DEPOSITIONAL HISTORY OF THE ELMONT LIMESTONE

by

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INTRODUCTION

Most investigations concerning Upper Pennsylvanian and Lower Permian strata in Kansas are regional and individually encompass sediments of diverse age and origin. Conclusions pertaining to the depositional environment of these strata, as a result, are vague and generalized. The need for detailed stratigraphic studies of single lithologic units is illustrated by the difficulties and disagreements that have arisen in concern with the Pennsylvanian-Permian contact in Kansas. Detailed studies of individual lithologic units are necessary if accurate interpretations are to be made.

This investigation involves description of lithologic and biolithologic divisions of the Elmont limestone and evaluation of the divisions in terms of depositional environments and paleoecology.

The Elmont was chosen for investigation because of the following reasons: 1) Its outcrops have previously been mapped in detail but described briefly; 2) Lithology of the Elmont is very different from other limestone members with which it crops out; 3) Lithotopes and biotopes of the Elmont are distinct.

Basic assumptions are necessarily made in all of the sciences and geology is no exception. The following assumptions are a critical part of this investigation: 1) Natural laws are qualitatively unchanging, though possibly variable quantitatively; 2) Observations of present processes are the best known methods to use in interpreting the past.

METHODS OF STUDY AND PRESENTATION

Definitions

Standard geologic terminology is used throughout the text, however several terms have more than one definition and require individual explanation. Definitions of terms used are listed below.

Biolithite - undisturbed biohermal limestone (Folk, 1961).

Biosparite - fossil debris averaging less than one millimeter in diameter that are cemented with sparry calcite (Folk, 1961).

Biotope - an area inhabited by a uniform community adapted to its environment (Krumbein and Sloss, 1958).

Conglomeratic mudstone - mudstone containing up to 30% gravel size particles (Folk, 1961).

Disbiolithite - slightly disturbed biohermal limestone, not transported but shows signs of pre-lithification disturbance such as desiccation cracks (Author).

Facies - sedimentary facies is defined as any areally restricted part of a designated stratigraphic unit which exhibits characters significantly different from those of other parts of the unit (Moore, 1949).

Intrasparudite - rock composed of transported carbonate particles averaging greater than one millimeter in diameter that are cemented with sparry calcite (Folk, 1961).

Lithotope - area of uniform sedimentation. Each specific portion of an environment pattern is a lithotope (Krumbein and Sloss, 1958).

Micrite - calcite grains ranging from one to five microns in diameter (Folk, 1961).

Muddy dismicrite - limestone composed of micrite that has been disturbed prior to lithification and contains between 10 and 50% mud contamination (Folk, 1961).

Mudstone - indurated, non-fissible rock composed of subequal amounts of silt and clay (Folk, 1961).

Sparite - authigenic calcite that forms in voids of sedimentary deposits (Folk, 1961).

Field Procedures

Outcrops of the Elmont limestone were identified on United States Geologic Survey maps of Wabaunsee, Riley, and Pottawatomie Counties, Kansas (Mudge and Burton, 1959; Mudge and Beck, 1949; Scott, Foster, and Crumpton, 1959). Sections were measured in areas chosen with respect to relative distribution and accessibility. Beds below the Elmont were examined as possible source areas of gravel contained within the Elmont.

Thicknesses of beds were measured with a steel tape to the nearest one-tenth of a foot and gravel sizes were measured with a millimeter ruler. Directional and angular properties as strike and dip of beds and joints were measured with a Brunton Compass. Each sample collected was labeled with the number of its measured section. Directional symbols, denoting the spatial attitude of the specimen in the outcrop, were placed upon fossiliferous and conglomeratic samples.

Laboratory Procedures

The specimens were sawed, polished and then etched with dilute hydrochloric acid. The etched surfaces were examined with a binocular microscope. Microscopic textural, biologic, and mineralogic features were analyzed by use of thin sections and a petrographic microscope. Compositions of pebbles from the St. George area that were not positively determined microscopically or chemically were analyzed with x-rays. The pebbles were also analyzed for insoluble residue. Samples from the conglomeratic mudstone of the Onaga vicinity were washed and screened into sand, gravel, and mud fractions and each fraction was examined to determine the lithology and fossil content.

Diagrams

A panel diagram of each vicinity is used to depict stratigraphic correlations. Stratigraphic features observed at the measured sections are accurately portrayed, except at localities 21 and 22 (Plate II) where lateral changes are too abrupt to be illustrated. Interpretations of successive environmental conditions of the Onaga vicinity are depicted by facies and lithotope maps (Plate XIV).

GENERAL SETTING

The Elmont limestone is exposed, with other Pennsylvanian rocks of the Wabaunsee group, from southeastern Nebraska to northern Pottawatomie County, Kansas, and at the junctures of Pottawatomie, Riley, and Wabaunsee Counties. These outcrops have developed along the breached crest of the Nemaha anticline. Another series of outcrops has developed along a general line from southeastern Nebraska to southeastern Kansas. Outcrops associated with the Nemaha anticline are discussed.

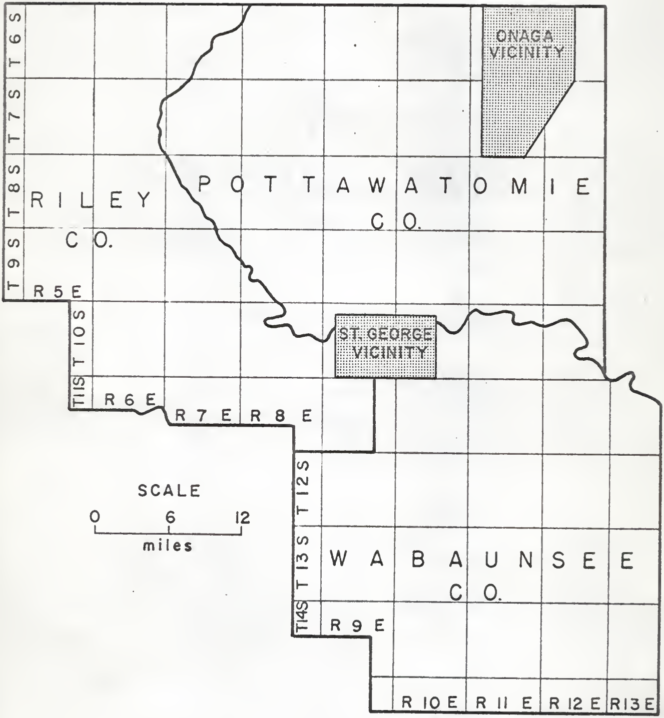
The area of investigation is subdivided into the St. George vicinity and the Onaga vicinity, as the Elmont does not make a continuous outcrop along the Nemaha anticline but is exposed in two distinctly isolated localities (Plate I).

Pennsylvanian rocks in the vicinities consist of thin fossiliferous limestones and relatively thick mudstones and shales. Several of the clastic units above the Elmont contain sandstone lenses and thin coal seams. The Elmont generally makes poor outcrops for it is low in the exposed stratigraphic section and is, in most places, covered by thin deposits of Quaternary

EXPLANATION OF PLATE I

Map showing location of the Onaga and St. George vicinities.

PLATE-I


ONAGA VICINITY
ST. GEORGE VICINITY
RILEY CO.
POTTAWATOMIE CO.
WABAUNSEE CO.
T 6 S
T 7 S
T 8 S
T 9 S
T 10 S
T 11 S
T 12 S
T 13 S
T 14 S
R 5 E
R 6 E
R 7 E
R 8 E
R 9 E
R 10 E
R 11 E
R 12 E
R 13 E
SCALE
0
6
12
miles

and Recent sediments. Surface structures associated with movement and differential compactions over the Nemaha anticline are evident in rocks of Pennsylvanian and Permian age. Gross lithologic variations indicate that the Nemaha anticline has been an influential part of the depositional and erosional environments since Late Mississippian time.

PREVIOUS WORK

The Elmont limestone was originally named by Beede in 1898. The type locality is in northern Shawnee County near the town of Elmont for which the unit is named. Condra (1935), classified the Elmont as the upper member of the Preston (Emporia) limestone formation. The Elmont was called a formation by Moore in 1936, but Moore and Mudge in 1956, reconsidered and accepted Condra's definition of the Elmont limestone as a member of the Emporia limestone formation. Condra's classification of the Elmont is used in the text.

Moore (1949) states:

> "In southern Shawnee County the lowest Elmont member is a dense, very fine-grained unfossiliferous blue limestone containing round pebbles of limestone slightly different in color and texture from the matrix."

Mudge and Burton (1959), in describing a section of northwestern Wabaunsee County state:

> "The Elmont limestone member consists of a single thin massive hard bed. ----- Toward the north there is a thin porous conglomeratic zone in the lower part of the limestone. The conglomerate consists mainly of small (one-eighth to one-half inch in diameter) rounded to subangular clay balls and limonite nodules."

Scott, Foster, and Crumpton (1959) describe the Elmont in Pottawatomie County as:

> "---massive hard gray or dark gray limestone that weathers to tan-gray or brown shaly fragments. Brown limonite particles lie on the weathered limestone in most outcrops and in some exposures clay nodules give the limestone a conglomeratic appearance."

DESCRIPTION OF ZONES

General Statement

The Elmont limestone is divided according to lithology and fossil content. Biolithologic nomenclature is used where possible to stress the inter-relationships of the biotopes and lithotopes. The zones discussed in the following order, from oldest to youngest, are: 1) the Muddy Dismicrite-Mudstone zone; 2) the Anchicodium Biolithite zone; 3) the Conglomeratic zone; and 4) the Triticites-Osagia Biosparite zone. Relative distribution of the zones are illustrated (Plates II and X).

The Muddy Dismicrite - Mudstone Zone

The Muddy Dismicrite-Mudstone zone crops out in the Onaga vicinity, but is absent at St. George. The zone consists of from one to three distinct beds of micrite limestone interbedded with partings and thin beds of slightly calcareous mudstone. The muddy dismicrite and mudstone are groups as a single zone as fossils are sparse in both lithologies and the mud and micrite fractions probably accumulated under similar environmental conditions (Folk, 1961, p. 148).

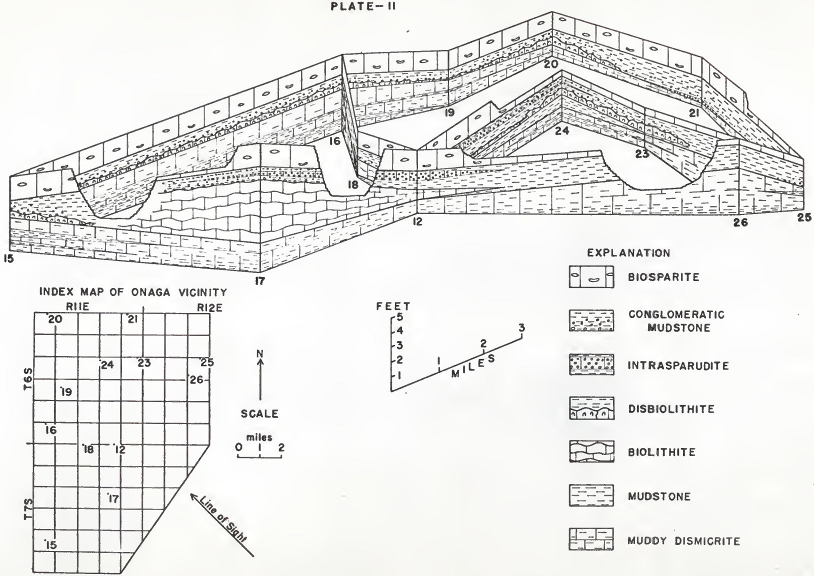
Bedding between the muddy dismicrite and the mudstone lithologies is best developed in western and northern parts of the Onaga vicinity (Plate II), where the bedding surfaces are distinct but irregular. The zone grades from a very dark gray mudstone upward to a dark gray muddy dismicrite at measured section 17 and 26. The lithology is transitional and distinct bedding planes are not evident.

Both the mudstone and the dismicrite contain well preserved terrestrial plant fossils at

EXPLANATION OF PLATE II

Panel diagram showing the stratigraphy of the Onaga vicinity.

PLATE-II


15
17
12
16
18
19
20
24
21
23
26
25
INDEX MAP OF ONAGA VICINITY
R11E
R12E
T6S
T7S
20
21
24
23
25
26
19
16
18
12
17
15
Line of Sight
N
SCALE
miles
0 1 2
FEET
5
4
3
2
1
1 2 3
MILES
EXPLANATION
BIOSPARITE
CONGLOMERATIC MUDSTONE
INTRASPARUDITE
DISBIOLITHITE
BIOLITHITE
MUDSTONE
MUDDY DISMICRITE

section 26. Annularia and Neuropteris (Plate III) are two identifiable genera. The plant content increases downward to the Harveyville shale which has a six inch thick, black carbonaceous fissile shale deposit at its upper surface. Derbyia, Chonetes, Orbiculoidea, Marginifera, Orthetes, and carbonized plant remains occur at section 17. The fossils are accompanied with thin, (less than one inch), veins of megacrystalline dolomite, celestite, pyrite, and sphalerite.

The muddy dismicrities are soft, poorly jointed, irregular beds characterized by clear and brick red sparry calcite cavity fillings. The cavity fillings range from less than a millimeter to five millimeters in diameter and are evenly distributed throughout the rocks. Colors of the dismicrite vary from light greenish gray in the west to dark gray in the east and are churned and cloudy on polished sections. Similar structures have been reported by Rusnak (1960, p. 183) in his study of Laguna Madre. The cavities and peculiar coloration seem to indicate disturbance prior to lithification and possibly reflect the activity of an unpreserved benthos community (Folk, 1961, p. 142). Single specimens of a burrowing pelecypod, Allorisma, occur in the muddy micrite near sections 22 and 24. Western outcrops are void of fossils.

The mudstones vary from several soft, moderately well indurated, blocky, grayish green beds in the north and west to a single, platy, calcareous, dark gray bed in the south and east. Fossils in the mudstone are restricted to sections 17 and 26.

Between measured sections 21 and 22 individual beds of the Muddy-Dismicrite-Mudstone zone are lenticular and cannot be correlated for more than a few feet. Thickness of the Muddy Dismicrite-Mudstone zone range from a featheredge to 3.3 feet.

EXPLANATION OF PLATE III

Neuropteris frond. Approximately one foot above the base of measured section 26. (X 1)

PLATE III

Anchicodium Biolithite Zone

The biolithite zone occurs at all outcrops except 25 and 26 in the Onaga vicinity and is absent in the St. George vicinity. Two distinct lithofacies, the undisturbed biolithite (biolithite) and the disturbed biolithite (disbiolithite) occur.

Undisturbed Biolithite Facies. The undisturbed biolithite is a dense, hard, crinkled (Plate IV, Fig. 1), medium to thick bedded, yellowish brown limestone ranging from eight inches to four feet in thickness. The rock is composed almost entirely of the calcareous green algae, *Anchicodium*. The biolithite, in thin sections, is micro-laminated with clear, calcified algal thalli and dark brown, acid insoluble carbonaceous material (Plate IV, Fig. 2). The thalli are sheet or blade like in planar dimensions and average approximately 0. 16 millimeters in thickness. Though very delicate, the thalli are unbroken, thus indicating *in situ* growths or disintergrated remains of upright forms. Cellular structure is absent from the thalli and the manner of calcite formation is obscure. It may be either directly secreted skeletal material or a film of sediments collected on an adhesive surface of the algae.

A few well preserved ostracodes and foraminifera were deposited with the thalli (Plate IV, Fig. 2), however terrigenous material is absent.

Upper surfaces of the undisturbed biolithite are undulating, and are depressed where large cobbles of the Conglomeratic zone came to rest. These are no signs of erosional disturbance, indicating the deposits were little affected by currents that transported the cobbles.

Disbiolithite Facies. Disturbed *Anchicodium* biolithite (disbiolithite) occurs in sections 15, 16, 18, 19, 20, 23, and 24. The deposit is very patchy and ranges from a featheredge to 1. 5 feet in thickness over horizontal distance of a few feet (Plate V, Fig. 1). It is dark and light brown banded, dense, and poorly jointed algal limestone. Upper surface of

EXPLANATION OF PLATE IV

Fig. 1. Weathered outcrop of crinkled Anchicodium biolithite. Quarry, near measured section 17.

Fig. 2. Vertical thin section of Anchicodium biolithite showing draped effect of thalli over a fusulinid test. Top of Anchicodium biolithite zone, measured section 17. (X 25)

PLATE IV

Fig. 1

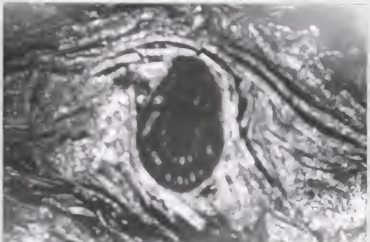


Fig. 2

EXPLANATION OF PLATE V

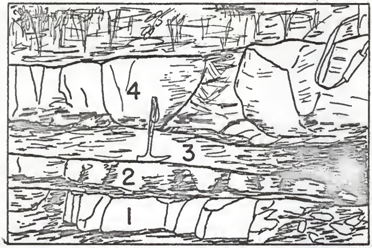


Fig. 1. Outcrop of the Elmont limestone containing a lenticular bed of Anchicodium disbiolithite. Measured section 15.

4. Triticites-Osagia Biosparite zone
3. Conglomeratic zone
2. Anchicodium disbiolithite facies
1. Muddy Dismicrite-Mudstone zone

Fig. 2. Polished vertical section of disbiolithite showing interruption of laminated Anchicodium by cracks and tubes. Measured section 15. (X 1)

PLATE V

Fig. 1

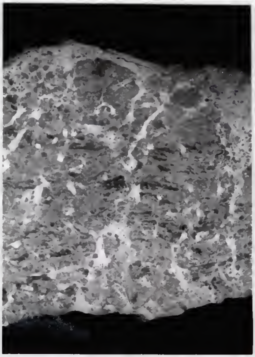


Fig. 2

the disbiolithite are knobby and pitted and resemble flatted cauliflower heads. The knobs are masses of subparallel algae laminae that have been upturned after deposition (Plate V, Fig. 2).

Cracks and tubes containing mud, sand, and sparry calcite are evident on polished sections (Plate V, Fig. 2). The structures apparently are of multiple origin. The cracks could have resulted from algal desiccation or strong current action and the tubes from burrowing organism or root growths. Similar structures have been reported in modern algae by (Black, 1932, p. 165). Broken fronds of Anchicodium in a matrix of dark organic matter and sparry calcite are visible in thin sections.

Lower portions of the deposit are less disturbed than upper portions and contain more evenly laminated algae thalli. Components of the disbiolithite show no evidence of transportation, indicating disarrangement of in situ algal growths that were at one time similar to the undisturbed biolithite.

A one to two inch thick lens of limestone, composed of well preserved Myalina, Septimyalina, and Anchicodium?, crops out between sections 21 and 22 (Plate VI and VII). It is at the same stratigraphic level, between the Muddy Dismicrite-Mudstone zone and the Conglomeratic zone, as the Anchicodium Biolithite of other sections. The pelecypod lens is considered to be part of the disbiolithite facies.

The lens is irregular and cannot be traced for more than a few feet along the outcrops. It is similar, in this respect, to the underlying Muddy Dismicrite-Mudstone zone of the same locality (see page 11).

EXPLANATION OF PLATE VI

Fig. 1. Lower contact of pelecypod-algal lens containing Myalina shells. From stream cut, NE 1/4, NW 1/4, Sec. 1, T. 6 S., R 11 E. (Coin on sample is a quarter).

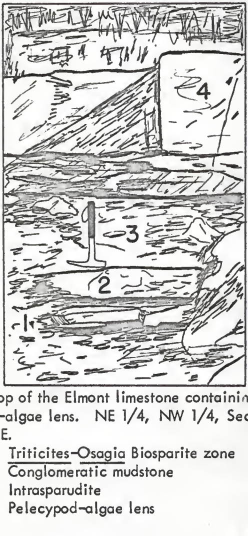
Fig. 2. Upper contact of pelecypod-algal lens containing Septimyalina shells. From stream cut, NE 1/4, NW 1/4, Sec. 1, T. 6 S., R 11 E. (Coin on sample is a quarter).

PLATE VI

Fig. 1

Fig. 2

EXPLANATION OF PLATE VII



Outcrop of the Elmont limestone containing pelecypod-algae lens. NE 1/4, NW 1/4, Sec. 1 T. 6 S., R. 11 E.

4. Triticites-Osagia Biosparite zone
3. Conglomeratic mudstone
2. Intrasparudite
1. Pelecypod-algae lens

PLATE VII

The Conglomeratic Zone

The Onaga Vicinity. The Conglomeratic zone occurs in all outcrops of the Onaga vicinity except at section 26. The zone varies from a yellowish gray, poorly indurated, graded, conglomeratic mudstone at sections 15, 16, 18, 19, 20, 23, and 25 to a well cemented, yellowish brown, moderately well sorted, intrasparudite limestone at section 12. Both conglomeratic mudstone and intrasparudite crop out at section 17, 22, and 24 (Plate II and VIII). The Conglomeratic zone is replaced at section 26 by a slightly calcareous, thin to medium bedded, poorly indurated mudstone ranging from yellowish gray at the base, through gray, to yellowish orange at the top.

The mudstone contains gravel at its base ranging from 2 millimeters to 200 millimeters in diameter. Upper parts of the unit are sandy to slightly pebbly. The sand and gravel content ranges from 5 to 30% by volume (figures are outcrop estimates). Complete fossils are absent in the unit, however brachiopod spines and other shell fragments are plentiful in the sand fraction. These are accompanied with very sparse amounts of coal granules.

The intrasparudite is an elongate lens, extending from section 17 to section 21, of well cemented, unfossiliferous, conglomeratic limestone that contains up to eighty percent mud free gravel (Plate VIII, Fig. 2). The gravel is very well rounded and has shapes ranging from discoidal to spherical.

Gravel in the Conglomeratic zone is composed entirely of algal limestone fragments. Most of the gravel was derived from the Anchicodium Biolithite zone and contains structures typical of the Anchicodium deposits. Some of the gravel fragments are void of lamination, but these have colors and pitted surface structures identical to the Anchicodium pebbles.

EXPLANATION OF PLATE VIII

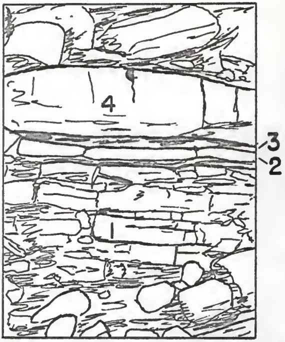


Fig. 1. Outcrop of the Elmont limestone containing intrasparudite. Quarry, at measured section 17.

4. Triticites-Osagia Biosparite zone
3. Conglomeratic mudstone
2. Intrasparudite
1. Anchicodium Biolithite zone

Fig. 2. Polished vertical section of intrasparudite containing pebbles derived from the Anchicodium disbiolithite facies. Measured section 12. (X approximately 1. 5)

PLATE VIII

Fig. 1

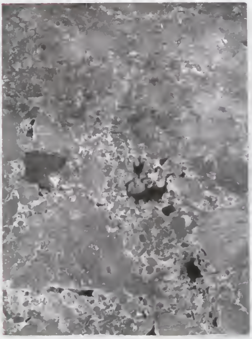


Fig. 2

Both types of gravel are encrusted with a zone of oxidation (Plate IX).

The St. George Vicinity. The Conglomeratic zone is the basal Elmont unit in the St. George vicinity and is present at measured section 1, 3, 4, 5, 6, 10, 11, and 13 (Plate X). It is a dark gray to brownish gray, dense intrasparudite limestone containing angular to subrounded limestone and subround to round dolomite gravel. The gravel ranges from two to seventy-five millimeters in diameter. The matrix between the gravel fragments is dominantly sparry calcite accompanied with small amounts of carbonate sand and mud. Osagia, Girvanella?, Bellerphon, Straparollus, Myalina, Chonetes, crinoid columnals and fenestrate bryozoan fragments are scattered along shale partings within the intrasparudite.

The Conglomeratic zone thins and maximum gravel size decreases southward. The lower contact surface is flat to slightly undulating and is void of scouring features. Upper limits of the Conglomeratic zone are indistinct in most outcrops and grade from an intrasparudite to a biosparudite, however a distinct upper contact is present at measured sections 1 and 8 where the intrasparudite and biosparite are separated by thin shale partings (Plate XI, Fig. 1).

Complete megafossils, except for Bellerphon, are restricted to the shale partings. Fossil debris and well preserved Bellerphon shells are sparsely distributed throughout the intrasparudite. Encrusting algae deposits cover many of the clastic particles (Plate XI, Fig. 2).

The limestone pebbles are angular to subround and are dark gray in color. They are much less evident than the dolomite pebbles in outcrops for the limestone pebbles weather to nearly the same color as the matrix. The pebbles appear slightly lighter colored and

EXPLANATION OF PLATE IX

Fig. 1. Large cobble with pitted surface structure. Base of Conglomeratic zone, measured section 15. (X approximately 0. 66)

Fig. 2. Polished section of pebble with burrows? and an oxidized crust. Conglomeratic zone, measured section 16. (X 2)

PLATE IX

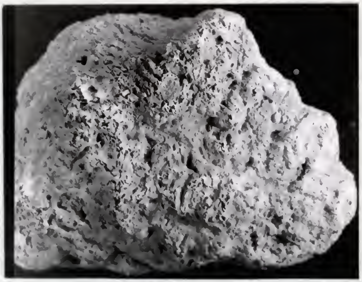


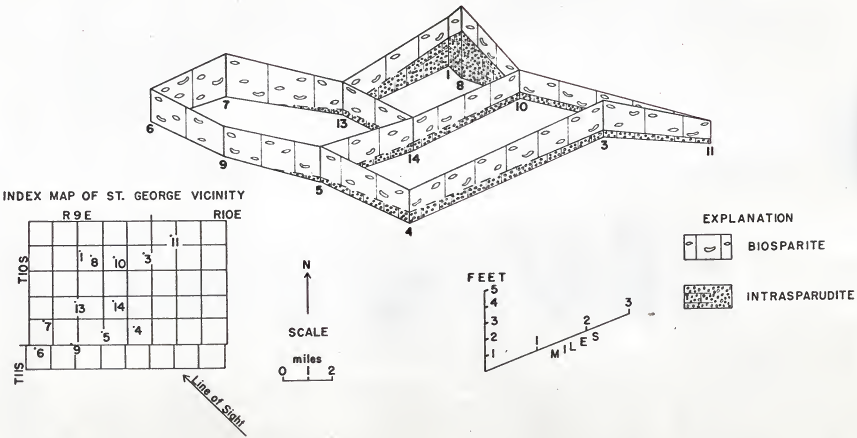
Fig. 1

Fig. 2

EXPLANATION OF PLATE X

Panel diagram showing the stratigraphy of the St. Geoge vicinity.

PLATE – X



INDEX MAP OF ST. GEORGE VICINITY
R9E
RIOE
TIOS
TIIS
Line of Sight
N
SCALE
miles
0 1 2
FEET
MILES
EXPLANATION
BIOSPARITE
INTRASPARUDITE

EXPLANATION OF PLATE XI

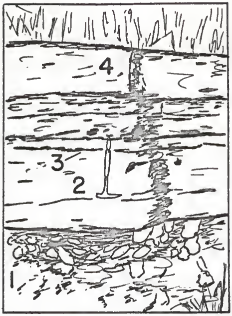


Fig. 1. Outcrop of the Elmont limestone showing shale partings within and at the top of the intrasparudite. Between measured sections 1 and 8.

4. *Triticites–Osagia* Biosparite zone
3. Shale partings
2. Intrasparudite
1. Top of Harveyville shale

Fig. 2. Microbedded dolomite pebble. Dark area on lower corner is encrusting algae. Measured section 1. (X 2)

PLATE XI

Fig. 1

Fig. 2

finer textured than the matrix on polished sections. An oxidized band, encrusted by limonite is present on many of the pebbles, but other internal structure, such as bedding, is absent.

Dolomite pebbles are the most prominent features of the intrasparudite zone in the St. George vicinity. The pebbles are light grayish yellow, soft, micro-bedded, very fine grained dolomite. They weather more rapidly than the matrix, thus causing the intrasparudite to have a rough pitted appearance. None the less, the pebbles stand in relief on polished and etched surfaces. They are easily distinguished on a freshly exposed surface by their light color (Plate XII, Fig. 1).

Insoluble residue and x-ray analysis revealed the compositions of the pebbles to be approximately 87% dolomite and 13 % insoluble residue. The insoluble residue is predominately clay minerals with minor amounts of quartz silt and siliceous foraminifera tests.

The pebbles are encrusted by limonite and algae. Some contain calcite veinlets that resemble septarian structures, whereas others contain black dendritic mineral deposits. Microbedding is the most striking feature of the dolomite and is visible on both weathered and fresh surfaces (Plate XI, Fig. 2). The bedding occurs as light and dark bands ranging from one to two millimeters in thickness with darker bands being limonite stained. The microbedding has not been distorted, indicating that the parent material was well lithified prior to erosion.

Triticites-Osagia Biosparite Zone

The Triticites-Osagia Biosparite zone is a dense, massive bedded, well jointed, brownish gray, laterally persistent limestone ranging from one to 2.5 feet and averaging 1.8 feet

EXPLANATION OF PLATE XII

Fig. 1. Polished section of intrasparudite containing light colored dolomite pebbles and Osagia. Base of measured section 14. (X 1.5)

Fig. 2. Limestone pebbles cemented to lower contact of a block of Triticites–Osagia biosparite. Quarry, near measured section 17.

PLATE XII

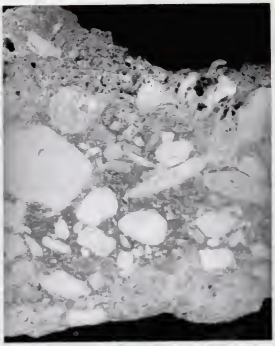


Fig. 1

Fig. 2

in thickness. Thin limonite partings and limonite concretions are characteristic of the upper surface. The lower surface has pebbles cemented to it where the unit overlies conglomeratic mudstone (Plate XII, Fig. 2). The biosparite is the uppermost bed of the Elmont throughout the area of investigation.

Fusulinids, Osagia, Anchicodium, Bellerphon, Derbyia, Chonetes, crinoid columnals, ostracodes, and bryozoans occur in the biosparite. All fossils except Triticites fusulinids and the green? encrusting algae, Osagia are relatively sparse. The Osagia, (Plate XIII), are most highly concentrated in lower portions of the bed and the fusulinids are most highly concentrated toward the top. The change in fossil concentration is gradational and distinct biotopes did not develop. Subparallel horizontal alignment of platy fossil fragments occur in some outcrops.

ENVIRONMENT OF DEPOSITION

Muddy Dismicrite-Mudstone Zone

The Muddy Dismicrite-Mudstone zone is interpreted as a deposit laid down by shallow transgressing seas as the younger beds of the zone are progressively more free of land plant remains, carbonaceous fragments and mud.

The churned nature and presence of calcite vugs in the muddy dismicrite beds are characteristic of lagoonal and tidal flat sediments (Folk, 1961, p. 149). The initial deposit was probably uniform in color and texture, but current action and organic activity is believed to have disrupted the conformity of the deposits and produce voids that were later filled with sparry calcite. Lateral changes in the Muddy Dismicrite-Mudstone zone seem to reflect the effects and control of Late Harveyville topography upon the depositional environ-

EXPLANATION OF PLATE XIII

Fig. 1. Thin section containing fusulinid test and Osagia colony. Middle portion of Triticites-Osagia Biosparite zone, measured section 10. (X 25)

Fig. 2. Thin section containing Osagia colonies encrusted around Anchicodium fragment and shell? fragment. Triticites Osagia Biosparite zone, measured section. (X 25)

PLATE XIII

Fig. 1

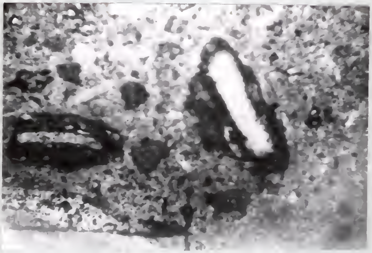


Fig. 2

ment. Distinct interbedding of dismicrite and mudstone in western and northern parts of Onaga vicinity is probably indicative of mudflat deposition, whereas the lack of distinct bedding between the dismicrite and mudstone in southeastern parts of the Onaga vicinity reflect deposition in quiet protected lagoonal waters (Plate XIV).

Semi-stagnant, foul bottom conditions appear to have existed in southeastern parts of the area as attested by carbonized plant remains at sections 24 and 26 and carbonaceous material, celestite, pyrite, and brachiopods at section 17. The area inclusive of these outcrops was probably a lagoon, bordered on the north and west by mudflat banks and on the east and south by the partially emerged main axis of the Nemaha anticline.

The mudflat deposits accumulated in a reducing environment as indicated by the grayish green color of the mudstone and the greenish gray color of the dismicrite (Grim, 1951, p. 231). Micrite was the most prevalent sediment and it was interbedded with stringers and blanket deposits of mudstone. Abrupt lateral variations in the lithology of the mudstone deposits were probably controlled by wave and tide action or by the topography of the depositional surface (Folk, 1961, p. 146). The lateral change from lagoonal environment to mudflat environment was gradual and the dividing boundary between the two was indistinct.

Most of the non-calcareous mud within the Muddy Dismicrite-Mudstone zone was probably swept from upper surface of the Harveyville shale and from nearby land associated with the main axis of the Nemaha anticline. Some mud may have been derived from a stable land mass that is thought to have existed to the north. It is assumed that the micrite calcite was precipitated by inorganic processes such as heating or agitation of the shallow water. No substantial evidence was found to support organic origin.

Sparsity of fossils denotes either that the conditions were not favorable for preservable

EXPLANATION OF PLATE XIV

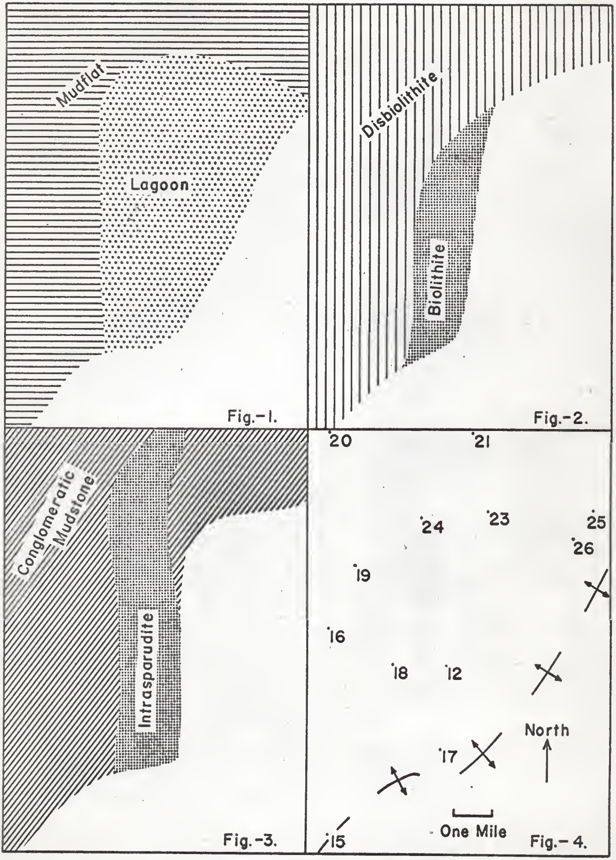
Fig. 1. Map showing distribution of the mudflat and lagoon lithotopes of the Muddy Dismicrite-Mudstone zone.

Fig. 2. Lithofacies map of the Anchicodium Biolithite zone showing distribution of the disturbed and undisturbed biolithite facies.

Fig. 3. Map showing distribution of the conglomeratic mudstone and intrasparudite of the Conglomeratic zone.

Fig. 4. Map showing area covered by Figures I, 2, and 3, and location of the main axis of the Nemaha anticline as preposed by Scott, Foster, and Crumption (1959). Measured sections are numbered.

PLATE XIV



Mudflat
Lagoon
Fig.-1.
Disbiolithite
Biolithite
Fig.-2.
Conglomeratic Mudstone
Intrasparudite
Fig.-3.
20
21
24
23
25
26
19
16
18
12
North
17
One Mile
15
Fig.-4.

forms of life or that most of the biota was destroyed by predatory organisms and scavengers (Beales, 1963, p. 684). The disturbed nature of the micrite could possible have resulted from organic activity. The accumulation of well preserved plant remains and pyrite bearing carbonaceous shale reflect toxic, low oxidizing conditions in the lagoonal facies (Krumbein and Sloss, 1958, p. 207). It is possible that seas overlying both lithotopes were very shallow and muddy enough to discourage photosynthesis. Perhaps the lack of oxygen and the presence of turbid waters were sufficient to prevent an active community from developing.

Lack of Muddy Dismicrite-Mudstone zone in the St. George vicinity poses a problem. Greater thickening of the Harveyville shale indicates that non-calcareous mud, rather than micrite and mudstone accumulated, however it is conceivable that the Muddy Dismicrite-Mudstone zone was deposited and later removed by erosion.

Anchicodium Biolithite Zone

The widespread occurrence of Anchicodium Biolithite above the mudflat facies denotes an appreciable change, from poorly oxygenated, turbid conditions to well oxygenated, well lighted conditions for algae are dependent upon sunlight and oxygen (Johnson, 1946; Tasch, 1957). Continued deepening of Elmont seas may have protected the muddy depositional interface from wave action, thus eliminating the most likely source of material which produced turbidity. Relatively quiet and clearly lighted waters would have been ideally suited to algal growth and it is likely that such existed for the plants accumulated in great quantities.

Growth habits of the lime secreting Anchicodium are vague. They possibly grew in thin flat sheets upon the sea floor. More likely, however, they grew as upright forms that, after death, collapsed to form the laminated deposits. Arching of the thalli over microfossils (Plate IV, Fig. 2) substantiates the latter concept. Sparsity of other benthos fauna reflects the extent of algal domination of the depositional environment.

Lithified algal deposits overlying central portions of the mudflat facies were probably disturbed by wave action, burrowing organisms, and desiccation. Cobble size masses of the laminated thalli were torn loose from the beds and were subjected to abrasion. Anchicodium deposits that fringe the lagoon area of the underlying Muddy Dismicrite-Mudstone zone are thicker and better preserved than equivalents strata to the west and south (Plate X). The nature and distribution of the disturbed biolithite and undisturbed biolithite beds supports the supposition that a broad, nearly flat marine bank area existed in western and northern parts of the Onaga vicinity and a protected shallow topographic basin existed to the south and east.

The pelecypod-algae lens (Plate VI) between measured section 21 and 22, is indicative of very shallow, possibly hypersaline conditions (Moore, 1948, p. 126). The lens is correlated as part of the disbiolithite facies though it shows no signs of having been disturbed. Mytilus, a modern gregarious relative of Myalina and Septimylina, flourishes in a habitat between the high water mark and depths of a few fathoms (Moore, Lalicker, and Fischer, 1952, p. 429). Mytilus are little affected by strong wave action. Similar abilities, is possessed by the Pennsylvanian pelecypods, would explain their lack of abrasion features. Abrupt lateral variations of beds associated with the pelecypod-algae lens seems to substantiate the concept of shallow water origin.

Anchicodium deposits are restricted from the area of measured section 25 and 26.

Explanations for the absence of Anchicodium biolithite from the St. George vicinity are identical to those proposed for lack of the Muddy Dismicrite-Mudstone zone in the same area.

The Conglomeratic Zone

Onaga Vicinity. Gravel of the Onaga vicinity was derived from upper surfaces of the disbiolithite facies. Areal configuration of the source is identical with that of the disbiolithite and very similar to that of the mudflat lithotope. Mud fractions of the Conglomeratic zone may have been in part, locally derived, however breached portions of the Anchicodium Biolithite are of limited extent and the underlying muddy beds are only partially eroded. Most of the mud undoubtedly was transported from a source outside the area of investigation.

The intrasparudite represents an exceptionally high energy environment for sparry calcite that cements the intrasparudite bed formed where hydraulic action was sufficient to remove the mud fraction and concentrate the gravel. Its distribution coincides in part with the west boundary of the protected basin. The intrasparudite was probably deposited at the lowest strand line of a regressing sea (Plate XIV, Fig. 2). Abundant small shell fragments within the Conglomeratic zone are indicative of an active biota. Size of the fragments does not preclude their having local origin, however it is likely that at least a few locally derived fossils would have survived intact.

St. George Vicinity. The Conglomeratic zone represents the first permanent deposit of Elmont age in the St. George vicinity. Sources of the St. George gravel are unknown. The gravel was probably derived from earlier deposited Elmont beds as pre-Elmont beds occur in normal sequence and have lithologies quite different from that which might be associated with a dolomite forming environment.

Largest gravel fragments are found in northern outcrops, indicating a source to the north. Absence of beds ordinarily present between the post-Elmont, Dry shale and Pony Creek shale in an area just north of the St. George vicinity denotes the crest of an anticlinal fold. The fold might have been present as a land mass during Elmont time and thus have been effected by lowering of sea level. The Zeandale dome, a prominent surface structure that includes part of the St. George vicinity, is flanked on the north by the Conglomeratic zone. The dome was possibly subjected to erosion during Elmont time, however lack of scouring features and absence of remanent carbonate beds at lower contacts of the Elmont are considered reliable criteria for excluding a source associated with this structure.

The finely bedded, yellowish gray dolomite pebbles indicate the source had a low energy depositional environment. Such an environment would exist in a partially restricted or restricted brine pan, where primary dolomite is believed to precipitate. Fineness of grain and microbedding suggests that the dolomite may have been primary, however lack of organic coloration contradicts a primary origin (Carozzi, 1960, p. 284). Although the dolomite may not be primary, it definitely was deposited in a low energy, magnesium rich environment (Kramer, 1958).

The St. George instrasparudite seems to have been deposited in an environment affected by strong wave and current action. This concept is supported by the abundance of gravel and lack of mud. Geometry of the intrasparudite is that of a low, broad shoal, seemingly bordered on the east, west, and south by deeper water and on the north by land. Deposition of the gravel occurred during the second phase of Elmont transgression as the dolomite pebbles probably came from a restricted low energy environment such as that left by a regressing sea.

Continuous organic activity was restricted to hardy forms such as Bellerphon, Myalina, and algae. Encrusting habits of the algae were influential in binding the gravel deposits. The more delicate, fragmented fossils presumably were transported from a less violent environment, though some undoubtedly lived in protected portions of the shoal. Short periods of quiescence may have stimulated organic activity and caused the fossils to be concentrated along the shale partings.

Triticites-Osagia Biosparite Zone

Biosparite represents the most stable and uniform phase of Elmont deposition as attested by the persistency of its lithology and paleontology. Abundant fossils probably reflect the presence of a very active, though not too diverse, bottom community. Osagia, an important segment of the biota, were dependent upon well lighted water. Progressive deepening may have enabled fusulinids to flourish and surpass the Osagia in relative abundance. The fossil record of such forms as crinoids, bryozoans, and brachiopods is uniform. It seems plausible that these forms were able to cope with the changing conditions and occurred at a constant rate.

Current and wave action apparently were slight during deposition of the biosparite for thickness variations and bedding of fossils are meager. Apparently, transgression of the Elmont sea had progressed sufficiently to place the sea floor near to wave base, thus preventing abrasion and current bedding.

CONCLUSIONS

1. The Elmont limestone can be divided into four zones, each of which reflects the topographic configuration and environment of the depositional surface.

2. Zones of the Elmont were deposited in the following sequence with respect to the phase of inundation.

Triticites-Osagia Biosparite zone	Transgression
Conglomeratic zone	Regression
Anchicodium Biolithite zone	Transgression
Muddy Dismicrite-Mudstone zone	

3. The greenish colored beds of the Muddy Dismicrite-Mudstone zone were deposited in a reducing, mudflat environment. The mudflats were shoal-like and probably separated from any permanent land mass. Brackish conditions and repetitious emergence above sea level impeded growth of a preservable bottom community.

   The dark gray beds of the Muddy Dismicrite-Mudstone zone accumulated in a semi-foul, lagoonal basin, that was situated in a protected position between the mudflats and the main crest of the Nemaha anticline. Plant fragments in the lagoon deposits were transported from the exposed anticlinal crest.

4. Progressive clearing and deepening of the Elmont sea encouraged development of an

Anchicodium algae bank over the submerged mudflats. Anchicodium were upright growths that possessed pliable, sheet-like calcareous thalli. Water in which they grew was well oxygenated and well lighted.

5. Abrupt regression of the Elmont sea caused wave action to erode shallower portions of the algae bank. Gravel debris, from the algae beds and mud, were deposited over the erosional surface and formed conglomeratic mudstone. The intrasparudite lens is composed of lag gravel from a winnowed portion of the conglomeratic mudstone and its position marks the lowest strand line of regression.

   Intrasparudite of the St. George vicinity was deposited during the initial part of the second transgressive phase. Limestone pebbles and dolomite pebbles in the intrasparudite were transported from the north and the dolomite source was a semi-restricted or restricted, magnesium rich brine pan. The dolomite pebbles are composed of poorly indurated, clay size crystals of dolomite and in a textural sense can correctly be called clay balls. Oxidized crust on some of the gravel is indicative of sub-aerial weathering.

6. The most stable period of Elmont deposition is represented by the Triticites-Osagia Biosparite. The biosparite was deposited during the period of maximum inundation near wave base. The bottom community consisted mainly of fusulinids and Osagia.

7. Waves were normally about three feet high and tides averaged less than ten feet if the seas of Elmont time were comparable to those of today (Twenhofel, 1950, p. 120 and Curray, 1960, p. 231). Wave height/length ratios would have ranged from 1/13 to 1/30 and the effective theoretical wave base would have been one-half the wave length (Guilcher, 1958, p. 20).

   The calculated base for Elmont sea waves, using the above figures, could range from

29.5 feet to 55 feet, allowing 10 feet for tides. The attitude of fossils in the Biosparite zone indicates some wave action; it is probable that maximum depths of Elmont deposition did not exceed 55 feet and on an average were much less, perhaps near thirty feet.

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APPENDIX

MEASURED SECTIONS

MEASURED SECTION 1: NW 1/4, NW 1/4, Sec. 15, T. 10 S., R. 9 E. (Hillside north of old U.S. 24 highway, 1/2 mile east of St. George)

Elmont limestone member

Biosparite: brownish gray to gray, weathers brown. Thick bedded, massive dense. Weathers into very large rectangular blocks. Limonite concretions on weathered upper surface. Fusulinids and Osagia abundant. Crinoid columnals and fenestrate bryozoans common. Fossils weather in relief causing crinoid columnals to appear most numerous.	0.9 ft.
Intrasparudite: medium to dark gray, weathers yellowish brown. Sparry calcite cement weathers pitted and is very rough. Shale partings 1.8 ft. from lower contact. Gray limestone pebbles and light yellowish gray dolomite pebbles, moderate to well rounded, in a slightly muddy sparry calcite cement. Dominant pebble size ranges from 5 to 10 millimeters, maximum size 75 millimeters. Pebbles covered with encrusting algal deposits. Osagia, Anchicodium, Bellerphon, Myalina, Chonetes, rugose coral, fenestrate bryozoans, crinoid columnals. Most mega fossils fragmented. Bellerphon well preserved.	2.1 ft.
Total thickness of Elmont----------------	3,0 ft.

Harveyville shale member (part)

Mudstone: greenish gray to gray, weathers to gray angular blocks. Moderately well indurated. Mud pebble zone, approximately 3.0 feet from top of bed, is poorly defined. Selenite crystals, averaging approximately eight millimeters long, imbedded in upper surface. Slickensides developed on randomly oriented joint and fracture surfaces. Distinct break between Harveyville and Elmont.	4.0 ft.
Total thickness of Harveyville (exposed)----	4.0 ft.

MEASURED SECTION 2: SW 1/4, NW 1/4, Sec. 13, T. 10 S., R. 9 C. (Hillside north of old U.S. 24 highway between St. George and Wamego)

Harveyville shale (covered)

Reading limestone member--	3.2 ft.

Biosparite: brown, weathers light brown. Two beds of limestone separated by 6" to 10" thick bed of gray mudstone. Bedding planes of biosparite and mudstone are wavy and beds have very irregular thickness. Ostracodes, crinoid columnals, fenestrate bryozoans, gastropods occur in the limestone. Large fossils are fragmented. Mudstone is unfossiliferous.

Total thickness of Reading-------------- 3.2 ft.

MEASURED SECTION 3: SE 1/4, NE 1/4, Sec. 13, T. 10 S., R. 9 E. (Hillside north of old U.S. 24 highway, 2-1/2 miles southwest of Wamego)

Elmont limestone member

Biosparite: grayish brown to brown, weathers yellowish brown. Upper 0.33 feet thin bedded and very limonitic. Lower part massive and dense. Contains abundant fusulinids, Osagia, throughout. Girvanella?, Bellerphon, Straparolus, crinoid columnals, brachiopod fragments in lower portion of zone. Lower contact transitional to Intrasparudite zone. Fusulinids and crinoids weather in relief. 2.0 ft.

Intrasparudite: brownish gray, weathers yellowish brown. Dolomite and limestone pebbles, intermingled with Anchicodium, cemented by sparry calcite. Dolomite pebbles up to 100 millimeters in maximum diameter. Pebbles protrude into underlying Harveyville shale. Some mud in lower part of zone. 0.3 ft.

Total thickness of Elmont--------------- 2.3 ft.

Harveyville shale (part)

Mudstone: light greenish gray, weathers gray. Massive and irregularly jointed. Slickensides on joint and fracture surfaces. Large limonite clay concretions up to five inches long near upper contact. No apparent zonation in mudstone. 9.0 ft.

Exposed thickness of Harveyville--------- 9.0 ft.

MEASURED SECTION 4: NW 1/4, NW 1/4, Sec. 36, T. 10 S., R. 9 E. (Bar ditch, north side of gravel road near culvert)

Elmont limestone member

Biosparite: grayish brown, weathers yellowish brown. Dense, massive with thin bedded limonite partings at top. Lower contact gradational into 1.7 ft.

Intrasparudite zone. Fusulinids and Osagia dominant fossils. Girvanella?, crinoid columnals, fenestrate bryozoans, Archimedes?, and rugose coral. Fossils weather in relief.

Intrasparudite: light greenish brown, weathers yellowish brown. Slightly muddy. Limestone and dolomite pebbles up to 60 millimeters in diameter. Yellowish gray dolomite pebbles prominent on fresh surface. Pebbles intermixed with Osagia and shell fragments. — 0.2 ft.

Total thickness of Elmont-------------- 1.9 ft.

MEASURED SECTION 5: SW 1/4, NW 1/4, Sec. 34, T. 10 S., R. 9 C. (Stream bank in pasture approximately 50 feet from county line)

Elmont limestone member

Biosparite: grayish brown, weathers light gray. Dense, massive with platy limonitic partings on upper surface. Black sulfide or carbon streaks on horizontal fractures. Fusulinids, Osagia, Anchicodium, fragmented shell debris. Lower contact gradational but tends to break near top of Intrasparudite zone. — 2.0 ft.

Intrasparudite: greenish brown, weathers gray. Contains platy, horizontally aligned yellowish gray dolomite pebbles. Pebbles range 2.0 to 10 millimeters in diameter. Osagia abundant in pebble zone. — 0.2 ft.

Total thickness of Elmont--------------- 2.2 ft.

MEASURED SECTION 6: NE 1/4, NW 1/4, Sec. 5, T. 11 S., R. 9 E. (Stream bank and water fall at Pillsbury Crossing)

Elmont limestone member

Biosparudite: grayish brown, weathers gray. Dense, massive, fractures into rectangular blocks. Sulfide or carbonaceous streaks on fracture surfaces. Pelecypod burrows? on upper contact. Fusulinids abundant. Contains dark gray calcareous sand in lower part. Nodules of clastic material protrude into underlying shale. Fusulinids, Bellerphon, crinoid columnals. — 2.1 ft.

Total thickness of Elmont--------------- 2.1 ft.

MEASURED SECTION 7: NW 1/4, NE 1/4, Sec. 32, T. 10 S., R. 9 E. (Hillside approximately 100 yards northwest of concrete bridge)

Elmont limestone member

Biosparite: grayish brown, weathers brown. Dense, massive. Breaks into rectangular blocks. Upper contact crossed by solution channels. Fusulinids very abundant in upper one foot of bed. Fusulinids, Osagia, Anchicodium, Bellerphon, shell fragments in lower portion of bed. Lower part of bed has mud and calcareous sand impurities. — 2.7 ft.

Total thickness of Elmont--------------- 2.7 ft.

MEASURED SECTION 8: SW 1/4, NE 1/4, Sec. 15, T. 10 S., R. 9 E. (Hillside between Tarkio limestone quarry and old U. S. 24 highway)

Elmont limestone member

Biosparite: grayish brown, weathers brown. Dense, massive, separated from Intrasparudite zone by shale parting. Fusulinids, Osagia, Anchicodium, Bellerphon, brachiopod fragments, crinoid columnals, fenestrate bryozoans. — 1.5 ft.

Intrasparudite: grayish brown to dark gray, weathers brown. Dense, medium bedded with three shale partings. Abundant limestone and dolomite pebbles. No evidence of graded bedding. Anchicodium, Osagia, fossil debris, Bellerphon. Pebbles encrusted by algae. — 3.0 ft.

Total thickness of Elmont--------------- 4.5 ft.

MEASURED SECTION 9: SW 1/4, SW 1/4, Sec. 33, T. 10 S., R. 9 E. (Intermittent stream bed just above juncture of two valleys)

Elmont limestone member

Biosparite: grayish brown, weathers light brown. Fusulinids abundant in upper 1.66 feet of bed. Bellerphon, Osagia, Marginifera, crinoid columnals, and brachiopod fragments abundant in lower part with fusulinids. Dense and massive, breaks into rectangular blocks in upper part, lower part breaks irregular. — 1.8 ft.

Total thickness of Elmont--------------- 1.8 ft.

MEASURED SECTION 10: SE 1/4, NE 1/4, Sec. 14, T. 10 S., R. 9 E. (Bar ditch on west side of graveled north-south road)

Elmont limestone member

Biosparite: brown, weathers yellowish to grayish brown. Dense, massive hard platy limonitic fragments on upper surface. Fusulinids, Osagia, Anchicodium, Bellerphon, Allorisma? crinoid columnals. Fusulinids and algae are most abundant fossils. 1.5 ft.

Intrasparudite: brown to grayish brown, weather grayish brown. Gray limestone and yellowish white dolomite pebbles up to 15 millimeters in diameter. Pebbles subrounded. Sparry calcite cement weathers in relief. Osagia and Anchicodium are abundant. 0.4 ft.

Total thickness of Elmont---------------- 1.9 ft.

MEASURED SECTION 11: SE 1/4, NE 1/4, Sec. 7, T. 10 S., R. 10 E. (Waterfall in stream channel of heavily wooded area)

Elmont limestone member

Biosparite: brown, weathers grayish brown. Fractures into rhombic blocks. Separated from intrasparudite by bedding plane. Fusulinids, Osagia, Bellerphon. 1.1 ft.

Intrasparudite: brown, weathers grayish brown. Fractures conchoidal. Contains gray limestone and yellowish gray dolomite pebbles ranging from 10 millimeters to 50 millimeters in diameter. Bellerphon, encrusting algae. 0.3 ft.

Total thickness of Elmont---------------- 1.4 ft.

MEASURED SECTION 12: SW 1/4, SE 1/4, Sec. 34, T. 6S., R. 11 E. (Road cut on north side of state highway K-16, 1 mile east of Onaga)

Elmont limestone member

Biosparite: yellowish brown, weathers brown. Massive and dense. Fusulinids, Osagia, Marginifera, Chonetes, crinoid columnals, and fenestrate bryozoans. Fusulinids and Osagia most abundant. Fusulinids weather in relief. 1.3 ft.

Intrasparudite: yellowish brown to brown, weathers yellowish brown. Pebbles 0.7

platy to near spherical, well rounded to subangular. Most are moderately well rounded. Bed is approximately 80% pebbles. Non-fossiliferous. Pebbles resemble next lower limestone bed.

Mudstone: yellowish gray, weathers gray, moderately well indurated, unfossiliferous.	0.7 ft.
Biolithite: brown, weathers yellowish brown. Upper part contains distinct algal laminations. Lower part massive, more dense, and hard.	0.7 ft.
Dismicrite: yellowish gray to gray, weathers dark gray. Massive, soft, poorly indurated. Contains small (1/2 to 3 millimeters in diameter) sparry calcite vug fillings. Unfossiliferous.	1.1 ft.
Total thickness of Elmont----------------	4.5 ft.

MEASURED SECTION 13: NW 1/4, NW 1/4, Sec. 28, T. 10 S., R. 9 E. (Hillside and bar ditch on west of gravel road, one mile east and one-fourth south of Zeandale)

Elmont limestone member

Biosparite: brownish gray, weathers yellowish brown. Massive, dense, weathered upper surface covered with platy limonitic fragments. Fusulinids (very heavily concentrated in upper part), Osagia (dominant fossil in lower two to five inches of bed), Chonetes, fenestrate bryozoans. Fossils weather in relief. Lower contact transitional.	1.7 ft.
Intrasparudite: dark brownish gray, weathers yellowish brown. Contains grayish yellow dolomite pebbles averaging four millimeters in diameter. Largest pebbles rang up to forty millimeters in diameter. Pebbles are well rounded and platy. Myalina, Bellerphon, Marginifera?, Chonetes, large fenestrate bryozoan fragments imbedded in lower surface, lower contact is distinct and rest on greenish gray Harveryville shale.	0.5 ft.
Total thickness of Elmont-----------------	2.2 ft.

MEASURED SECTION 14: SE 1/4, NW 1/4, Sec. 26, T. 10 S., R. 9 E. (Dry stream bed on wooded hillside, about one-fourth mile east from county line)

Elmont limestone member

Biosparite: brownish gray, weathers yellowish gray, dense, massive and hard.	1.5 ft.

Fusulinids and Osagia are very heavily concentrated. Fossils weather in relief. Lower contact transitional.

Intrasparudite: very dark brownish gray, weathers yellowish gray, dolomite pebbles, ranging between two and thirty-six millimeters and average approximately five millimeters in diameter. Pebbles not obvious on weathered surface. Osagia and Anchicodium are abundant throughout bed. 0.5 ft.

Total thickness of Elmont--------------- 2.0 ft.

MEASURED SECTION 15: NE 1/4, SE 1/4, Sec. 29, T. 7 S., R. 11 E. (South bank of stream at water level)

Elmont limestone member

Biosparite: dark gray at base to brown at top, weathers grayish yellow to grayish brown, tense, hard, two sets of vertical joints with very smooth and flat surfaces. Lower part of bed slightly muddy and breaks into irregular platy fragments. Fusulinids, Osagia, crinoid columnals are abundant throughout bed. 1.8 ft.

Conglomeratic mudstone: dark gray mudstone containing gravel ranging from 2 millimeters to 200 millimeters in diameter. Gravel most highly concentrated toward base and was derived from underlying bed. Gravel is subspherical pitted and well rounded to subrounded. Shell fragments in sand fraction of unit. 0.3 ft.

Disbiolithite: light and dark brown banded, weather brownish gray. Very hard and dense. Contains cracks and tubes filled with sparry calcite and mud. Upper surface of unit is pitted and very irregular. Bed is lenticular and feathers out over short distances. Composed of disturbed Anchicodium deposits, lower part of which are only slightly disturbed and resemble biolithite of section twelve. 0.4 ft.

Dismicrite: greenish gray, weathers light gray, muddy, soft, very fine grained, cloudy colored. Unfossiliferous, irregular thickness. Contains vugs of clear and brick red sparry calcite. 0.8-1.0 ft.

Mudstone: grayish green, weathers gray, soft, poorly indurated, thin bedded and unfossiliferous. Protrudes into joint gaps of overlying unit. 0.2-0.4 ft.

Dismicrite: light brownish gray, weathers gray, very muddy, soft, fine grained. Contains calcite vugs, unfossiliferous. 0.2-0.3 ft.

Mudstone: grayish green, poorly indurated, bedding absent, unfossiliferous. 0.3 ft.

Dismicrite: grayish green, weathers gray, joints poorly developed, and filled with mudstone, breaks into rounded fragments. Upper and lower surface indistinct. Unfossiliferous. 0.3-0.5 ft.

Total maximum thickness of Elmont------- 5.0 ft.

MEASURED SECTION 16: NW 1/4, NE 1/4, Sec. 32, T. 6 S., R. 11 E. (South bank of Mill Creek, approximately eight feet above stream bed)

Elmont limestone member

Biosparite: grayish brown, weathers light yellowish gray. Dense, massive and hard. Upper surface covered with limonite fragments. (Unit overlain by thin bedded, poorly indurated sandstone of Willard shale member). Fusulinids abundant, crinoid columnals, Bellerphon, Allorisma?. 1.3 ft.

Conglomeratic mudstone: light greenish gray, weathers gray. Contains pebbles ranging up to 150 millimeters in diameter, pebbles concentrated in lower part of bed. Sand fraction contains fossil fragments and coal, 0.6 ft.

Disbiolithite: light and dark brown banded, weathers medium dark brownish gray. Unit composed of disturbed Anchicodium laminae, upper surface rough and pitted, bed is lenticular. 0.0-0.4 ft.

Dismicrite: light brownish gray, weathers light to dark gray. Muddy, dense and moderately hard, contains clear and brick red sparry calcite vugs and brachiopod? fragments. 0.0-0.4 ft.

Mudstone: gray to greenish gray, weathers gray, soft, poorly indurated. Unfossiliferous. 0.1 ft.

Dismicrite: greenish gray, weathers limonite stained gray. Muddy, moderately soft, irregular lower surface. Unfossiliferous. Contains sparry calcite vugs. 0.6 ft.

Mudstone: green and weathers greenish gray. Slightly calcareous, soft, poorly indurated. Unfossiliferous. 0.3 ft.

Dismicrite: greenish gray and weathers gray. Very muddy, soft, irregularly jointed, breaks into irregular rounded fragments. 0.5 ft.

Total maximum thickness of Elmont-------- 4.2 ft.

MEASURED SECTION 17: SE 1/4, NW 1/4, Sec. 14, T. 7 S., R. 11 E. (Quarry at end of one-half mile long graveled road)

Elmont limestone member

Biosparite: grayish brown and weathers brownish yellow. Hard, massive and dense. Set of vertical joints intersect at right angles. Upper surface of bed flat, lower surface flat and covered with limestone pebbles. Fusulinids, Osagia, crinoid columnals, fenestrate bryozoans, brachiopod fragments. Fossils are abundant. Thickness variable.	1.5-2.0 ft.
Conglomeratic mudstone: yellowish gray to gray and weathers gray. Poorly indurated. Contains well rounded, sub-spherical limestone gravel ranging up to 150 millimeters in diameter. Gravel is from disturbed Anchicodium bed. Mudstone contains intrasparudite lens in middle part that is 0.3 feet thick. Intrasparudite is well indurated, slightly muddy and composed of approximately 60% gravel, cemented with sparry calcite.	1.0-3.0 ft.
Biolithite: yellowish brown, weathers very light yellowish brown. Hard crinkled, irregular thin beds. Bedding planes are undulating. Composed of laminated, undisturbed Anchicodium thalli. Anchicodium are accompanied with sparse number of fusulinids and ostracodes. Brachiopods and crinoid columnals in lower part. Lower part contains black carbonaceous streaks resembling bladed plant fronds in outline.	4.0-4.5 ft.
Dismicrite: dark gray, weathers gray. Soft and very muddy at base to hard silty at top. Megacrystals of celestite, sphalerite, pyrite, and carbonaceous fragments on upper surface. Lower portion of bed is platy. Marginifera, Chonetes, Orbiculoidea, crinoid columnals, restricted to silty zone.	2.0 ft.
Total average thickness of Elmont--------	9.0 ft.

MEASURED SECTION 18: NE 1/4, NW 1/4, Sec. 13, T. 7 S., R. 11 E. (Abandoned trench silo just south of graveled county road)

Elmont limestone (part)

Biosparite: grayish brown, weathers light yellowish gray, dense well indurated, upper surface weathered and very irregular. Covered with Pleistocene till. Only part of biosparite bed present. Fusulinids and Osagia abundant, crinoid columnals sparse.	1.0 ft.

Conglomeratic mudstone: yellowish gray, weathers dark yellowish gray. Soft, poorly indurated, calcareous mudstone containing abundant granule and few pebble sized limestone fragments. 0.8 ft.

Disbiolithite: dark brown, weathers brownish gray, very hard, dense. Composed of disturbed Anchicodium laminae. Upper surface rough and pitted. 1.0 ft.

Dismicrite: greenish gray, weathers gray, soft, poorly jointed, very muddy. Sparry calcite vugs. Bed is lenticular and breaks into rounded fragments. 0.2 ft.

Total thickness of Elmont present--------- 3.0 ft.

MEASURED SECTION 19: SW 1/4, NW 1/4, Sec. 21, T. 6 S., R. 11 E. (South bank of stream approximately 8 feet above stream bed)

Elmont limestone member

Biosparite: brown, weathers light yellowish gray. Upper part dense, hard. Lower part more soft and slightly muddy. Fusulinids, Osagia, crinoid columnals, and brachiopod fragments. Fusulinids abundant in upper portion of bed. 1.4 ft.

Conglomeratic mudstone: yellowish gray, weathers gray. Poorly indurated, contains abundant limestone gravel ranging from 2 to 140 millimeters in diameter. Gravel derived from disbiolithite. Sand fraction contains humus? and shell fragments. 0.9 ft.

Disbiolithite: brown weathers brownish gray. Hard, dense, well indurated. Upper surface very irregular and pitted. Bed lenticular. Composed of disturbed Anchicodium thalli. 0.1-0.5 ft.

Dismicrite: light greenish gray, weathers gray. Clear and brick red calcite vugs. Bed contains 0.1 foot thick green mudstone parting in middle part. Upper surface of dismicrite is irregular. 1.2-1.8 ft.

Total maximum thickness of Elmont-------- 4.6 ft.

MEASURED SECTION 20: NW 1/4, NE 1/4, Sec. 5, T. 6 S., R. 11 E. (Bar ditch on south side of gravel road that separates Pottawatomie and Nemaha counties)

Elmont limestone member

Biosparite: Gray, weathers yellowish gray. Dense and hard at top, to slightly muddy and platy at base. Fusulinids, crinoid columnals abundant in upper part; Osagia, Anchicodium? concentrated toward base. Brachiopod fragments sparse throughout. 1,2 ft.

Conglomeratic mudstone: greenish gray, weathers gray. Has poorly developed thin bedding toward top. Gravel concentrated toward base, was derived from disbiolithite. Gravel moderately well rounded, and subspherical. 0. 5 ft.

Disbiolithite: brown, weathers grayish brown. Hard, dense, slightly muddy Algae lamination distinct, pseudo-brecciated appearance. Upper surface irregular and rough, lower surface flat and distinct. 0. 6 ft.

Disbiolithite: greenish gray, weathers gray, limonite stained. Separated from disbiolithite by thin shale parting and contains thin shale parting in middle part. Soft, weathers subrounded fragments. (Rests on calcareous yellowish gray Harveyville shale which is 8 ft. thick.) 0. 8 ft.

Total thickness of Elmont---------------- 3. 1 ft.

MEASURED SECTION 21: NE 1/4, NW 1/4, Sec. 1, T. 6 S., R. 11 E. (East of small bridge in bar ditch)

Biosparite: light brown, weathers yellowish gray. Dense, hard, breaks into elongated blocks. Fusulinids abundant toward top, Osagia, brachiopod and crinoid fragments abundant throughout. Contacts flat and distinct. 1. 4 ft.

Conglomeratic Mudstone: Greenish gray, weathers gray. Poorly indurated. Contains sparse number of pebbles, abundant sand. Humus and shell fragments in sand fraction. One inch thick brachiopod lens near top. Pebbles concentrated toward base. 1. 5 ft.

Intrasparudite: brownish gray, weathers gray. Moderately well indurated. Contains well rounded gravel. Maximum gravel size 180 millimeters in diameter. Small gravel fine grained, large gravel resembles disbiolithite. Terrestrial plant fragments. 0. 5 ft.

Dismicrite: greenish gray, weathers gray, limonite stained. Bed lenticular, soft, breaks into well rounded fragments. Contains sparry calcite vugs. 0. 0-0. 3 ft.

Total maximum thickness of Elmont-------- 3. 7 ft.

MEASURED SECTION 22: NW 1/4, NE 1/4, Sec. 1, T. 6 S., R. 9 E. (South bank of small stream, outcrop visible from county line road)

Biosparite: brownish gray, weathers yellowish gray. Dense, hard, massive, joint surfaces flat and smooth. Lower 4 inches of bed contains abundant Osagia, is muddy and breaks into platy fragments. Fusulinids, Osagia, crinoid columnals. 1.6 ft.

Conglomeratic mudstone: greenish gray, weathers gray, bedding indistinctly developed in upper part, lower part contains pebbles. (Four inch thick intrasparudite bed at base of unit in outcrop 100 yards southwest, intrasparudite underlain by 2 inch thich bed composed of Myalina, Septimylina, and Anchicodium). 1.0 ft.

Dismicrite: one bed, brownish gray to greenish gray, weathers yellowish gray dense, hard, smooth and flat joint surfaces, Allorisma; or 3 to 4 beds, gray to greenish gray, cloudy colored, soft to hard, poorly jointed, containing clear and brick red calcite vugs and interbedded with green mudstone. Lithology and number of beds change abruptly. 0.0-1.8 ft.

Thickness of Elmont present-------------- 4.4 ft.

MEASURED SECTION 23: NE 1/4, NE 1/4, Sec. 13, T. 6 S., R. 11 E. (Bar ditch, south side of graveled road, very poor outcrop)

Elmont limestone (part)

Biosparite: brown, weathers light yellowish to brownish gray. Upper part of bed eroded and covered. Fusulinids. 0.8 ft.

Conglomeratic mudstone: greenish gray, weathers gray. Pebbly toward base. 0.5 ft.

Disbiolithite: brown, weathers light yellowish to brownish gray. Limonite stained on upper surface. Upper surface irregular and has gravel cemented to it. Composed of disturbed Anchicodium?

Dismicrite: gray, weathers light gray. Colors clouded. Soft, contains calcite vugs. Mudstone parting in middle portion of bed. Unfossiliferous. 1.0 ft.

Thickness of Elmont Present--------------- 3.1 ft.

MEASURED SECTION 24: NW 1/4, NW 1/4, Sec. 14, T. 6 S., R. 11 E. (Cut on east side of road)

Elmont limestone (part)

Biosparite: grayish brown, weathers light yellowish brown. Dense, hard and well jointed. Elliptical solution channels along joints. Upper part of bed absent (removed by Recent and Pleistoncene weathering) Fusulinids, Osagia, fenestrate bryozoan fragments, Allorisma. 0.4-0.6 ft.

Conglomeratic mudstone: greenish gray, weathers gray, pooly to moderately indurated. 2 inch thick intrasparudite bed in middle part. Maximum pebble size 125 millimeters. Mudstone contains humus and carbonized plant fragments. 0.7 ft.

Disbiolithite: brownish gray, weathers gray. Muddy, moderately hard, upper surface irregular and has pebbles cemented to it. Breaks into irregular platy fragments. Algal structure pooly defined. 0.5 ft.

Mudstone: grayish green, weathers gray. Soft, pooly indurated. Poorly developed bedding of colors. Breaks into platy fragments when dry. 0.8 ft.

Dismicrite: gray weathers dark gray. Moderately hard, slightly platy. Middle part contains two inch thick dark gray mudstone parting. Blade-like brown plant? fragments. 1.2 ft.

Total thickness of Elmont present---------- 3.8 ft.

MEASURED SECTION 25: NW 1/4, NE 1/4, Sec. 16, T. 6 S., R. 12 E. (Bar ditch on south side of road; poor outcrop)

Elmont limestone member

Biosparite: brown, weathers grayish to yellowish brown. Dense, hard. Top irregular and contains solution channels. Upper part removed by Pleistocene and Recent erosion. Fusulinids, Osagia, Marginifera? crinoid columnals. 0.6 ft.

Conglomeratic mudstone: greenish gray, weathers gray. Fissile toward top. Limestone gravel at base. Brachiopod fragments with gravel. 1.5 ft.

Dismicrite: gray, weathers light gray, limonite stained. Three beds separated by dark gray mudstone partings. Upper most bed is of irregular thickness and contains calcite vugs. Lower bed dense and hard, breaks 1.6 ft.

into rectangular blocks.

Total thickness of Elmont present---------- 3.1 ft.

MEASURED SECTION 26: SW 1/4, SW 1/4, Sec. 16, T. 6 S., R. 12 E. (Cut on east side of road at base of hill)

Elmont limestone member

Biosparite: brownish gray, weathers yellowish gray. Upper surface removed by Recent erosion. Fragmented to incomplete singular bed. Fusulinids, fenestrate bryozoans, and crinoids abundant. Osagia common. 0.0–0.5 ft.

Mudstone: varies from yellowish gray at base through gray to dull yellowish orange at top. Slightly calcareous, fissile to massive, moderately well indurated. Unfossiliferous. 1.7 ft.

Dismicrite: dark gray at base to gray at top. Varies from calcareous platy mudstone upward to muddy dismicrite. Annularia, Neuropteris, stems and other fragments are abundant in lower part of bed. Fronds are well preserved. (Unit overlies black fissile Harveyville shale that has a high organic content). 3.3 ft.

Total thickness of Elmont present---------- 4.5 ft.

DEPOSITIONAL HISTORY OF THE ELMONT LIMESTONE

by

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AN ABSTRACT OF THE THESIS

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ABSTRACT

The purpose was to describe lithologic and biolithologic zones of the Upper Pennsylvanian Elmont limestone and evaluate the descriptions in terms of depositional history. Elmont outcrops associated with the Nemaha anticline in Pottawatomie, Riley, and Wabaunsee Counties, Kansas were investigated. The outcrops are not continuous along the anticline, but are restricted to the Onaga and St. George vicinities.

Sections of Elmont limestone were measured at outcrops chosen with respect to relative distribution and accessibility. Samples of each lithology were collected and examined in the laboratory. Optical, chemical, and x-ray analytical techniques were applied. The zones, established on basis of composition, texture, fossil content, and sedimentary structure, are from oldest to youngest: 1) the Muddy Dismicrite-Mudstone zone; 2) the Anchicodium Biolithite zone; 3) the Conglomeratic zone; and 4) the Triticites-Osagia Biosparite zone. The two oldest zones do not occur in the St. George vicinity.

The Muddy Dismicrite-Mudstone zone was deposited in mudflat and lagoon environments by a muddy, reducing, transgressing sea. Gradual clearing of the sea encouraged growth of Anchicodium algae banks over the mudflat deposits. Abrupt marine regression exposed the algae beds to erosion and the Conglomeratic zone of the Onaga vicinity was formed from their debris. The Conglomeratic zone is the basal unit of the Elmont in the St. George vicinity. The dolomite pebbles it contains were derived from a magnesium rich brine pan that lay to the north. The brine pan was a remnant part of the regressing sea and was destroyed during the second phase of transgression. The Triticites-Osagia Biosparite accumulated near wave base during the deepest, most stable phase of inundation.