand-sized skeletal grains (30-35%); most fossils entirely algal-coated (up to 2 cm thick, somewhat less well coated upward); articulated brachiopods more common upward; olive black (5Y2/1) clay-rich laminae throughout (imparts nodular appearance to bed); lower 1 cm black (N1) platy calcareous shale with fragmented skeletal debris (productid spines and shell fragments, Lingula?, unidentifiable medium to fine sand-sized skeletal grains); upper 1 cm olive black (5Y2/1) platy shale with articulated algal-coated Composita and productids (biscuit shaped), unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, passes through previously described columnar chaetetid.

7. Calcareous Mudshale, 1-4 cm thick; grayish olive (10Y4/2), weathers pale olive (10YR6/2); plant remains, rare brachiopod shell fragments; thin (up to 0.5 cm thick) discontinuous grayish black (N2) clay-rich laminae in lower portion; flaggy to platy partings; upper contact sharp.

6. Skeletal Carbonate Mudstone, 9-15 cm thick; very light gray (N8), weathers same; well-sorted, fine-grained; rare fossils (2-3%), including high- and low- spired gastropods, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (1-2%); fossils randomly oriented; numerous burrow- and/or rootlet-like structures (up to 10 cm long, most 2-3 cm long, up to 1 cm wide, mostly mud-filled and iron stained, few spar-filled, occasionally bifurcate downward); stylolites throughout, frequently associated with olive black (5Y2/1) clay-rich laminae; upper surface pitted, eroded, with occasional in-place brecciation; discontinuous dark yellowish orange (10YR6/6) mudstone at upper contact, inter-fingered with in-place brecciation; spar-filled fractures on upper surface; upper contact sharp.

5. Wackestone to Boundstone: 134-140 cm thick; divisible into three units, a-c.

Unit a: Chaetetid Wackestone, 30-35 cm thick, medium gray (N5), weathers moderate brown (5YR4/4); poorly-sorted, coarse- to fine-grained; 60% chaetetids; matrix 40-45% fossils, including fusulinids (2-3%), crinoid debris (2-3%), Composita (mostly shell fragments, few articulated), other brachiopod shell fragments, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (30-35%, 2/3 algal-coated); laminar chaetetids at lower contact, continue upward as high domical (ragged, smooth) to columnar forms, some continue into overlying unit (matrix drapes over chaetetids 3-4 cm in places); matrix wavy bedded; upper contact sharp, marked by thin black (N1) clay-rich laminae;

Unit b: Chaetetid Boundstone, 50-60 cm thick; light gray (N7) to very light gray (N8), weathers dark yellowish brown (10YR4/2) to light brown (5Y5/6); nearly entirely columnar and high domical chaetetids (95%), begin at lower contact or have continued

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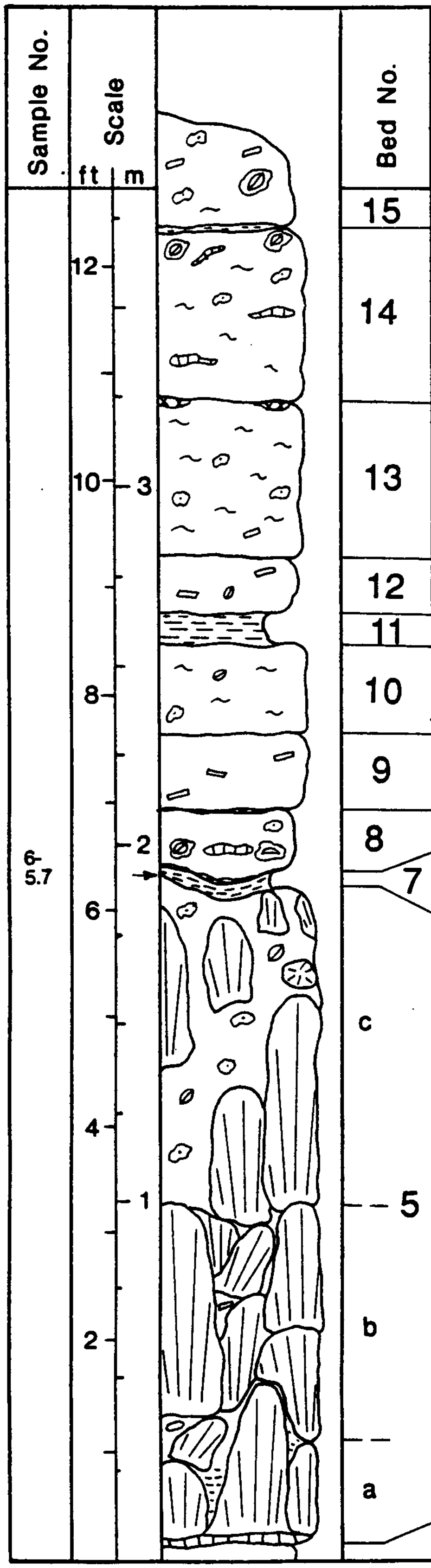
into the unit from unit a; some chaetetids at angles other than vertical, few toppled over; some open cavities between chaetetids, elsewhere inter-chaetetid areas filled with olive black (5Y2/1) shale or wavy bedded skeletal wackestone to packstone with crinoid debris, fusulinids, small angular chaetetid fragments, brachiopod shell fragments, echinoid spines and plates, gastropods, few articulated Composita, unidentifiable medium to fine sand-sized skeletal grains (most algal-coated); few articulated Crurithyris and Composita (crushed and flattened) attached to surface of chaetetids; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper contact; upper contact sharp, few chaetetids continue through contact.

Unit c: 50-56 cm thick; light gray (N7), weathers pale yellowish brown (10YR8/2) to very pale orange (10YR6/2); 60% high domical to columnar chaetetids, most have continued into unit from unit b, few begin at lower contact; few laminar to low domical chaetetids in upper part (toppled or overturned, fragmented); chaetetid growth more ragged upward; no inter-chaetetid cavities; matrix skeletal wackestone to grainstone; moderately well-sorted, medium- to fine-grained; 40-80% fossils, including crinoid debris (4-5%), Composita (few articulated with spar-filling, randomly oriented), ostracodes, gastropods, unidentifiable medium to fine sand-sized skeletal grains (30-70%, frequently algal-coated); fossils (except chaetetids) randomly oriented; upper contact irregular, very sharp.

4. Phylloid Algal Wackestone, 23-33 cm thick; medium gray (N5), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, less abundant upward, third algal-coated), crinoid debris (2-5%, more common upward), brachiopod shell fragments (quarter algal-coated), fusulinids, Composita (one articulated, random orientation), unidentifiable medium to fine sand-sized skeletal grains (20-25%, third algal-coated); fossils randomly oriented; bedding indistinct; olive black (5Y2/1) clay-rich laminae common in upper 3 cm; upper contact very sharp, irregular.

3. Phylloid Algal Wackestone, 55-60 cm thick; light gray (N7), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 35-35% fossils, including phylloid algal fragments (15-20%, up to several cm long, quarter algal-coated), crinoid debris (1-2%), gastropods, Composita (few articulated), unidentifiable medium to fine sand-sized skeletal grains (10-15%, 15% algal-coated); fossils randomly oriented; bedding indistinct; upper contact sharp, marked by olive gray (5Y2/1) clay-rich laminae.

2. Phylloid Algal Wackestone, 28 cm exposed, lower contact covered; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including phylloid algae (10%, half algal-coated in lower part, less coated upward), brachiopod shell fragments (most algal-coated), crinoid debris, fusulinids, Composita (two articulated, random orientation), unidentifiable medium to fine sand-sized skeletal grains (5-10%, most algal-coated); fossils randomly oriented; wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.



DESCRIPTION: Section 693-S5, Locality 693

14 meters south of NW corner

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S,

R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1989

SECTION 693-S5

bed

Amoret Limestone Member

15. **Brachiopod Crinoidal Wackestone, 31-33 cm, upper surface is top of exposure; very light gray (N8), weathers light olive gray (5Y6/1) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including Composita (6-7%, occasionally articulated, occasionally algal-coated, few in life position), productids (Juresania?, Desmoinesia?, 1-2%, rarely articulated, overturned), crinoid debris (8-10%), Crurithyris, echinoid spines, low- and high-spired gastropods, ramose bryozoan fragments, bellerophontids, phylloid algal fragments (2-3% in lower 10 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%); most brachiopods fragmented; most small fossil grains algal-coated, some larger fossils algal-coated; fossils randomly oriented; bedding indistinct; moldic porosity throughout (leached out fossils grains, iron stained).**

14. **Phylloid Algal Brachiopod Wackestone; 40-42 cm thick; light gray (N7), weathers light olive gray (5Y5/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (15-20%, up to several cm long, half algal-coated), Composita (1-2%, mostly fragmented, frequently algal-coated), productids (shell fragments, frequently algal-coated), other brachiopod shell fragments, crinoid debris (3-4%, often clumped together), unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); few small (<10 cm long, 2-3 cm thick) laminar chaetetids throughout, encrusting phylloid algal fragments (some chaetetids in upper quarter overturned, fragmented); fossils randomly oriented (except most chaetetids which occur in place); bedding indistinct; light gray (N7) to medium light gray (N6) mottling in lower 3-4 cm and upper 5-10 cm; moldic porosity throughout (leached out fossils grains); on upper surface are numerous articulated and fragmented Composita and Juresania (half completely algal-coated, rest partially algal-coated to uncoated, few Juresania with well preserved spines), also Crurithyris, Neospirifer, echinoid spines and plates, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, marked by 2-5 cm thick dark yellowish orange (10YR6/6) calcareous clayshale with brachiopod fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains.**

13. **Phylloid Algal Crinoidal Wackestone, 40 cm thick; light gray (N7), weathers pale yellowish orange (10 YR 8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments**

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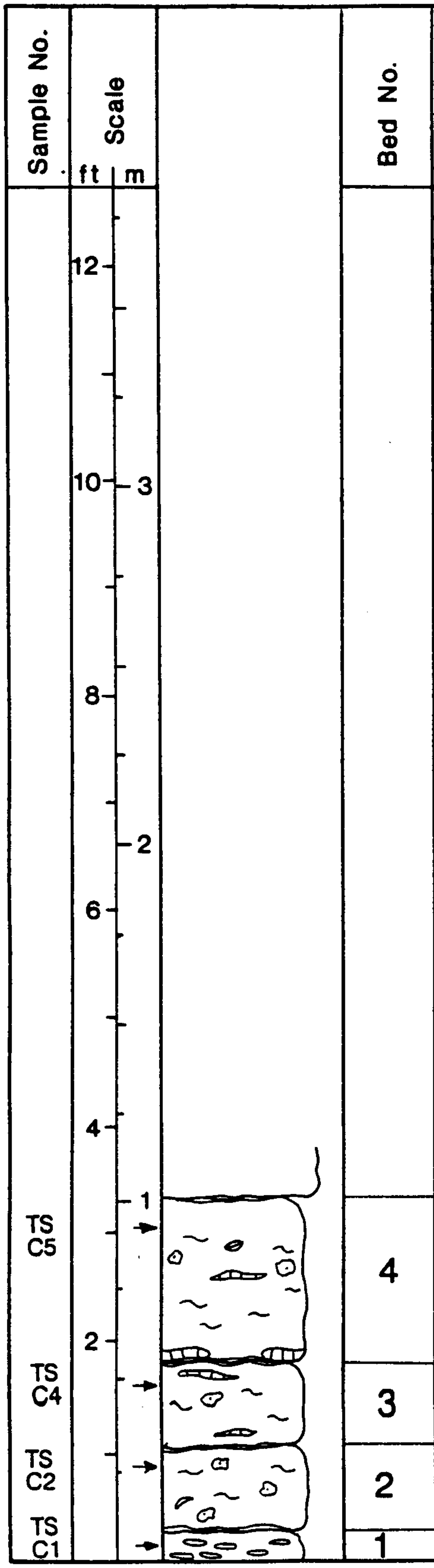


DESCRIPTION: Section 693-S5, Locality 693

14 meters south of NW corner

LOCATION: (cont.)

MEASURED BY:

(15-20%, up to several cm long, half algal-coated), crinoid debris (1-2%, few algal-coated, ossicles and other fragments), Composita (mostly shell fragments, rarely articulated), Crurithyris (few articulated), echinoid spines and plates, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); fossils randomly oriented; bedding indistinct; light gray (N7) to medium light gray (N6) horizontal mottling in upper 10 cm; discontinuous band of chert nodules at upper contact (same skeletal composition as surrounding rock); upper contact gradational.

12. Crinoidal Wackestone, 13 cm thick; light gray (N7), weathers pale yellowish orange (10YR8/6) to yellowish gray (5Y7/2); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including crinoid debris (10-15%), Composita shell fragments, brachiopod spines, phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; few spar-filled fractures (up to 10 cm long, 1 cm thick); bedding indistinct; upper contact is sharp.

11. Calcareous Clayshale, 10 cm thick; dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6); 20-25% fossils, including crinoids (10-15%, ossicles, plates), Mesolobus (2-3%, often whole valves, frequently articulated), fenestrate and ramose bryozoan fragments, productid shell fragments, Composita shell fragments, unidentifiable medium to fine sand-sized skeletal grains; discontinuous wackestone to packstone lenses of crinoid debris and Mesolobus valves; flaggy to platy partings; upper contact sharp.

10. Phylloid Algal Brachiopod Wackestone, 25 cm thick; medium light gray (N6), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, most less than 1 cm in length, half algal-coated), crinoid debris (2-3%), Composita (1%, few articulated, randomly oriented, mud- or rarely spar-filled), productids (2-3%, Juresania, Desmoinesia, frequently articulated, mud- or spar-filled), unidentifiable medium to fine sand-sized skeletal grains (10-15%). phylloid algae third algal-coated, fifth of other fossils algal-coated; fossils randomly oriented; bedding indistinct; some medium gray (N5) mottling throughout; upper contact sharp, iron stained.

9. Crinoidal Wackestone, 18 cm thick; medium gray (N5), weathers dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained; 20-25% fossils, including crinoid debris (5-10%), Composita shell fragments, Juresania (mostly shell fragments, one articulated), ramose and fenestrate bryozoan fragments, Mesolobus shell fragments, echinoid spines, phylloid algae (in upper quarter, highly fragmented), unidentifiable medium to fine sand-sized

(cont.)

skeletal grains (10-15%); many fossils partially to completely algal-coated; fossils randomly oriented; medium light gray (N6) horizontal mottling throughout; bedding indistinct; upper contact gradational.

8. Brachiopod Oncolitic Wackestone, 17-20 cm thick; light gray (N7), weathers light gray to very light gray (N8); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including productids (Juresania, Desmoinesia, 8-10%, mostly shell fragments and spines in lower third, often articulated in upper two-thirds, mud-filled), Composita (2-3%, frequently articulated, mud-filled), crinoid debris (1-2%), laminar chaetetid (3 cm long, in middle part), unidentifiable medium to fine sand-sized skeletal grains (25-30%); most fossils entirely algal-coated in lower half (up to 2 cm in thickness), less well coated upward; articulated brachiopods more common upward; fossils randomly oriented; olive black (5Y2/1) clay-rich laminae occur throughout; lower 2 cm black (N1) platy calcareous shale with fragmented skeletal debris (productid spines and shell fragments, other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains); upper 1-2 cm olive black (5Y2/1) platy shale with articulated algal-coated biscuit-shaped Composita and Juresania, also crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (two-thirds algal-coated); upper contact gradational.

7. Calcareous Mudshale, 2-3 cm thick; grayish olive (10Y4/2), weathers pale olive (10YR6/2); plant remains, rare brachiopod shell fragments; abraded limestone clast; thin (up to 0.5 cm thick) discontinuous grayish black (N2) clay-rich laminae in lower part; flaggy to platy partings, upper contact sharp.

6. Discontinuous laterally, missing at this section.

5. Wackestone to Boundstone: 175-180 cm thick; divisible into three units, a-c.

Unit a: Chaetetid Boundstone, 25-38 cm thick; medium dark gray (N4), weathers olive black (5Y2/1); nearly 100% chaetetids; chaetetids begin as laminar forms at lower contact, continue upward as low domical to high domical forms, some continue into overlying unit; few chaetetids at angles less than 90 degrees; numerous open cavities around individual chaetetids, some partially filled with black (N1) shale; few areas of skeletal packstone around chaetetids, contains fusulinids, crinoid debris, echinoid spines, brachiopod shell fragments; articulated Composita attached to surface of chaetetid.

Unit b: Chaetetid Boundstone, 43-66 cm thick; light gray (N7), weathers dark yellowish brown (10YR4/2) to light brown (5Y5/6); nearly entirely columnar and high domical chaetetids, begin at lower contact or have continued into the unit from unit a; some chaetetids at angles less than 90 degrees, few toppled over (more common near upper contact); some open cavities between chaetetids, elsewhere inter-chaetetid areas filled with olive black (5Y2/1) shale or wavy bedded skeletal wackestone to packstone with crinoid debris, fusulinids, small angular chaetetid fragments, Composita and other brachiopod shell fragments, echinoid spines and plates, gastropods, unidentifiable medium to fine sand-sized skeletal grains (most algal-coated); much of the unit and underlying unit stained black (N1) (petroleum staining?); few articulated Crurithyris and Composita near, or attached to, chaetetids; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper contact; upper contact sharp, few chaetetids continue through contact.

Unit c: Chaetetid Wackestone to Skeletal Grainstone, 93-100 cm thick; light gray (N7), weathers pale yellowish brown (10 YR 8/2) to very pale orange (10 YR 6/2); 50% high domical (ragged) to columnar chaetetids, most have continued into unit from unit b, few begin at lower contact; chaetetid growth more ragged upward; no inter-chaetetid cavities; matrix skeletal wackestone to grainstone; moderately well-sorted, medium- to fine-grained; 40-80% fossils, including crinoid debris (4-5%), Composita (few articulated with spar filling, randomly oriented), ostracodes, gastropods, unidentifiable medium to

(cont.)

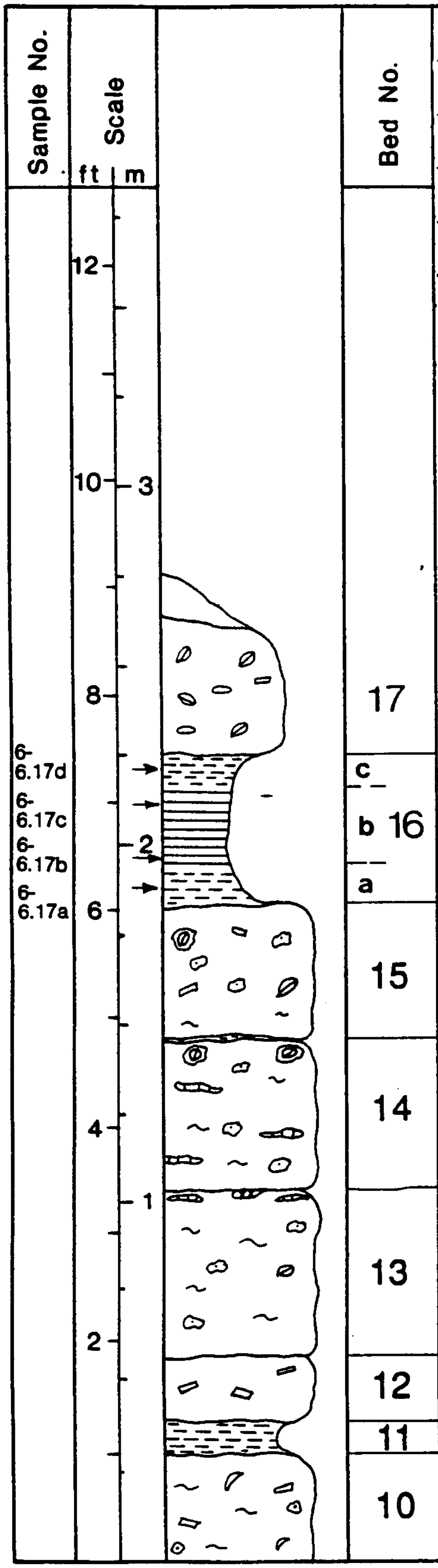
fine sand-sized skeletal grains (30-70%, frequently algal-coated); fossils (except chaetetids) randomly oriented; upper contact irregular, very sharp, pitted, eroded, with in-place brecciation; brecciated areas inter-fingered with discontinuous 1-2 cm thick dark yellowish orange (10YR6/6) mudstone.

4. Phylloid Algal Wackestone, 46 cm thick; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (10-12%, less abundant upward, third algal-coated), crinoid debris (2-3%, more common upward), brachiopod fragments (third algal-coated), fusulinids, productids (few articulated, mostly shell fragments, most algal-coated), Composita (one noted, articulated), Lophophyllidium (in upper 10 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%, half algal-coated); few laminar chaetetids throughout, concentrated at lower contact (in-situ); other fossils randomly oriented; bedding indistinct; upper contact very sharp, marked by olive black (5Y2/1) clay-rich laminae.

3. Phylloid Algal Wackestone, 24 cm thick; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (15-20%, up to several cm long, quarter algal-coated), crinoid debris (2-3%), Composita (few articulated), other brachiopod shell fragments (most algal-coated), unidentifiable medium to fine sand-sized skeletal grains (5-10%, 15% algal-coated); few small laminar chaetetids throughout, concentrated at upper contact; fossils (other than chaetetids, that are in-situ) randomly oriented; bedding indistinct; upper contact sharp, marked by olive gray (5Y2/1) clay-rich laminae.

2. Phylloid Algal Wackestone, 25 cm thick; light olive gray (5Y6/1), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including phylloid algal fragments (10%, half algal-coated in lower part, less coated upward), productids (few articulated, most algal-coated), other brachiopod shell fragments (most algal-coated), crinoid debris, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (5-10%, most algal-coated); fossils randomly oriented; somewhat wavy bedded; olive black (5Y2/1) clay-rich laminae in lower 8 cm; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

1. Fusulinid Skeletal Packstone, 7 cm exposed, lower contact covered; medium light gray (N6), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 75-80% fossils, including fusulinids (50%, some appear fragmented, abraded), phylloid algae? (5-7%, highly fragmented), brachiopod shell fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15-20%); 20% of fusulinids, 80% of other fossils algal-coated; wavy bedded; upper contact gradational.



DESCRIPTION: Section 693-S6, Locality 693

7 meters east of SW corner, north wall

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S, R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1990

SECTION 693-S6

bed

Worland Limestone Member

17. Brachiopod Skeletal Wackestone, 33 cm thick, modern soil developed on upper surface; light olive gray (5Y6/1), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including Composita (8-10%, frequently articulated, some with geopetal, few in life to near life position), Crurithyris (7-8%, frequently articulated), Hustedia, Mesolobus, productids, crinoid debris, low-spired gastropods, fenestrate and ramose bryozoan fragments, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (20-25%); fossils randomly oriented; bed highly weathered, fragmented; some moldic porosity (leached out fossil grains); medium gray (N5) mottling throughout.

Lake Neosho Shale

16. Shale: 39 cm thick; divisible into three units, a-c; all units are disturbed by modern plant roots, most bedding structures destroyed.

Unit a: Calcareous Clayshale, 8 cm thick; light olive gray (5Y6/1), weathers pale olive (10YR6/2) to pale yellowish orange (10YR8/6); 10-15% fossils, including brachiopod fragments, ramose bryozoan, high- and low-spired gastropods, crinoid ossicles, unidentifiable medium to fine sand-sized skeletal grains; calcareous nodules common; gradational upper contact.

Unit b; Non-calcareous Phosphatic Shale; 22 cm thick, grayish black (N2), weathers olive black (5Y2/1); 1-2% fossils, including Orbiculoidea, Petrodus, ramose bryozoan fragments and holdfast, conodonts, plant fragments?; some fossils may be from mixing with overlying bed due to rooting; Spherical to discoidal phosphate nodules throughout, more common in upper 1/2 (contain nucleus of Orbiculoidea, plant fragments, Petrodus, or unidentifiable debris); Planolites-like traces in lower part; fissile to platy bedding; upper contact gradational?.

Unit c: Calcareous Clayshale, 9 cm thick, yellowish gray (5Y7/2), weathers grayish orange (10YR7/4) to dark yellowish orange (10YR6/6); 10-15% fossils, including Orbiculoidea (1-2%), productid shell fragments and spines, crinoid ossicles, ramose bryozoan fragments, Donaldina-like gastropods, unidentifiable medium to fine sand-sized skeletal grains (4-5%); few spherical to discoidal phosphate nodules throughout (nucleus of Orbiculoidea, plant fragments, fish bones?, or unidentifiable debris); upper contact gradational.

(cont.)

Amoret Limestone Member

15. Brachiopod Crinoidal Wackestone, 35-40 cm thick; very light gray (N8) to light gray (N7), weathers grayish brown (5YR3/2)); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (5%, occasionally articulated, rarely in life position), productid shell fragments, Crurithyris, Mesolobus, crinoid debris (5%), echinoid spines, low- and high-spired gastropods, ramose bryozoan fragments, bellerophontids, phylloid algal fragments (1-2% in lower 10 cm), sharks tooth, unidentifiable medium to fine sand-sized skeletal grains (10-15%); most brachiopods fragmented; much small fossil debris algal-coated, some larger fossils algal-coated; fossils randomly oriented; bedding indistinct; moldic porosity throughout; depressions on upper surface occasionally filled with discontinuous skeletal wackestone consisting of unidentifiable fragmented skeletal debris; upper contact sharp.

14. Phylloid Algal Brachiopod Wackestone; 35-40 cm thick; light gray (N7), weathers dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (15-20%, up to several cm long, half algal-coated), Composita (1-2%, mostly fragmented, frequently algal-coated), productids (shell fragments, frequently algal-coated), other brachiopod shell fragments, crinoid debris (3-4%, often clumped together), unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); few small (<10 cm long, 1 cm thick) laminar chaetetid throughout, encrusting phylloid algal fragments (some chaetetids in upper quarter overturned, fragmented); fossils randomly oriented (except most chaetetids that are in place); bedding indistinct; light gray (N7) to medium light gray (N6) mottling in lower 3-4 cm and upper 5-10 cm; moldic porosity throughout (leached out fossils grains); on upper surface are numerous articulated and fragmented Composita and Juresania (half completely algal-coated, rest partially algal-coated to uncoated, some with well preserved brachidia, few Juresania with well preserved spines), also Crurithyris, Neospirifer, echinoid spines and plates, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, marked by 2-5 cm thick dark yellowish orange (10YR6/6) calcareous clayshale with brachiopod fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains.

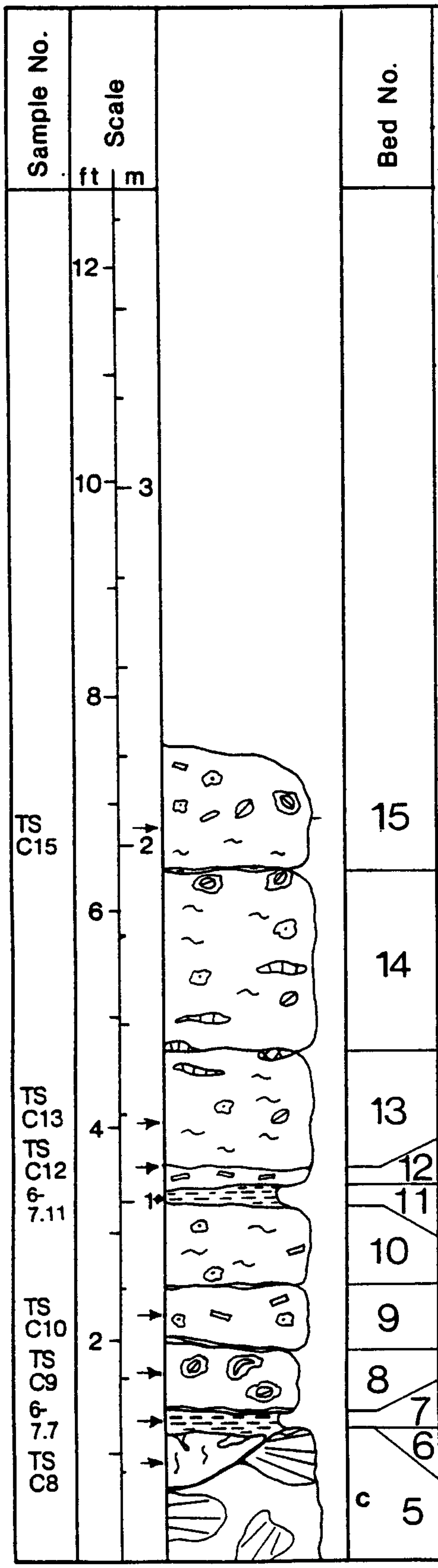
13. Phylloid Algal Crinoidal Wackestone, 40-45 cm thick; very light gray (N8), weathers dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (15-20%, up to several cm long, half algal-coated), crinoid debris (1-2%, few algal-coated, ossicles and other fragments), Composita (mostly shell fragments, rarely articulated), Crurithyris (few articulated), echinoid spines and plates, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); few large (2-3 cm in length, 1 cm diameter) crinoid columnals at lower contact; two small laminar chaetetids (up to 10 cm long, 1 cm high, begin phylloid algal fragments, terminated by algal overgrowth) noted just below upper contact; fossils (except for in-situ chaetetid) randomly oriented; bedding indistinct; light gray (N7) to medium light gray (N6) horizontal mottling in upper 5-10 cm; discontinuous band of chert nodules at upper contact; upper contact gradational.

12. Crinoidal Wackestone, 12-14 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6) to yellowish gray (5Y7/2); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including crinoid debris (10-15%), Composita shell fragments, brachiopod spines, phylloid algae? (highly fragmented), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; bedding indistinct; upper contact sharp, irregular.

11. Calcareous Clayshale, 9 cm thick; dark yellowish orange (10YR6/6), weathers pale yellowish orange (10YR8/6); 20-25% fossils, including crinoids (10-15%, ossicles, plates),
(cont.)

Mesolobus (2-3%, often whole valves, frequently articulated), fenestrate and ramose bryozoan fragments, productid shell fragments, unidentifiable medium to fine sand-sized skeletal grains; discontinuous wackestone to packstone lenses of crinoid debris and Mesolobus valves; flaggy to platy partings; upper contact sharp.

10. Phylloid Algal Brachiopod Wackestone, 30 cm thick; light gray (N7), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (15-20%, most < 1 cm long, two-thirds algal-coated), crinoid debris (5-7%), productids (2-3%, frequently articulated, mud- to spar-filled with geopetal, some algal-coated), Composita (1-2%, few articulated, randomly oriented, mud- or rarely spar-filled, few algal-coated), low-spired gastropods, bellerophontids, unidentifiable medium to fine sand-sized skeletal grains (10-15%, two-thirds algal-coated); fossils randomly oriented; bedding indistinct; upper contact sharp.



DESCRIPTION: Section 693-S7, Locality 693

51 meters south of NW corner

LOCATION: SE 1/4, SE 1/4, sec 36, T.35S,

R.18 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1990

SECTION 693-S7

bed

Amoret Limestone Member

15. Brachiopod Crinoidal Wackestone, 31-33 cm thick, upper surface top of rock exposure; light gray (N7), weathers very pale orange (10YR 6/8) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 20-25% fossils, including Composita (2-3%, occasionally articulated, mud- to spar-filled with geopetal, few in life position, fifth algal-coated), productids (Desmoinesia?, 1-2%, rarely articulated, some with moderately well-preserved spines, mud- to spar-filled, overturned), Crurithyris, crinoid debris (5%, few large columnals in upper half, up to 2-3 cm long, 1-2 cm diameter), echinoid spines, Aviculopecten, Hustedia, low- and high-spired gastropods, fenestrate bryozoan fragments, phylloid algae (2-3% in lower 10 cm, relatively absent in upper part, most algal-coated), unidentifiable medium to fine sand-sized skeletal grains (8-10%); most brachiopods fragmented; most small fossil debris algal-coated, some larger fossils algal-coated; fossils randomly oriented, decrease in abundance upward; bedding indistinct; small chert nodule in center (5 cm long); moldic porosity throughout (leached out fossil grains).

14. Phylloid Algal Brachiopod Wackestone, 48-50 cm thick; very light gray (N8), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 45-50% fossils, including phylloid algal fragments (20-25%, up to several cm long, quarter algal-coated), Composita (2-3%, rarely articulated), productids (Desmoinesia, Linoproductus, rarely articulated), Crurithyris, crinoid debris (3-4%), echinoid spines and plates, Omphalotrochus-like gastropod, bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); few small (<10 cm long, 2-4 cm thick) laminar chaetetid in lower 3/4, encrusting phylloid algal fragments, some overturned; fossils randomly oriented (except chaetetids which occur in place); bedding indistinct; chert nodules common at lower contact, few throughout; light gray (N7) to medium light gray (N6) mottling in lower 5-7 cm; on upper surface are numerous articulated and fragmented Composita (most algal-coated, few uncoated, randomly oriented), echinoid spines and plates, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp, marked by 1-2 cm thick calcareous clayshale with crinoid and brachiopod debris.

13. Phylloid Algal Crinoidal Wackestone, 38-40 cm thick; light gray (N7), weathers dark yellowish brown (10YR4/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-

(cont.)

grained; 35-40% fossils, including phylloid algal fragments (15-20%, up to several cm long, half algal-coated), crinoid debris (1-2%, few algal-coated, ossicles and other fragments), Composita (mostly shell fragments, rarely articulated), Crurithyris (few articulated), echinoid spines and plates, unidentifiable medium to fine sand-sized skeletal grains (15-20%, some algal-coated); small laminar chaetetid (5 cm long, 3 cm high) in upper half; fossils (except for in-situ chaetetid) randomly oriented; bedding indistinct; light gray (N7) to medium light gray (N6) horizontal mottling in upper 5 cm; discontinuous band of chert nodules at upper contact; upper contact gradational.

12. Crinoidal Wackestone, 6-8 cm thick; very light gray (N8), weathers olive gray (5Y4/1) to dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including crinoid debris (10-15%), brachiopod shell fragments and spines, phylloid algae? (highly fragmented, few large fragments in upper 2 cm), unidentifiable medium to fine sand-sized skeletal grains (20-25%); fossils randomly oriented; bedding indistinct; upper contact sharp, tightly fused to overlying bed.

11. Calcareous Clayshale, 5-9 cm thick; yellowish gray (5Y7/2), weathers dark yellowish orange (10YR6/6); 25-30% fossils, including crinoids (15-20%, ossicles, plates, few stems up to 2-3 cm in length), Mesolobus (4-5%, common whole valves, frequently articulated), fenestrate and ramose bryozoan fragments, productid shell fragments and spines, unidentifiable medium to fine sand-sized skeletal grains; flaggy to platy partings; becomes crinoidal wackestone in upper 3 cm with similar fossils composition as clayshale; upper contact very sharp.

10. Phylloid Algal Brachiopod Wackestone, 16-20 cm thick; light gray (N7), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (15-20%, most less than 1 cm long, 2/3 algal-coated), crinoid debris (5-7%), productids (2-3%, frequently articulated, mud- to spar-filled with geopetal, some algal-coated), Composita (1-2%, few articulated, randomly oriented, mud- or rarely spar-filled, few algal-coated), low-spired gastropods, bellerophontids, unidentifiable medium to fine sand-sized skeletal grains (10-15%, 2/3 algal-coated); fossils randomly oriented; bedding indistinct; few small chert nodules throughout; upper contact sharp.

9. Crinoidal Wackestone, 12-14 cm thick; light gray (N7), weathers pale yellowish orange (10YR6/6) to dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained; 25-30% fossils, including crinoid debris (5-10%), Composita shell fragments, Juresania (few noted, mostly shell fragments, one articulated), ramose and fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (15-20%); many fossils partially to completely algal-coated; fossils randomly oriented; medium light gray (N6) horizontal mottling throughout; bedding indistinct; upper contact gradational, marked by slabby partings.

8. Brachiopod Oncolitic Wackestone, 14-20 cm thick; very light gray (N8), weathers pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including productids (Juresania, Desmoinesia, 8-10%, mostly shell fragments and spines in lower third, often articulated in upper two-thirds, mud-filled), Composita (2-3%, frequently articulated, mud-filled), crinoid debris (1-2%), unidentifiable medium to fine sand-sized skeletal grains (25-30%); most fossils entirely algal-coated in lower half (up to 2 cm in thickness), less well coated upward; articulated brachiopods more common upward; fossils randomly oriented; olive black (5Y2/1) clay-rich laminae occur throughout, imparts a nodular appearance; lower 2 cm black (N1) platy calcareous shale with fragmented skeletal debris (productid spines and shell fragments, other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains); upper 1-2 cm olive black (5Y2/1) platy shale with articulated algal-coated biscuit-shaped

(cont.)

Composita and productids (Juresania, Antiquatonia), also crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (two-thirds algal-coated); upper contact gradational.

7. Calcareous Mudshale, 4-5 cm thick; grayish olive (10Y4/2), weathers olive gray (5Y3/2); plant remains, rare brachiopod (Composita?) shell fragments; platy to flaggy partings; upper contact sharp.

6. Skeletal Carbonate Mudstone, 0-13 cm; light gray (N7), weathers very light gray (N8); well-sorted, fine-grained; rare fossils (1-2%), including high-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains; fossils randomly oriented; numerous burrow- and/or rootlet-like structures (up to 5 cm long, most 2-3 cm long, up to 1 cm wide) throughout, mud-filled (iron stained) or spar-filled, occasionally bifurcate downward; stylolites throughout with, associated with olive black (5Y2/1) clay-rich laminae; pinches out against underlying bed; upper surface pitted, eroded; spar-filled fractures on upper surface; upper contact sharp.

5. Chaetetid Skeletal Wackestone to Grainstone, 20-32 cm exposed, lower contact covered; pinkish gray (5YR8/1), weathers very pale orange (10YR8/2); similar to unit c, bed 5, at sections 2, 5; 70% chaetetids (low domical to high domical (ragged) forms, all toppled or overturned); chaetetid lying on it's side at upper surface (40 cm long, 18 cm diam., eroded level with surface of bed); surrounding matrix skeletal wackestone to grainstone; moderately well-sorted, medium- to fine-grained; 50-80% fossils, including crinoid debris (4-5%), Composita (mostly shell fragments, one articulated), ostracodes, unidentifiable medium to fine sand-sized skeletal grains (40-75%, frequently algal-coated); fossils randomly oriented; upper contact with bed 6 irregular, sharp, scoured; elsewhere upper surface pitted, eroded.

APPENDIX D

MEASURED STRATIGRAPHIC SECTIONS

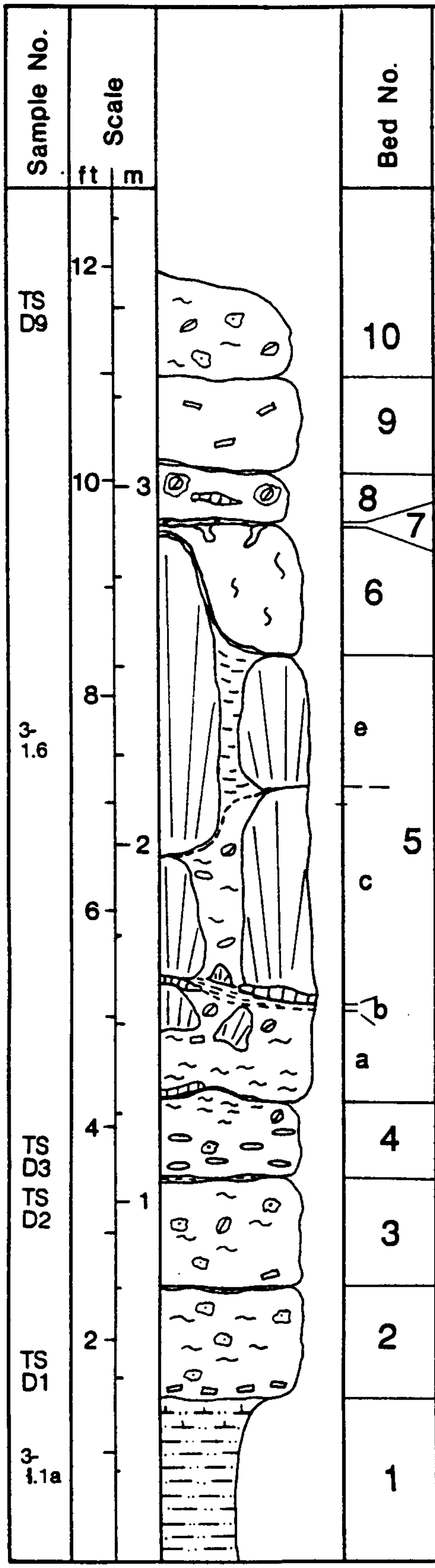
LOCALITY 782

Roadcut along US Highway 166,
east of Edna, Kansas

Samples collected at locality 782

Sample no.	Level
782-S1	
S-1.	
1	upper half, bed 1
2a	lower third, bed 2
2b	upper contact, bed 2
3a	lower contact, bed 3
3b	upper contact, bed 3
4	entire thickness, bed 4
5a	upper half, bed 5a
5b	lower contact, bed 5a
5c	middle part, bed 5c
6	matrix, bed 5e
7	upper contact, bed 6
10a	lower contact, bed 10
10b	upper surface, bed 10
782-S2	
S-2.	
5a	middle part, bed 5b
5b	middle part, bed 5b
5c	upper half, bed 5c
5d	entire thickness, bed 5d
5e	matrix, bed 5e
6a	upper third, bed 6
6b	upper contact, bed 6
7	entire thickness, bed 7
8a	lower contact, bed 8
8b	upper half, bed 8
9a	lower contact, bed 9
9b	middle part, bed 9
9c	upper contact, bed 9
11a	lower half, bed 11
11b	upper half, bed 11
11c	contact of bed 10, 11
12	entire thickness, bed 12
12b	mudstone parting, upper contact, bed 12
13a	lower contact, bed 13
13b	middle part, bed 13
13c	middle part, bed 13
13d	upper contact, bed 13
14a	contact of beds 13, 14
14b	lower contact, bed 14
14c	upper contact, bed 14
KLP-S1	middle part, bed 5c, 20 yds west of 782-S2

DESCRIPTION: Section 782-S1, Locality 782
52 meters east of 782-S4
LOCATION: NE 1/4, SE 1/4, sec 32, T.34S, R.19 E, Labette Co., Kansas
MEASURED BY: Vincent Voegeli 1989



SECTION 782-S1

bed

Amoret Limestone Member

10. Phylloid Algal Brachiopod Wackestone, 30 cm thick, overlain by modern soil; light gray (N7) weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (15-20%, quarter algal-coated), productids (Desmoinesia, Echinaria; 3-4%, commonly articulated, often spar-filled with geopetal, quarter algal-coated), Composita (1-2%, few articulated, few algal-coated), Crurithyris (few articulated), crinoid debris (3-4%), low-spired gastropods (frequently with geopetal, few algal-coated), unidentifiable medium to fine sand-sized skeletal grains (10-15%, third algal-coated); most articulated brachiopods in lower half; fossils randomly oriented, become more fragmented upward; dark yellowish orange (10YR6/6) mottling throughout; discontinuous chert layer in lower third (similar skeletal composition as surrounding rock), silicified fossils common in this area: upper part fragmented.

9. Crinoidal Wackestone, 30-25 cm thick; medium gray (N5), weathers medium light gray (N6) in center, dark yellowish orange (10YR6/6) to yellowish brown (10YR5/4) elsewhere; moderately well-sorted, medium- to fine-grained; 10-15% fossils, including crinoid debris (2-3%), Composita (rarely articulated, mud- filled), other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (5-10%); fossils randomly oriented; chert nodules common throughout; dark yellowish orange (10YR6/6) horizontal mottling throughout; upper contact sharp, marked by thin (0.5 cm) dark yellowish orange (10YR6/6) mudshale parting.

8. Brachiopod Oncolitic Wackestone, 18-23 cm thick; very light gray (N8), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (10-12%, frequently articulated), productids (2-3%, mostly Juresania, frequently articulated, also shell fragments, spines), crinoid debris, ostracodes, echinoid spines, ramose bryozoan fragments, low-spired gastropods, bellerophontids, unidentifiable medium to fine sand-sized skeletal grains (8-10%); nearly all fossils algal-coated (80%, up to several cm thick, most completely algal-coated, some algal-coated only on one side); fossils randomly oriented; laminar chaetetid (8 cm long, 2 cm high) in lower half (growing on productid oncolite); olive black (5Y2/1) clay-rich laminae throughout, concentrated in upper and lower part; indistinct bedding; lower 1 cm dark gray (N3) platy shale with productid shell fragments and spines, unidentifiable skeletal grains; upper 2-3 cm dark gray (N3) platy shale with algal-coated articulated productids (biscuit shaped), other brachiopod shell fragments,
(cont.)

crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

7. Calcareous Mudshale, 1-5 cm thick; pale yellowish orange (10YR8/6) in lower half, moderate yellow (5Y7/6) in upper half, locally grayish olive (10 YR 4/2), weathers dark yellowish orange (10YR6/6); lower half less calcareous with plant remains, black (N1) organic stringers; upper half contains rare fragmented fossil debris; thickens over depressions in underlying bed, thickens and thin considerable laterally away from section; upper contact sharp.

6. Gastropod Skeletal Wackestone, 3-36 cm thick; very light gray (N8), weathers grayish orange (10YR7/4); moderately well-sorted, medium- to fine-grained; 15-25% fossils, including Donaldina-like gastropods (5-7%), low-spired gastropods (1%), Composita (mostly shell fragments, rarely articulated), other brachiopod shell fragments, crinoid debris, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (7-15%); fossils randomly oriented, less common and more fragmented upward; numerous small (2-8 cm long, 0.5 cm wide) vertical burrow and/or rootlet structures (occasionally bifurcate downward, more abundant in the upper part, half mud-filled, half spar-filled); large vertical solution, burrow, and/or rooting structures common extending from upper surface downward (up to 30 cm long, 6 cm wide, taper downward, few bifurcate downward, spar- or mud-filled, or filled with fragmented skeletal grains); thickens and thins considerable over depressions in underlying bed; nearly pinches out over chaetetid buildup in underlying bed; upper surface irregular, pitted and eroded; upper contact sharp.

5. Wackestone to Boundstone: 130-160 cm thick; divisible into 5 units (a-e) elsewhere, four units (a-c, e) present at this section.

Unit a: Phylloid Algal Chaetetid Packstone to Wackestone, 31-38 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; lower half 60-70% fossils, including phylloid algal fragments (40-50%, up to several cm long), Composita (few articulated), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; fossils randomly oriented; laminar chaetetid at lower contact (begins on clay seam); upper half 35-40% fossils, including phylloid algal fragments (10-15%), Composita (1-2%, few articulated), Crurithyris (few articulated), crinoid debris (4-5%), gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%); some fossils algal-coated; two low domical chaetetids in middle part (begin on clumps of phylloid algal fragments); one chaetetid (12 cm high, 15 cm wide) ends below upper contact, other (15 cm high, 25 cm wide) continues through upper contact; sediment drapes over chaetetids 5-6 cm; laminar chaetetids common away from this section; upper contact sharp, irregular, marked by olive black (5 Y 2/1) clay-rich laminae.

Unit b: Calcareous Shale, 2-6 cm thick; olive black (5Y2/1), weathers brownish gray (5YR4/1); contains brachiopods shell fragments, laminar chaetetids, unidentifiable medium to fine sand-sized skeletal grains); some chaetetids continue into this unit from domical forms in unit a, become laminar, continue into overlying unit; thickens considerable laterally to phylloid algal chaetetid wackestone; upper contact irregular, sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit c: Chaetetid Skeletal Wackestone, 30-61 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); moderately well-sorted, medium- to fine-grained; 40-45% fossils, including fusulinids (10-15%), crinoid debris (10%), phylloid algal fragments (2-3%), Composita (few articulated), Crurithyris (few articulated), angular chaetetid fragments, ramose and fenestrate bryozoan fragments, Lophophyllidium, Straporollus, unidentifiable medium to fine sand-sized skeletal grains (10-15%, quarter algal-coated); two columnar chaetetids, one continues into unit from underlying unit, other begins at lower contact as laminar form (begins on clay-rich laminae); both

(cont.)

chaetetids continue through entire thickness of unit and into overlying unit; upper contact irregular, sharp.

Unit e: Chaetetid Boundstone with inter-bedded fossiliferous clayshale, 36-84 cm thick; chaetetids light gray (N7) to medium light gray (N6), weather grayish orange (10YR7/4) to dark yellowish orange (10YR6/6); low domical to columnar chaetetids, form in-situ buildup (buildup pinches out laterally away from section, underlying unit c scoured out around buildup); columnar forms continue into unit from underlying unit, low domical forms begin within unit (some at angles less than 90 degrees); chaetetids terminate at upper contact, frequently appear toppled, displaced, fragmented (30%) (some may be broken off pieces of columnar forms), appear weathered (spar-filled desiccation-like cracks on surface); inter-bedded fossiliferous clayshale moderate yellowish brown (10YR5/4), weathers pale yellowish orange (10YR8/6); contains brachiopod shell fragments, crinoid ossicles, angular chaetetid fragments, unidentifiable medium to fine sand-sized skeletal grains; upper contact irregular, sharp.

4. Fusulinid Skeletal Packstone to Phylloid Algal Wackestone, 20-30 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; lower two-thirds 65-75% fossils, including fusulinids (30-35%, few algal-coated), phylloid algae? (5%, highly fragmented, algal-coated), brachiopod shell fragments (1-2%, algal-coated), crinoid debris, laminar chaetetid (near center, 10 cm long, 4 cm high); unidentifiable medium to fine sand-sized skeletal grains (20-25%, algal-coated); wavy bedded; few partially silicified nodules (some fossil composition as surrounding rock); upper third 30-35% fossils, including phylloid algal fragments (10-15%, occasionally algal-coated), Composita (few articulated), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15-20%, quarter algal-coated); fossils randomly oriented; indistinct bedding; upper surface irregular; upper contact sharp, marked by thin (1-3 cm) moderate yellowish brown (10YR5/4) calcareous shale, mostly unidentifiable skeletal grains, also crinoid fragments, ramose bryozoan fragments, Composita (mostly shell fragments), fusulinids.

3. Skeletal Packstone to Phylloid Algal Gastropod Wackestone, 33 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); well-sorted, fine-grained in lower 7 cm, poorly-sorted, coarse- to fine-grained above this; lower 7 cm 70-75% fossils, including crinoid debris, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (65-70%); upper 26 cm 30-35% fossils, including phylloid algal fragments (10-15%, up to 10 cm long) low-spired gastropods (1-2%), Soleniscus-like gastropods, Composita (few articulated, mostly shell fragments), Crurithyris (few articulated, mostly shell fragments), crinoid debris, Heliospongia (in upper 5 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented, one-third algal-coated; indistinct bedding; upper contact is sharp, marked by thin (0.5-2.5 cm) moderate yellowish brown (10YR5/4) calcareous clayshale with brachiopod shell fragments, unidentifiable fossils grains.

2. Crinoidal Packstone to Phylloid Algal Wackestone, 35 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); moderately well-sorted, medium- to fine-grained in lower 8 cm, poorly-sorted, coarse- to fine-grained above this; lower 8 cm 60-70% fossils, including crinoid debris (40-50%), brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (15-20%, occasionally algal-coated); wavy bedded; upper 25 cm 30-35% fossils, including phylloid algal fragments (10-15%), crinoid debris (2-3%), Composita (mostly shell fragments, few articulated), productids (mostly shell fragments, few articulated), low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented, frequently algal-coated; bedding indistinct; upper contact sharp, marked by thin (2 cm) moderate yellowish brown (10YR5/4) calcareous clayshale with brachiopod shell fragments, unidentifiable skeletal grains.

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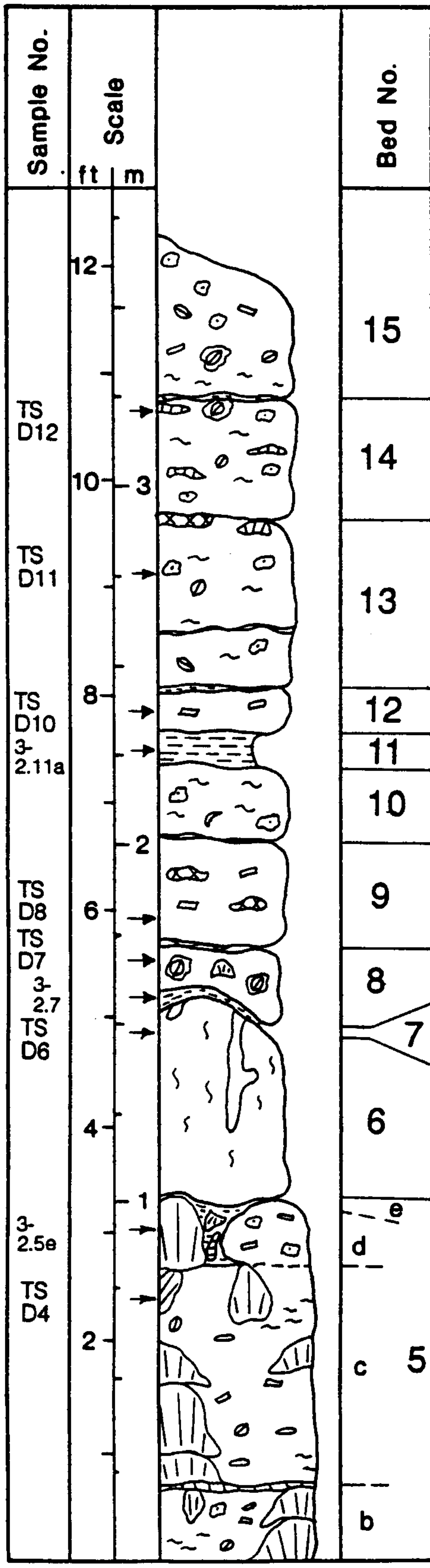
Bandara Shale Formation

1. Non-calcareous to Calcareous Micaceous Siltstone, 46 cm exposed, lower contact covered; dark gray (N3), weathers grayish orange (10YR7/4); lower 36 cm non-calcareous with few plant fragments, root traces and/or small burrow structures; indistinct bedding; becomes calcareous in upper 10 cm, contains rare (1%) small unidentifiable fossil fragments; flaggy bedding; upper contact sharp to gradational, marked by olive black (5Y2/1) clay-rich laminae.



DESCRIPTION: Section 782-S2, Locality 782 south side of roadcut, S13 W of 782-S1

LOCATION: NE 1/4, SE 1/4, sec 32, T.34S, R.19 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1989

SECTION 782-S2

bed

Amoret Limestone Member

15. Brachiopod Skeletal Wackestone, 30-50 cm thick, modern soil developed on surface; medium gray (N5) to medium light gray (N6), weathers yellowish gray (5Y8/1) to pale yellowish orange (10YR8/6); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (2-3%, mostly shell fragments, few articulated, most algal-coated), Crurithyris (few articulated), productids (Desmoinesia, Juresania, Antiquatonia, rarely articulated), Hustedia, crinoid debris (1-2%, few stems 2-3 cm long), phylloid algal fragments (2-3% in lower 10 cm, absent above this, two thirds algal-coated), Leptozyga-like gastropods, low-spired gastropods (few algal-coated), echinoid spines and plates, bellerophontids, Girtyocoelia, Omphalotrochus, unidentifiable medium to fine sand-sized skeletal grains (15-20%, two-thirds algal-coated); two small laminar chaetetids to right of section (7 and 5 cm long, 1 cm high, overturned several times); fossils randomly oriented, more fragmented upward, decrease in abundance upward; numerous small vertical burrow-like structures throughout (up to 7 cm long, 0.5 cm wide, iron stained, open or mud-filled); few chert nodules near upper contact (< 5 cm long); bedding indistinct; discoidal to spherical phosphate nodules on upper surface (nucleus is Orbiculoidea or unidentifiable debris); discontinuous (eroded) laterally.

14. Phylloid Algae Brachiopod Wackestone, 30-33 cm thick; light gray (N7), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (10-15%, third algal-coated, less abundant and more fragmented upward), Composita (1-2%, occasionally articulated, mud- to spar-filled), Crurithyris (few articulated), Juresania (mostly shell fragments and spines), crinoid debris (1-2%), echinoid spines, unidentifiable medium to fine sand-sized skeletal grains (20-25%, two-thirds algal-coated); few laminar chaetetids throughout (10-30 cm long, 5-6 cm high, some overturned, growth continued upward after overturning); fossils (except in-situ chaetetids) randomly oriented, more fragmented and fine-grained upward; dark yellowish orange (10YR6/6) mottling in lower 5-10 cm; on upper surface is thin fine-grained skeletal packstone, also few algal-coated articulated Composita; upper contact sharp, marked by 4-5 cm thick dark yellowish orange (10YR6/6) clayshale.

13. Phylloid Algal Brachiopod Wackestone, 41-44 cm thick; light gray (N7), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-

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grained; 40-45% fossils, including phylloid algal fragments (15-20%, third algal-coated, up to several cm long), Composita (2-3%, occasionally articulated, frequently algal-coated), Crurithyris (occasionally articulated, algal-coated), Juresania (mostly shell fragments and spines, rarely articulated, frequently algal-coated), Neospirifer (one observed, articulated with geopetal, in-situ?), crinoid debris (5%), unidentifiable medium to fine sand-sized skeletal grains (10-15%, half algal-coated); one partially silicified laminar chaetetid at upper contact (8 cm long, 3 cm high, in situ); fossils randomly oriented (except as noted); distinct platy parting 15-17 cm above lower contact; dark yellowish orange (10YR6/6) mottling throughout, concentrated in upper 10-15 cm; discontinuous nodular chert layer at upper contact (same fossil composition as surrounding rock); upper contact gradational.

12. Crinoidal Skeletal Wackestone, 11-13 cm thick; light gray (N7), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained, 15-20% fossil, including crinoid debris (2-3%), brachiopod shell fragments, gastropod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; dark yellowish orange (10YR6/6) horizontal mottling throughout (some preferentially silicified); upper contact sharp, irregular, marked by 1-2 cm thick dark yellowish orange (10YR6/6) clayshale.

11. Calcareous Clayshale, 10-12 cm thick; grayish orange (10YR7/4) to pale yellowish orange (10YR8/6), weathers dark yellowish orange (10 YR 6/6); 15-20% fossils, including crinoids (10-12%, ossicles, plates, few 1-2 cm long articulated stems), Mesolobus (1-2%, whole valves common, frequently articulated), productid shell fragments and spines, other brachiopod shell fragments, echinoid spines, unidentifiable medium to fine sand-sized skeletal grains (2-5%); grainstone lenses in lower 1-2 cm (same fossil as surrounding clayshale); discontinuous wackestone lenses in the upper third (same fossils as surrounding clayshale); thickens and thins considerable laterally; upper contact irregular, sharp.

10. Phylloid Algal Brachiopod Wackestone, 20-22 cm thick; medium gray (N5), weathers medium light gray (N6) to light gray (N7); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (10-15%, half algal-coated), productids (Juresania, Desmoinesia, Echinaria; 4-5%, commonly articulated, half algal-coated), Composita (1%, few articulated, most algal-coated), Crurithyris, crinoid debris (1-2%, mostly small fragments, one large 2 cm diam. stem), low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%, most algal-coated); few articulated productids in life position (most in lower half; few chert-filled, others spar- to mud-filled, frequent geopetal), other fossils randomly oriented, more fragmented upward; dark yellowish orange (10YR6/6) mottling throughout; few chert nodules (5-10 cm long) throughout, concentrated near center (similar fossils as surrounding rock); upper surface irregular, iron stained; upper contact sharp.

9. Crinoidal Wackestone, 30-33 cm thick; medium gray (N5) to medium dark gray (N4), weathers medium light gray (N6) in center, elsewhere dark yellowish orange (10YR6/6) to yellowish brown (10YR5/4); moderately well-sorted, medium- to fine-grained; 20-25% fossils, including crinoid debris (2-3%), productids (mostly shell fragments, rarely articulated), other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (15-20%); fossils randomly oriented; few chert nodules throughout; dark yellowish orange (10YR6/6) mottling throughout; upper contact sharp, marked by thin (1 cm) dark yellowish orange (10YR6/6) clayshale.

8. Brachiopod Oncolitic Wackestone, 10-22 cm thick; medium light gray (N6), weathers pale yellowish orange (10YR8/6) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including productids (10-12%, mostly Juresania;

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20% articulated, rest shell fragments, spines), Composita (1-2%, frequently articulated), echinoid spines, Donaldina-like gastropods, low-spired gastropods, bellerophontids, Lophophyllidium, Hustedia, Amblysiphonella, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (10-15%); nearly all fossil material algal-coated (up to several cm thick; most completely coated, some coated on one side only); most gastropods uncoated; fossils randomly oriented; low domical chaetetid (10 cm wide, 8 cm high) in center (growing on productid oncolite, overturned at least once during growth); small (5 cm long) laminar chaetetid in middle part; few algal-coated lithoclast; olive black (5Y2/1) clay-rich laminae throughout, concentrated at upper and lower contacts and where bed thins (when abundant impart a nodular appearance to bed); lower 1 cm dark gray (N3) platy shale with productid shell fragments and spines, unidentifiable skeletal grains; upper 2 cm dark gray (N3) platy shale with algal-coated articulated productids (biscuit shaped), other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains; upper contact gradational.

7. Calcareous Mudshale, 0.5-5 cm thick; pale yellowish brown (10YR6/2), weathers dark yellowish orange (10YR6/6); lower part less calcareous with plant remains, black (N1) organic stringers; upper part with rare (< 1%) fragmented fossil debris; becomes grayish olive (10YR4/2) locally; thickest over depressions in underlying bed, thickens and thin considerable laterally; upper contact sharp.

6. Gastropod Skeletal Carbonate Mudstone to Wackestone, 46-60 cm thick; light gray (N7) to very light gray (N8), weathers very pale orange (10YR8/2); moderately well-sorted, medium- to fine-grained; 10-30% fossils, including Donaldina-like gastropods (2-3%), low-spired gastropods, Composita (mostly shell fragments, rarely articulated), other brachiopod shell fragments, crinoid debris, bellerophontids, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (7-25%); fossils randomly oriented, less abundant and more fragmented upward; few laminar chaetetids in lower part away from this section (nearly all fragmented and/or overturned, few in-situ, continue into this bed from underlying bed); numerous small (2-6 cm long, 0.5 cm wide) vertical burrow and/or rootlet structures throughout, occasionally bifurcate downward (more abundant in upper part; half mud-filled, half spar-filled); large (up to 30 cm long, 6 cm wide) vertical solution- or root-like structures common, extend from upper surface downward (taper downward, few bifurcate downward; spar- to mud-filled, or filled with fragmented skeletal debris); upper surface irregular with solution pits and cavities; upper contact sharp.

5. Wackestone to Packstone, 99-104 cm thick; divisible into 4 units, b-e.

Unit b: Chaetetid Skeletal Wackestone to Packstone, 23 cm thick; medium gray (N5), weathers grayish orange (10YR7/4); moderately well-sorted, medium- to fine-grained; 40-60% fossils, including phylloid algal fragments (10-15%, in discontinuous lenses), crinoid debris (2-3%, clumped together), ramose bryozoan fragments, Composita (mostly shell fragments, few articulated), Crurithyris (few articulated), unidentifiable medium to fine sand-sized skeletal grains (20-25%, quarter algal-coated); high domical chaetetid (lower part covered, continues to upper contact, matrix drapes over surface 3-4 cm); low domical chaetetid in upper part (7 cm high, ends at upper contact); articulated brachiopods in close association with columnar chaetetid (few possible attached to surface), other fossils randomly oriented; skeletal debris finer-grained away from chaetetids; somewhat wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit c: Chaetetid Skeletal Wackestone to Packstone, 55-60 cm thick; medium gray (N5), weathers grayish orange (10YR7/4); moderately well-sorted, medium- to fine-grained; 45-65% fossils, including fusulinids (5-8%, less common upward), crinoid debris (10%), Composita and other brachiopod shell fragments, phylloid algal fragments (in discontinuous lenses), ramose and fenestrate bryozoan fragments, bellerophontids, straight shelled cephalopod, angular chaetetid fragments; unidentifiable medium to fine

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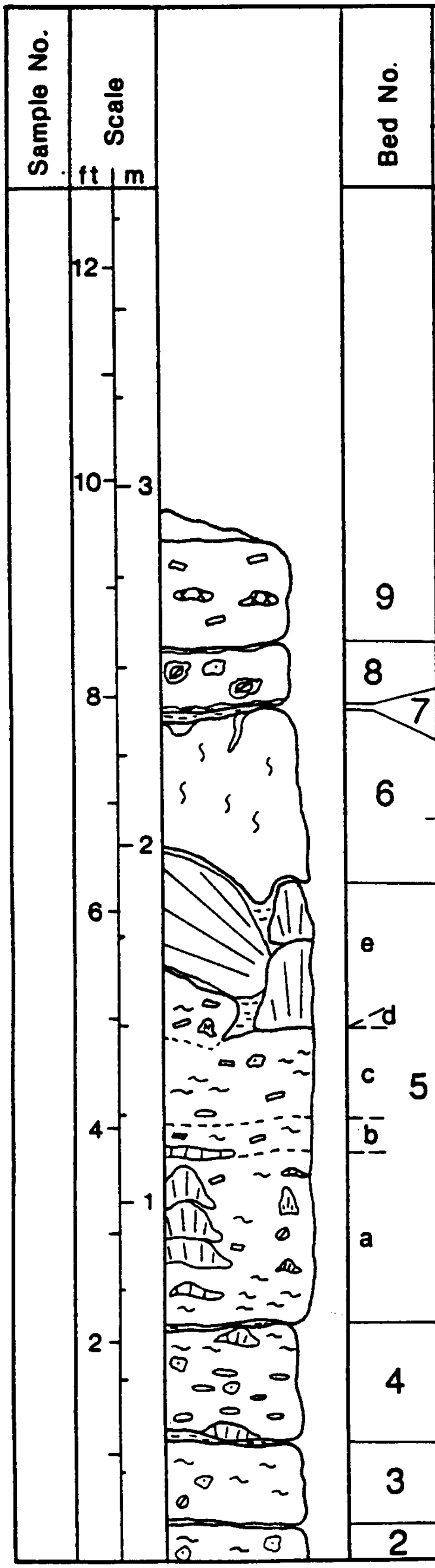
sand-sized skeletal grains (25-45%, quarter algal-coated); chaetetids common,(away from this section large areas devoid of chaetetids); thin laminar chaetetid (70 cm long) at lower contact, continues upward as a columnar form (35 cm high); low domical chaetetid 32 cm above lower contact (10 cm high, 20 cm wide, begins on phylloid algal fragments); two low domical chaetetids near upper contact: one begins 13 cm below upper contact, continues to upper contact; other just below the upper surface (partially toppled over); away from this section chaetetids in upper part of unit are frequently overturned or toppled; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae (were unit d present);

Unit d: Skeletal Wackestone, 0-16 cm thick; medium gray (N5), weathers grayish orange (10YR7/4); moderately well-sorted, medium- to fine-grained; 35-40% fossil, including crinoid fragments, brachiopod shell fragments, angular chaetetid fragments, unidentifiable medium to fine sand-sized skeletal grains (30-35%, third algal-coated); few small low domical chaetetids elsewhere within unit; discontinuous, usually laterally continuous with unit e, although in places unit e partially overlies the unit; upper contact sharp, marked by moderate yellowish brown (10YR5/4) clayshale.

Unit e: Chaetetid Boundstone to Rudstone with inter-bedded fossiliferous clayshale, 0-20 cm thick; light gray (N7) to medium light gray (N6), weather grayish orange (10YR7/4) to dark yellowish orange (10YR6/6); low domical chaetetids (appears in place), few chaetetid fragments; elsewhere unit contains high domical to columnar chaetetids, occasionally continuing up from unit c, some begin within the bed (nearly all terminate at upper contact, few away from the section continue into overlying bed); chaetetids frequently toppled, displaced, fragmented (20-30% across outcrop); inter-bedded fossiliferous clayshale moderate yellowish brown (10YR5/4), weathers pale yellowish orange (10YR8/6); coarse- to fine-grained, poorly-sorted; few articulated Composita, angular chaetetid fragments, unidentifiable medium to fine sand-sized skeletal grains; thickens and thin considerable laterally; where both units d and e missing, fossiliferous clayshale up to 10 cm thick; upper contact irregular, sharp; lower contact covered.



DESCRIPTION: Section 782-S3, Locality 782

82 meters east of western edge

LOCATION: NE 1/4, SE 1/4, sec 32, T.34S, R.19 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1989

SECTION 782-S3

bed

Amoret Limestone Member

9. Crinoidal Wackestone, 33 cm thick, modern soil developed on upper surface; medium gray (N5), weathers light brown (5YR5/6); moderately well-sorted, medium- to fine-grained; 10-15% fossils, including crinoid debris (2-3%), Composita and other brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (5-10%); fossils randomly oriented; few chert nodules in center; light gray (N7) horizontal mottling throughout; weathers differentially, chert and mottled areas more resistant.

8. Brachiopod Oncolitic Wackestone, 18-19 cm thick; light gray (N7), weathers very light gray (N8); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (10-12%, frequently articulated), productids (2-3%, mostly Juresania, frequently articulated, also shell fragments, spines), crinoid debris, echinoid spines, ramose bryozoan fragments, low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (8-10%); nearly all fossils algal-coated (80%, up to several cm thick, most completely algal-coated, some algal-coated only on one side), few uncoated productids (in-situ?, well preserved spines); fossils randomly oriented; few olive black (5Y2/1) clay-rich laminae, concentrated in upper and lower part; indistinct bedding; lower 1 cm dark gray (N3) platy shale with productid shell fragments and spines, unidentifiable skeletal grains; upper 2-3 cm dark gray (N3) platy shale with algal-coated articulated productids (biscuit shaped), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

7. Calcareous Mudshale, 0.5-2 cm thick; moderate yellow (5Y7/6), weathers dark yellowish orange (10YR6/6); contains rare fragmented fossil debris; thickens over depressions in underlying bed, thickens and thin considerable laterally away from section; upper contact sharp.

6. Gastropod Skeletal Carbonate Mudstone to Wackestone, 33-43 cm thick; light gray (N7), weathers very light gray (N8); moderately well-sorted, medium- to fine-grained; 10-30% fossils, including Donaldina-like gastropods (2-3%), low-spired gastropods, Composita (mostly shell fragments, rarely articulated), Neochonetes shell fragments, other brachiopod shell fragments, crinoid debris, bellerophontids, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (7-25%); fossils randomly oriented, less abundant and more fragmented upward; numerous small (2-6 cm long, 0.5 cm wide) vertical burrow and/or rootlet structures throughout, occasionally bifurcate downward (more abundant in upper

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part; half mud-filled, half spar-filled); large (up to 30 cm long, 6 cm wide) vertical solution- or root-like structures common, extend from upper surface downward (taper downward, few bifurcate downward; spar- to mud-filled, or filled with fragmented skeletal debris); upper surface irregular with solution pits and cavities; upper contact sharp.

5. Wackestone to Boundstone: 122-128 cm thick; divisible into 5 units, a-e.

Unit a: Phylloid Algal Chaetetid Packstone to Wackestone, 48-53 cm thick; medium gray (N5), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; 40-70% fossils, including phylloid algal fragments (20-50%, up to several cm long, somewhat clumped together), Composita (2-3%, several articulated, few in-situ?), high- and low- spired gastropods, crinoid debris, Lophophyllidium (in upper 5 cm), unidentifiable medium to fine sand-sized skeletal grains (10-15%); laminar chaetetid (14 cm long, 4 cm high) at lower contact (begins on clay-rich laminae); columnar chaetetid (38 cm high, starts on clump of phylloid algal fragments), begins at 10 cm above lower contact (phylloid algal fragments drape over surface 10-15 cm); other small (10 x 4 cm or less) chaetetids occur in middle part; most fossils randomly oriented (except for chaetetids and Composita as noted); upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit b: Phylloid Algal Chaetetid Wackestone, 10 cm thick; medium gray (N5), weathers moderate brown (5YR4/4); moderately well-sorted, medium- to fine-grained; 35-40% fossils, including phylloid algal fragments (5-10%, up to 2 cm long), crinoid debris (5-10%), brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (20-25%, quarter algal-coated); laminar chaetetid (15 cm long, 3 cm high) at lower contact, begins on clay-rich laminae; fossils randomly oriented (except for chaetetid); wavy bedded; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit c: Skeletal Wackestone to Packstone, 15-25 cm thick; medium gray (N5), weathers moderate brown (5YR4/4); moderately well-sorted, medium- to fine-grained; 40-60% fossils, including phylloid algal fragments (5-10%, in laterally discontinuous lenses), crinoid debris (5-10%), fusulinids (2-3%), unidentifiable medium to fine sand-sized skeletal grains (10-40%, half algal-coated); fossils randomly oriented; possible wavy bedding; upper contact sharp, very irregular.

Unit d: Crinoidal Skeletal Wackestone, 0-15 cm thick; medium dark gray (N4), weathers moderate brown (5YR4/4); moderately well-sorted, medium- to fine-grained; 30-35% fossil, including crinoid debris (4-5%), phylloid algal fragments (1-2%), Composita (few articulated), low domical chaetetid (5 x 5 cm); unidentifiable medium to fine sand-sized skeletal grains (20-25%, half algal-coated); discontinuous laterally, partially underlies unit e; upper contact sharp, marked by moderate yellowish brown (10YR5/4) clayshale.

Unit e: Chaetetid Boundstone with inter-bedded Fossiliferous Clayshale, 33-38 cm thick; chaetetids light gray (N7) to medium light gray (N6), weather grayish orange (10YR7/4) to dark yellowish orange (10YR6/6); low domical and bulbous chaetetids; bulbous form partially overlies upper surface of unit d; chaetetids in-situ, begin at lower surface, terminate at upper contact; inter-bedded clayshale moderate yellowish brown (10YR5/4), weathers pale yellowish orange (10YR8/6); articulated Composita, other brachiopod shell fragments, crinoid ossicles, unidentifiable medium to fine sand-sized skeletal grains; pinches out against unit d left of the section; upper contact very irregular, sharp.

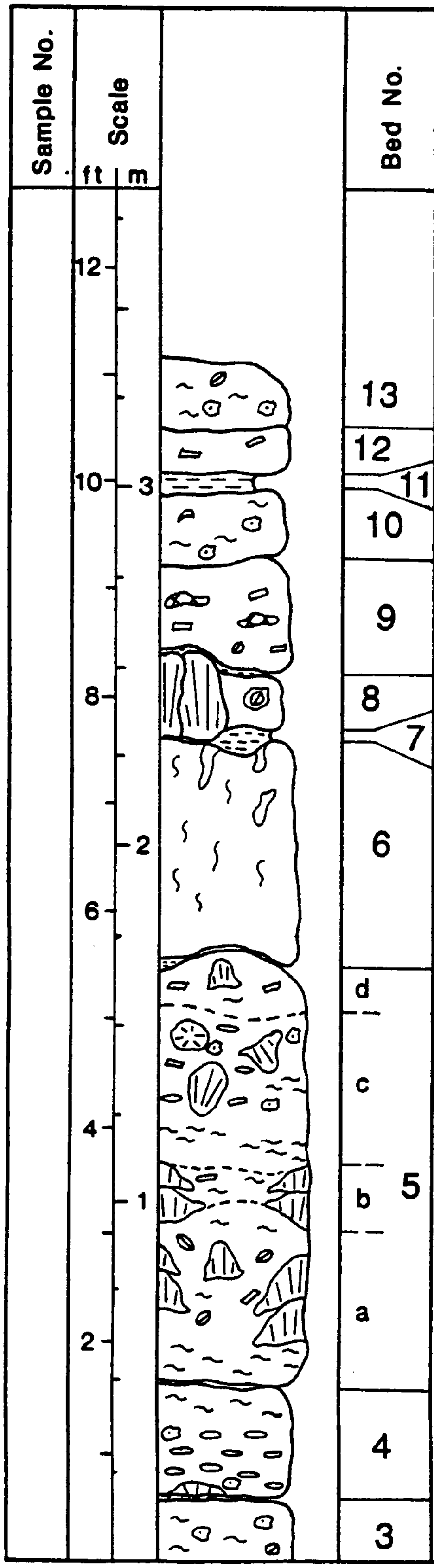
4. Fusulinid Skeletal Packstone to Phylloid Algal Wackestone, 33-35 cm thick; medium gray (N5), weathers light brown (5YR5/6); poorly-sorted, coarse- to fine-grained; lower two-thirds 65-75% fossils, including fusulinids (30-35%, few algal-coated), phylloid algae? (5%, highly fragmented, algal-coated), brachiopod shell fragments (1-2%, algal-coated), crinoid debris, laminar chaetetid (at lower contact, 8 cm long, 2 cm high); unidentifiable medium to fine sand-sized skeletal grains (20-25%, algal-coated); wavy bedded; few

(cont.)

partially silicified nodules (some fossil composition as surrounding sediment); upper third 30-35% fossils, including phylloid algal fragments (10-15%, occasionally algal-coated), Composita (few articulated), crinoid debris, laminar chaetetid (near upper contact, 3 cm long, 2 cm high), unidentifiable medium to fine sand-sized skeletal grains (15-20%, quarter algal-coated); fossils randomly oriented; indistinct bedding; upper surface irregular; upper contact sharp, marked by thin (1-3 cm) light brown (5YR5/6) calcareous shale, contains predominantly unidentifiable skeletal grains, also crinoid debris, fenestrate and ramose bryozoan fragments, Composita (mostly shell fragments), fusulinids.

3. Skeletal Packstone to Phylloid Algal Gastropod Wackestone, 22-27 cm thick; medium gray (N5), weathers light brown (5YR5/6); well-sorted, fine-grained in lower 5 cm, poorly-sorted, coarse- to fine-grained above this; lower 5 cm 70-75% fossils, including crinoid debris, brachiopod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (65-70%); upper part 30-35% fossils, including phylloid algal fragments (10-15%, up to 10 cm long) low-spired gastropods (1-2%), Crurithyris (few articulated, mostly shell fragments), crinoid debris, Heliospongia (in upper 5 cm); bellerophontids, fusulinids, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented, one-third algal-coated; indistinct bedding; upper contact is sharp, marked by thin (1-3 cm) moderate yellowish brown (10YR5/4) calcareous clayshale with Composita (mostly shell fragments, few whole disarticulated valves), crinoid debris, unidentifiable fossils grains.

2. Phylloid Algal Wackestone, 8 cm thick; medium light gray (N6), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (10-15%), crinoid debris (2-3%), Composita (mostly shell fragments, few articulated), productids (mostly shell fragments, few articulated), Crurithyris (few articulated); low-spired gastropods, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented, frequently algal-coated; bedding indistinct; upper contact sharp, marked by thin (1-3 cm) grayish orange (10YR7/4) to dark yellowish orange (10YR6/6) calcareous clayshale, contains mostly unidentifiable fossil grains, also few Neochonetes shell fragments, Crurithyris, Lophophyllidium, fenestrate bryozoan fragments; lower contact covered.



DESCRIPTION: Section 782-S4, Locality 782
18 meters east of 782-S3

LOCATION: NE 1/4, SE 1/4, sec 32, T.34S, R.19 E, Labette Co., Kansas

MEASURED BY: Vincent Voegeli 1989

SECTION 782-S4

bed

Amoret Limestone Member

13. Phylloid Algal Brachiopod Wackestone, 20 cm thick, overlain by modern soil; light gray (N7), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); poorly-sorted, coarse- to fine-grained; 40-45% fossils, including phylloid algal fragments (15-20%, third algal-coated, up to several cm long), Composita (2-3%, occasionally articulated, frequently algal-coated), Juresania (mostly shell fragments and spines, rarely articulated, frequently algal-coated), crinoid debris (5%), unidentifiable medium to fine sand-sized skeletal grains (10-15%, half algal-coated); fossils randomly oriented; dark yellowish orange (10YR6/6) mottling throughout; upper contact gradational.

12. Crinoidal Skeletal Wackestone, 10-11 cm thick; light gray (N7), weathers pale yellowish brown (10YR6/2) to dark yellowish orange (10YR6/6); moderately well-sorted, medium- to fine-grained, 15-20% fossil, including crinoid debris (2-3%), brachiopod shell fragments, Echinaria, gastropod shell fragments, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented; dark yellowish orange (10YR6/6) horizontal mottling throughout (some preferentially silicified); upper contact sharp, irregular, marked by 1 cm thick dark yellowish orange (10YR6/6) clayshale.

11. Calcareous Clayshale, 4-6 cm thick; pale yellowish orange (10YR8/6), weathers dark yellowish orange (10YR6/6); 10-15% fossils, including crinoid debris (5-10%, ossicles, plates), Mesolobus (1%, whole valves common, frequently articulated), productid shell fragments and spines, unidentifiable medium to fine sand-sized skeletal grains (2-5%); thickens and thins considerable laterally; upper contact irregular, sharp.

10. Phylloid Algal Brachiopod Wackestone, 22 cm thick; medium gray (N5), weathers light gray (N7); poorly-sorted, coarse- to fine-grained; 35-40% fossils, including phylloid algal fragments (15-20%, quarter algal-coated), Desmoinesia (3-4%, commonly articulated, often spar-filled with geopetal, quarter algal-coated), Composita (1-2%, few articulated, few algal-coated), Crurithyris (few articulated), crinoid debris (3-4%), low-spired gastropods (frequently with geopetal, few algal-coated), unidentifiable medium to fine sand-sized skeletal grains (10-15%, third algal-coated); most articulated brachiopods in lower half; fossils randomly oriented, become more fragmented upward; dark yellowish orange (10YR6/6) mottling throughout; upper surface irregular, iron stained;

(cont.)

upper contact sharp.

9. Crinoidal Wackestone, 23-30 cm thick; medium gray (N5), weathers medium light gray (N6) in center, yellowish brown (10YR5/4) elsewhere; moderately well-sorted, medium- to fine-grained; 10-15% fossils, including crinoid debris (2-3%), Composita (rarely articulated, mud- filled), productids (in lower half, few articulated); unidentifiable medium to fine sand-sized skeletal grains (5-10%); fossils randomly oriented; chert nodules common throughout; dark yellowish orange (10YR6/6) horizontal mottling throughout; drapes over chaetetids in underlying bed; upper contact sharp.

8. Brachiopod Oncolitic Wackestone, 10-13 cm thick; very light gray (N8), weathers grayish orange (10YR7/4); poorly-sorted, coarse- to fine-grained; 25-30% fossils, including Composita (10-12%, frequently articulated), productids (2-3%, mostly Juresania, frequently articulated, also shell fragments, spines), two high domical chaetetids (ragged, begin on oncolites in depressions on upper surface of underlying bed, merge into a single chaetetid mass upward, terminate at upper contact), crinoid debris, ostracodes, echinoid spines, ramose bryozoan fragments, low-spired gastropods, bellerophontids, unidentifiable medium to fine sand-sized skeletal grains (8-10%); nearly all fossils algal-coated (80%, up to several cm thick, most completely algal-coated, some algal-coated only on one side); fossils randomly oriented; olive black (5Y2/1) clay-rich laminae throughout, concentrated in upper and lower part; indistinct bedding; upper 2 cm dark gray (N3) platy shale with algal-coated articulated productids (biscuit shaped), other brachiopod shell fragments, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains; upper contact sharp.

7. Calcareous Mudshale, 1-8 cm thick; pale yellowish orange (10YR8/6), grayish olive (10 YR 4/2) locally, weathers dark yellowish orange (10YR6/6); lower half slightly calcareous with possible plant remains, black (N1) organic stringers; upper half with rare (1%) unidentifiable fossil grains; thickens over depression on surface of underlying bed; upper contact sharp.

6. Gastropod Skeletal Carbonate Mudstone to Wackestone, 58-61 cm thick; very light gray (N8), weathers grayish orange (10YR7/4); moderately well-sorted, medium- to fine-grained; 10-30% fossils, including Donaldina-like gastropods (2-3%), low-spired gastropods, Composita (mostly shell fragments, rarely articulated), other brachiopod shell fragments, crinoid debris, bellerophontids, ostracodes, unidentifiable medium to fine sand-sized skeletal grains (7-25%); fossils randomly oriented, less abundant and more fragmented upward; numerous small (2-6 cm long, 0.5-1 cm wide) vertical burrow and/or rootlet structures throughout, occasionally bifurcate downward (more abundant in upper part; half mud-filled, half spar-filled); large (up to 30 cm long, 6 cm wide) vertical solution- or root-like structures common, extend from upper surface downward (taper downward, few bifurcate downward; spar- to mud-filled, or filled with fragmented skeletal debris); upper surface irregular with solution pits and cavities; upper contact sharp.

5. Wackestone: 111-121 cm thick; divisible into 4 units, a-d.

Unit a: Phylloid Algal Chaetetid Packstone to Wackestone, 48-53 cm thick; medium gray (N5), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; 40-70% fossils, including phylloid algal fragments (20-50%, up to several cm long, somewhat clumped together), Composita (2-3%, several articulated, few in-situ?), low-spired gastropods, crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10-15%); columnar chaetetid (begins at 10 cm above lower contact on clump of phylloid algal fragments, continues into overlying unit), high domical (ragged) chaetetid (begins at 15 cm above lower contact on clump of phylloid algal fragments, 18 cm high), small laminar chaetetid (10 cm below upper contact, 10 cm long, 4 cm high,

(cont.)

begins on phylloid algal fragments); upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit b: Phylloid Algal Chaetetid Wackestone, 10-12 cm thick; medium gray (N5), weathers moderate brown (5YR4/4); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (10-15%), crinoid debris (5%), Composita (1-2%, several articulated), Crurithyris (few articulated), other brachiopod shell fragments, medium to fine sand-sized skeletal grains (10-15%, quarter algal-coated); columnar chaetetid (continued from underlying unit, terminates at upper contact); laminar chaetetid (15 cm long, 3 cm high) at lower contact (begins on clay-rich laminae), continues upward as high domical (ragged) form; possible wavy bedding; fossils randomly oriented (except chaetetids); upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit c: Chaetetid Skeletal Wackestone to Packstone, 48-52 cm thick; medium gray (N5), weathers moderate brown (5YR4/4); moderately well-sorted, medium- to fine-grained; 45-55% fossils, including phylloid algal fragments (10-15%, laterally discontinuous lenses), crinoid debris (5-10%), fusulinids (5-7%), Composita (rarely articulated, mostly shell fragments), fenestrate bryozoan fragments, unidentifiable medium to fine sand-sized skeletal grains (10-40%, half algal-coated); high domical (ragged) chaetetid (15 cm high, begins at 5 cm above lower contact on unidentifiable skeletal grains); two overturned low domical chaetetids in the upper half (approx. 15 cm high, 20 cm wide); possible wavy bedding; upper contact sharp, marked by olive black (5Y2/1) clay-rich laminae.

Unit d: Crinoidal Skeletal Wackestone, 10-20 cm thick; medium dark gray (N4), weathers moderate brown (5YR4/4); moderately well-sorted, medium- to fine-grained; 30-35% fossil, including crinoid debris (4-5%), phylloid algal fragments (1-2%), Composita (few articulated), low domical chaetetid (6 x 7 cm); unidentifiable medium to fine sand-sized skeletal grains (20-25%, half algal-coated); discontinuous laterally; pinches out to left and right of section; upper contact sharp, marked by moderate yellowish brown (10YR5/4) clayshale.

4. Fusulinid Skeletal Packstone to Phylloid Algal Wackestone, 27-30 cm thick; brownish gray (5YR4/1), weathers moderate yellowish brown (10YR5/4); poorly-sorted, coarse- to fine-grained; lower two-thirds 65-75% fossils, including fusulinids (30-35%, few algal-coated), phylloid algae? (5%, highly fragmented, algal-coated), brachiopod shell fragments (1-2%, algal-coated), crinoid debris, laminar chaetetid (near lower contact, 10 cm long, 5 cm high); unidentifiable medium to fine sand-sized skeletal grains (20-25%, algal-coated); wavy bedded; few partially silicified nodules (some fossil composition as surrounding sediment); upper third 30-35% fossils, including phylloid algal fragments (10-15%, occasionally algal-coated), Composita (few articulated), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (15-20%, quarter algal-coated); fossils randomly oriented; thickens and thin laterally, upper phylloid algae-rich part discontinuous laterally; indistinct bedding; upper surface irregular; upper contact sharp, marked by thin (0.5 cm) moderate yellowish brown (10YR5/4) calcareous shale with unidentifiable skeletal grains.

3. Phylloid Algal Gastropod Wackestone, 17 cm thick; medium gray (N5), weathers light brown (5YR5/6); poorly-sorted, coarse- to fine-grained; 30-35% fossils, including phylloid algal fragments (10-15%, up to 10 cm long) low-spired gastropods (1-2%), Composita (few articulated, mostly shell fragments), Crurithyris (few articulated, mostly shell fragments), crinoid debris, unidentifiable medium to fine sand-sized skeletal grains (10-15%); fossils randomly oriented, one-third algal-coated; indistinct bedding; upper contact sharp, marked by a thin olive black (5Y2/1) clay-rich laminae; lower contact covered.

APPENDIX E

THIN SECTION DESCRIPTIONS

LOCALITY 729

Thin section A1 -- from lower part of sample 4-1.1a

Skeletal Wackestone to Packstone -- medium- to fine-grained; 15-70% fossils: productid shell fragments and spines, crinoid debris, fenestrate and ramose bryozoan fragments, high- and low-spired gastropods, ostracodes, Endothyra, Tetrataxis, biserial foraminiferids, mostly fine sand to coarse silt-sized unidentifiable skeletal grains; skeletal debris mostly fragmented and rounded, randomly oriented; one articulated productid present; larger skeletal fragments occasionally "algal"-coated; pellets and micrite envelopes; bioturbated; few fine sand-sized quartz grains; lower part has dark brown clay-rich laminae; pressure solution and compaction evident along laminae; matrix ferroan to non-ferroan calcite; most crinoid and brachiopod shell fragments non-ferroan calcite; other skeletal debris ferroan calcite.

Thin section A2 -- from lower part of sample 4-1.1b

Foraminiferid Crinoidal Wackestone -- medium- to fine-grained; similar to thin section A1, but finer grained; 30-40% fossils: crinoid fragments, productid shell fragments and spines, recrystallized phylloid algae, low- and high-spired gastropods, ostracodes, bryozoan fragments, fusulinids, Endothyra, biserial foraminiferids, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; one articulated but splayed open Composita; gastropods preserved as micrite envelopes; most skeletal debris broken and abraded, sub-angular to rounded, randomly oriented; many larger fossil fragments partially to completely "algal"-coated; micrite pellets; some micrite matrix replaced by coarse spar.

Thin section A3 -- from lower part of sample 4-1.2

Fusulinid Wackestone to Packstone -- medium- to coarse-grained; 60-70% fossils: predominantly fusulinids (most with micrite- filled outer chambers, spar-filled or silicified inner chambers, appear abraded, often outer chambers of test eroded away), also crinoid fragments, brachiopod shell fragments, recrystallized bivalve shell fragments, gastropods (recrystallized, some preserved as micrite envelopes), ostracodes (articulated and fragmented), Endothyra, Globivalvulina, other small foraminiferids; fusulinids and larger skeletal fragments occasionally "algal"-coated; skeletal debris shows some preferential horizontal alignment; micrite pellets; lower part has numerous clay-rich laminae with microstylolites; some micrite matrix replaced by patchy spar; skeletal debris ferroan calcite except for crinoid and brachiopod shell fragments which are non-ferroan calcite; matrix predominantly ferroan calcite with patches of non-ferroan calcite; interior chambers of some fusulinids have early marine bladed low-Mg calcite; middle part completely silicified, some individual dolomite rhombs in silicified area; late stage ferroan calcite filled fracture, cut across matrix and skeletal debris, two generations of spar cement within some, an early moderate ferroan calcite (purple) followed by high ferroan calcite (dark blue).

Thin section A4 -- From the middle part of sample 4-1.2

Fusulinid Wackestone to Packstone -- very similar to thin section A3, slightly coarser grained; fusulinids decrease in abundance upward, phylloid algal blades in upper half (recrystallized), one whole valve of Crurithyris, gastropods more common than in thin section A3; many skeletal grains partially to completely coated.

Thin section A5 -- from the upper part of sample 4-1.2

Phylloid Algal Fusulinid Packstone to Phylloid Algal Wackestone -- medium- to coarse-grained; lower half 60-80% fossils: predominantly phylloid algae (fragmented, recrystallized to coarse spar), fusulinids (abraded, occasionally "algal"-covered), also gastropods (low-spired, recrystallized, mud- to spar-filled, some geopetal), crinoid debris (broken and abraded), bivalve shell fragments, ostracodes, foraminiferids, calcareous red algae, unidentifiable fine sand to coarse silt-sized skeletal debris; some "algal"-coated skeletal grains; skeletal debris randomly oriented; neomorphic spar throughout, replacing micrite matrix; upper half 10-15% fossils: predominantly phylloid algae (recrystallized, up to 15 mm long, one with preserved bifurcation), ostracodes, Globivalvulina, fine sand to coarse silt-sized unidentifiable skeletal debris; contact of upper and lower parts marked by clay-rich laminae with microstylolites.

Thin section A6 -- from lower part of sample 4-1.3

Phylloid Algal Wackestone -- coarse-grained; 20-40% fossils: nearly all phylloid algae (up to 14 mm long, recrystallized), also ostracodes, one articulated Crurithyris with geopetal, small foraminiferids; skeletal debris randomly oriented; micrite pellets; micrite envelopes; coarse spar under some phylloid algal fragments, original shelter porosity?; black clay-rich laminae in lower part, contain microstylolites and evidence of pressure solution; some late stage spar-filled fractures, cut across matrix and skeletal debris.

Thin section A7 -- from lower part of sample 4-4.3

Phylloid Algal Wackestone -- medium- to coarse-grained; 15-20% fossils: nearly all phylloid algae (recrystallized, up to several cm in length), also ostracodes, Crurithyris (some articulated with geopetal); coarse spar under some phylloid algae fragments, original shelter porosity?; micrite pellets; black clay-rich laminae throughout, contain microstylolites, evidence of pressure solution, compaction; spar-filled compaction fractures throughout, cut across matrix and phylloid algal fragments.

Thin section A8 -- from upper part of sample 4-4.3

Phylloid Algal Wackestone -- medium to coarse grained; lower 2/3 entirely recrystallized to coarse spar, micrite envelopes (originally phylloid algae?) within this area; upper third similar to thin section A7; few bryozoan fragments noted; numerous clay-rich laminae, similar to those in thin section A7.

Thin section A9 -- from upper part of sample 4-2.4a

Phylloid Algal Gastropod Foraminiferid Wackestone -- medium- to coarse-grained; 15-30% fossils: predominantly phylloid algae (recrystallized, up to 20 mm in length), gastropods (recrystallized, fragmented to whole), foraminiferids (Tetrataxis, Globivalvulina, fusulinids), also bivalve shell fragments, Composita shell fragments, brachiopod spines, fine sand to coarse silt-sized unidentifiable skeletal debris; skeletal debris randomly oriented, concentrated in upper 2/3; micrite pellets; clay-rich laminae with microstylolites throughout; coarse spar has replaced much of micrite matrix in upper half; micrite envelopes within coarse spar.

Thin section A10 -- from the lower part of sample 4-2.4b

Phylloid Algal Chaetetid Brachiopod Wackestone -- fine- to coarse-grained; 35-40% fossils: predominantly phylloid algae (40-50% of total fossils, recrystallized, up to 14 cm in length), Composita and productid shell fragments, also crinoid fragments, echinoid spines, ostracodes (fragmented to articulated, some spar-filled with geopetal), trilobite fragments, ramose bryozoan fragments, Tetrataxis, calcispheres, Lithophyllum-like algae, bivalve shell fragments, fine sand to coarse silt-sized unidentifiable skeletal debris; 0.5 cm thick laminar chaetetid at base (upper tubules micrite filled, below this tubules spar-filled, begins on "algal"-coated skeletal debris); few "algal"-coated skeletal grains; fossil debris randomly oriented; micrite pellets; some micritic matrix replaced by coarse spar; clay-rich laminae with microstylolites in lower 1/4.

Thin section A11 -- from the upper part of sample 4-2.4d

Phylloid Algal Wackestone -- fine to medium grained; 15-20% fossils: phylloid algae (recrystallized), brachiopod and bivalve shell fragments, ostracodes, one Lophophyllidium (not in life position), Tetrataxis, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; "algae" encrusting some skeletal grains; skeletal debris randomly oriented; micrite pellets; some spar replacing micrite matrix.

Thin section A12 -- from lower part of sample 4-1.5a

Phylloid Algal Bryozoan Skeletal Wackestone -- fine to medium grained; 35-55% fossils: phylloid algae (15-20%, recrystallized, highly fragmented, most < 5 mm in length), bryozoan fragments (fenestrate and ramose), Composita (few articulated with spar-filling, geopetal structure), brachiopod spines, gastropods (often preserved as micrite envelopes, mostly fragments, one whole high-spired form with geopetal), crinoid debris, ostracodes, fusulinids, other small foraminiferids, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; skeletal debris more abundant in lower 3/4; fossils enhance wavy bedding; micrite envelopes; clay-rich laminae with microstylolites throughout; some patchy spar replacing micrite matrix.

Thin section A13 -- from sample 4-4.6a

Chaetetid Crinoidal Wackestone -- fine- to coarse-grained; 20-50% fossils: crinoid fragments, laminar chaetetid (dominates much of the slide), Composita (few articulated and spar-filled), productid and other brachiopod shell fragments, gastropods (preserved as micrite envelopes), trilobite fragments, fenestrate bryozoan, calcispheres, Tetrataxis, Globivalvulina, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; some small skeletal debris "algal"-coated; skeletal debris (except for chaetetid) randomly oriented; few quartz grains (<1 mm, sub-angular to rounded); partially recrystallized to blocky ferroan dolomite (euhedral to sub-euhedral, restricted to darker zones), some non-dolomitized skeletal debris in dolomitized zones, rest of matrix and most skeletal debris ferroan calcite; crinoid and brachiopods non-ferroan calcite; articulated Composita has first generation internal cement of non-ferroan bladed calcite followed by later generations of ferroan sparry calcite; chaetetid partially silicified.

Thin section A14 -- from sample 4-4.6b

Ostracode Foraminiferid Mudstone to Wackestone -- fine-grained; 5-20% fossils: predominantly ostracodes (fragmented to spar-filled articulated with geopetal), foraminiferids (Tetrataxis, Endothyra, Globivalvulina), also brachiopod shell fragments, crinoids (few with syntaxial overgrowths), gastropods, calcispheres, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; micrite pellets; spar-filled rootlet-like structure, some show bifurcation, alveolar texture (see fig. 66, Estaban and Klappa, 1983) around many; some micrite matrix replaced by spar.

Thin section A15 -- from sample upper part of 4-2.8b

Ostracode Calcisphere Wackestone -- similar to thin section A14, slightly finer grained; 10-20% fossils: calcispheres more abundant than in thin section A14, mostly fine sand to coarse silt-sized unidentifiable skeletal debris; few skeletal fragments "algal"-coated; some rounded quartz grains (< 1 mm); microstylolites throughout; skeletal debris and most of matrix non-ferroan to slightly ferroan calcite; coarse spar ferroan calcite; some calcispheres silicified.

Thin section A16 -- from lower part of sample 4-2.10a

Brachiopod Oncolitic Packstone -- coarse- to fine-grained; 60-70% fossils: predominantly productid shells fragments and spines, also ramose bryozoan fragments, bivalve shell fragments, calcispheres, ostracodes (most disarticulated and fragmented), fusulinids, Tetrataxis, Globivalvulina, Endothyra, fine sand to coarse silt-sized unidentifiable skeletal debris; most larger skeletal grains partially to completely "algal"-coated; skeletal debris randomly oriented; one lithoclast, "algal"-coated; few quartz grains; borings on many "algal"-coated grains; deformation of "algal"-coatings evident at some grain contacts; clay-rich laminae, contain microstylolites and evidence of compaction and pressure solution; spar-filled fractures, pass through matrix and skeletal grains.

Thin section A17 -- from just above thin section A16

Brachiopod Oncolitic Wackestone -- coarse- to fine-grained; 20-30% fossils: predominantly productid and Composita shell fragments, also crinoid and bryozoan fragments, productid spines, chaetetid fragments, ostracodes, Tetrataxis and other small foraminiferids, fine sand to coarse silt-sized unidentifiable skeletal debris; one articulated productid, micrite-filled and entirely "algal"-coated ("algal"-coating has digitate structure) roughly equally on all sides, partially silicified; one articulated Composita, small areas of "algal"-coating, mostly micrite-filled but with early marine bladed non-ferroan cement on internal surface, compaction fractured; partial to complete "algal"-coatings on 70-80% of skeletal grains; one Tetrataxis attached to "algal"-coated skeletal fragment, also coated over by "algae"; some borings on skeletal debris and "algal"-coatings; few quartz grains; matrix and bryozoans ferroan calcite, brachiopods and crinoids non-ferroan calcite; "algal"-coatings mixture of non-ferroan and ferroan calcite.

Thin section A18 -- from sample 4-2.11a

Crinoidal Bryozoan Skeletal Wackestone -- fine-grained; 10-30% fossils: predominantly crinoid debris (sub-angular to well-rounded, corroded, worn, often bored), bryozoan fragments (ramose, fenestrate, and encrusting), also brachiopod shell fragments, Tetrataxis, other small foraminiferids, mostly unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal fragments partially to completely "algal"-coated; skeletal debris shows some horizontal alignment; few quartz grains.

LOCALITY 693

Thin section C1 -- from upper part of sample 6-5.1a

Fusulinid Phylloid Algal Packstone to Wackestone -- medium- to coarse-grained; 40-50%

fossils: predominantly phylloid algae (highly fragmented, < 2 mm long, recrystallized), fusulinids (many abraded and/or "algal"-coated), also crinoid debris, brachiopod shell fragments and spines, calcispheres, gastropods, ostracodes, bryozoan fragments, Tetrataxis, Globivalvulina, other small foraminiferids; few skeletal grains "algal"-coated; some preferential horizontal alignment of skeletal debris.

Thin section C2 -- from sample 6-5.2b

Phylloid Algal Wackestone -- fine- to coarse-grained; 15-25% fossils: predominantly phylloid algae (up to 30 mm long, recrystallized), also crinoid fragments, gastropods (fragmented to whole, some geopetal, preserved as micrite envelopes), brachiopod shell fragments and spines, calcispheres, Tetrataxis (one noted attached to phylloid algae fragment), other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal grains "algal"-coated; fossil debris randomly oriented; micrite pellets; clay-rich laminae in upper part; microstylolites and evidence of compaction and pressure solution along laminae; some micrite matrix replaced by spar; some skeletal fragments compaction? fractured.

Thin section C3 -- from sample 6-1.2c

Phylloid Algal Wackestone -- nearly identical to thin section C2; matrix and skeletal debris ferroan calcite; minor silica replacement of some skeletal debris; closely associated with silica are patchy areas of euhedral ferroan dolomite.

Thin section C4 -- from upper part of sample 6-5.3

Phylloid Algal Chaetetid Wackestone -- fine- to coarse-grained; 15-20% fossils: mostly phylloid algae (up to 30 mm long, recrystallized), also gastropod fragments, Composita (shell fragments, one articulated, micrite-filled), fusulinids, Tetrataxis, other small foraminiferids, ostracodes (fragmented to articulated and spar-filled), unidentifiable fine sand to coarse silt-sized skeletal debris; skeletal debris shows preferential horizontal alignment; one laminar chaetetid at base (spar-filled tubules, one phylloid algae fragment incorporated in skeleton); phylloid algae fragments drape over chaetetid; compaction fractures; some micrite matrix replaced by sparry calcite.

Thin section C5 -- from lower part of sample 6-5.4b

Phylloid Algal Foraminiferid Wackestone -- medium- to fine-grained; 10-40% fossils: predominantly phylloid algae (fragmented, most < 1 mm in length, recrystallized) foraminiferids (Tetrataxis, Globivalvulina, Endothyra, other small forms), also calcispheres, one Lophophyllidium, crinoid debris, one Composita, encrusting bryozoans, one high-spired gastropod (recrystallized), unidentifiable fine sand to coarse silt-sized skeletal debris; few partially to completely "algal"-coated skeletal fragments; skeletal debris has strong horizontal alignment in places; clay-rich laminae throughout, occasionally marked by microstylolites.

Thin section C6 -- from sample 6-2.5a

Chaetetid Wackestone -- coarse- to fine-grained; half of slide part of ragged low domical chaetetid; rest 30-40% fossils: mostly crinoid fragments, fusulinids, also bryozoan fragments, one Composita (articulated, spar-filled with geopetal), productid shell fragments, Endothyra, Tetrataxis, other small foraminiferids, chaetetid fragments, unidentifiable fine sand to coarse silt-sized skeletal debris; some fossil fragments partially to completely "algal"-coated; fossil fragments randomly oriented; growth interruptions on chaetetid, marked by micrite and "algal"-coatings, tubules at surface of growth interruptions micrite-filled, rest are spar-filled; spar-filled fractures, cut through skeletal debris and matrix.

Thin section C7 -- from upper part of sample 6-1.5c

Foraminiferid Skeletal Grainstone to Wackestone -- fine-grained; 60-80% fossils: predominantly foraminiferids (Globivalvulina, Endothyra, Tetrataxis, fusulinids), also ostracodes, crinoid fragments, calcispheres, brachiopod shell fragments, unidentifiable fine sand to coarse silt-sized skeletal debris; micrite envelopes; most skeletal fragments sub-round to rounded; equant sparry calcite cement and patchy micrite matrix.

Thin section C8 -- from sample 6-7.6

Skeletal Mudstone -- fine-grained; 2-5 % fossils: ostracodes fragments, gastropod fragments, calcispheres, small foraminiferids, mostly unidentifiable fine sand to coarse silt-sized skeletal debris; micrite pellets; dense micrite matrix; spar-filled rootlet-like structures (alveolar texture around some) and fractures.

Thin section C9 -- from sample 6-7.8b

Brachiopod Oncolitic Wackestone -- coarse- to fine-grained; 30-40% fossils: predominantly productids shell fragments and spines, articulated to fragmented Composita (articulated ones have micrite to sparry calcite internal filling,one with preserved brachidia), also echinoid spines, crinoid debris, gastropod shell fragments, ostracodes, Tetrataxis, Globivalvulina, unidentifiable fine sand to coarse silt-sized skeletal debris; most fossil material partially to entirely "algal"-coated; skeletal debris randomly oriented.

Thin section C10 -- from sample 6-7.9

Crinoidal Bryozoan Skeletal Wackestone -- medium- to fine-grained; 10-15% fossils: mostly crinoid debris (sub-angular to rounded, often bored, abraded, and corroded), bryozoan fragments (ramose, fenestrate, and encrusting), also brachiopod shell fragments, echinoid spines, ostracodes, unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal grains "algal"-coated; few coarse silt-sized quartz grains.

Thin Section C11 -- from upper part of sample 6-1.10b

Phylloid Algal Brachiopod Wackestone -- medium- to fine-grained; 15-30% fossils: predominantly phylloid algae fragments (recrystallized, up to 5 mm long), also productid shell fragments, Composita (one articulated with geopetal), Crurithyris (few articulated with geopetal), crinoid debris, bryozoan fragments, calcispheres, gastropods (fragmented to whole, preserved as micrite envelopes), Tetrataxis, other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; fossil fragments partially to completely "algal"-coated; skeletal debris randomly oriented, some partially silicified.

Thin Section C12 -- from sample 6-7.12

Phylloid Algal Crinoidal Wackestone to Packstone -- medium- to fine-grained: 60-70% fossils in lower half, 15-30% in upper half; lower half predominantly crinoid debris, phylloid algae (highly fragmented, recrystallized), also gastropods (fragmented to whole, preserved as micrite envelopes), brachiopod shell fragments, ostracodes, fusulinids, Endothyra, other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; micrite pellets; upper half mostly phylloid algae fragments (up to 12 mm) and lesser amounts of above skeletal material; "algal"-coated grains, decrease in abundance upward; one intraclast in upper half; some micrite envelopes; micrite matrix partially replaced by coarse spar; few skeletal grains partially silicified.

Thin section C13 -- from sample 6-7.13a

Phylloid Algal Wackestone -- coarse- to fine-grained; 15-20% fossils: mostly phylloid algae (recrystallized, up to 25 cm in length), also Composita (mostly fragments, one articulated and spar-filled), crinoid debris, bryozoan fragments, gastropods (whole to fragmented, recrystallized), calcispheres, ostracodes, small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; partially to completely "algal"-coated skeletal grains; one lithoclast; phylloid algae more fragmented upward; "algal"-coated grains more abundant upward; skeletal debris shows some preferential horizontal alignment.

Thin section C14 -- from lower part of sample 6-2.14b

Phylloid Algal Brachiopod Wackestone -- coarse- to fine-grained; 15-30% fossils: predominantly phylloid algae (recrystallized, up to 20 mm long), Composita (several articulated ones noted, spar-filled with geopetal structure, random orientation), also productid shell fragments and spines, crinoid debris, bryozoan fragments, gastropods, one Multithecopora (overturned, partially silicified), ostracodes, Globivalvulina, Tetrataxis, one Endothyra, one fusulinid, unidentifiable fine sand to coarse silt-sized skeletal debris; many skeletal fragments partially to completely "algal"-coated (up to 4 mm thick); some phylloid algal blades bored; skeletal material shows some preferential horizontal alignment.

Thin section C15 -- from sample 6-7.15b

Brachiopod Crinoidal Mudstone to Wackestone -- medium- to fine-grained; 5-15% fossils: predominantly brachiopod shell fragments (?Composita, productids) and spines, crinoid debris (sub-round to rounded), also fenestrate bryozoan fragments, ostracodes (articulated to fragmented), Globivalvulina, Tetrataxis, Endothyra, other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal grains partially to completely "algal"-coated (< 0.5 mm thick); fossil fragments show some preferential horizontal alignment.

LOCALITY 782

Thin section D1 -- from lower part of sample 3-1.2a

Crinoidal Packstone to Phylloid Algae Calcisphere Wackestone -- lower third fine-grained, upper two thirds fine- to coarse-grained; 60-70% fossils in lower third: mostly well-sorted crinoid debris (< 2 mm in size), also brachiopod shell fragments, encrusting bryozoan, unidentifiable fine sand-sized skeletal debris; quartz grains very common (up to 1 mm, sub-angular to rounded); upper 2/3 predominantly phylloid algae (recrystallized, up to 10 mm in length), calcispheres, also brachiopod shell fragments, gastropods, ramose bryozoan fragments, unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal grains partially "algal"-coated; quartz grains nearly absent in upper part; fossils in lower third shows preferential horizontal alignment, upper 2/3 randomly oriented.

Thin section D2 -- from sample 3-1.3b

Phylloid Algal Gastropod Wackestone -- coarse- to fine-grained; 15-25% fossils: mostly phylloid algae (recrystallized, up to 10 mm in length), Donaldina-like gastropods (most abraded, mud-filled, few whole with geopetal), also brachiopod shell fragments, crinoid debris, ostracodes (fragmented to articulated), Composita (two articulated, one possibly in life position), bryozoan fragments, calcispheres, Tetrataxis (one attached to skeletal fragment), other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; partially to completely "algal"-coated skeletal grains; skeletal debris randomly oriented.

Thin section D3 -- from lower part of sample 3-1.4

Phylloid Algal Fusulinid Packstone to Wackestone -- coarse- to fine-grained; 50-70% fossils: predominantly phylloid algae (highly fragmented, recrystallized, up to 5 mm long, most < 2 mm long), fusulinids (some abraded), also Composita shell fragments, bryozoan, ostracodes (fragmented to articulated), one chaetetid fragment, Tetrataxis, Globivalvulina, other small foraminiferids; few fossil fragments partially to completely "algal"-coated (< 0.5 mm thick); micrite envelopes; patchy replacement of micrite matrix by spar; skeletal debris shows some preferential horizontal alignment.

Thin section D4 -- from sample 3-2.5c

Chaetetid Skeletal Wackestone -- coarse- to fine-grained; 40-50% fossils: part of low domical chaetetid is 1/3 of thin section (contains growth interruptions marked by micrite partings); matrix mostly fine sand to coarse silt-sized skeletal debris (highly fragmented phylloid algae?), also gastropods (recrystallized, fragmented), crinoid debris, Composita, other brachiopod shell fragments, fenestrate bryozoan fragments, calcispheres, chaetetid fragments, fusulinids, Globivalvulina, biserial foraminiferids; few skeletal grains partially to completely "algal"-coated; skeletal debris randomly oriented.

Thin section D5 -- from sample KLP-1, large area devoid of chaetetids in unit b, bed 5

Skeletal Wackestone -- medium- to fine-grained; 20-30% fossils: predominantly unidentifiable fine sand to coarse silt-sized skeletal debris (highly fragmented phylloid algae?), calcispheres, also fusulinids, echinoid spines, crinoid debris, gastropod shell fragments, ostracodes (disarticulated and fragmented), small foraminiferids; few grains partially to completely "algal"-coated; most fossil material highly fragmented, sub-angular to rounded.

Thin section D6 -- from upper part of sample 3-2.6b

Ostracode Skeletal Wackestone -- fine-grained; 15-30% fossils: ostracodes (articulated to fragmented), Donaldina-like gastropods (whole to fragmented), crinoid debris, brachiopod shell fragments, one chaetetid? fragment, Endothyra, Globivalvulina, other small foraminiferids, mostly unidentifiable fine sand to coarse silt-sized skeletal debris; few skeletal grains "algal"-coated (< 0.5 mm thick); fossils randomly oriented; fossils and most of matrix non-ferroan to low ferroan calcite, few patches of high ferroan calcite.

Thin section D7 -- from sample 3-2.8a

Oncolitic Brachiopod Wackestone -- coarse- to fine-grained; 25-35% fossils:

predominantly Composita (mostly shell fragments, one articulated, mud-filled), productid shell fragments and spines, also calcispheres, one chaetetid fragment, crinoid debris, gastropods, Endothyra, one articulated Hustedia in upper part (overturned, partially spar-filled, rest open void space, early marine bladed cement on inner surface of shell, partially "algal"-coated, does not encrust over commissure or hinge area); many skeletal grains partially to entirely "algal"-coated; few fossils partially silicified; skeletal material randomly oriented.

Thin section D8 -- from sample 3-2.9a

Crinoidal Bryozoan Wackestone -- medium- to fine-grained; 5-15% fossils: predominantly crinoid debris (sub-round to rounded, corroded), bryozoan (encrusting, ramose and fenestrate fragments), also brachiopod spines, bivalve shell fragments, ostracodes, gastropod shell fragments, fish? bones (phosphatic), unidentifiable fine sand to coarse silt-sized skeletal debris; some preferential horizontal alignment of skeletal debris; few quartz grain.

Thin section D9 -- from lower part of sample 3-1.10b

Phylloid Algal Wackestone -- coarse- to fine-grained; 30-40% fossils: mostly phylloid algae (recrystallized, up to 20 mm long), also productid shell fragments, Composita (mostly shell fragments, one articulated with geopetal), crinoid debris, calcispheres, ostracodes, bryozoan fragments, Tetrataxis, fine sand to coarse silt-sized skeletal debris; partially to completely "algal"-coated grains; some preferential horizontal alignment of skeletal debris.

Thin section D10 -- from sample 3-2.12

Skeletal Wackestone -- fine-grained; 50-60% fossils: bryozoan fragments, crinoid debris, brachiopod shell fragments, ostracodes, small foraminiferids, phylloid algae fragments in upper part, mostly unidentifiable fine sand to coarse silt-sized skeletal debris.

Thin section D11 -- from sample 3-2.13c

Phylloid Algae Brachiopod Wackestone -- coarse- to fine-grained; 20-30% fossils: mostly phylloid algae fragments (recrystallized, up to 15 mm in length), Composita (fragments, 3 articulated, two in possible life position, spar-filled with geopetal), also crinoid debris, productid shell fragments, ostracodes, calcispheres, Endothyra, Tetrataxis, other small foraminiferids, unidentifiable fine sand to coarse silt-sized skeletal debris; partially to entirely "algal"-encrusted fossil fragments (up to 2 mm thick); some preferential horizontal alignment of skeletal debris; limonite staining throughout.

Thin section D12 -- from sample 3-2.14c

Phylloid Algal Brachiopod Wackestone -- coarse- to fine-grained; 10-15% fossils: predominantly phylloid algae (recrystallized, up to 10 mm long), Composita (fragments, two articulated, spar-filled with geopetal, randomly oriented, fractured), also productid shell fragments, crinoid debris, ostracodes (articulated to fragmented), calcispheres, bryozoan fragments, Endothyra, Tetrataxis, other small foraminiferids, fine sand to coarse silt-sized skeletal debris; few partially to entirely "algal"-coated skeletal fragments; skeletal debris shows some preferential horizontal alignment; micrite pellets; one lithoclast; few micrite envelopes; micrite matrix replaced by patchy spar.

APPENDIX F

WASHED RESIDUE

* note for samples: "common" = 15% or more of washed residue retained on sieves

LOCALITY 729

Sample 4-1.8 -- from bed 8, section 729-S1

Non-calcareous to Calcareous Clayshale -- Composita (articulated to fragmented), crinoid ossicles and fragments, Juresania (shell fragments and spines), low-spired gastropods, Endothyra (highly abraded and corroded), and carbonized and pyritized plant debris.

Sample 4-3.12c -- from unit g, bed 11, section 729-S3

Calcareous Clayshale -- common Crurithyris (articulated to fragmented), also Orbiculoidea (articulated), ramose bryozoan, Aviculopecten (shell fragments), crinoid plates and ossicles, productids (shell fragments and spines), Donaldina-like gastropods, conodonts (Idioprioniodus, Idiognathodus, Diplognathodus, Hindeodus), anhedral pyrite grains, and phosphate nodules.

Sample 4-4.12c -- from unit g, bed 11, section 729-S4

Calcareous Clayshale -- common Crurithyris, also Aviculopecten (shell fragments), crinoid ossicles, Hustedia, Juresania (shell fragments), fusulinids, dermal denticles (Petrodus), brachiopod spines, ramose bryozoans, and discoidal to spherical phosphate nodule.

Sample 4-1.12f -- from unit g, bed 11, section 729-S1

Calcareous Clayshale -- common Crurithyris, also crinoid ossicles, Orbiculoidea, Composita (shell fragments), low-spired gastropods, Donaldina-like gastropods (some pyritized), productid spines, conodonts (including Diplognathodus, Idiognathodus, Neognathodus), and spherical phosphate nodules.

LOCALITY 692

Sample 1-10.7 -- from bed 8, section 692-S10

Non-calcareous to Slightly Calcareous Clayshale -- common Crurithyris (shell fragments and articulated valves), Composita (shell fragments and articulated valves), also Myalina, Phestia, Leptozyga, Anomphalus, Goniasma, Microdoma, Donaldina, crinoid ossicles, fusulinids, bryozoan holdfast (unattached), chaetetid fragments (abraded, pitted), Endothyra (abraded and worn), ostracodes (smooth and rough shelled), and carbonized plant remains.

Sample 1-10.10a -- from unit a, bed 11, section 692-S10

Calcareous Clayshale -- ramose and fenestrate bryozoan, crinoid ossicles, Aviculopecten, productid shell fragments and spines, Composita shell fragments, Plagioglypta, low-spired gastropods, and Derbyia shell fragments.

Sample 1-10.10b -- from unit b, bed 11, section 692-S10

Calcareous Shale -- Mesolobus shell fragments, productid shell fragments and spines, Crurithyris, ramose bryozoan fragments and holdfast (unattached), pyritized Donaldina, Aviculopecten shell fragments, and conodonts (including Idiognathodus).

Sample 1-10.10c -- from unit c, bed 11, section 692-S10

Calcareous Clayshale -- common Crurithyris, also Mesolobus, Orbiculoidea, Myalina, productid fragments and spines, conodonts (including Idioprioniodus, Cavusgnathus, Streptognathodus, bar type elements), and small phosphate nodules.

Sample 1-10.10g -- from unit g, bed 11, section 692-S10

Calcareous Clayshale -- common Crurithyris, also Mesolobus, Petrodus, Orbiculoidea, Juresania, Hustedia, Composita, productid spines, crinoid ossicles, Derbyia, ramose and fenestrate bryozoan, low-spired gastropods, fusulinids, Plagioglypta, conodonts (including Diplognathodus, Idioprioniodus, Idiognathodus, Neognathodus), and phosphate nodules (discoidal to spherical).

LOCALITY 693

Sample 6-5.7 -- from bed 6 (upper surface), section 693-S5

Calcareous Mudshale -- crinoid debris, high-spired gastropods, fish? bones (phosphatic), bryozoan fragments, ostracodes, and corroded limestone fragments with chert filled fractures; skeletal debris small (0.25 mm or smaller) and fragmented.

Sample 6-7.7 -- from bed 6 (upper surface), section 693-S7

Calcareous Mudshale -- chaetetid fragments (highly abraded and worn), one small abraded low-spired gastropod, one brachiopod shell fragment, carbonized plant remains, coal fragments, and corroded limestone fragments with chert-filled fracture; skeletal debris small (0.25 mm or smaller) and fragmented.

Sample 6-1.11 -- from bed 11, section 693-S1

Calcareous Clayshale -- common crinoid ossicles, Mesolobus (articulated to fragmented shells), also ramose bryozoan, Juresania (shell fragment and spines), Derbyia shell fragments, one Ditomopyge pygidium, echinoid spines and plates, Aviculopecten shell fragments, low- and high- spired gastropods, Composita shell fragment, Plagioglypta, and sponge spicules, and crinoid-Mesolobus packstone fragments.

Sample 6-7.11 -- from bed 11, section 693-S7

Calcareous Clayshale -- common crinoid debris (single ossicles and articulated stems up to 20 mm long), Mesolobus (articulated to fragmented shells), also Juresania shell fragments and spines, Aviculopecten shell fragments, fenestrate and ramose bryozoan (fragments and unattached holdfast), Donaldina, low-spired gastropods, echinoid spines, Derbyia shell fragments, one straight shelled cephalopod, Neospirifer shell fragments, ostracodes, Plagioglypta, fusulinids, fish? bones (phosphatic), and two broken conodont elements.

Sample 6-6.17a -- from unit a, bed 17, section 693-S6

Calcareous Clayshale -- ramose bryozoan fragments, echinoid spines, Crurithyris shell fragments, crinoid ossicles and plates, Donaldina, productid shell fragments, Plagioglypta, low-spired gastropods, foraminiferids, conodonts (including Streptognathodus, Idioprioniodus, Cavusgnathus), phosphatic fish bones, fine sand-sized quartz grains, and small (< 10 mm) platy phosphate nodules; all skeletal debris small (1 mm or smaller) and corroded.

Sample 6-6.17b -- from unit b, bed 17 (lower half), section 693-S6

Non-Calcareous Black Shale -- (very little residue retained on sieves) Orbiculoidea, fish scales, Plagioglypta, ramose bryozoan fragments, brachiopod? shell fragments, shark's tooth, and conodonts (including Streptognathodus, Cavusgnathus, Idioprioniodus, Hindeodella, Diplognathodus), and discoidal to spherical phosphate nodules.

Sample 6-6.17c -- from unit b, bed 17 (upper 1/2), section 693-S6

Non-calcareous Black Shale -- (very little residue retained on sieves) Orbiculoidea, dermal denticles (Petrodus), ramose bryozoan fragments and holdfast (unattached), Crurithyris shell fragments, crinoid ossicles and plates, echinoid spines, one small low-spired gastropod, and foraminiferids; above skeletal grains small and highly corroded; robust un-fragmented conodonts (including Diplognathodus, Hindeodella, Ideognathodus, Streptognathodus, Gondolella, Idioprioniodus, Cavusgnathus, Lonchodus); discoidal to spherical phosphate nodules.

Sample 6-6.17d -- from unit c, bed 17, section 693-S6

Calcareous Clayshale -- common Orbiculoidea, Juresania shell fragments and spines, crinoid debris (stems, ossicle and plates), also ramose bryozoan fragments and holdfast (unattached), echinoid spines, low-spired gastropods, Neochonetes shell fragments, Donaldina, Plagioglyopta, one silicified bellerophontid, conodonts (Idiognathodus, Streptognathodus, Neognathodus, Diplognathodus, Idioprioniodus), and discoidal to spherical phosphate nodules.

LOCALITY 782

Sample 3-1.1a -- from bed 1, section 782-S1

Micaceous Siltstone -- skeletal debris absent; carbonized and limonitic plant fossils recovered.

Sample 3-2.5e -- from unit e, bed 5, section 782-S2

Calcareous Clayshale -- common Composita (articulated to fragmented shells), ostracodes (smooth- and rough-shelled), also Crurithyris shell fragments, Juresania shell fragments and spines, ramose bryozoan, echinoid spines, crinoid ossicles, low-spired gastropods, and chaetetid fragments.

Sample 3-1.6 -- from unit e, bed 5, section 782-S1

Calcareous Clayshale -- common Composita (articulated to fragmented shells), ostracodes (articulated, smooth- and rough-shelled), also crinoid ossicles, Juresania shell fragments and spines, ramose bryozoan, echinoid spines, Omphalotrochus, gastropod shell fragments, chaetetid fragments, and carbonate nodules.

Sample 3-2.7 -- from bed 7, section 782-S2

Non-Calcareous to Calcareous Clayshale -- crinoid ossicles, echinoid spines and plates, brachiopod shell fragments, ramose bryozoans, ostracodes, carbonized plant remains, and small (1-2 cm) chert nodules; skeletal debris abraded and worn.

Sample 3-2.11a -- from bed 11, section 782-S2

Calcareous Clayshale -- common crinoid stems (up to 3 cm long), ossicles, and plates, Mesolobus (articulated to fragmented shells), also ramose bryozoans, Derbyia shell fragments, Juresania shell fragments and spines, fusulinids, low-spired gastropods, echinoid spines, fish? bones (phosphatic), and crinoid-Mesolobus packstone fragments.

PALEOECOLOGY OF CHAETETIDS IN THE AMORET LIMESTONE MEMBER (DESMOINESIAN) IN SOUTHEAST KANSAS

by

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B.S., Kansas State University, 1985

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTERS OF SCIENCE

(Geology)

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1992

ABSTRACT

The Amoret Limestone Member of the Altamont Limestone Formation (Desmoinesian) is exposed at four localities in Labette and Montgomery counties of Kansas. Chaetetids occur within the Amoret Limestone at each of these localities. Other members of the Altamont Limestone Formation include the Lake Neosho shale and Worland limestone.

Previous work has suggested that the Altamont Limestone represents deposition during a single marine transgressive-regressive event, with the Amoret limestone being deposited during the transgressive part. In this study, bed by bed analysis and correlation of Altamont limestone in the area using genetic/event surfaces has revealed a more complex history of deposition.

The majority of the Amoret limestone records an overall transition from a deltaic to open marine environment, then upward shallowing to subaerial exposure. Three small scale cycles are superimposed on this sequence. The uppermost part of the Amoret limestone, the Lake Neosho shale, and the Worland limestone represent a transition from subaerial exposure to open marine environment, then upward shallowing to deltaic environment. Four small scale cycles are superimposed on this. The Lake Neosho shale was apparently deposited in a nearshore environment where influxes of organic-rich terrestrial sediment, carried in by fluvial

systems, led to the deposition of the fissile black shale.

Chaetetids in the Amoret limestone apparently grew in environments ranging from open marine to lagoonal. Chaetetids grew the most vigorously in the eastern area of this study, apparently as a result of more offshore, less turbid conditions. Chaetetid buildups served as haven for an abundance of coexisting organisms.

The diagenetic history of these rocks records a complex sequence of fluctuating pore waters, with an overiding late-stage diagenetic imprint. Late-stage burial led to the formation of dolomite in the western area of this study.

The Amoret and Worland limestones are presently good sources of construction aggregate due to low insoluble residues in most beds. Chaetetid buildups could potentially make excellent hydrocarbon zones due to the abundance of open cavities between chaetetid heads, potential source rock, and overlying and underlying shale units.