# SEDIMENTARY GEOLOGY OF THE LATE CAMBRIAN HONEY CREEK AND FORT SILL FORMATIONS AS EXPOSED IN THE SLICK HILLS OF SOUTHWESTERN OKLAHOMA

By

MARY BETH RAFALOWSKI

Bachelor of Science

Ohio State University

Columbus, Ohio

1982

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
Master of Science
December, 1984

SEDIMENTARY GEOLOGY OF THE LATE CAMBRIAN

HONEY CREEK AND FORT SILL FORMATIONS

AS EXPOSED IN THE SLICK HILLS

OF SOUTHWESTERN OKLAHOMA

Thesis Approved:

R. Nowell Donovan

Thesis Adviser

A. Hounslow

John R. Groves

Norman N. Durham

Dean of the Graduate College

# PREFACE

The purpose of this thesis is to describe the sedimentary geology of the Late Cambrian Honey creek and Fort Sill Formations as exposed in the Slick Hills of southwestern Oklahoma. Specifically, this study presents an interpretation of the environments of deposition and the diagenetic histories of these Formations.

I would like to extend my gratitude to my thesis advisor and friend, Dr. R. Nowell Donovan, for his guidance, support and advice. I would also like to give special thanks to my committee members, Dr. John Groves and Dr. Arthur Hounslow for their assistance and advice.

Thanks are extended to the Oklahoma Geological Survey for financial support. Thanks are also due to the many land owners of the Slick Hills.

I am indebted to my fellow graduate students and friends, Kath McBride, Freddie Manni, Jenny Richardson, and Kelly Race, for their unending encouragement and ceaseless palaver. Special thanks to Brian Brurud for instilling inspiration.

Most especially, I would like to express my deepest gratitude to my parents, Paul and Ann Rafalowski, who have given me their love and support throughout all of my endeavors.

TABLE OF CONTENTS

Chapter Page

Chapter Page

LIST OF FIGURES

| Figure | | Page |
|---|---|---|

LIST OF PLATES

# CHAPTER I

# INTRODUCTION

## Purpose

The purpose of this study is to describe the sedimentary geology of the Honey Creek and Fort Sill Formations as they are exposed in the Slick Hills of southwestern Oklahoma. Particular attention is given to determining both the environments of deposition of these formations and their diagenetic histories.

The Late Cambrian Honey Creek and Fort Sill Formations, outcrop both in the Arbuckle Mountains of south central Oklahoma and in the Slick Hills (to the north of the Wichita Mountains) of southwestern Oklahoma. Stratigraphic sections of the Honey Creek and Fort Sill Formations have been measured and described in both areas (Merritt, 1928; Decker, 1939; Chase, Frederickson and Ham, 1956), but no detailed sedimentological study has yet been published for the Wichita Mountains area.

## Location of Study

Locations of the five sections that were measured in the Slick Hills are:

1. Blue Creek Canyon - A

   Comanche County, section 1, T. 4 N., R. 13 W.

2. Blue Creek Canyon - B

   Comanche County, section 12, T. 4 N., R. 13 W.

3. Bally Mountain

   Kiowa County, section 26, T. 6 N., R. 14 W.

4. Zodletone Mountain

   Kiowa County, section 16, T. 6 N., R. 14 W.

5. Stumbling Bear Pass

   Comanche County, section 24, T. 4 N., R. 13 W.

(Figure 1, and Appendix A, Plate I and II).

Surface exposure of the Honey Creek and Fort Sill Formations are up to 90% complete. However detailed field examination of the two Formations is made difficult by the precipitation of a thin caliche crust.

## Methods of Investigation

The five detailed sections that were measured comprise three complete sections of both Honey Creek and Fort Sill Formations (Blue Creek Canyon A, Bally Mountain, Zodletone Mountain), one complete section of the Honey Creek Formation (Blue Creek Canyon B), and one incomplete section of the Fort Still Formation (Stumbling Bear Pass).

Initially, a Jacob's staff and Brunton compass were used to measure total vertical thicknesses of all sections; subsequently, ten foot intervals were marked with red spray paint and then logged in detail using a tape measure. Samples were selected for further study where apparently significant lithologic changes occurred.

Laboratory work included slabbing and etching hand samples and preparing thin sections. One hundred twenty-three thin sections were selected for petrographic study. Detailed descriptions of hand samples and

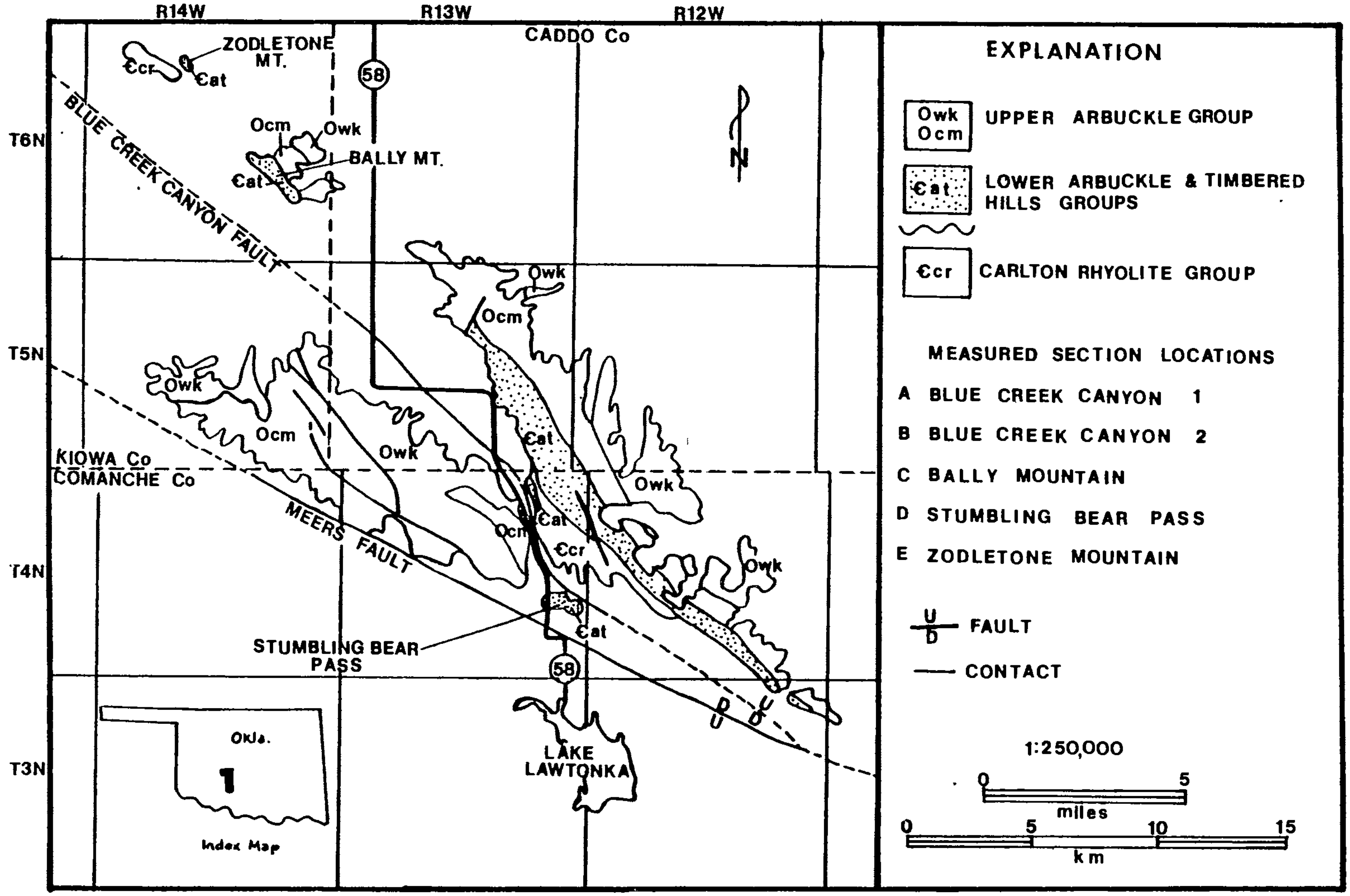



Figure 1. Index Map Showing Locations of Measured Sections (Modified from Havens, 1977)

thin sections were augmented by staining both with potassium ferrocyanide and alizarin red-S in order to distinguish dolomite, calcite and ferroan varieties of each.

# CHAPTER II

## STRATIGRAPHY-AGE CORRELATION

The Honey Creek Formation, uppermost unit of the Timbered Hills Group, is assigned to the Franconian Stage, Croixan Series and consequently is early Late Cambrian in age. It conformably overlies the Reagan Sandstone (lowermost unit of the Timbered Hills Group) and locally unconformably overlies the mid-Cambrian Carlton Rhyolite Formation.

The Fort Sill Formation, lowermost unit of the Arbuckle Group, is assigned to the upper Franconian and lower Trempaleauan Stages, Croixian Series and consequently is mid-Upper Cambrian in age. It conformably overlies the Honey Creek Formation and locally unconformably overlies the Carlton Rhyolite. In some areas the Royer Dolomite is recognized as a distinct unit within the formation. The Fort Sill Formation is overlain by the Signal Mountain Formation, also of the Arbuckle Group (Figure 2).

Contacts between the above mentioned sedimentary formations are lithologically gradational (Figure 3).

The remaining formations exposed in the Slick Hills are included in the Arbuckle Group. These are the Upper Cambrian-Lower Ordovician Signal Mountain, Lower Ordovician McKenzie Hill, Cool Creek, Kinblade and West Spring Creek Formations. In the Wichita Mountains, the Arbuckle Group comprises more than 5,000 feet of limestone and dolomite (Figure 4).

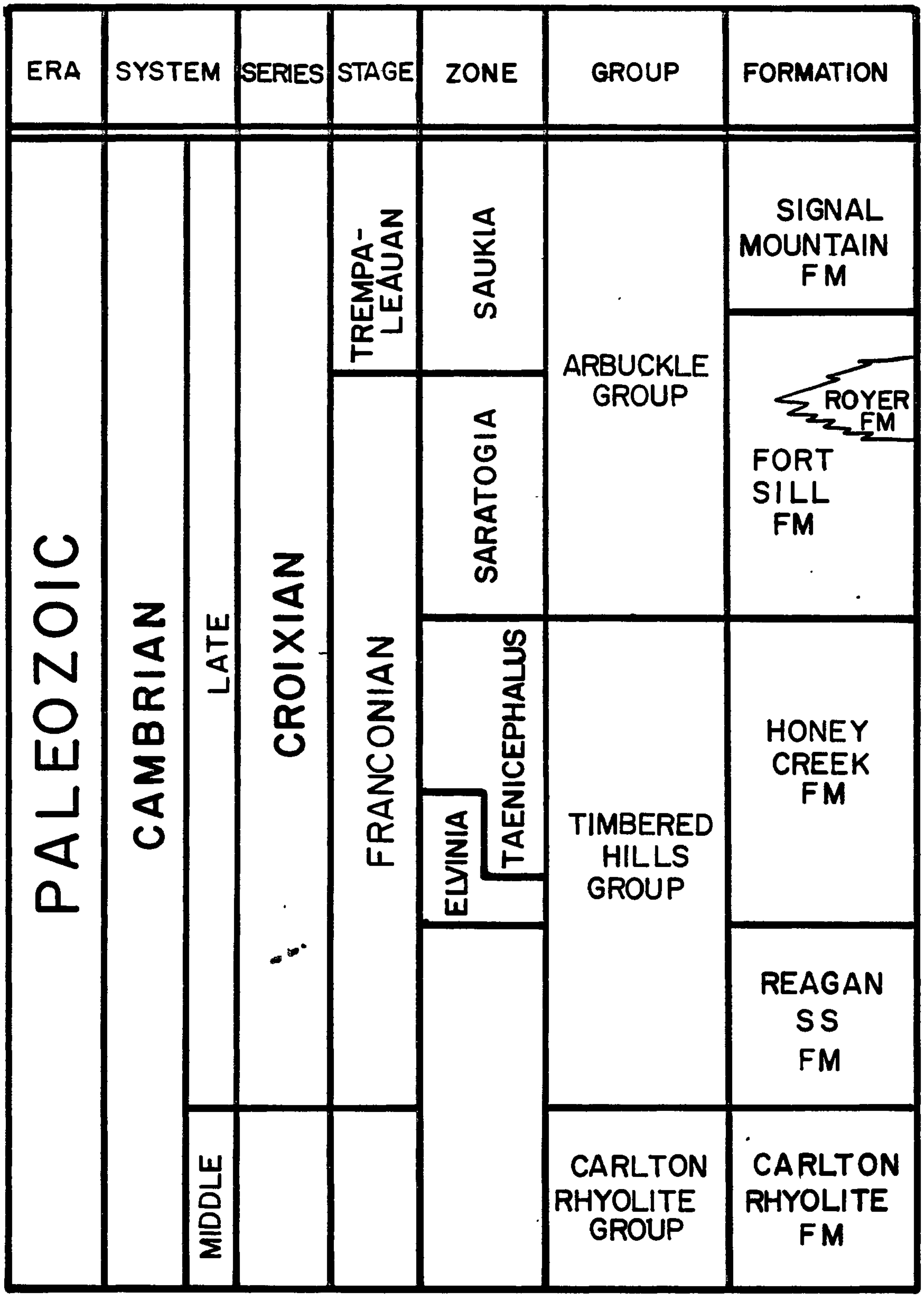



Figure 2. Generalized Stratigraphic Column of the Upper Carlton Rhyolite, Timbered Hills and Lower Arbuckle Groups

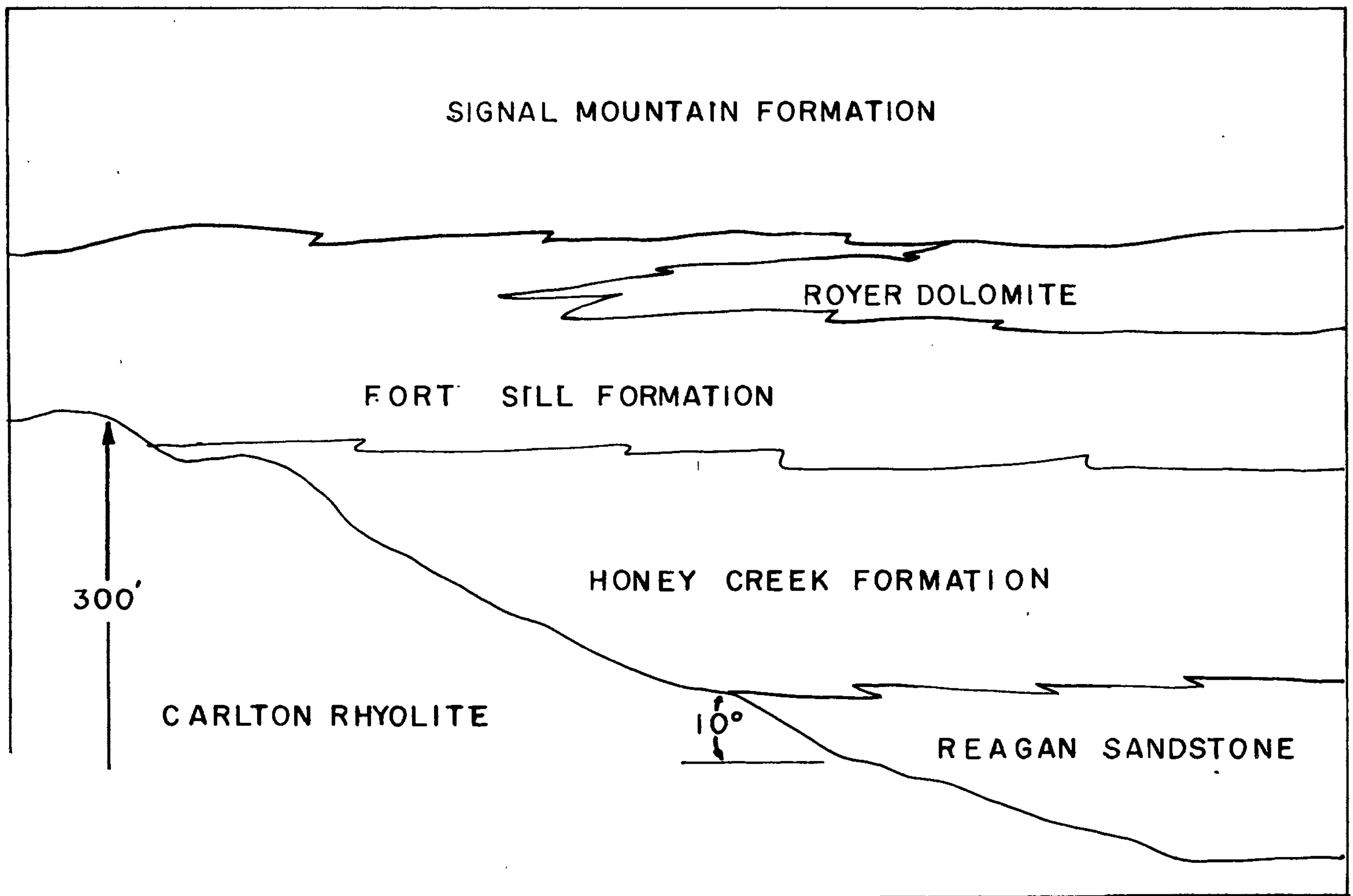



Figure 3. Schematic Diagram Illustrating Stratigraphic Relationships of the Formation Studied

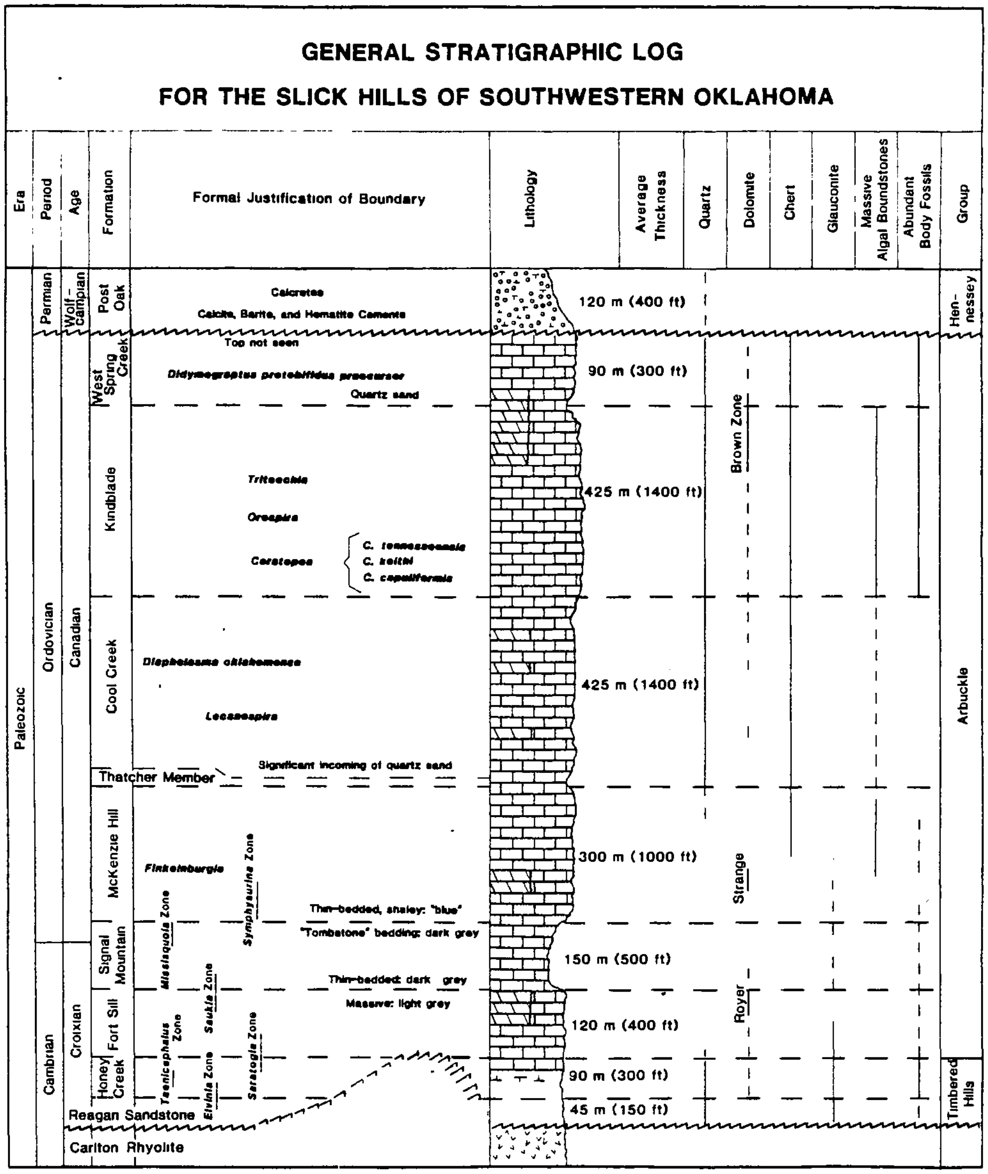



Figure 4. General Stratigraphic Log for the Slick Hills of Southwestern Oklahoma (after Ragland and Donovan, 1984)

## Biostratigraphy

Howell (1944) placed the Honey Creek Formation in the lower Franconian Stage of the mid-Upper Cambrian Series Croixian Series based on the presence of particular trilobite fauna. He recognized the following zones: Elvinia, Ptychopleurites, and lower Conapis (Eoorthis and Taenicephalus Subzone) (Figure 5).

The Honey Creek Formation correlates biostratigraphically with the Davis Limestone of Missouri, the Welge Sandstone, Morgan Creek Limestone and lower Point Rock Shale Members of the Wilberns Formation of Texas, the Goodenough and Ironton Members of the Franconia Formation of Wisconsin and Minnesota, the Deadwood Formation of South Dakota, and the Copper Ridge Dolomite of northeastern Alabama, northwest Georgia and southeast Tennessee.

The Fort Sill Formation is placed in the mid-to-upper Franconian and lower Trempaleauan Stages of the Upper Cambrian Series. Trilobites of this age are of the faunal zones: Prosaukia-Ptychaspis, Briscola, Dikeocephalus-Postrectus (of the Franconian Stage), and Platycolpus-Sroevogyra of the Trempeauleauian Stage (Figure 5).

Biostratigraphically, the Fort Sill correlates with the Derby, Doe Run and lower Potosi Dolomites of Missouri, the upper Point Rock Shale, San Saba Limestone and Pedernales Dolomite Members of the Wilberns Formation of Texas, the Hudson, Bad Axe and Lower St. Lawrence Members of the Franconian Formations of Wisconsin and Minnesota, the Deadwood Formation of South Dakota and the Copper Ridge Dolomite of northeast Alabama, northwest Georgia, and southeast Tennessee.

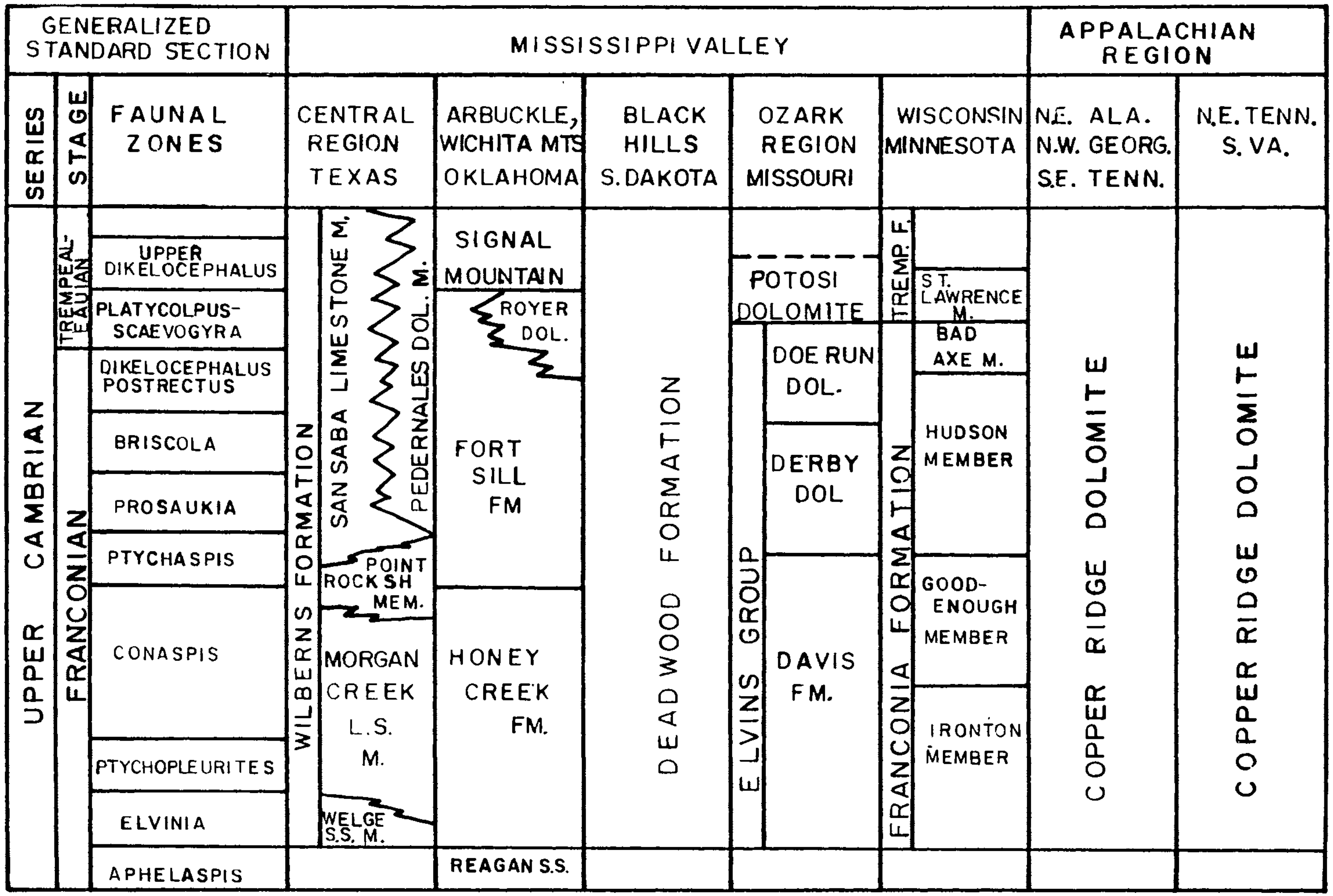



Figure 5. Regional Correlation Chart Showing the Stratigraphic Relationships of the Honey Creek and Fort Sill Formations (Modified after Howell, 1944)

The laterally impersistant Royer Dolomite of the Slick Hills is correlated with the above-mentioned zones of the Upper Fort Sill (Figure 5.

## Paleolatitude

Habicht (1979) suggested that because of the widespread presence of dolomite, limestone, archeocyathid reefs, evaporites and red beds which are found in the early Paleozoic Formations of the Northern Continents, very warm and arid climatic conditions existed on the area of the American craton under consideration. Habicht further supported his suggestion with paleomagnetic data which implies that the northern continents of today were located in the low latitudes in Cambrian time. According to Habicht's suppositions, during the Cambrian, southern Oklahoma lay about 28° south of the equator (Figure 6).

## Regional Tectonics and Structural Evolution

The dominant structural features of southern Oklahoma are a series of northwest-southeast trending en echelon linear basins, troughs and faults extending from the Texas panhandle into south-central Oklahoma (Figure 7). Evolution of these entities occupied most of the Paleozoic time. To the south of the Anadarko Basin rises the Wichita-Criner Uplift. This uplift features the Wichita Mountains to the southwest and the Criner Hills to the southeast. The structural relief along the Wichita front exceeds 40,000 feet (Ham and Wilson, 1967, Gilbert and Donovan, 1982). To the east, is the Wichita-Criner Uplift, it is flanked by the Ardmore Basin to its north and the Marietta Basin to its south. To the south-west of the Wichita Mountain Uplift lies the Hollis Basin. To the south of the Marietta Basin is the Waurika-Meunster Arch

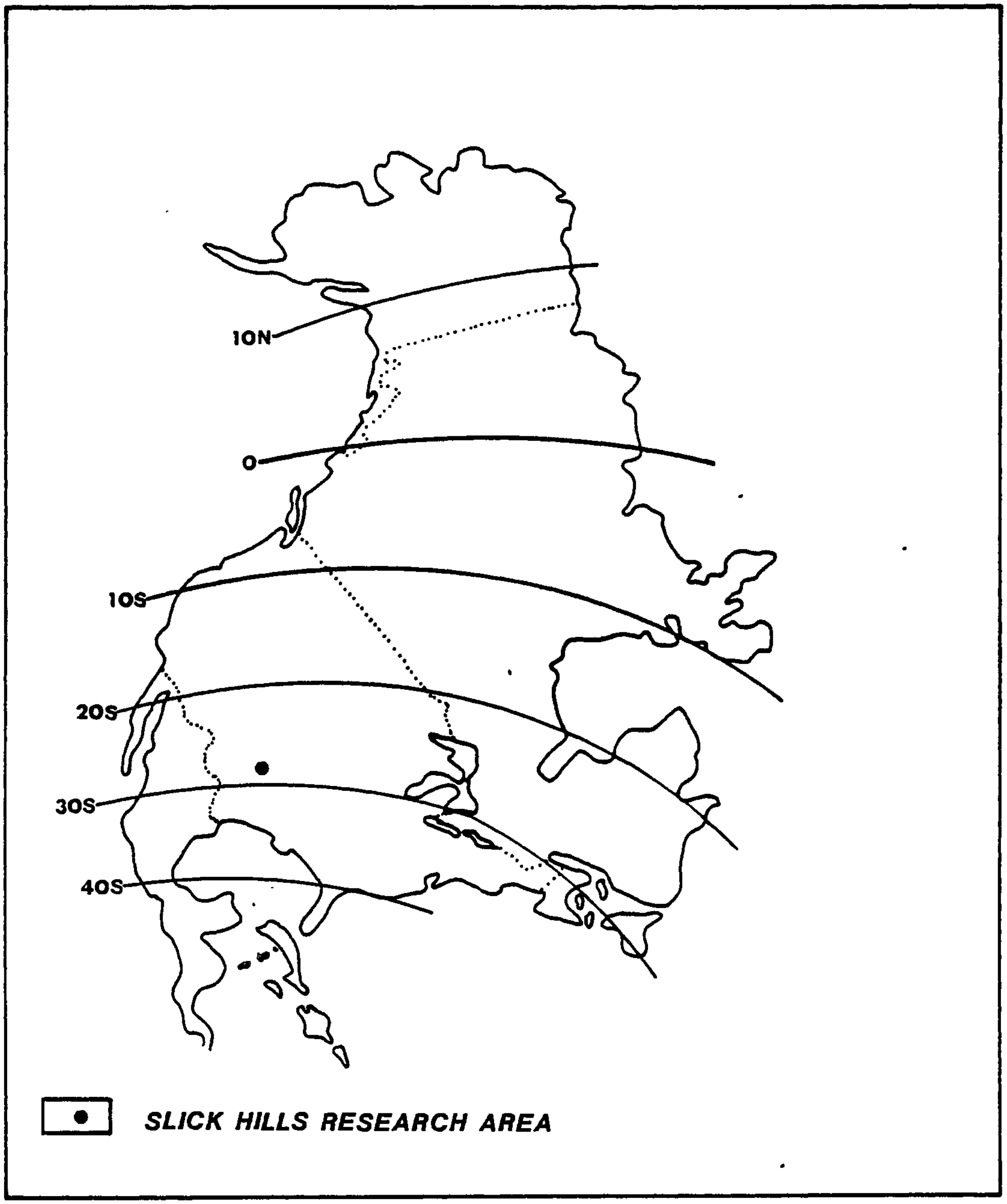



Figure 6. Paleoposition of North America During the Late Cambrian (Modified after Habicht, 1979)

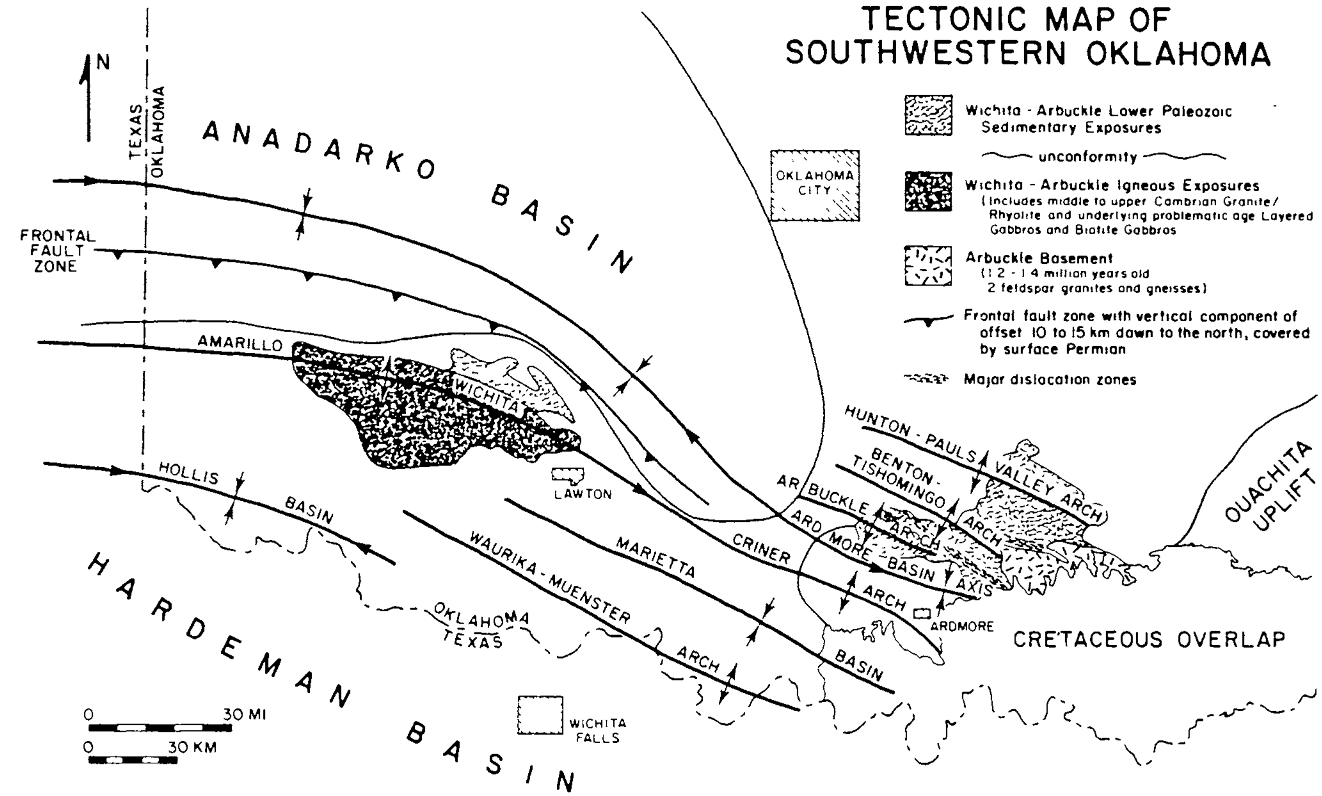



Figure 7. Tectonic Map of Southwestern Oklahoma (from Gilbert and Donovan, 1982)

and to the north of the Ardmore Basin is the Arbuckle Uplift (Ham, 1967; Donovan, 1984).

Structural development began in Precambrian times when the stable craton was cut by a series of northwest-southeast trending dikes. In Early Cambrian times tensional rifting, active along this trend, led to the development of the Southern Oklahoma Aulacogen as the failed rift arm of a triple junction. Early stages of development involved both basic and silicic Early and Mid-Cambrian intrusives and extrusives. Some rift valley sediments may have formed at this time (Gilbert and Donovan, 1982). Subsequently rapid subsidence in the failed rift area trapped a considerable thickness of dominantly carbonate sediments (the Arbuckle Group and Timbered Hills Group) as a marine transgression affected the mid-American craton (Figure 8). A total of at least 6,000 feet of sediment was deposited in the aulacogen area at this time. Subsequently, a hiatus persisted throughout Silurian, Devonian and Early Mississippian time. However, in Late Mississippian, Pennsylvanian and Early Permian time, the early structural weaknesses were rejuvenated by the oblique collision of the Iapetus Ocean (Gilbert and Donavon, 1982). The principal results were the synchronous uplifts and basins which are presently exposed in southern Oklahoma (as described previously). Bounding faults to the basins show evidence of left lateral compressive movement. Two principal periods of deformation have been recognized by Ham and Wilson (1967); the Wichita or Early Pennsylvanian "Orogeny" and the Arbuckle or Late Pennsylvanian "Orogeny". These two orogenies record intense folding, plus transcurrent and thrust faulting.

The field area studied herein is located in the frontal Wichita fault zone between the Wichita Mountains and the Anadarko Basin (Figure

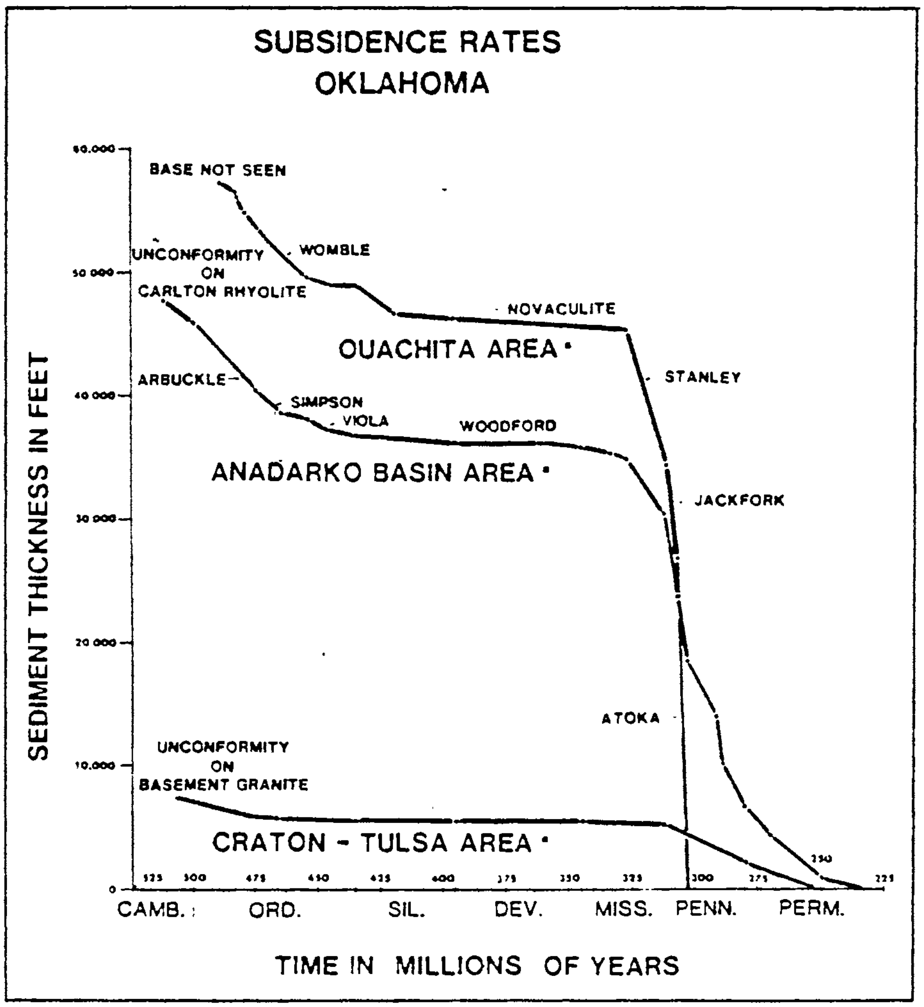



Figure 8. Sediment Thickness and Subsidence Rates as a Function of Geologic Time During the Paleozoic (after Donovan et al., 1982)

9). Considerable structural deformation has affected the outcrops. Furthermore, the present landscape has recently been exhumed from beneath a cover of Permian fanglomerates deposited at the culmination of the orogenies described above.

## History of Previous Research

The first expeditions and geological surveys of the Wichita Mountains were made by George G. Shumard (1852), T. B. Comstock and W. F. Cummins (1889), T. Wayland Vaughn (1899) and Foster H. Bain (1900). Shumard, who was with Captain R. B. Marcey's expedition to the North Fork of the Red River, made the first reconnaissance trip through the Wichita Mountains in 1852. He noted the igneous rocks of the mountains and the sedimentary rocks of the surrounding plains. In 1889, Comstock and Cummins, of the Texas Geological Survey, reported that the geology of the Wichita Mountains is related to that of central Texas. In 1899, Vaughn briefly described the petrography of the Wichita Mountains and the Arbuckle Hills. One year later, in 1900, Bain was the first to recognize and describe the general relationships of the igneous and sedimentary rocks in the Wichita Mountains. He divided the sedimentary rocks into the Cambrian Blue Creek Series and the Ordovician Rainy Mountain Limestone Formation. The Blue Creek Series included what is now known as the Reagan Sandstone and Honey Creek Limestone. The Rainy Mountain Limestone Formation included what is now known as the Arbuckle Group.

J. A. Taff, C. W. Gould, and E. O. Ulrich, in 1901, completed the first map and general report on the Wichita Mountains. Gould briefly described thicknesses, distributions, ages and stratigraphic

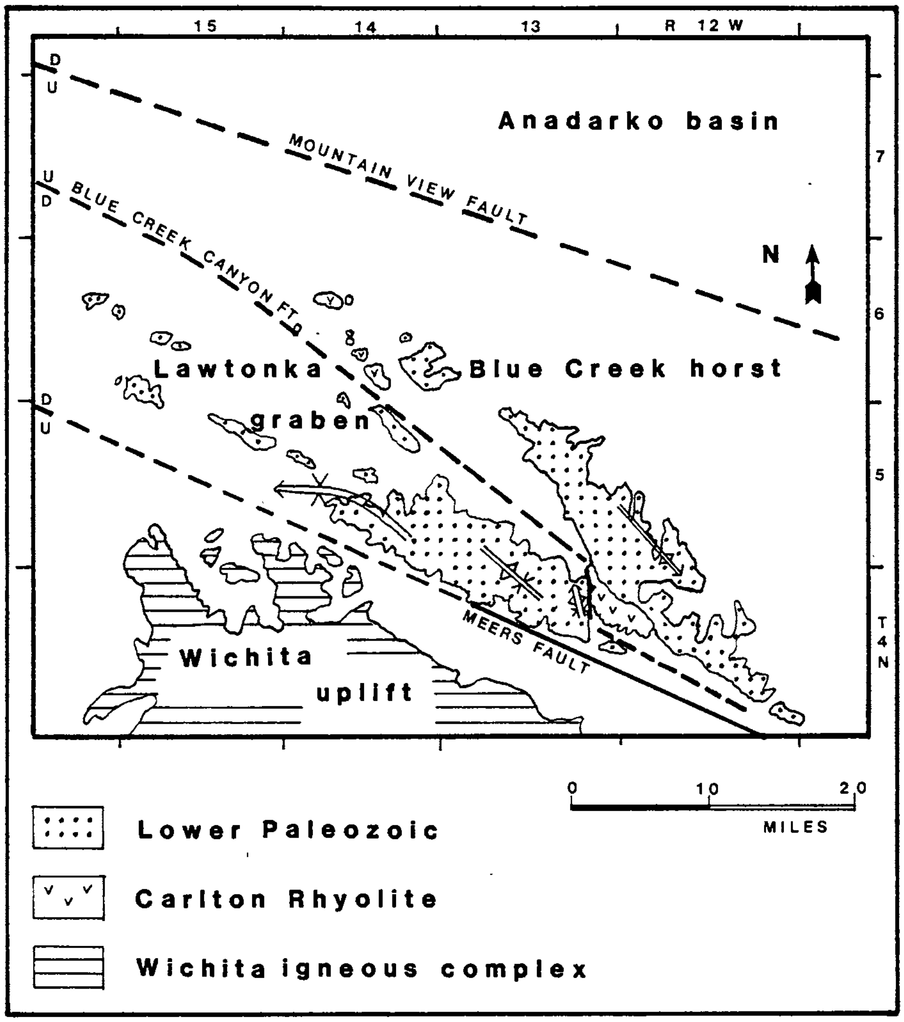



Figure 9. Location Map Showing the Principal Tectonic Elements in the Study Area (after Donovan, 1982)

correlations of the sedimentary rocks. Taff (1902) designated the Arbuckle Limestone at a type locality in the Arbuckle Mountains. In 1904, Taff mapped, differentiated and described formations and elucidated general structural relationships in the Arbuckle and Wichita Mountains; he correlated the Arbuckle Limestone in the Wichitas to the Arbuckle Limestone in the Arbuckles. He recognized the Reagan Sandstone as the earliest Cambrian formation in the Wichita Mountains.

In his "Revision of the Paleozoic System", Ulrich (1911) recognized the Reagan Sandstone as an Upper Cambrian formation. He separated and named it the Honey Creek Limestone Member. He subdivided the term Arbuckle Group to include, in ascending order, Fort Sill Limestone, Royer Marble, Signal Mountain Limestone, Chapman Ranch Dolomite, McKenzie Hill Limestone and Wolf Creek Dolomite. He drew the upper boundary of the Cambrian at the Honey Creek-Fort Sill contact where he thought an unconformity existed.

Howell (1922) characterized Paleozoic rocks of the Wichita Mountains by examining well cuttings. He distinguished the formations by their textures and noted that much of the limestone contained 2-10% magnesium. He also estimated that the Arbuckle Limestone Group is 6,000 feet thick.

Gould and Decker (1925) briefly discussed the Arbuckle Limestone and correlated it with the upper Collier Shale, Crystal Mountain Sandstone, and lower Mazarn Shale of southeastern Oklahoma. They suggested that the Arbuckle Limestone was equivalent to the Cap Mountain, Wilberns, and Ellenburger Formations of Texas.

Ulrich (1927) conjectured, from faunal studies, that the Reagan Sandstone and overlying sediments are the deposits of a sea that transgressed from the Pacific side of the continent.

Decker and Merritt (1928) measured a detailed section of the Arbuckle Limestone along U. S. Highway 77 in the Arbuckle Mountains. They noted composition and general physical and diagenetic characteristics.

Hoffman (1930), described the igneous rocks of the Wichita Mountains. This description helped later workers to differentiate igneous fragments found in the overlying basal sedimentary rocks.

Ulrich (1932) raised the Honey Creek Limestone Member of the Reagan Formation to the rank of formation. He divided the Honey Creek into zones by trilobites collected from the type section. Ulrich (1932) also recognized the Fort Sill Limestone as a unit occurring near the base of the Arbuckle Limestone, on the presence of abundant hexactinellid glass sponges. He recognized and described the contact between the Fort Sill and Signal Mountain Formations by a thin zone of reworked detrital material. Ulrich (1932) noted that in the Wichita Mountains, the Fort Sill is everywhere succeeded by the Signal Mountain Formation, whereas in the Arbuckles the two formations are separated by a massive unfossiliferous dolomite which represents the Royer Marble.

Decker (1933) described and formally designated type sections for the various formations in the Arbuckle and Wichita Mountains. He suggested that the Cap Mountain Sandstone of Texas was equivalent to the Honey Creek Limestone. Subsequently, Decker (1939) separated the lower Paleozoic formations of the Arbuckle and Wichita Mountains into the Timbered Hills and Arbuckle Groups. Decker placed the "basal limestone unit", Reagan Sandstone, Cap Mountain Sandstone and Honey Creek

Limestone in the Timbered Hills Group, which he assigned to the Upper Cambrian. He elevated the Arbuckle Limestone to the status of group and designated the Fort Sill Formation as the base of this group. Decker also noted that the Honey Creek is not everywhere underlain by the Reagan Sandstone, but in some places unconformably overlies the igneous rocks in the Wichita Mountains.

Farmillo (1943) recognized sponges in the Royer Dolomite that Ulrich (1932) had previously found in the Fort Sill Formation, establishing an age equivalence between the two units.

Frederickson (1948, 1949) described trilobites from the Honey Creek Formation in the Arbuckle and Wichita Mountains. He concluded from faunal evidence that the Cap Mountain Formation and "basal limestone" recognized by Decker are equivalent to all or portions of the Honey Creek Formation. He found no evidence of an unconformity between the Fort Sill and Honey Creek Formations as had been previously proposed by Ulrich (1911).

Chase, Frederickson and Ham (1956) in a "Resume of the Geology of the Wichita Mountains" gave detailed descriptions of measured sections. They delineated formation boundaries using Upper Cambrian and Lower Ordovician faunal and lithostratigraphic markers.

Nelms (1958) informally divided the Fort Sill Formation into three lithologic units. He placed the Royer Dolomite in the Upper Fort Sill Unit. In the same year, Fox (1958) attempted to determine the relationship between sandstone and limestone in the Honey Creek Formation. Harlton (1964) subdivided the Ordovician part of the Arbuckle Group based on the results from insoluble residue studies. He described the

Honey Creek, Fort Sill and Royer Dolomite from a section measured on Raggedy Mountain in the Wichita Mountains.

Stitt (1971) recognized trilobites of Late Cambrian and Early Ordovician age in the Timbered Hills and Lower Arbuckle Groups in the western Arbuckle Mountains. Subsequently (1977) he described trilobites collected from the Wichita Mountain area and assigned them to zones of the Franconian Stage of the Upper Cambrian. He also briefly described the lithologies of the Reagan Sandstone, Honey Creek Limestone, Fort Sill Formation, and Royer Dolomite. His lithostratigraphic and biostratigraphic correlations indicated that taxa from the upper half of the Reagan Sandstone of the Wichita Mountains occur in the lower one third of the Honey Creek Limestone in the Arbuckles. On this evidence he suggested an east to west marine transgression. In a later paper Stitt (1978) described the biostratigraphy and depositional history of the Timbered Hills Group and lower Arbuckle Groups of the Arbuckle Mountains.

Donovan (1982) discussed and described sediments in the Blue Creek Canyon area of the Wichita Mountains, with particular attention to the basal unconformity of the Timbered Hills Group.

# CHAPTER III

## DESCRIPTIVE GEOLOGY OF THE UNCONFORMITY BETWEEN THE HONEY CREEK AND FORT SILL FORMATIONS AND THE CARLTON RHYOLITE

Regionally, the Honey Creek Formation conformably overlies the Reagan Sandstone and is conformably overlain by the Fort Sill Formation. However, in several localities, the Reagan Sandstone is absent and the Honey Creek (in one instance, the Fort Sill Formation) rests unconformably on the irregularly-eroded Middle Cambrian [(525 $\pm$ 25 m.y.)(Gilbert, 1982)] Carlton Rhyolite. More than a 15 m.y. hiatus is represented by this unconformity; the overlying sediments record a major Franconian marine transgression. Recent exhumation of the rock sequence has revealed onlapping of Late Cambrian sediments onto gently sloping Middle Cambrian rhyolite hills up to 300 feet high (Donovan, 1984).

Five localities in the Slick Hills display excellent exposure of this unconformity. The Honey Creek-Carlton Rhyolite unconformity exposures are located in the Blue Creek Canyon area and at Bally Mountain. For the purposes of this thesis, the specific localities are referred to as; Blue Creek Canyon A, Blue Creek Canyon B, Ring Top Mountain, and Bally Mountain. The Fort Sill Formation-Carlton Rhyolite unconformity exposure is located at Stumbling Bear Pass (Figure 10).

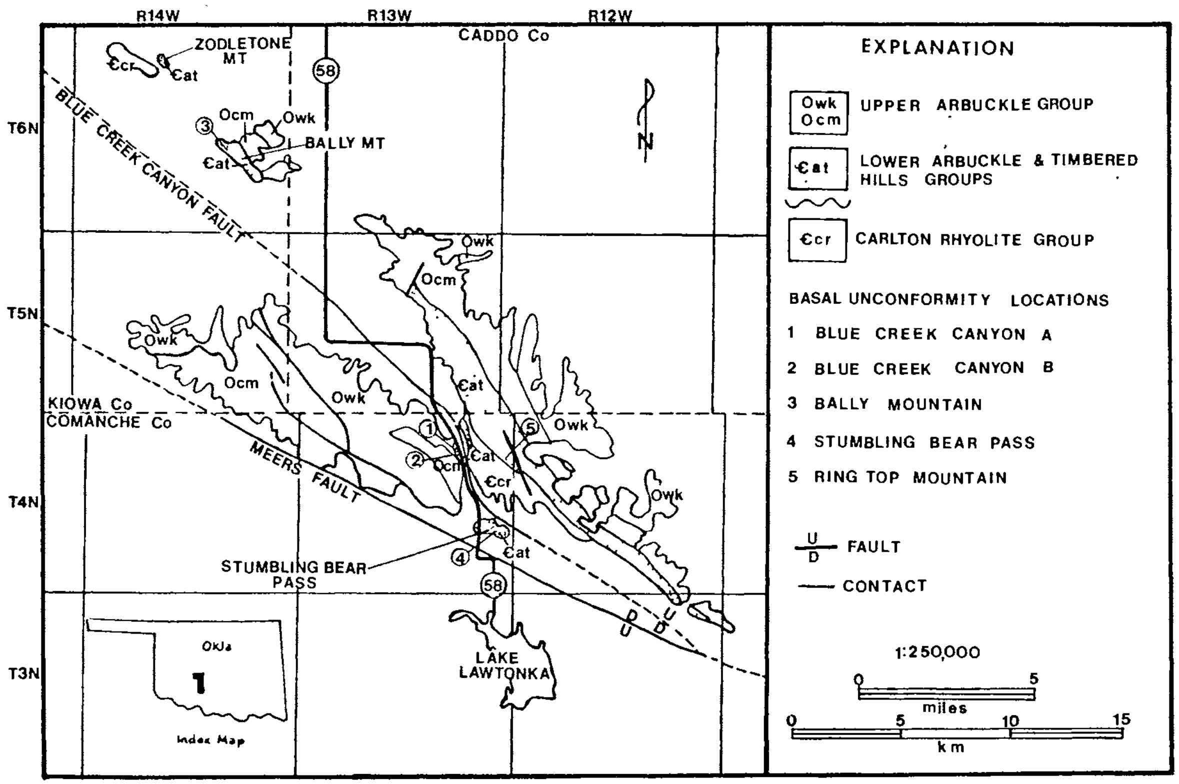



Figure 10. Map Showing Locations of Unconformities Between the Honey Creek and Fort Sill Formations and the Carlton Rhyolite

## Blue Creek Canyon A

This exposure is located on the west side of highway 58, section 11, T.4N., R.13W., Comanche County (Figure 10). The Honey Creek Formation lies unconformably on a relatively smooth surface of Carlton Rhyolite. The exposure is continuous for 60 feet. The top of the Honey Creek is approximately 40 feet above the unconformity. Six facies are developed in the Honey Creek above this unconformity. These facies are labeled as follows (Figure 11):

Facies A - basal breccia

Facies $B_1$ - washed mechanical bafflestone

Facies $B_2$ - filled mechanical bafflestone

Facies $B_3$ - horizontally packed brachiopod packstone

Facies C - mudstone

Facies D - grainstone.

The following is a petrographic description of each facies.

### Facies A

The basal breccia consists primarily (50%) of well sorted angular to subangular clasts of Carlton Rhyolite up to 3.75 mm in diameter. The rhyolite clasts display snowflake texture due to devitrification. Many clasts are partially replaced by calcium carbonate. The carbonate fraction consists of 20% spar and 28% micrite. The sparite is apparently a cement as it displays drusy texture. However, this cement does not exhibit plane compromise boundaries, presumably as the result of pressure solution. Some iron oxide is associated with this cement (Figure 12).

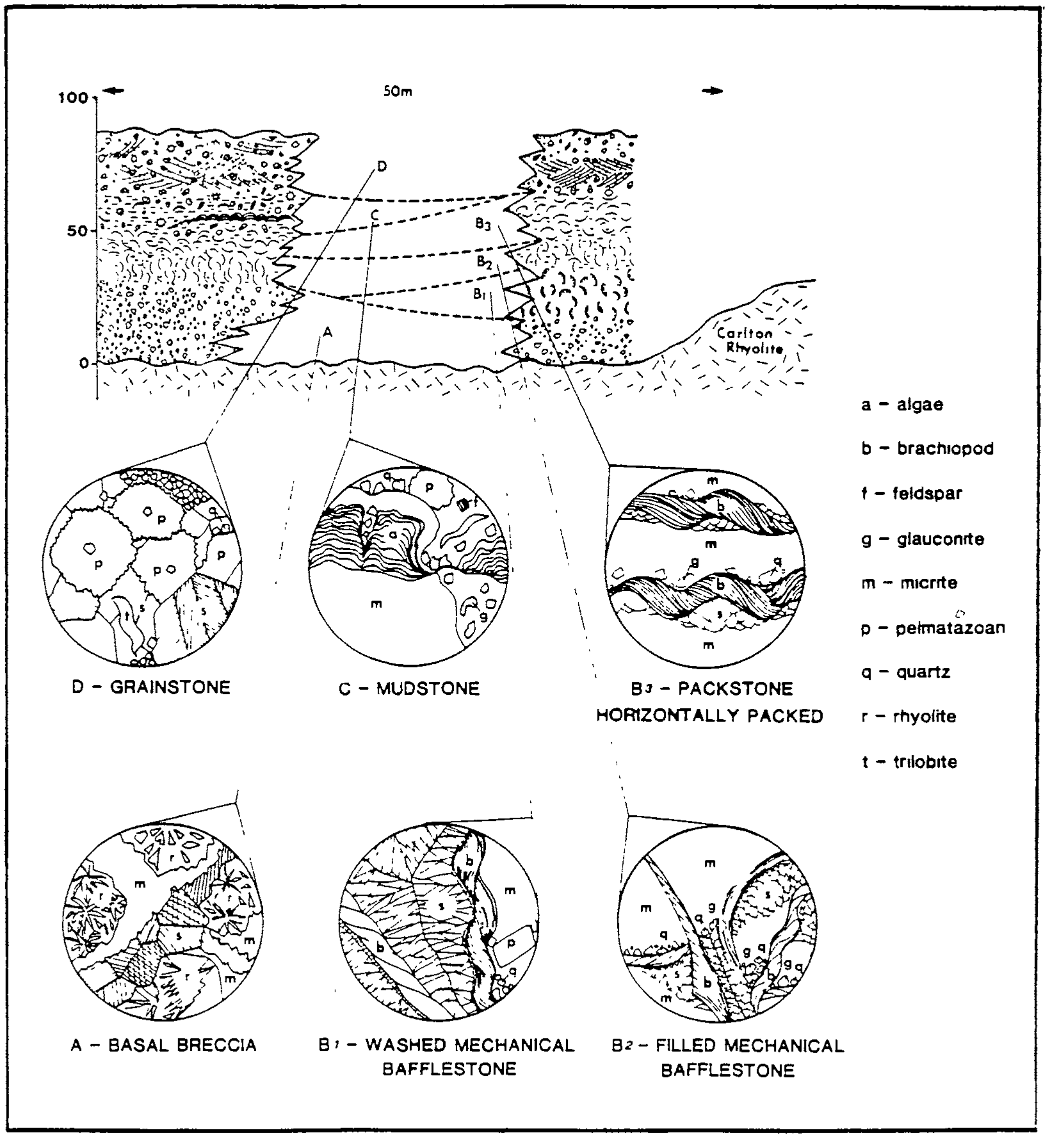



Figure 11. Facies Developed at the Unconformity Between the Honey Creek and Carlton Rhyolite Formations, Blue Creek Canyon A

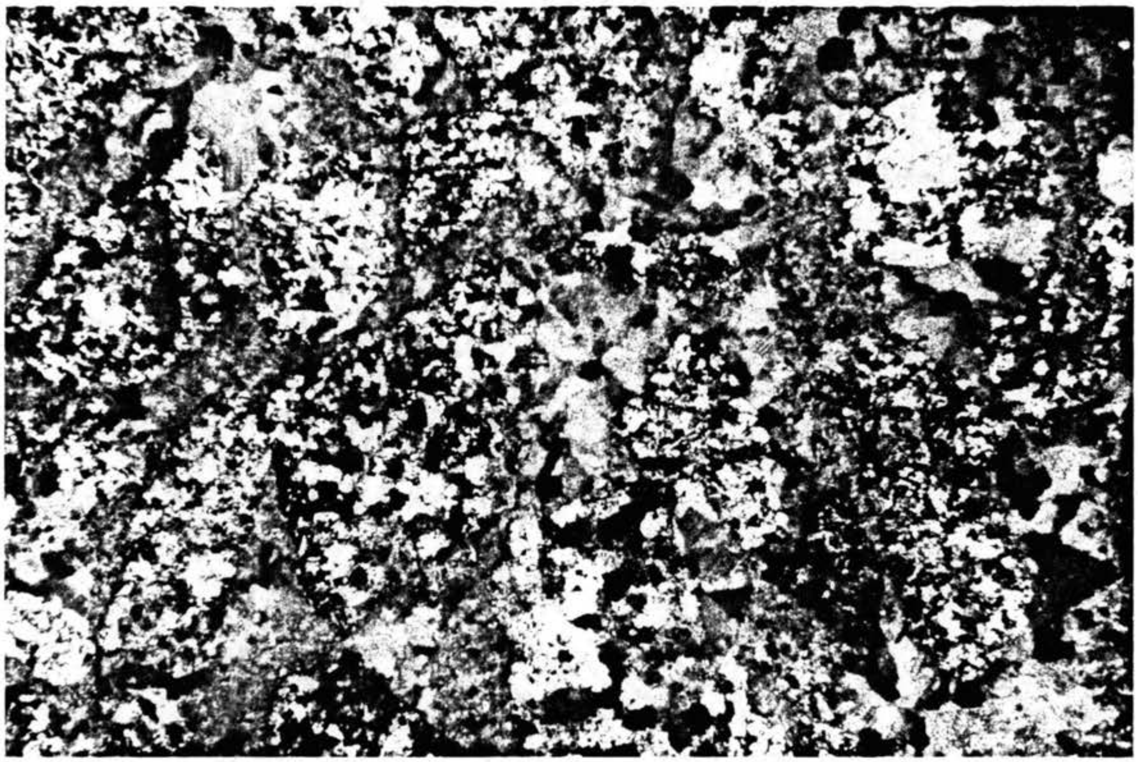


Figure 12. Facies A, Blue Creek Canyon A: Basal Breccia. Clasts of Carlton Rhyolite in Sparite Cement. Note Snowflake Textures in the Clasts Which Show Signs of Considerable Corrosion by Calcite (x 80)

Facies A represents the initial inundation of the Carlton Rhyolite land surface by transgressing seas. The well sorted and yet angular character of the clasts is suggestive of both moderate wave action and perhaps rapid cementation.

Facies $B_1$

The washed vertically packed mechanical bafflestone consists of:

(i) c.25% vertically or subvertically oriented disarticulated orthid brachiopod shell valves

(ii) c.3% subangular very fine sand size quartz grains

(iii) c.20% micrite

(iv) c.52% calcium carbonate cement, mostly of the radiaxial variety (Kendall and Tucker, 1973), but also including some anhedral equant spar. The radiaxial cement fills voids between brachiopod valves. Some of the spar has crenulated boundaries which are suggestive of pressure solution (Figure 13).

Facies $B_1$ is interpreted as a shell bank which was washed by waves with sufficient energy to have removed most, but not all, of the mud infilling between brachiopod valves.

Facies $B_2$

The filled, vertically packed, mechanical bafflestone consists of:

(i) c.30% vertically or subvertically oriented orthid brachiopod shells

(ii) c.7% angular very fine sand size quartz grains

(iii) c.3% fine sand size glauconite grains

(iv) c.50% micrite

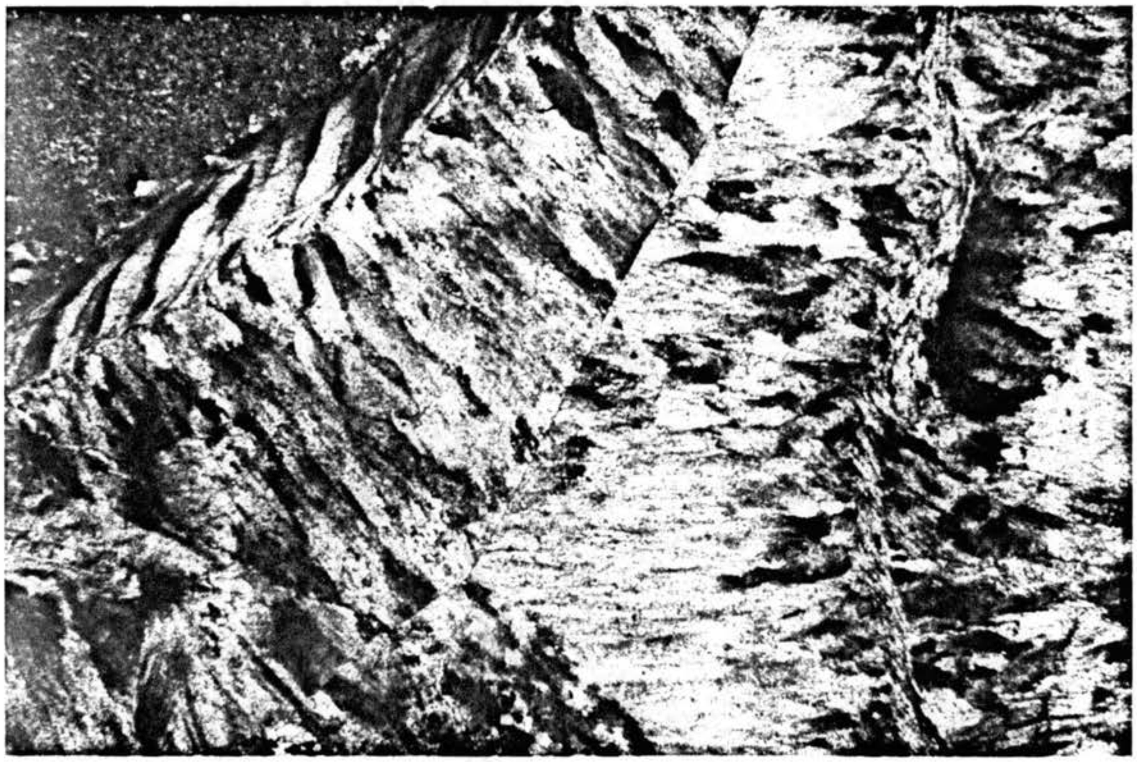


Figure 13. Facies $B_1$, Blue Creek Canyon A: Washed Vertically Packed Mechanical Bafflestone. Radiaxial Fibrous Cement has Grown Normal to and in Optical Continuity with Shell Wall. Orthid Brachiopod Shell has Acted as a Barrier Which has Prevented Mud Infiltration (x 80)

(v) 10% equant spar (Figure 14).

Facies $B_2$ is similar to facies $B_1$ except for the increase in lime mud (micrite). This suggests that the shell bank was less well washed either as a result of deepening water (transgression) and/or a decrease in wave energy.

Facies $B_3$

The horizontally packed brachiopod packstone contains:

(i) c.32% horizontally oriented orthid brachiopod shells

(ii) c.10% angular very fine sand size quartz grains

(iii) c.5% fine sand size glauconite grains

(iv) c.46% micrite

(v) c.7% anhedral equant spar (Figure 15).

Facies $B_3$ is similar to facies $B_1$ and $B_2$ except for the orientation of the brachiopod shell valves. It, perhaps, represents the zone below the influence of breaking waves.

Collectively, facies $B_1$, $B_2$, $B_3$ are interpreted as the record of a brachiopod shell bank. This shell bank consisted of the shells and valves of orthid brachiopods which are not found in growth position, but were deposited by current and wave action. The distinctive vertical packing fabric is analagous to that described in modern shell beach deposits by Sanderson and Donovan (1974). These authors described the vertical packing of scallop shells on a rocky substrate within the intertidal zone. A stable packing arrangement was observed to form when waves of moderate energy (but not storm waves) caused valves to become wedged around boulders and in fissures of underlying rock. Such arrangements in facies $B_1$ and $B_2$ are termed "mechanical bafflestone" because they

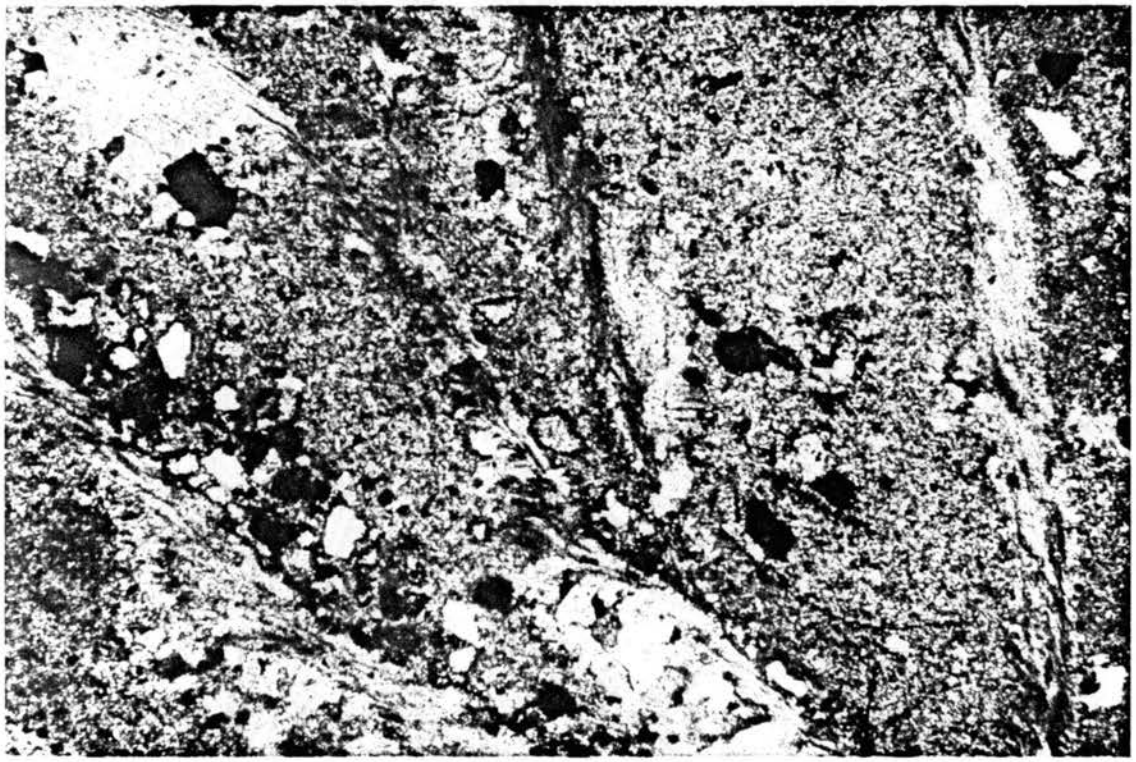


Figure 14. Facies $B_2$, Blue Creek Canyon A: Filled Vertically Packed Mechanical Bafflestone. Orthid Shells Acting as Sediment Baffles, Trapping Lime Mud and Quartz and Glauconite Silt. Shelter Porosity Infilled with Anhedral Spar (x 80)

Figure 15. Facies $B_3$, Blue Creek Canyon A: Horizontally Packed Brachiopod Packstone. Horizontally Oriented Brachiopod has Acted Both as a Sediment Trap and as a Creator of Shelter Porosity; Porosity is Infilled by Drusy Spar (x 80)

are of clastic origin (not biological origin, as is usually the case in bafflestones) and have acted as sediment traps.

Facies C

The mudstone facies consists of:

(i) c.15% subrounded-subangular fine sand size quartz grains

(ii) c.10% fine sand size feldspar grains

(iii) c.2% fine sand size angular rhyolite grains

(iv) c.3% fine sand size glauconite grains

(v) c.10% brachiopods, trilobites and pelmatozoan fragments. Some pelmatozoans have pores which are infilled with authigenic glauconite.

(vi) c.60% lime mud - blue-green algae (stromatolites, oncolites, *Renalcis* sp., and *Girvanella* sp. are incorporated within the lime mud) (Figure 16).

The presence of hematitic stromatolites, the poor sorting, and absence of grainstones suggest that a quiet probably shallow water environment prevailed during deposition of this facies.

Facies D

The grainstone facies is a well washed pelmatozoan rich biosparite. It consists of:

(i) c.90% pelmatozoans, with large syntaxial overgrowths up to 1 cm across

(ii) c.8% subrounded very fine sand size quartz grains

(iii) c.2% subangular to subrounded very fine sand size feldspar grains (Figure 17)

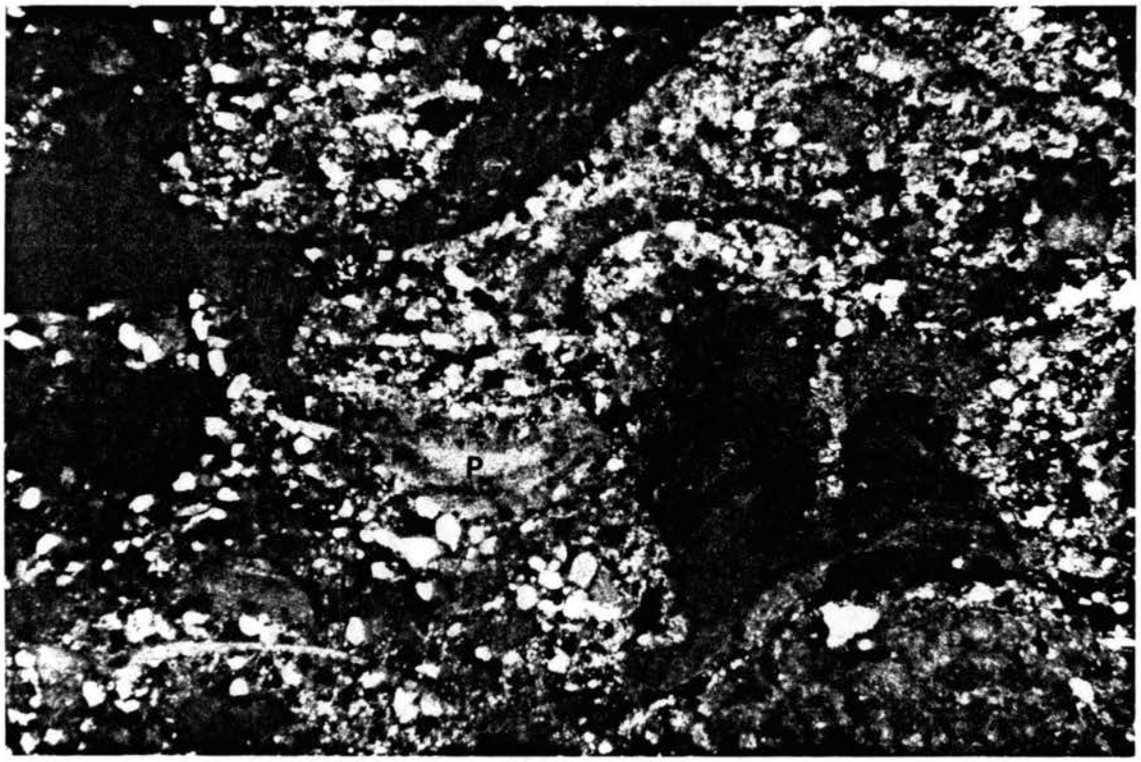



Figure 16. Facies C, Blue Creek Canyon A: Mudstone. Note Lime Mud, Stromatolite(s), <u>Girvanella</u> sp (G), Silt Size Quartz, Glauconite Filling Pelmatozoan Pores (p) (x 80)

Figure 17. Facies D, Blue Creek Canyon A: Grainstone. Note Pelmatozoan Fragments, Silt Size Quartz, Crenulated Pressure Solution Boundaries Between Grains (x 80)

Facies D blankets all the underlying facies. The grain fabrics and ubiquitous, medium-scale cross-bedding in this facies are interpreted to record the migration of shallow water marine sand shoals as the transgressing seas deepened and the entire area was gradually submerged.

Combined, the lower five facies are thought to represent a sheltered coastline, initially characterized by a smooth wave cut platform, abundant mud, brachiopod shell banks and stromatolites. Eventually the area was mantled by the coarse skeletal sands characteristic of most of the Honey Creek Formation.

## Blue Creek Canyon B

This exposure is located on the west side of highway 58, section 11, T.4N., R13W., Comanche County (Figure 10). Here the Honey Creek Formation overlies the Carlton Rhyolite surface which is highly irregular and consists of rock pedestals up to 89 cm in height and fissures 91 cm deep (Figure 18). The fissures are filled with vertically wedged orthid brachiopod shells and rounded rhyolite clasts up to 30 cm across. Medium-scale cross-bedded pelmatozoan-rich sand facies blanket the entire sequence, resting directly on the rock pedestals (Figure 19). The top of the Honey Creek is approximately 45 feet above the unconformity.

Two distinct facies are found at this locality;

1.) Facies E - fissure fill

2.) Facies F - medium-scale cross-bedded pelmatazoan grainstone/-packstone.

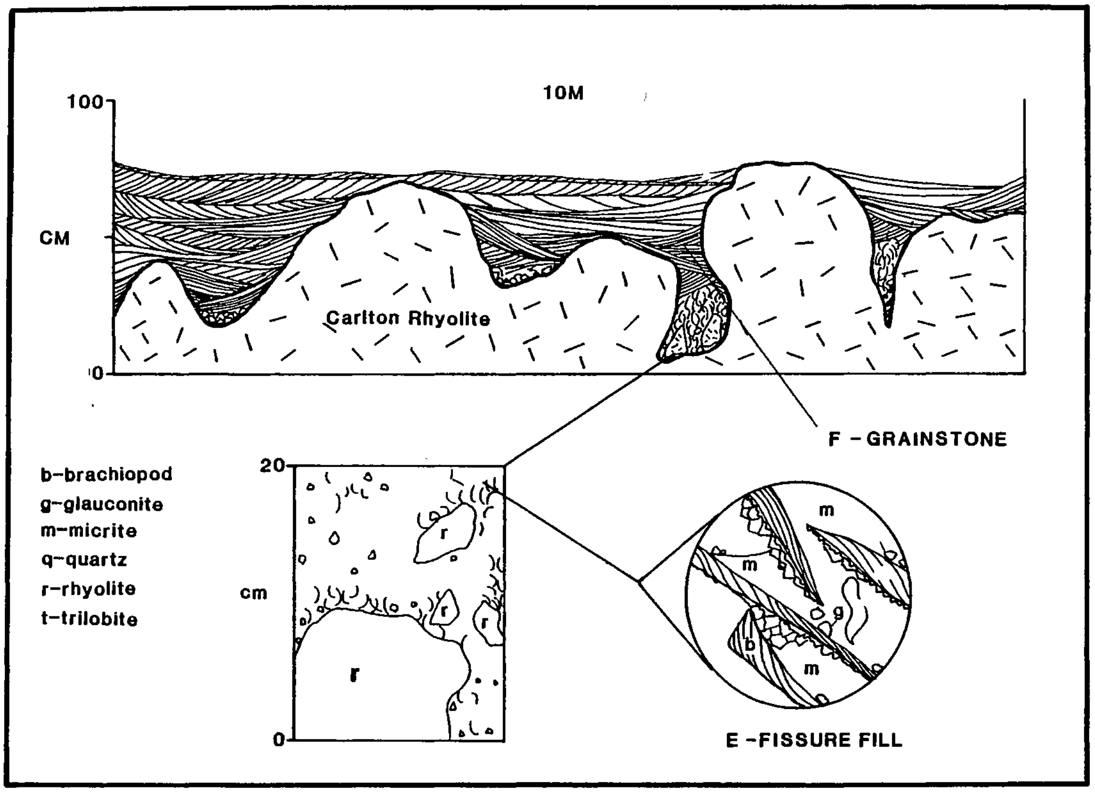



Figure 18. Facies Diagram of the Unconformity Between the Honey Creek and Carlton Rhyolite Formations at Blue Creek Canyon B

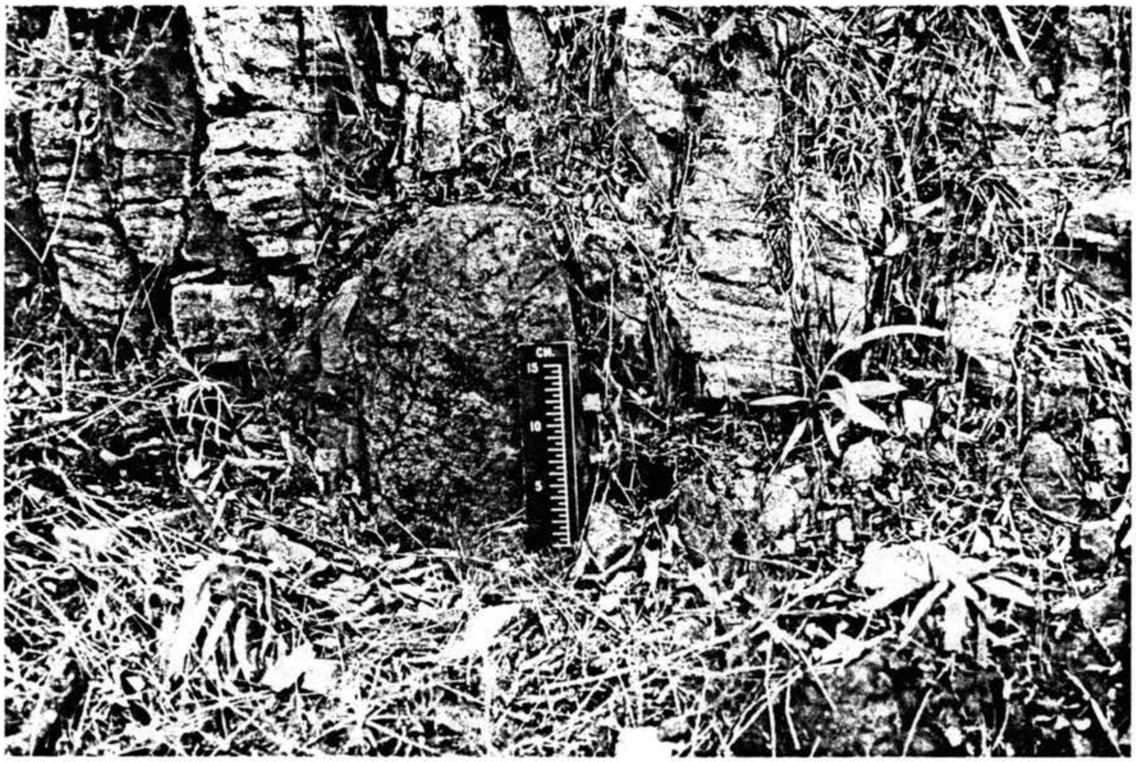


Figure 19. Carlton Rhyolite Rock Pedestal Overlapped by Medium Scale Cross-Bedded Pelmatozoan-Rich Sandstone Facies at Blue Creek Canyon B

Facies E

The fissure fill, classified, as a bioclastic calcirudite consists of:

(i) c.35% brachiopoods, which are vertically oriented and coated with thin hematite rinds

(ii) c.10% subrounded very fine sand size quartz grains

(iii) c.10% devitrified rhyolite pebbles and boulders

(iv) c.6% subrounded very fine sand size feldspar grains

(v) c.2% well rounded pelmatozoan grains with syntaxial overgrowths

(vi) c.23% anhedral equant spar

(vii) c.5% micrite

(viii) c.6% hematite that fills pore spaces and coats grains (Figure 20).

This facies is interpreted as a debris-filled fissure on a rocky shoreline.

Facies F

The coarse grained medium scale cross-bedded pelmatozoan grainstone/packstone consist of:

(i) c.88% pelmatazoan plates with syntaxial overgrowths up to 1 cm in diameter.

(ii) c.10% subrounded very fine sand size quartz grains.

(iii) c.5% micrite (Figure 21).

Facies F is interpreted as representing the blanketing of the unconformity by migrating pelmatozoan sand shoals.


Figure 20. Facies E, Blue Creek Canyon B: Fissure Fill. Wedged Orthid Brachiopod Shells (b) and Rhyolite Clasts (r) (x 160)

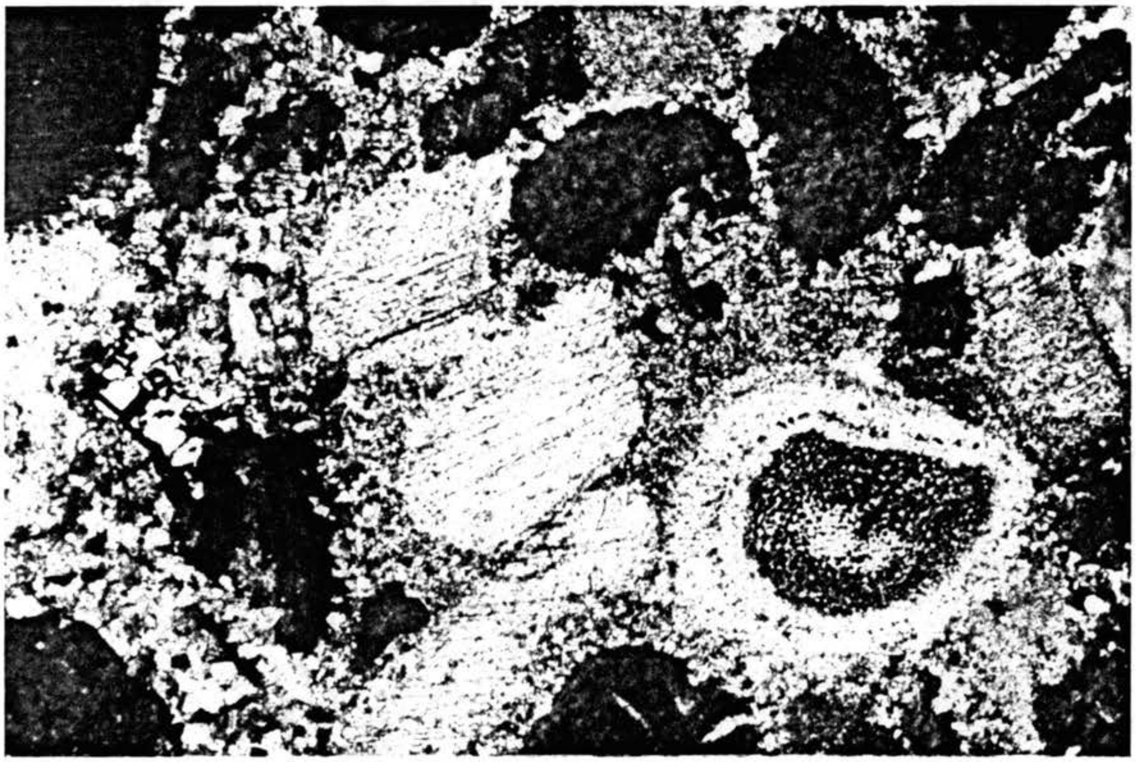


Figure 21. Facies F, Blue Creek Canyon B: Grainstone. Note Pelmatozoan Ossicles, One of Which Shows Pores Filled with Glauconite. Some Grains Show Two Generations of Syntaxial Cement. Note Also Calcite Replacing Glauconite (x 160)

Facies E and F are believed to record a scenario in which an exposed rocky coastline, characterized by rock pedestals and fissures (in which were wedged rounded rhyolite boulders and fossil debris), was gradually covered by coarse-grained cross-bedded pelmatozoan sands.

## Bally Mountain

This section is located eastward of Bally Mountain summit at section 26, T.6N., R.14W., Kiowa County (Figure 10). The Honey Creek Formation at this locality overlaps the Reagan Sandstone onto an emergent paleohill of Carlton Rhyolite (Figure 22). Observed overlap of the Honey Creek across the Reagan Sandstone is approximately 67 meters (220 feet). Intimate details at the unconformity are not exposed. The basal Honey Creek here consists of:

(i) c.30% angular rhyolite clasts up to 4 cm (0.13 feet) in diameter

(ii) c.40% anhedral sparite

(iii) c.15% pelmatozoan fragments of coarse sand size

(iv) c.2% angular very fine sand size quartz grains

(v) sparse brachiopod and trilobite fragments and glauconite.

## Ring Top Mountain

This exposure is located south, of Ring Top Mountain, section 12, T.4N., R.13W., Comanche County (Figure 10). The Honey Creek Formation overlaps the Reagan Sandstone onto a Carlton Rhyolite paleohill (Figure 23). Approximately 45 meters (150 feet) of overlap occurs in a horizontal distance of 365 meters (1200 feet).

Figure 22. Honey Creek Formation (Right) Overlapping the Reagan Sand-Stone onto an Exhumed Carlton Rhyolite Paleohill, Bally Mountain

Figure 23. Basal Overlap of Reagan Sandstone by the Honey Creek Formation onto an Exhumed Carlton Rhyolite Paleohill, South of Ring Top Mountain. The Carlton Rhyolite Forms the Hilly Ground to the Right. The Hill to the Left Consists of the Honey Creek Formation. The Valley in Center is Underlain by Reagan Sandstone (Photo by R. N. Donovan)

The Honey Creek above the unconformable contact is similar to that at Bally Mountain. It contains angular rhyolite clasts up to 215 cm (7 feet) across, numerous pelmatozoan fragments with syntaxial overgrowths, common brachiopods, detrital angular quartz grains, trilobites and glauconite pellets. In many places this bioclastic sand shows medium-scale cross-bedding.

## Stumbling Bear Pass

The highest of the exhumed Cambrian paleohills is located on the east side of highway 58, section 24, T.4N., R.13W. (Figure 10), where an unconformity occurs between the base of the Fort Sill Formation and the Carlton Rhyolite Formation. No more than 18 m (60 feet) of contact between the Fort Sill and Carlton Rhyolite is seen.

At this locality, the basal Fort Sill Formation is a massive light grey micritic limestone which contains numerous angular rhyolite clasts up to 15 cm (6 inches) across. Other features include burrows which are infilled by a dark reddish brown micrite, and many oncolites up to 16 cm (7 inches) in diameter. Some oncolites surround angular rhyolite clasts.

## Environmental Interpretation

In Late Cambrian times, the rugged landscape of the Carlton Rhyolite was inundated by transgressing Franconian seas. The Carlton Rhyolite paleogeomorphology at this time consisted of hills up to 300 feet high with gentle slopes of less than 10° (Donovan, 1984). As transgressing seas deepened, gradual inundation of the Carlton Rhyolite land surface produced an archipelago of small islands surrounded by shallow seas. Ultimately the Reagan Sandstone Formation filled the valleys on the late Cambrian land surface and the Honey Creek and Fort Sill Formations capped the highest hills. The onlapping of Honey Creek and Fort Sill Formations onto the islands of Carlton Rhyolite created what is now seen as an irregular unconformity.

Several local environments were developed at this unconformity. Exposures at Blue Creek Canyon A and Blue Creek Canyon B are thought to record two coastal environments:

1.) A sheltered coastline, characterized by a smooth wave cut platform, abundant mud, stromatolites, and brachiopod shell banks. (Blue Creek Canyon A).

2.) An exposed coastline, characterized by rock pedestals, fissures, rounded rhyolite boulders and coarse-grained medium-scale cross-bedded pelmatozoan-rich grainstones/packstones (Blue Creek Canyon B).

These two localities may represent the lee and exposed sides, respectively, of a rocky island (Figure 24). Evidence discussed in the succeeding chapter suggests that strongly developed tidal currents were operative at this time.

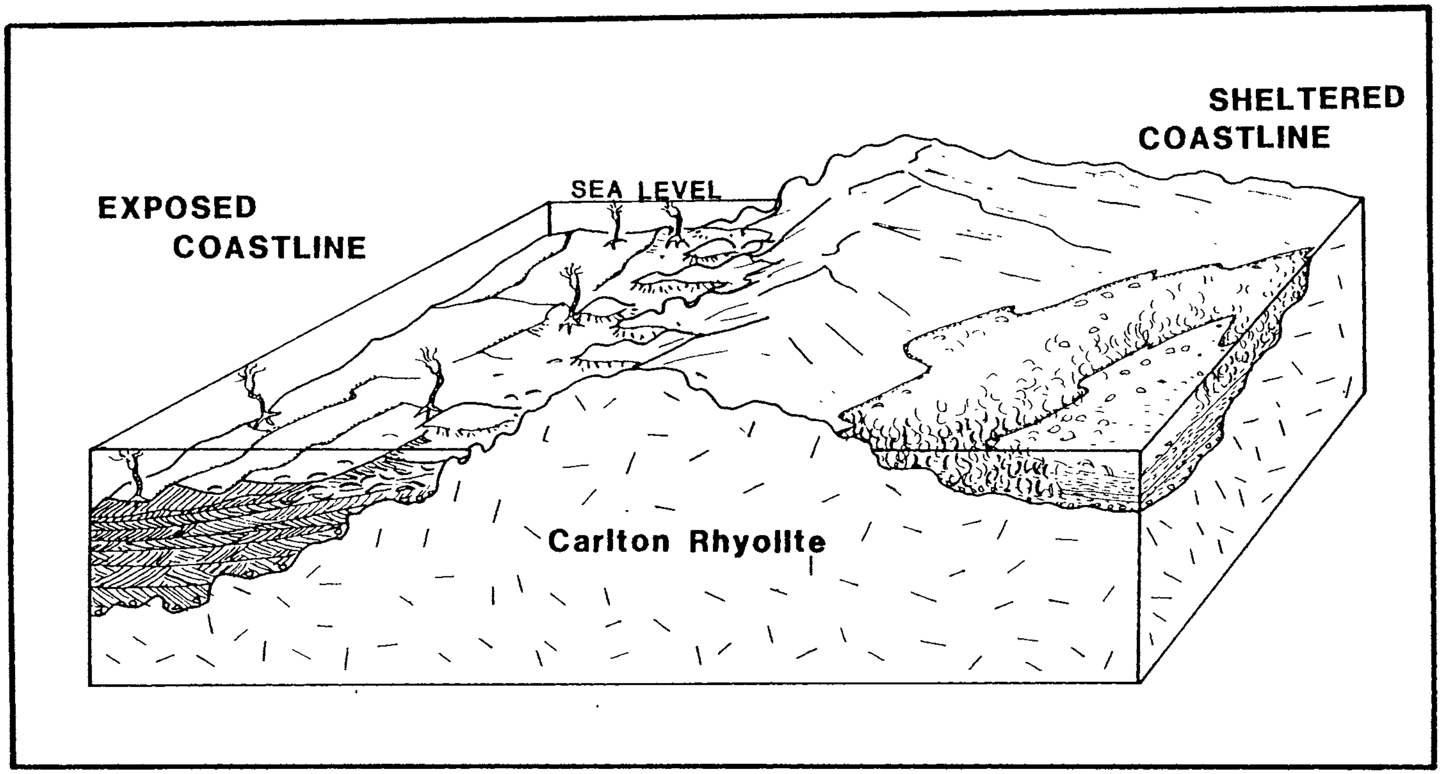



Figure 24. Diagrammatic Interpretation of the Environment Developed at the Unconformity Between the Honey Creek and Carlton Rhyolite Formations. The Exposure at Blue Creek Canyon A Represents a Sheltered Coastline. The Exposure at Blue Creek Canyon B Represents an Exposed Coastline.

# CHAPTER IV

# LITHOLOGIC DESCRIPTION OF THE HONEY CREEK FORMATION

## Field Descriptions

The greatest measured thickness (91 m, 300 ft) of the Honey Creek Formation is located at Blue Creek Canyon. The formation thins to the north and west; at Bally Mountain only 53 meters (175 feet) is present while at Zodletone Mountain the formation is only 37 meters (122 feet) thick (Plate I).

Most of the Honey Creek Formation is a resistant, coarsely crystalline, glauconitic, bioclastic limestone interbedded with tan to brown, fine grained, glauconitic, calcareous, bioclastic sandstone and green shales. The limestones display blocky weathering whereas the sandstones display a pitted "honey comb" weathering due to leaching of calcium carbonate. The weakly resistant shales are covered.

### Stratigraphic Boundaries

The stratigraphic boundary between the Reagan Sandstone and the Honey Creek Formation is defined as the first incoming of limestone in the section. In the field the approximate position of the contact is delineated by an irregular orange-weathering ankeritic zone up to two meters (seven feet) thick (Figure 25). The character of this ankerite has been discussed by Cloyd and Rafalowski (1984).

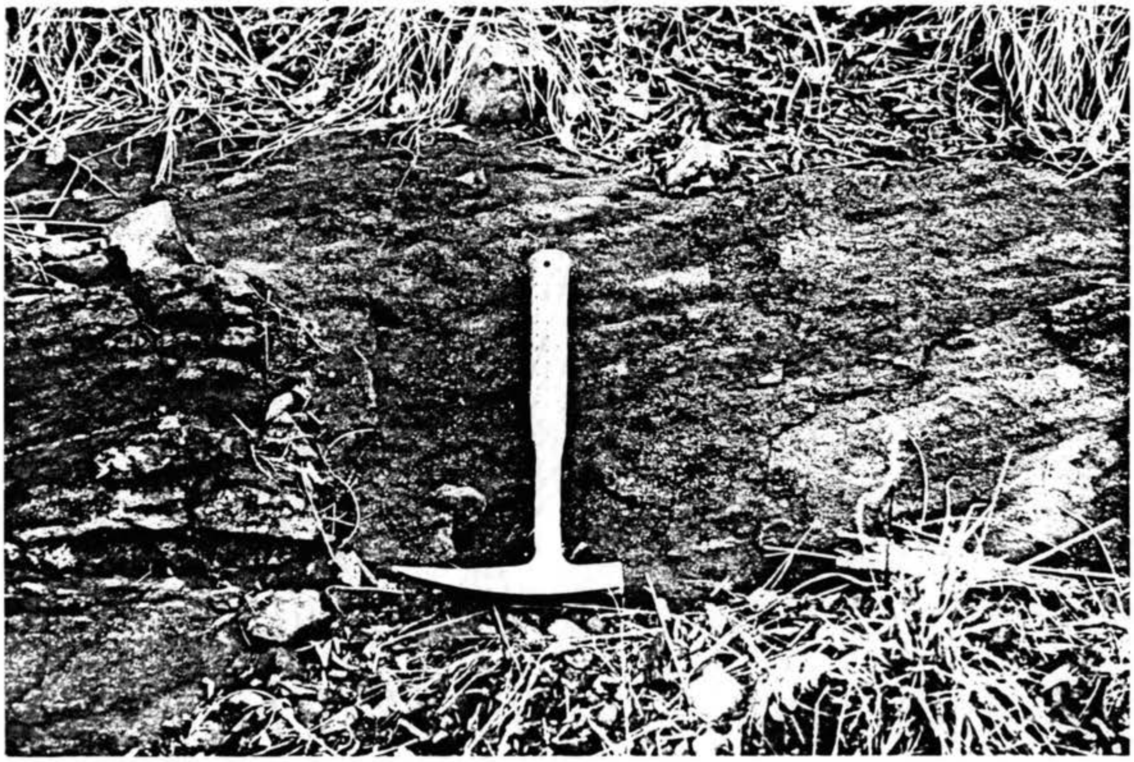


Figure 25. Stratigraphic Boundary Between the Reagan Sandstone and Honey Creek Formation marked by Orange-Weathering Ankerite Preferentially Precipitated Along Cross-Bedding Laminae

The conformable and gradational stratigraphic boundary between the Honey Creek and overlying Fort Sill Formation is determined lithologically by the change from the coarsely crystalline Honey Creek Limestone to dense cryptocrystalline Fort Sill Limestone. This contact was chosen at the base of the first occurrence of Fort Sill type lithology.

## Sedimentary Structures

The most obvious sedimentary structures found in the Honey Creek Formation are varieties of cross bedding (Figure 25). Small and medium scale trough, planar and herringbone cross bedding are present. Cross bedding occurs most commonly near the base of the formation in sets of up to 22 cm (9 inches) thick. Paleocurrent orientations reveal a bimodal current with opposing NW-SE polarities (Figure 26). These orientations are similar to those in the underlying Reagan Sandstone (Tsegay, 1983).

Alternating laminations of siliciclastic sandstone and limestone occur throughout the section. These laminations may be planar or wavy in form. The limestone laminae are medium to coarse grained skeletal grainstones whereas the siliciclastic laminae are fine to medium grained glauconitic sandstone. The content of siliciclastics increases gradually up-section to the extent that 15 m (50 feet) above the base of the formation a prominent ridge of predominantly siliciclastic sandstone displaying "honey comb" weathering can be traced throughout the area. Quartz content decreases above this level.

The interlamination of the two distinct lithologies clearly records the interplay between two grain populations. However the contact between the two lithologies, without exception, has been modified during

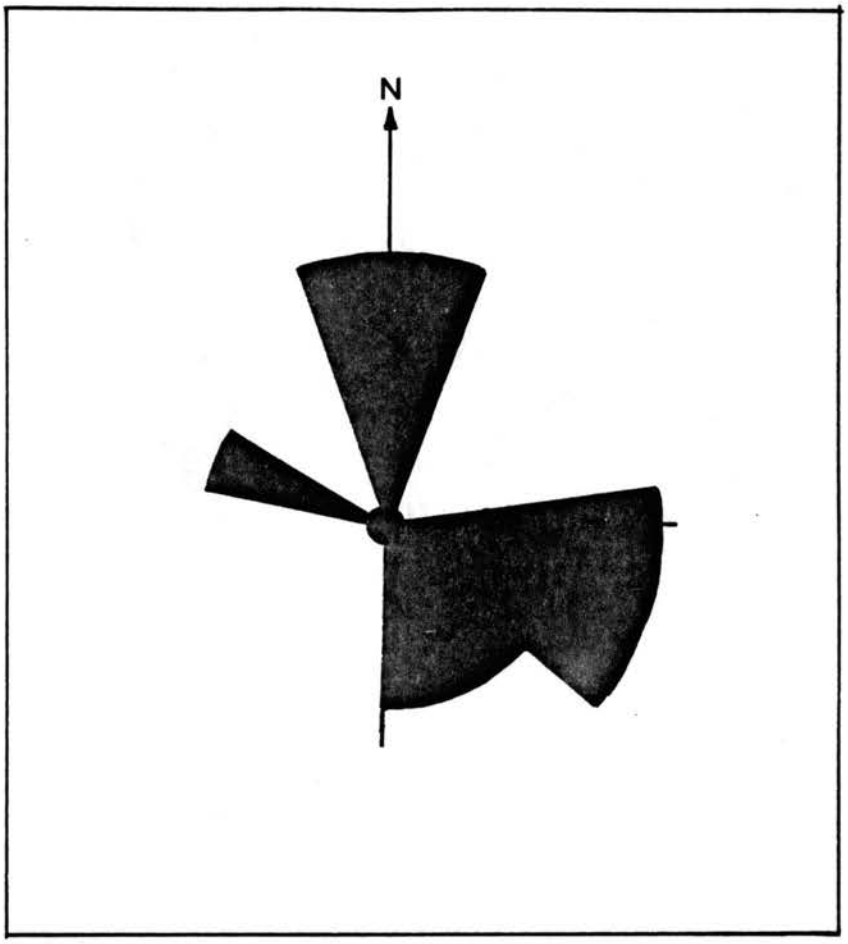



Figure 26. Paleocurrent Trends in the Honey Creek Formation from Measurements Taken Near the Base of the Formation. Readings, Which Have Been Corrected for Tectonic Tilt Show a Bimodal Distribution Similar to That Seen in Underlying Reagan Formation

diagenesis. This modification takes the form of significant grain boundary dissolution in the carbonates and intense stylotization involving carbonate solution. Stylolite amplitudes of up to 5 cm (2 inches) were measured.

## Petrography, Petrology and Related Sedimentary Features of the Honey Creek Formation

The Honey Creek Formation contains a variety of detritals, allochems, authigens and related sedimentary features. These constituents are categorized into four groups and will be discussed in the following order:

1. Siliciclastics - detritals
    - A. Quartz
    - B. Feldspar
    - C. Rhyolite
    - D. Zircon
    - E. Muscovite
2. Allochems
    - A. Body fossils - animals
        1. Pelmatozoans
        2. Trilobites
        3. Brachiopods
        4. Phosphatic brachiopods
    - B. Fossils - plants
        1. Stromatolites, oncolites, algae
    - C. Trace fossils
        1. Peloids

2. Bioturbation

D. Miscellany

1. Intraclasts

3. Authigens

A. Sparite

B. Micrite

C. Dolomite

E. Iron Minerals

4. Related Features

A. Stylolites

B. Geopetal Voids

C. Porosity

The general abundance of each constituent as related to distance above the base of the Honey Creek Formation are summarized in Figures 27-29. These diagrams depict cumulative constituents from all five measured sections.

## Siliciclastics

### Quartz

Quartz grains are important detrital constituents which occur throughout the formation. Quartz grains are found in lenses characterized by small scale cross bedding; in laminations; as detritus within micrite layers; and as undissolved debris along pressure solution seams.

In general, both grain size and content of quartz decreases up section, although, as noted above, there is an increase in quartz content

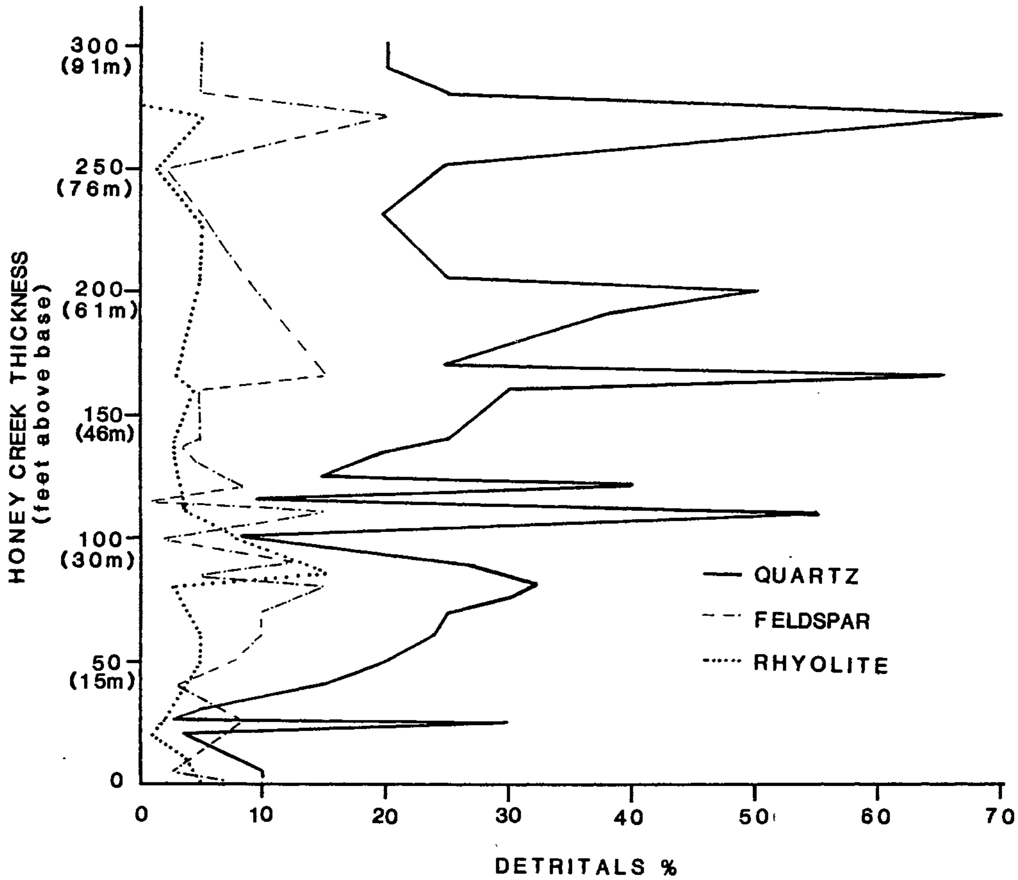



Figure 27. Variation in the Siliciclastic Detrital Content in the Honey Creek Formation

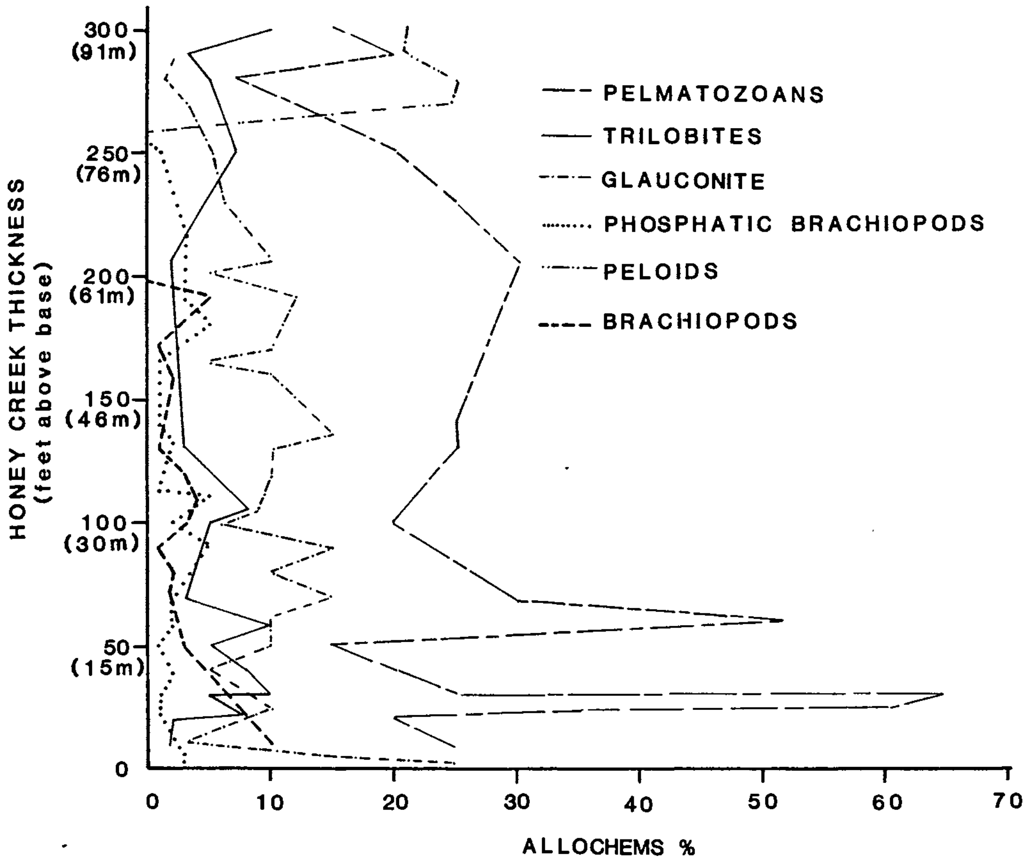



Figure 28. Variation in the Allochem Content of the Honey Creek Formation

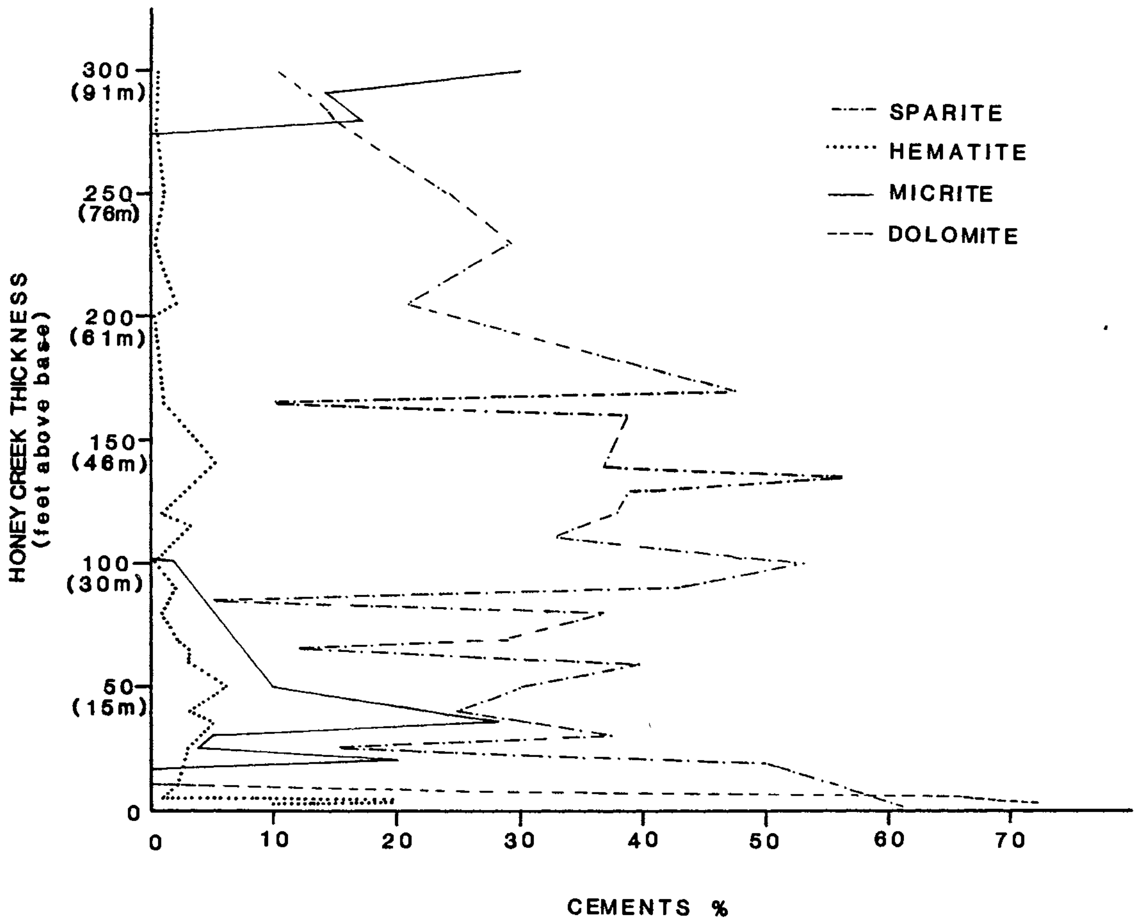



Figure 29. Variation in the Cement and Lime Mud Content of the Honey Creek Formation

approximately 15 m (50 feet) above the base, where a prominent 12 m (40 foot) ridge occurs (Figure 27).

The percentage of quartz present ranges from 0% to 75%. Grains, which are well sorted, vary from silt (0.006 m) to medium sand (0.30 mm) size, and are angular to subrounded. They are rarely polycrystalline, some contain Boehm lamellae, some display undulose extinction and most are commonly etched by calcium carbonate. Syntaxial overgrowths (which predate carbonate etching) occur commonly; in the laminated units they occlude most porosity. Sutured contacts between grains due to pressure solution are well developed in lenses with quartz overgrowths. There is a reciprocal relationship between quartz content and certain faunal elements. When the quartz content exceeds 75% usually less than 5% brachiopods and virtually no pelmatozoans occur. Conversely, in beds with 15% or less quartz, 10% or more pelmatozoans, brachiopods and trilobites are found. Hence, as suggested previously, mixing of siliciclastic and carbonate sources of sediment has occurred.

### Feldspar

The content of feldspar grains (mostly K-spar and rarely plagioclase) parallels that of quartz grains (Figure 27). The percentage of feldspar present ranges from 0 to 20%. Grains vary from very fine sand (0.065 mm) to medium sand (0.3 mm), from angular to sub angular, and are commonly etched by calcium carbonate.

### Rhyolite

Grains derived from the underlying Carlton Rhyolite Formation, generally decrease up section both in abundance and size (Figure 27).

Grains range in size from boulders (at the unconformity between the Honey Creek and Carlton Rhyolite Formations) to medium sand (0.3 mm). Roundness (which has a reciprocal relationship to grain size) decreases up section, with the boulders and clasts at the base being subrounded and the sand grains being subangular to angular.

The percentage of rhyolite present ranges form 0 - 7%. Most grains display snow flake texture and are often coated with hematite, both features being due to devitrification. A few grains have been partly replaced by authigenic glauconite.

#### Zircon

Zircon occurs throughout the formation in trace amounts. Grains appear fresh, subangular to subrounded, and average 0.12 mm in size. The most likely source of such grains is the underlying Carlton Rhyolite.

#### Muscovite

Flakes (up to 0.08 mm in length) of muscovite occur throughout the formation in trace amounts. Muscovite is most often associated with concentrations of other siliciclastic detritals (in laminations and stylolites).

### Allochems

#### Fossils - Animals

Pelmatozoans. Pelmatozoans are a major constituent of the formation. In some beds near the base of the formation, they comprise 90% of the grains present. In general, the abundance of pelmatozoans decreases up section (Figure 28).

Pelmatozoan fragments range in size from medium sand (0.5mm) to fine pebbles (6.76mm). In thin section they most commonly occur as a single carbonate crystal, displaying unit extinction. Most often early diagenetic syntaxial overgrowths have occluded pores within the plates. Nevertheless "ghosts" of original plates can be distinguished from syntaxial overgrowths by the relatively inclusion-free character of the syntaxial cement. In rare cases, pelmatozoan plates have been replaced by chalcedony, and plate pores infilled by glauconite and hematite. Calcitic overgrowths on such pore-occluded plates have also been observed. It is concluded that some grains had complex transport paths before final sedimentation. Relatively late stage pressure solution has led to considerable suturing of both pelmatozoan plates and their syntaxial overgrowths.

Trilobites. Trilobites found in the formation are the Elvinia, Ptychopleaurites, and Conaspis faunas (Frederickson, 1949). Although some relatively complete pieces of trilobites were broken out of coarsely-crystalline purple limestone pockets, the identification of trilobites was not attempted. The reader is referred to Stitt (1971, 1977, 1978) for specific identification.

In general, even though many trilobites are thick shelled, apparent robust forms, the great majority are fragmented. Most trilobites were found in the middle of the formation (Figure 28).

Fragments range in abundance from 0 to 20% and vary in size from 0.75 mm to 6 mm. Many fragments create shelter porosity and geopetal structures. They are commonly found in association with pelmatozoan fragments.

Brachiopods. Disarticulated brachiopods were found in abundance at the unconformity between the Honey Creek and Carlton Rhyolite Formations (Chapter III, Blue Creek Canyon A). They are identifiable in hand samples as *Eoorithis* sp. (Walcott, 1936).

In thin section, they vary in amounts from 0 to 10%, and range in size from 1.2 mm to 4.25 mm. Generally, fibrous internal shell structure is well preserved although a few brachiopods have been replaced by chalcedony and punctae are infilled with hematite. As with the trilobite fragments, brachiopod valves created shelter porosity and geopetal structures. As noted, packed arrangements of valves at the basal unconformity lead to the formation of bafflestones.

Phosphatic Brachiopods. Phosphatic brachiopods occur as broken fragments ranging in abundance from trace amounts to 5%. In general, they are most common in the middle of the section (Figure 28). Fragments vary in size from 0.12 mm to 4.75 mm. They are found most frequently in carbonate laminae and concentrated along pressure solution seams oriented parallel to bedding.

### Fossils-Plants

Stromatolites, Oncolites and Algae. Stromatolites, oncolites and algae were only found close to the basal unconformity between the Honey Creek and Carlton Rhyolite Formations (Blue Creek Canyon A, facies C-mudstone, Chapter III). They occur in a single laterally persistant (609 cm), 127 mm thick layer.

Megascopically, the stromatolites are reddish brown in color and are embedded in pinkish gray bioclastic limestone (Figure 30). Using Hoffman's (1969) classification, the stromatolites can be described as displaying columnar and bulbous growth factors, centrifugally inclined attitudes, tuberculate surface ornamentations and distinct light and dark (0.3mm) laminations. In profile view, columns are very closely laterally linked, asymmetric, acutely convex, approximately 10 mm high and 10.5 mm wide (Figure 31). In detail, the columns are comprised of alternating carbonate and hematite laminae; some carbonate bands are silicified. Columns appear to be attached to a hard ground substrate.

A few oncolites are found in the same horizon as the aforementioned stromatolites. They are composed of alternating laminations of carbonate and hematite which are nucleated on various fossil fragments. The average size of the oncolites reaches 2.0 mm (Figure 32).

Associated with the stromatolite bearing layer are a few clotted masses of irregular reddish brown tubules composed of carbonate and iron oxide. This texture is suggestive of the blue-green alga Girvanella sp. (Figure 16).

A second, less common type of clotted texture in the same layer, which is characterized by dense scallop-shaped arrangements of micrite, is suggestive of the blue-green alga, Renalcis sp.

## Trace Fossils

Peloids. Micrite peloids are found only at a level in the Honey Creek Formation 88 m (290 feet) above the base where they comprise up to 20% of the grains. The peloids are well sorted (from 0.2 mm to 0.3 mm in


Figure 30. Profile View of a Stromatolite Found Near the Unconformity Between the Honey Creek and Carlton Rhyolite Formations, Blue Creek Canyon A - Facies C. Substrate is a Hardground. Scale in cm

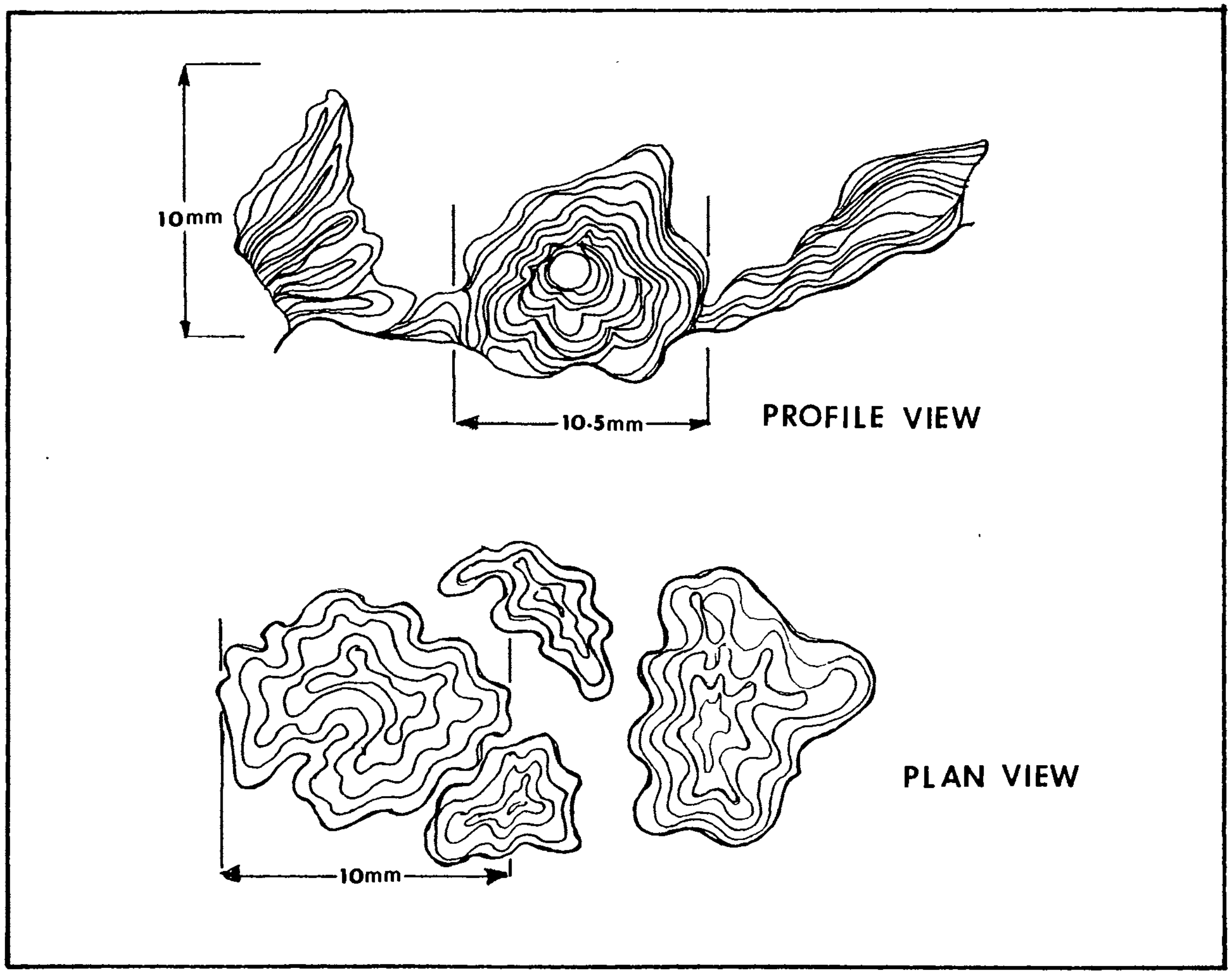



Figure 31. Plan and Profile View Sketch Depicting Dimensions of a Stromatolite Found Near the Unconformity Between the Honey Creek and Carlton Rhyolite Formations, Blue Creek Canyon A - Facies C

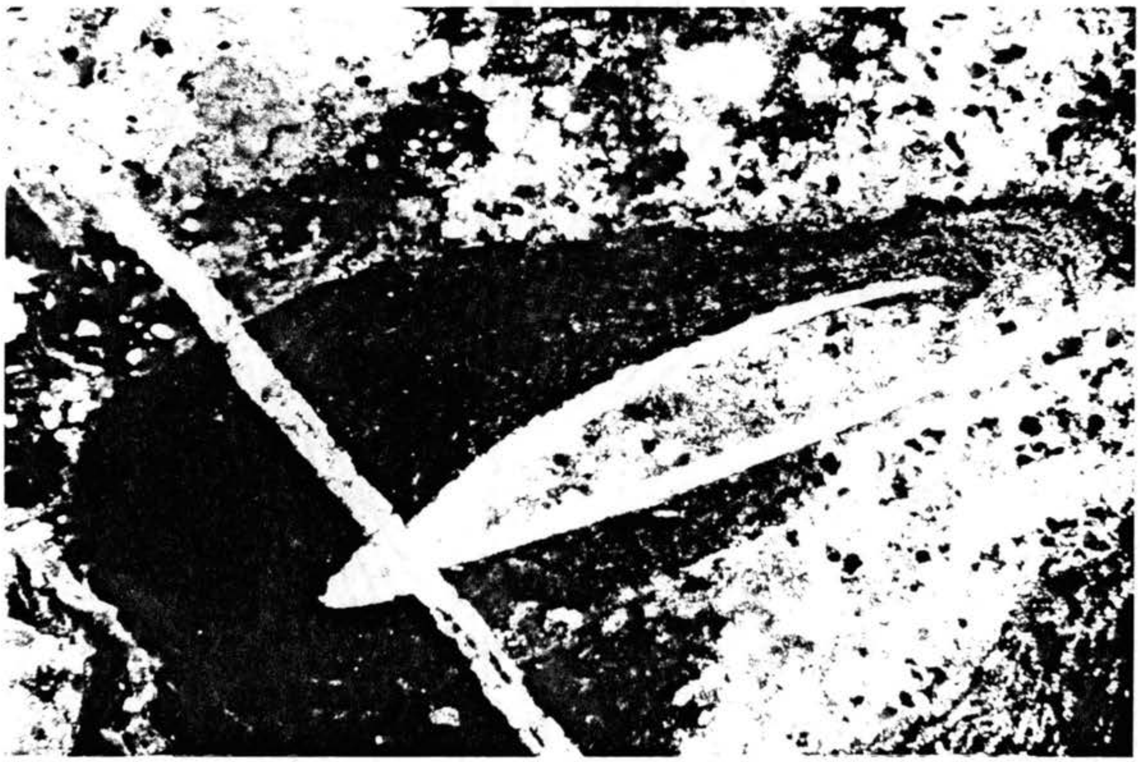


Figure 32. Oncolite Encrusting a Trilobite Fragment Found Near the Unconformity Between the Honey Creek and Carlton Rhyolite Formations - Blue Creek Canyon A - Facies C (x 80)

diameter) and are ovoid in shape. The sorting and shape of the peloids is suggestive of fecal origin.

Glauconite peloids are found throughout the entire formation, although, in general they decrease up section (Figure 28). They range from trace amounts up to 15%, vary in size from 0.14 mm to 0.3 mm (averaging 0.25 mm) and are mostly ovoid in shape. Many grains have been partly replaced by calcite. Grains which have been subject to pressure solution and stylotization have been squashed to form pseudomatrix.

Both micrite and glauconite peloids are associated with fossil fragments and are, therefore, interpreted as fecal pellets.

Bioturbation. Horizontal burrows occur near the top of the formation. They are most frequently found in glauconitic light gray, cryptocrystalline limestone, and may reach approximately 0.75 cm in diameter. They are filled with brown weathering micrite together with minor amounts of fossil detritus and quartz grains.

### Miscellany

Intraclasts. Intraclasts are rare in the formation. They were only detected in small amounts (0.6%) in a single thin section. The intraclasts average 2.3 mm in length, are rounded and contain silt size quartz, glauconite and micrite.

## Authigens

### Sparite

In general, sparite decreases up section (Figure 29). The abundance of sparite ranges from 3% to 56%. The size of sparite crystals vary from 10 mm (microspar) to 1.5 mm.

Sparite occurs as a cement primarily in the form of syntaxial overgrowths on pelmatozoan fragments. In most cases the outline of the pelmatozoan can be recognized because its exterior surface and interior pores are coated with lime mud. However in well washed grainstone fabrics where the initial grain was never coated the syntaxial overgrowths can only be detected by cathodoluminescence. Other forms of sparite are blocky, equant, drusy, radiaxial fibrous and neomorphic (Figures 13, 15, 17). Drusy cement is most often seen occluding shelter porosity; radiaxial fibrous cement is only found filling pore spaces in facies $B_1$, $B_2$, $B_3$ of Blue Creek Canyon A (Chapter III). Most forms of sparite have etched and replaced quartz, feldspar and glauconite grains.

Micrite

Micrite is mostly seen as internal sediment filling cavities, burrows, pore spaces and geopetal voids. In general, micrite decreases up section (Figure 29), but never constitutes more than 30% of the total rock. In some instances it has been replaced by microspar through the process of aggrading neomorphism (Tucker, 1981).

Dolomite-Ankerite

Two types of dolomite are found in the lowermost part of the formation (Cloyd and Rafalowski, 1984);

1. zoned single rhombohedrons that form less than 5% of the rock fabric. The zoning, which is due to variations in iron content, is clearly marked by the outward alteration to limonite.

2. sparry mosaics of interlocking, replacive, baroque, ferroan dolomite and ankerite which comprise up to 70% of the rock fabric.

### Glauconite

In general, glauconite decreases up section (Figure 29). It occurs most commonly in pellet form, but also replaces a few rhyolite fragments and fills pelmatozoan pores. Glauconite is often observed to have altered to illite, and more rarely to penninite (iron-rich chlorite), especially along pressure solution seams. It is commonly associated with pyrite and limonite (the latter as a weathering product).

### Hematite

Hematite occurs throughout the formation from trace amounts to 5%. In general, it decreases up section (Figure 29). It is most commonly found as grain coatings, replacing glauconite and filling voids.

### Pyrite

Pyrite occurs, in trace amounts, as cubes up to 0.08 mm across. It is most commonly associated with glauconite and has weathered to iron oxides.

## Related Sedimentary Features

### Stylolites

Horizontally-oriented stylolites are found throughout the formation. Vertical stylolites are less common. Horizontal amplitudes range from 0.15 mm to 1.5 mm. Zones immediately adjacent to stylolites contain a number of non-carbonate constituents; organics, hematite, feldspar and quartz grains, smashed glauconite peloids, illite and muscovite. In addition to well developed stylolites many carbonate grains show evidence of pressure solution in the form of sutured grain boundaries.

### Geopetal Voids

Geopetally-filled voids are abundant and most commonly formed as the result of arched trilobite and brachiopod fragments settling lengthwise and parallel to bedding. Fragments entrap and collect detritals (usually lime mud and siliciclastics) and effectively act as spirit levels at the time of sedimentation.

### Porosity

The Honey Creek Formation contains, virtually no porosity. Calcium carbonate cements have filled almost all potential types of pore space.

## Diagenesis in the Honey Creek Formation

The Honey Creek Formation has been affected by both chemical and physical diagenetic process. Chemical processes include:

1. secondary authigenic precipitation
2. alteration, dissolution and replacement

The principal physical processes are:

1. pressure solution
2. stylotization.

## Chemical Processes

### Secondary Authigenic Precipitation

Minerals recognized as secondary authigenic precipitants include calcite, silica, glauconite, and hematite.

Calcite. The major secondary authigenic precipitant in the Honey Creek Formation is pore-filling calcite cement. Cements characterized by differing fabric types may be recognized as occurring in successive diagenetic phases. Types of calcite cements found in the Honey Creek Formation include radiaxial fibrous, syntaxial overgrowths, drusy sparite, and anhedral equant sparite.

Radiaxial fibrous cement is found occluding voids in facies $B_1$, $B_2$, and $B_3$ at the basal unconformity between the Honey Creek and Carlton Rhyolite Formations (Blue Creek Canyon A, Chapter III). This type of cement is seen most commonly as fibrous crystals oriented normal to a substrate (mostly brachiopod valves). It is recognized as radiaxial fibrous cement by its characteristic curved twin lamelae, growth normal to pore walls, undulose extinction, non-planar intercrystalline boundaries and micro-inclusions. This type of cement is postulated to have formed originally as acicular aragonite or bladed high Mg-calcite synsedimentarily precipitated in an active marine phreatic zone (Kendall and Tucker, 1978; Flügel, 1982, Bathurst, 1969). This zone, as defined by Flugel (1982), is a zone characterized by "warm shallow (<100m) seas, with sediments or rocks in which pore spaces are filled with normal marine waters,...cementation occurs where tides, waves and currents are capable of moving sea water into sediments" (Figure 33). Radiaxial

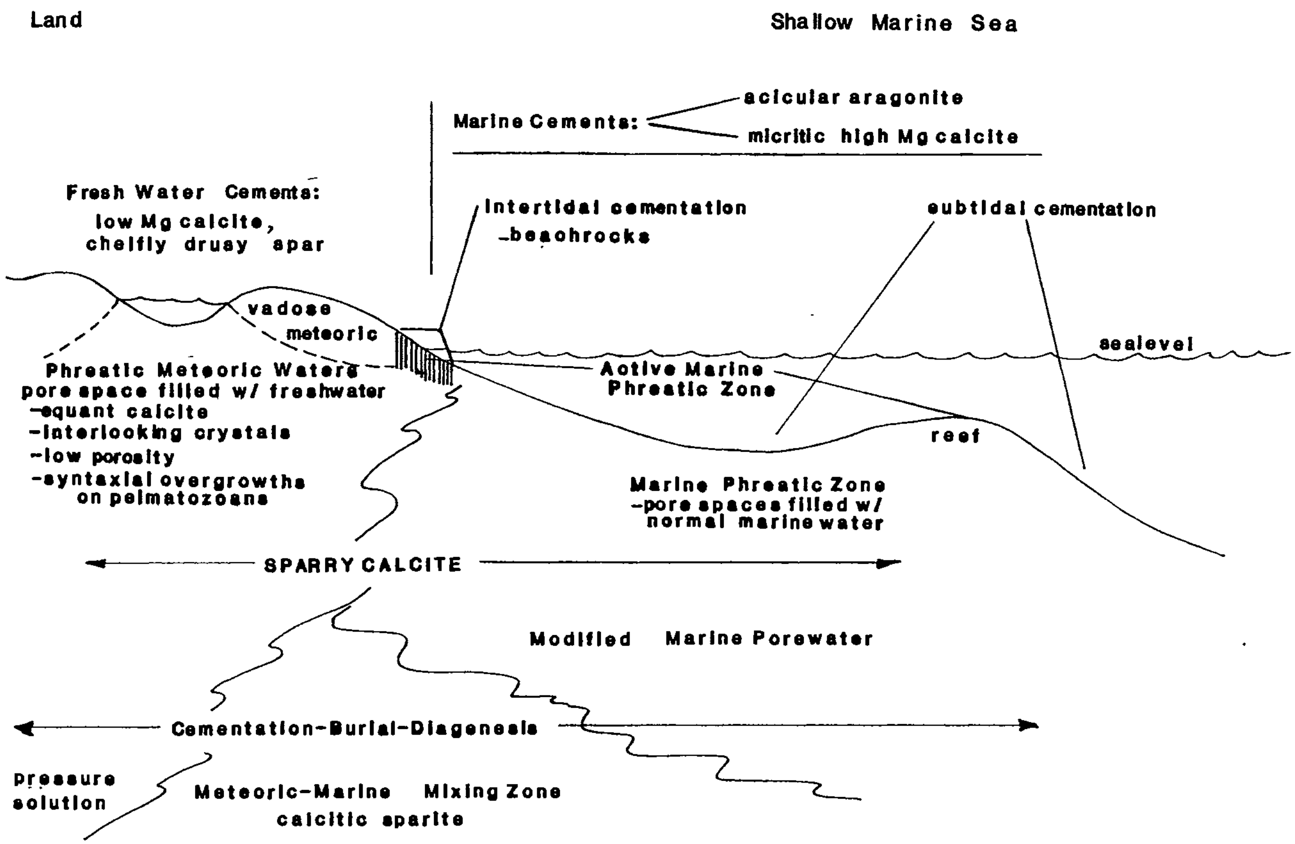



Figure 33. Diagram Depicting Principal Environments of Cementation of Carbonate Sediments (Modified from Tucker, 1981; Flugel, 1982)

fibrous cements are considered as an early cement in the paragenetic sequence of the Honey Creek Formation.

Characteristically, syntaxial overgrowths on pelmatozoan fragments, occur as an early phase of cementation (Longman, 1980). In this type of cementation calcium carbonate overgrowths grow freely into pore spaces as large, optically continuous crystals from pelmatozoan plates, spines and ossicles (Evamy and Shearman, 1964; Walkden and Berry, 1984). These overgrowths involve firstly, the infilling of pelmatozoan canals with either calcium carbonate, glauconite, organics or mud in a marine phreatic environment (Figure 33) (Flügel, 1982). Following initial pore filling, rapid cementation in the form of calcium carbonate syntaxial overgrowths develops around the pelmatozoan grains. This phase of cementation occurs in the freshwater phreatic-active zone which lies between the vadose and mixed marine and phreatic freshwater zones (Figure 33) (Flügel, 1982, Longman, 1980). In this zone of active circulation, all pore space is filled with mobile meteoric waters saturated with respect to calcium carbonate, allowing rapid and equal precipitation of calcium carbonate around pelmatozoan grains (Flügel, 1982). This type of cement is considered to have occurred relatively early in the paragenetic sequence of the Honey Creek.

Other forms of calcite cement that developed later in the paragenetic sequence of the Honey Creek Formation are drusy sparite and anhedral equant sparite. Both of these types of sparite are typical cements precipitated in either the meteoric phreatic zone (Tucker, 1981), or after deep burial where calcium carbonate is in solution due to dissolution of existing carbonates as a result of pressure solution. Both types of spar, but particularly the latter may be ferroan. Sparite of these two types usually infills voids remaining after initial cementation in submarine environments.

Silica. The secondary precipitation of silica occurs as a cement in the form of syntaxial overgrowths on detrital quartz grains. Overgrowths are seen most commonly in those laminae in which quartz is the main constituent. Overgrowths range from incomplete to complete grain enclosure and may have totally occluded porosity (Figure 34). Complex relationships exists between silica and calcite cements.

Glauconite. The formation of glauconite has long been problematic. It occurs in the Honey Creek replacing pellets, and as a pore-filling authigenic precipitant. Glauconite is seen in the latter state filling pores of pelmatozoan ossicles. Odin and Matter (1981) suggested that the precipitation of glauconite requires the conditions of a semi-confined microenvironment, which is slightly reducing to oxidizing ($Eh<0$), with chemically stable water (pH 7-8) and low sedimentation rates. Pore-filling glauconite is thought to be syndepositional in the Honey Creek Formation as evidenced by later syntaxial overgrowths on pelmatozoan grains with pores filled with glauconite (Figure 21).

Hematite. Hematite occurs both as grain coatings and as a pore filling cement. The main source of iron was probably derived from devitrifying rhyolite. Marine waters probably contained high concentrations of iron due to the major marine transgression over the Carlton Rhyolite land surface. Hematite is indicative of oxidizing conditions and is thought to have precipitated early in the paragenetic sequence of the Honey Creek Formation.


Figure 34. Quartz and Glauconite-Rich Facies of the Honey Creek Formation Showing Syntaxial Overgrowths on Quartz Grains (q) and Corrosion of Quartz and Glauconite by Calcite (c), Zircon Grain (z) Was Probably Derived from the Carlton Rhyolite (x 160)

Alteration, Dissolution and Replacement

Evidence of mineral alteration, dissolution and the replacement of one mineral by another is common in the Honey Creek Formation.

The minerals and constituents affected by one or more of these processes are rhyolite, glauconite, calcite, dolomite, and silica.

Rhyolite. Synsedimentary alteration and devitrification of rhyolite released ions of Si, Al, K, Fe and Mg into transgressing marine waters. The principal alteration products of rhyolite are hematite, silica and smectite/illite. Rhyolite was also observed to have been replaced by glauconite (Figure 35).

Glauconite. Glauconitized pellets (presumed to be of fecal origin) are an important constituent of the Honey Creek Formation. Minor amounts of glauconitized rhyolite fragments are also present (Figure 35).

The glauconitization of small rounded pellets and rhyolite fragments may be interpreted as occurring slightly after or during devitrification of the Carlton Rhyolite. The transgressing sea provided favorable environmental as well as chemical conditions for the glauconitization of fecal pellets and rhyolite fragments. Odin and Matter (1981) suggested that glauconitization is achieved by authigenic growth of Fe and K-rich smectitic glauconite in the porous grains of argillaceous fecal pellets. The slightly reducing environment may have been present in a reducing micro-environment within the fecal pellets (which are assumed to have contained decaying organic matter). Glauconitization of the rhyolite fragments may have taken place in quiet sheltered

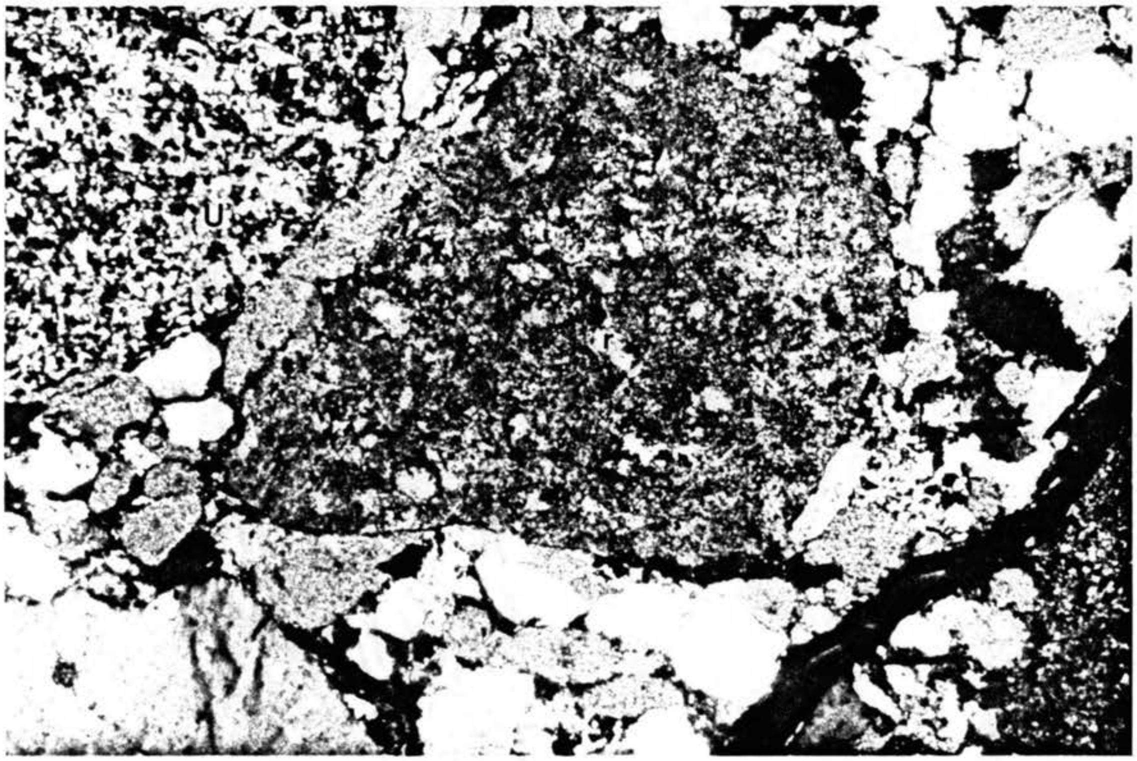



Figure 35. Glauconite Replacing Rhyolite Fragment (r), Unaltered Grain of Rhyolite (u), Honey Creek Formation, Blue Creek Canyon (x 80)

settings around the Honey Creek "archipelago" where the sea bottom was relatively oxygen-depleted and organic decay rates were retarded.

Calcite. The replacement of quartz, feldspar and glauconite grains by calcite was observed throughout the formation (Figure 34). The interrelationships between calcite and silica solubilities can be simplistically explained as controlled by fluctuating pH and temperature of formation waters. The critical range of pH in which silica-calcite replacement and dissolution occurs is 7-9 (this range in pH is common for most subsurface formation waters (Blatt, 1981).

Silica. Replacement by silica was only observed at the Honey Creek-Carlton Rhyolite Formation unconformity (Blue Creek Canyon A, facies D, Chapter III). This replacement occurred within stromatolite laminae which comprise alternating iron oxide and silica (Figure 36). The silica only replaced laminations which were carbonate in composition. The silica was probably derived from silica-rich waters due to the devitrification of the Carlton Rhyolite.

Dolomite. As noted previously dolomite occurs in two forms in the Honey Creek Formation:

1. scattered, zoned rhombohedrons of ferroan dolomite (ankerite)
2. a mosaic of baroque, ferroan dolomite.

Both varieties are found near the contact between the Honey Creek and Reagan Formations and are considered to have formed relatively late in the paragenetic sequence. Iron released from corroded glauconite, combined with carbonate-rich groundwater, lead to the precipitation of ankerite. Baroque dolomite probably formed later than the ankerite.

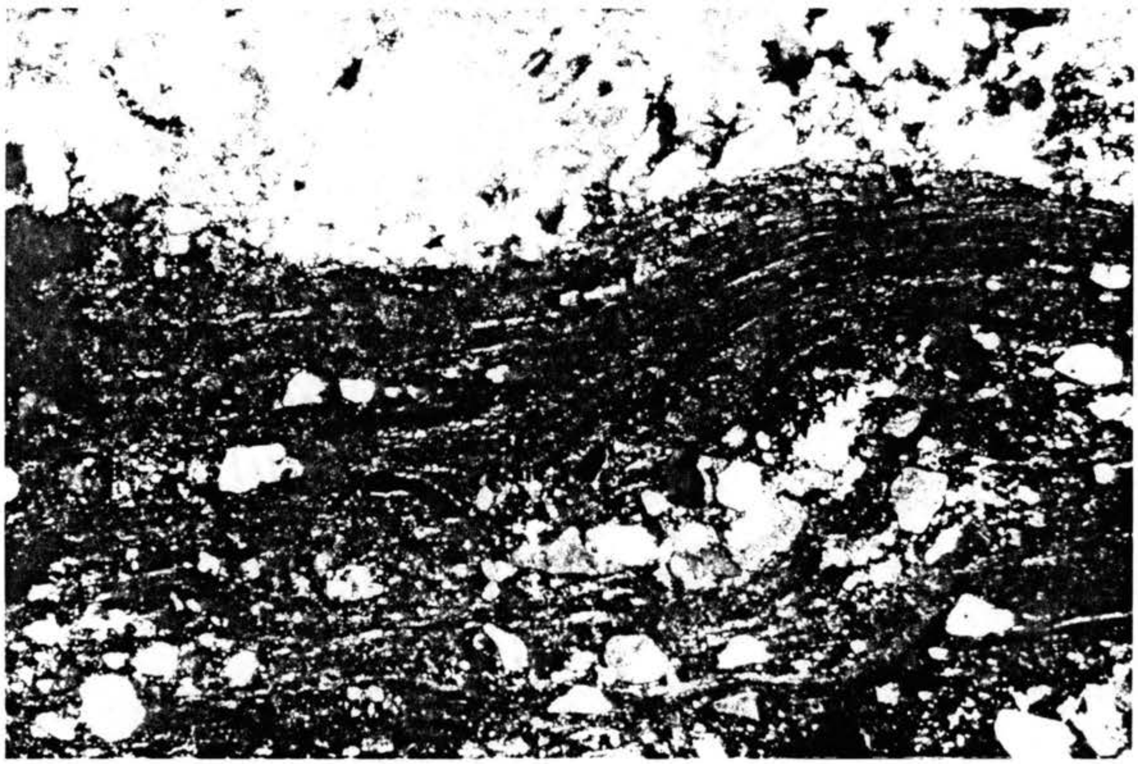


Figure 36. Partly Silicified Stromatolite at Blue Creek Canyon A - Facies C. Note That Iron Oxide Laminae Have Not Been Replaced by Silica (x 160)

Cloyd (1984) studied the geochemistry of dolomite in the Slick Hills area, including those described above.

## Physical Processes

### Stylotization and Pressure Solution

Pressure solution which, decreases the volume of grains and of cement minerals, is the primary mechanical diagenetic process that has affected the Honey Creek Formation. Stylolites, one of the results of pressure solution, record the dissolution of limestone due to overburden or tectonic pressure (Flügel, 1981). The other important solution process is pressure solution at crystal or grain boundaries. Both are common in the Honey Creek Formation. Pressure solution is an important process in supplying carbonate for the formation of late carbonate cements.

There are two theories on the timing of stylolite formation, "post-complete cementation" and "pre-complete cementation" (Park and Shot, 1968). These authors suggested that stylolization is continuous from the time before cementation by late drusy calcium carbonate and ends simultaneously with the complete elimination of pore space by this cement.

Amplitudes of stylolites measured in thin section (micro stylolites) were classified in the system of Logan and Semeniuk (1976). Most stylolites in the formation can be classified as parallel sets of peaks of low amplitude resulting in a condensed fabric. Pressure solution structures most often observed megascopically in the formation are stylonodular (Logan and Someniuk, 1976). This type of pressure solution is visually enhanced by the "honey comb" weathering of the Honey Creek

Formation. Pressure solution is most often observed to occur between detrital and carbonate laminae. Accumulations along stylolite seams consist of organic material, hematite, quartz, smashed glauconite and phosphatic brachiopod valves.

It is considered that pressure solution probably occurred throughout the late diagenetic stage of the Honey Creek Formation in the manner suggested by Park and Shot (1976).

Figure 37 is a paragenetic interpretation of the Honey Creek Formation. The figure depicts a general timing of diagenetic events deduced from textural evidence and inferred from observations by other authors.

## Environment of Deposition of the Honey Creek Formation

Gross environmental interpretation is based on an analysis of constituents and sedimentary features and the application of uniformitarian analogy. Together, constituents and sedimentary features point toward a shallow, mixed siliciclastic/carbonate marine environment. With time this environment gradually evolved from a dominantly siliciclastic irregular shoreline to a highly productive shallow carbonate shelf environment.

### Environmental Indicators

Constituents and sedimentary features provide evidence for constructing a more tightly defined environment of deposition. The most significant environmental indicators are body and trace fossils, sedimentary features and synsedimentary authigenic minerals.

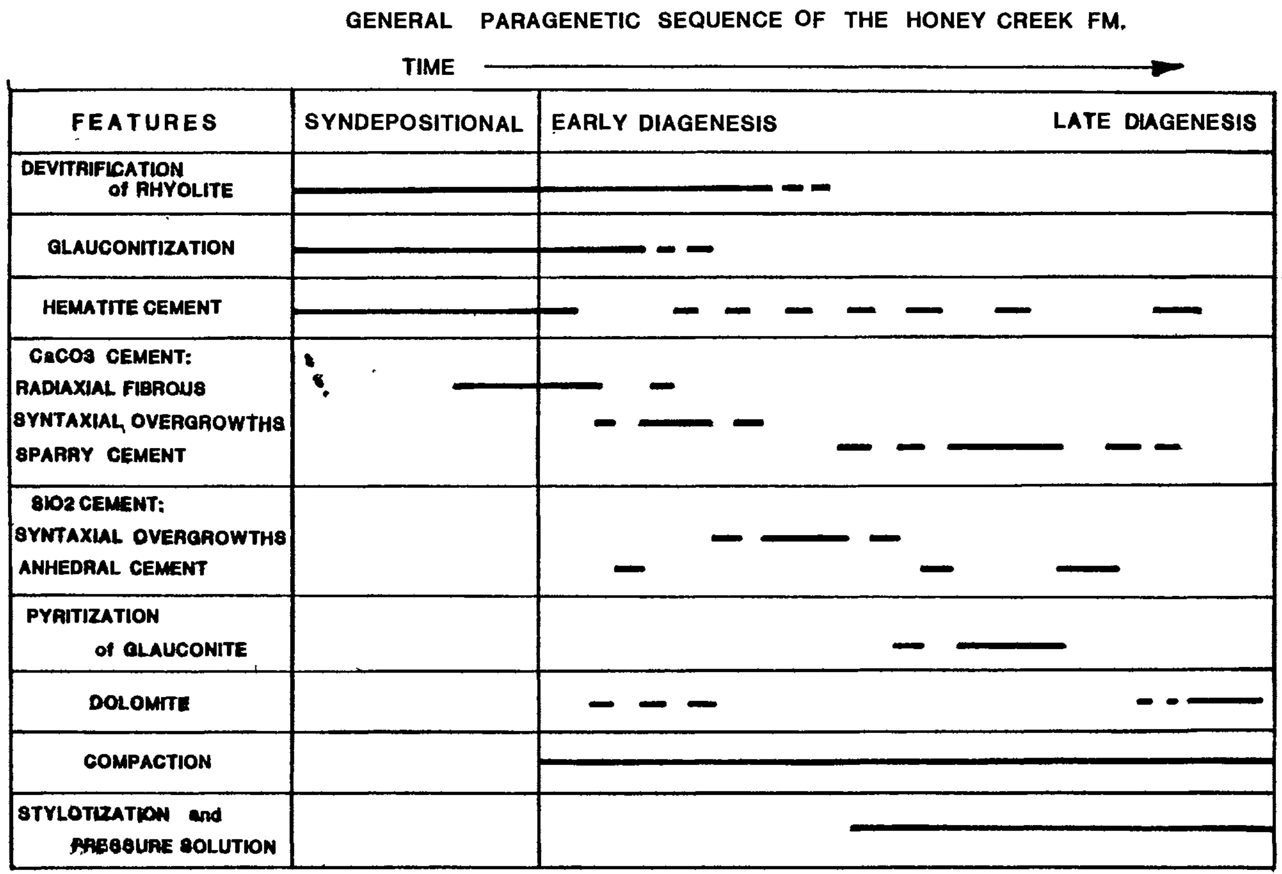



Figure 37. Generalized Paragenetic Interpretation of the Honey Creek Formation

Pelmatozoans

Pelmatozoans occur as disarticulated ossicles which form the bulk of grains incorporated in coarse grained bioclastic cross bedded sets. Recent pelmatozoans inhabit depth ranges from shallow (10m) to deep marine in normal saline water. They are both sessile and free swimming organisms requiring a firm substrate (in the former case) and clear circulating water (Flügel, 1982; Heckel, 1972). Most interpretations of primitive Cambrian pelmatozoans suggest that they were sessile organisms living in agitated oxygenated water (Heckel, 1972).

Trilobites

Trilobite fragments occur throughout the formation. They are well known to have been mobile benthonic organisms preferring soft substrates in a wide range of water depths. Most skeletons found in the formation are thick shelled, suggesting that they were robust enough to withstand agitated water.

Brachiopods

Two varieties of brachiopod shells, calcitic and phosphatic, are found in the Honey Creek Formation. Calcitic brachiopods are found most abundantly at the base, whereas phosphatic fragments occur throughout the formation. Modern brachiopods are sessile benthonic suspension feeders mostly intolerant of low salinities and rapid sedimentation, and tolerant of a wide range of water depths (shallow marine to 200m) (Heckel, 1972). Phosphatic shells are suggestive of high organic activity and nutrient rich waters.

Stromatolites, Oncolites, Algae

Stromatlites, oncolites and algae are found only at the basal unconformity between the Honey Creek and Carlton Rhyolite Formations. Modern stromatolites of similar morphology are found in open marine subtidal and low intertidal environments. Oncolites are most commonly associated with low intertidal zones where water agitation is constant (Gebelein, 1976). Girvanella sp., in association with oncolites and stromatolites, may be suggestive of shallow subtidal environments.

Peloids

Peloids are suggestive of a marine environment of high organic activity and all depths of shallow water.

Bioturbation

Horizontal burrows are found throughout the formation and are most common in the laminated facies. Bioturbation is most often found in intertidal and subtidal modern environments (Flügel, 1982).

Cross Bedding

Small and medium scale cross bedding occurs most commonly in the lower Honey Creek Formation. These structures record a low flow regime and are interpreted as recording the migration of bars and shoals in a shallow marine setting. The occurrence of herring bone cross bedding strongly suggests a tidal component of transport (Reading, 1978).

Radiaxial Fibrous Cement

As stated previously, radiaxial fibrous cement is thought to form synsedimentarily in the active marine phreatic zone (Kendall and Tucker, 1978). This zone, as defined by Flugel (1982), is often found in warm shallow (<100m) seas. Cementation occurs where tides, waves, and currents are capable of actively flushing the sediments.

Glauconite

Glauconite is being formed now on many continental shelves. Ideal conditions for the formation of glauconite are: normal marine salinity, slightly oxidizing to reducing waters, moderate to shallow water depths (uncommonly found forming above 5 m and below 500 m), slight sediment influx and high iron content (Cloud, 1955, Odin and Matter, 1981). Odin and Matter (1981) noted the association between marine transgressions and the presence of glauconite. They suggested that the grains most commonly glauconatized initially formed near shore and were later glauconitized (in quiet conditions) when submerged below 50 m. The influx of sediment is shifted landward during transgression leaving ideal conditions for glauconitization to take place. Although this scenario may well have operated in Honey Creek time, it is clear that many of the glauconite pellets were reworked as they are now found in association with cross bedded pelmatozoan sands immediately adjacent to the basal unconformity. This suggests that the Franconian transgression may have been accompanied by short term sea level oscillation.

## Hematite

Pore-filling and grain-coating hematite is characteristic of shallow water in which iron is fixed in an oxidizing environment (Tucker, 1981). Hematite is most common near the base of the formation suggesting that the mineral was quickly fixed during early stages of the Franconian transgression.

## Environmental Synopsis

A comparison of fossils and trace fossils found within the Honey Creek Formation with recent forms indicates that the former may be interpreted as typical of a variety of habitats ranging in depth from intertidal to offshore marine, from brackish to normal marine waters,and from low to high energy water turbulence.

The presence of stromatolites, oncolites, algae and radiaxial fibrous cement, perhaps, represents a near shore environment where relatively low energy waves, currents and tides provided favorable conditions for stable shell packing, algal growth and lime mud precipitation. This association is recorded at a single exposure.

The coarse, bioclastic, cross-bedded pelmatozoan-rich sands were probably deposited in turbulent conditions as modest-sized sand waves (influenced by tides and the wind) formed migrating offshore bars and shoals.

The finer-grained laminated and burrowed sediments are suggestive of less turbulent possibly offshore waters, below wave base, and perhaps at depths as great as that suggested by the fossils. Spatial distribution of this facies (near the top of the formation) suggests that deposition took place considerably offshore following the initial transgression. The presence of glauconitized grains is an expected feature of marine transgressions because of the abundance of ferric oxide on stable cratons. In addition to iron and other necessary ions, glauconite requires stable Eh conditions and time to form. Many of the rocks of the Honey Creek Formation do not appear to have formed in such an environment. Considerable reworking of grains is implicit. The original environment of formation may have been distal offshore marine.

The overall decrease in the grain size and abundance of quartz may well be a function of distance from the source area as the transgression spread. Donovan and Tsegay (1983) have shown that the likely source of quartz in the underlying Reagan Formation was from the north-northwest. The gradual decrease in quartz supply allowed the eventual development of a prolific carbonate producing shelf environment.

In summary, the Honey Creek Formation may be interpreted as the record of a marginal to shallow, tide dominated, intertidal-subtidal irregular siliciclastic shoreline/carbonate shelf.

This environment may be analagous physiographically to that of the northeastern Orkney Islands, Scotland as reported by Farrow, Allen and Akpan (1984). The Orkney Archipelago consists of very irregular shorelines where large areas of bare rock are exposed to tidal and storm currents due to shallowing and narrowing or obstructions such as islands and peninsulas. A rocky platform that grades into a shallow shelf contains irregular sand and gravel bodies. Coarse sands accumulate near the current swept rocky areas, and medium and finer sands occur in the open deeper shelf where currents are weaker. Thin veneers of sediment cover the rocky platforms and sediments fill crevices and fractures in the bed rock.

# CHAPTER V

# LITHOLOGIC DESCRIPTION OF THE FORT SILL FORMATION

## Field Description

Four Fort Sill sections were measured in the Slick Hills (Figure 1). The thickest of the sections, at Bally Mountian totaled 197 meters (645 feet) (Plate II). In general, the Fort Sill Formation is a light to dark gray, micritic, fossiliferous, locally silty and glauconitic limestone. Variable amounts of dolomite are present. A thick sequence of dolomite at Bally and Zodletone Mountains is assigned to the Royer Dolomite (Figure 38). In addition to the Royer Dolomite three ad hoc stratigraphic units were recognized in the field (after Nelms, 1958):

1. lower limestone unit
2. middle silty limestone unit
3. upper massive bedded limestone unit

### Lower Limestone Unit

The lower limestone unit is an alternation of thinly bedded, light gray limestone and thin laminae of calcareous siltstone. The unit contains glauconite and fossil fragments. The average thickness of the lower limestone unit is 40 meters (130 feet).

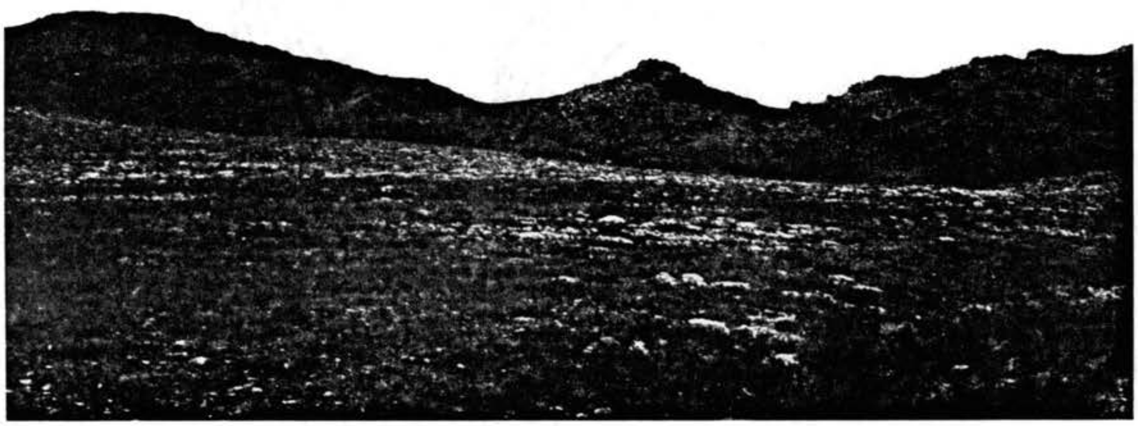


Figure 38. Royer Dolomite, Bally Mountain Showing Rugged Character of Exposure

## Middle Silty Limestone Unit

The middle silty limestone unit is recognizable as a flaggy bedded sequence comprising alternating dark to very dark gray, very finely crystalline silty limestone and massive light to dark gray (locally ankeritic), silty, micritic limestone. This unit contains horizons of oolites and stromatolites. It ranges in thickness from 34 to 58 meters (110 to 190 feet).

## Upper Massive Bedded Limestone Unit

The upper massive bedded limestone unit is the thickest of the three units, averaging 90 meters (295 feet). It is recognized as a light gray thickly bedded slightly ankeritic micritic limestone containing large algal mounds.

The Royer Dolomite is contained in this unit at Bally and Zodletone Mountains. It is characteristically a rough weathering massive light gray to brownish gray finely to coarsely crystalline dolomite (Figure 38).

## Stratigraphic Boundaries

The stratigraphic boundary between the Honey Creek and Fort Sill Formations is discussed in Chapter IV. The stratigraphic boundary between the Fort Sill and Signal Mountain Formations is gradational. It is determined lithologically by the change from light gray massive limestone (Fort Sill Formation) to dark gray thinly bedded limestone (Signal Mountain Formation). This contact was chosen at the base of the first occurrence of Signal Mountain type lithology (Figure 39).


Figure 39. Contact Between the Fort Sill (Left) and Signal Mountain Formations (Right), Bally Mountain. The Contact is the First Shaley Interval (s) Above the Massive Gray Limestone; Algal Mound (a), and Royer Dolomite (R) are Located at the Left Bottom Corner of the Photo

Sedimentary Structures

Parallel laminations of alternating siliciclastic siltstone and limestone occur throughout the section. The limestone laminae consist mostly of micrite whereas the siliciclastic laminae are dominantly very fine sand to coarse silt size quartz, feldspar and glauconite (Figure 40). Minor amounts of small scale cross bedding are defined by the two differing lithologies.

Stylolites and pressure solution seams occur between the two lithologies, with amplitudes of up to 4 cm (1.5 inches).

## Petrography, Petrology and Related Sedimentary Features of the Fort Sill Formation

The Fort Sill Formation contains a variety of detritals, allochems, authigens and related sedimentary features. These components are categorized into four groups and will be discussed in the following order:

1. Siliciclastics - Detritals
   - A. Quartz
   - B. Feldspar
   - C. Rhyolite
   - D. Muscovite
2. Allochems
   - A. Body Fossils - Animals
     1. Pelmatozoans
     2. Trilobites
     3. Phosphatic Brachiopods
     4. Brachiopods


Figure 40. Parallel Laminations of Alternating Siliciclastic Siltstone and Limestone Found in the Fort Sill Formation, Bally Mountain. Note Complex Burrow

5. Gastropods

6. Sponge Spicules

B. Fossils - Plants

1. Oncolites

2. Algal Boundstone

C. Trace Fossils

1. Peloids

2. Bioturbation

D. Miscellany

1. Ooids

2. Intraclasts

3. Authigens - Cements

A. Micrite

B. Sparite

C. Dolomite

E. Iron Minerals

4. Related Sedimentary Features

A. Laminations

B. Stylolites

C. Geopetal Voids

Siliciclatics - Detritals

Quartz

Quartz grains are found throughout the formation in lenses, laminations and as undissolved accumulations in pressure solution seams. In general, both grain size and content of quartz decrease up section

(Figure 41). Grains that are well sorted and angular to subrounded, range in abundance from trace amounts to 35%. They vary in size from coarse silt (0.05 mm) to medium sand (0.25 mm). Syntaxial overgrowths are common. Most grains (including syntaxial overgrowths) are etched by calcium carbonate.

#### Feldspar

Highly altered feldspar grains range in abundance from trace amounts to 2% (Figure 41). Subangular to subrounded grains vary in size from coarse silt (0.05 mm) to medium sand (0.25 mm). Grains are most often found in lenses, laminations and as undissolved detritus in pressure solution seams.

#### Rhyolite

Rhyolite fragments occur in the lower half of the formation in trace amounts, although abundant angular rhyolite clasts up to 5 mm in diameter are found near the basal unconformity between the Fort Sill Formation and Carlton Rhyolite (Stumbling Bear Pass, Chapter III).

#### Muscovite

Muscovite flakes occur only in trace amounts, and are usually found along pressure solution seams.

### Allochems

#### Fossils - Animals

Pelmatozoans. The content of pelmatozoan grains remains constant

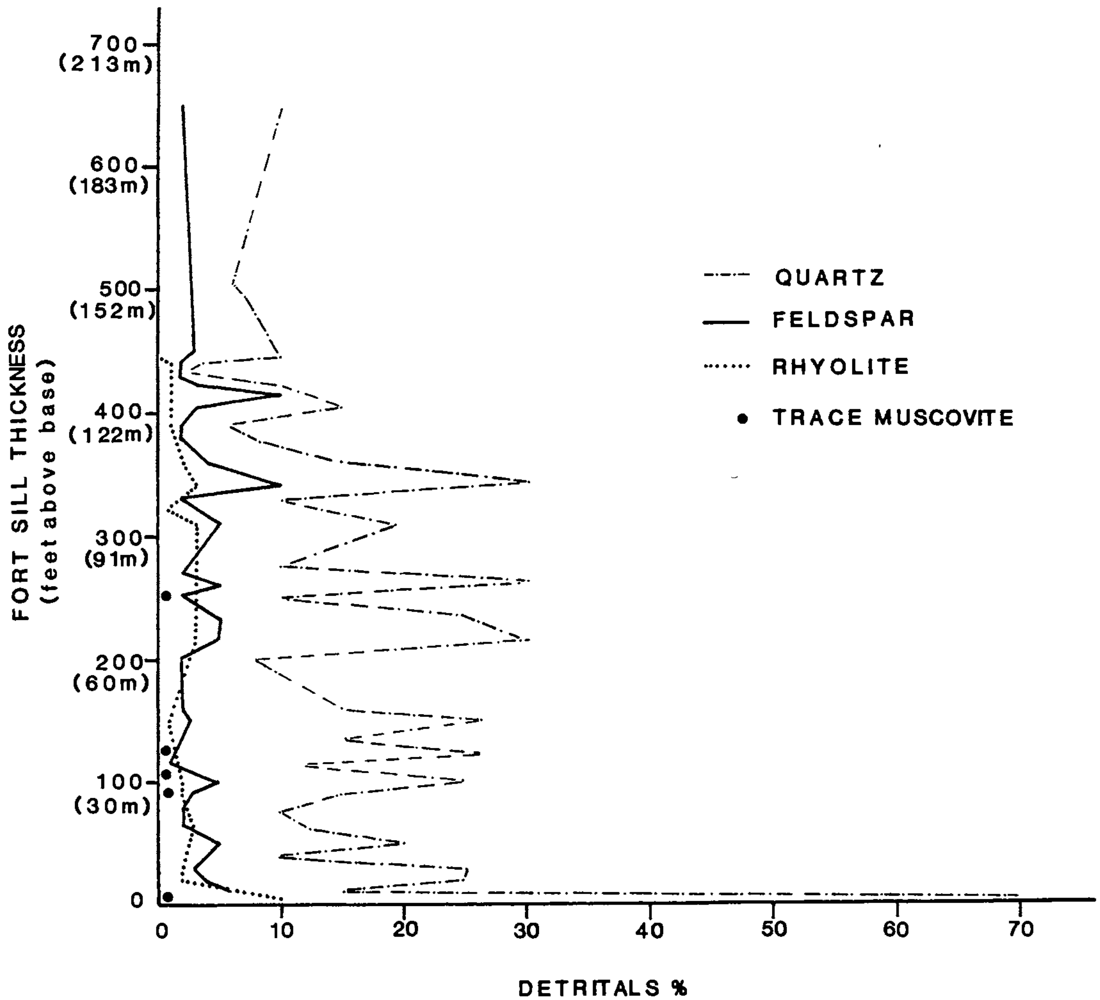



Figure 41. Variation in the Siliciclastic Detrital Content in the Fort Sill Formation

throughout the formation, averaging 15% (Figure 42). The grains range from fine pebble (2.5 mm) to very fine sand (0.45 mm) size. Micrite has filled many plate pores and coated many grains. Syntaxial overgrowths occur on most pelmatozoan fragments. Some of these syntaxial overgrowths are rounded. In rare cases, pelmatozoan fragments have been silicified (Figure 43).

Trilobites. The content of triliobite fragments remains constant at approximately 10% throughout the formation (Figure 42). The fragments range from medium pebble (8 mm) to very coarse sand (1 mm) size. Many fragments have created shelter porosity and geopetal structures. They are most commonly found in association with pelmatozoan fragments.

Brachiopods. Silicified brachiopods, were first identified and used as a marker in the Fort Sill Formation by Ulrich (1932). In the present study fragments were found in trace amounts in the upper massive unit of the formation (Figure 42). Fragments ranging in size from 2.75 mm to 1.5 mm, are most commonly found as undissolved accumulations in pressure solution seams.

Phosphatic Brachiopods. Trace amounts of phosphatic brachiopods are present in the lower two ad hoc units but were not found above the lower part of the uppermost unit (Figure 42). Fragments averaging 1.5 mm in length are most commonly found in laminae and along pressure solution seams.

Gastropods. Gastropods are generally uncommon; none were found in the lowermost seventy-three m (240 ft) of the formation (Figure 42). Shell shapes are preserved due to the early diagenetic polymorph

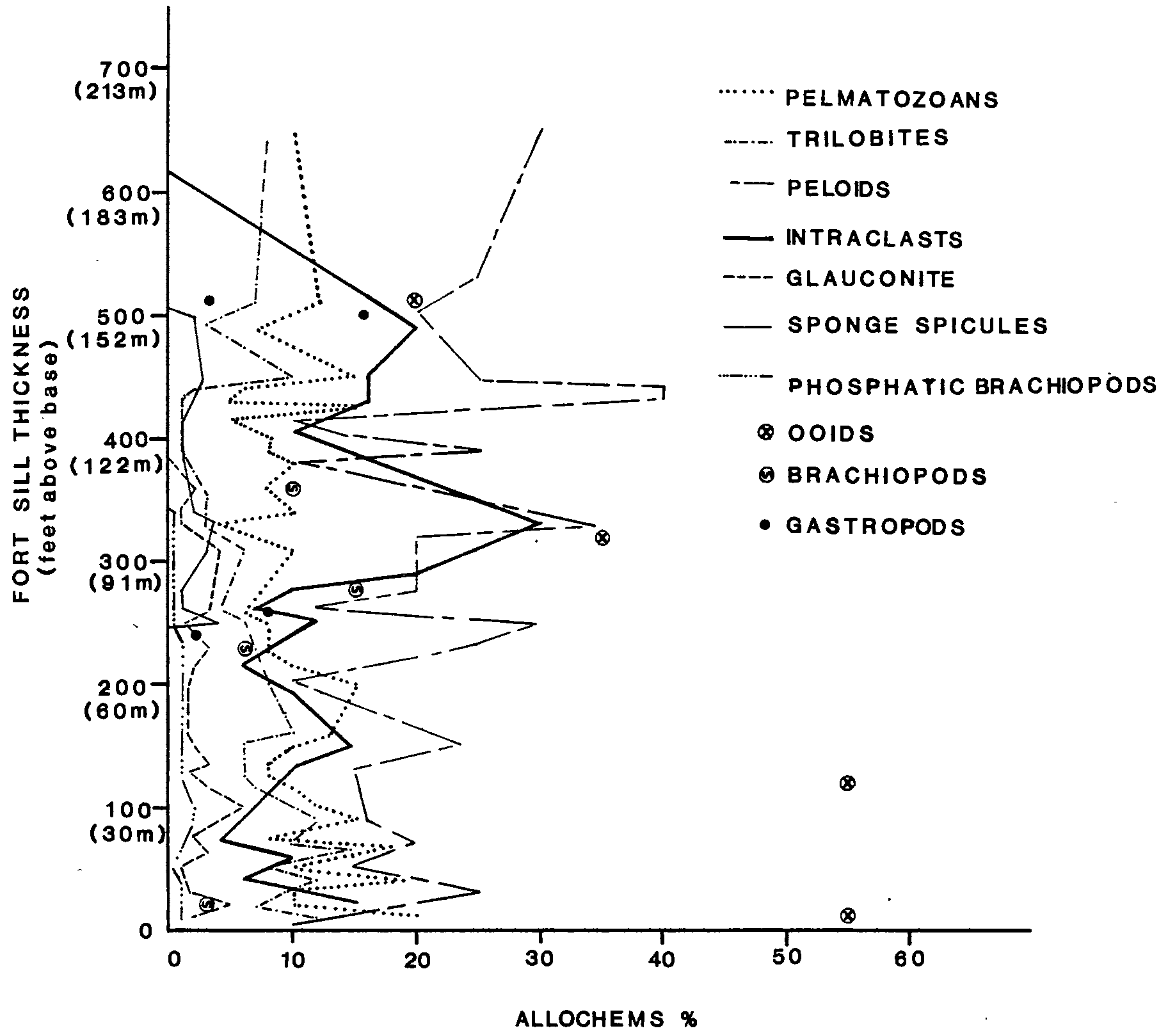



Figure 42. Variation in the Allochem Content of the Fort Sill Formation

Figure 43. Geopetal Modified by Diagenesis. Micrite Partially Infilling Brachiopod Has Been Repalced by Zoned Ferroan Dolomite. The Pelmatozoan (p) Ossicle Has Been Partially Replaced by Silica (x 80)

inversion of aragonite to drusy spar and the filling of the spire by micrite. The internal molds of micrite are sometimes replaced by ferroan dolomite. Gastropods average 2.75 mm in diameter (Figure 44).

Sponge Spicules. Trace amounts of siliceous sponge spicules (identified by Ulrich (1932) as hexactinellid glass sponges) were found in the upper massive limestone unit of the formation Figure 42). Spicules range in length from 0.055 mm to 0.95 mm. They are most commonly found associated with micrite (Figure 45).

### Fossils - Plants

Oncolites. Oncolites of up to 10.5 mm in diameter occur near the basal unconformity between the Fort Sill and Carlton Rhylolite Formations (Stumbling Bear Pass, Chapter 3). The oncolites consist of light gray micrite surrounding angular rhyolite clasts (Figure 46).

Algal Boundstone. Algal boundstones of two varieties occur in the Fort Sill Formation; algal mounds and stromatolites.

Algal mounds are found in the upper massive limestone unit of the Fort Sill Formation immediately above the Royer Dolomite (45 m below the base of the Signal Mountain Formation) at Bally and Zodletone Mountains; and in the upper massive limestone unit at Blue Creek Canyon. They occur as mounds in laterally persistent beds. The mounds are dome shaped with elliptical outlines in plane view. Dimensions of the mounds are up to 6 m (20 feet) wide and 13 m (40 feet) long. In many areas the mounds coalesce and are therefore difficult to distinguish as discrete entities (Figure 47). Slabbed hand samples and thin sections reveal

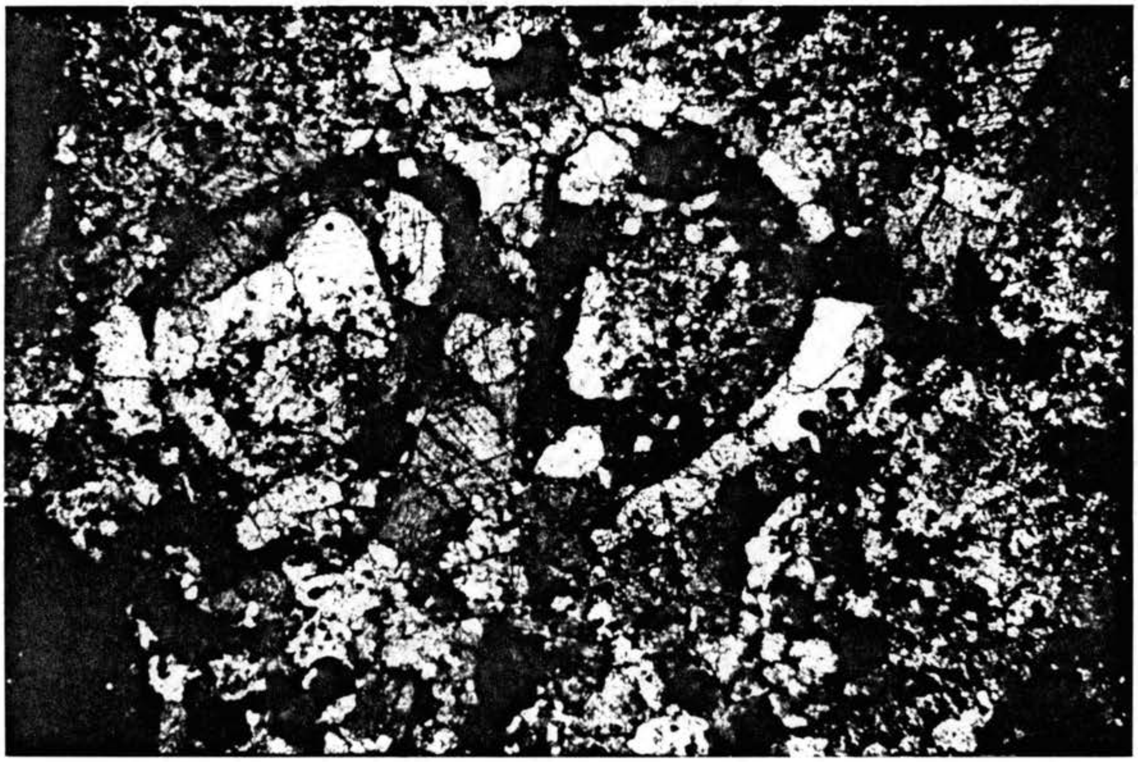


Figure 44. Gastropod Mold Composed of Micrite and Infilled by Drusy Spar (x 80)

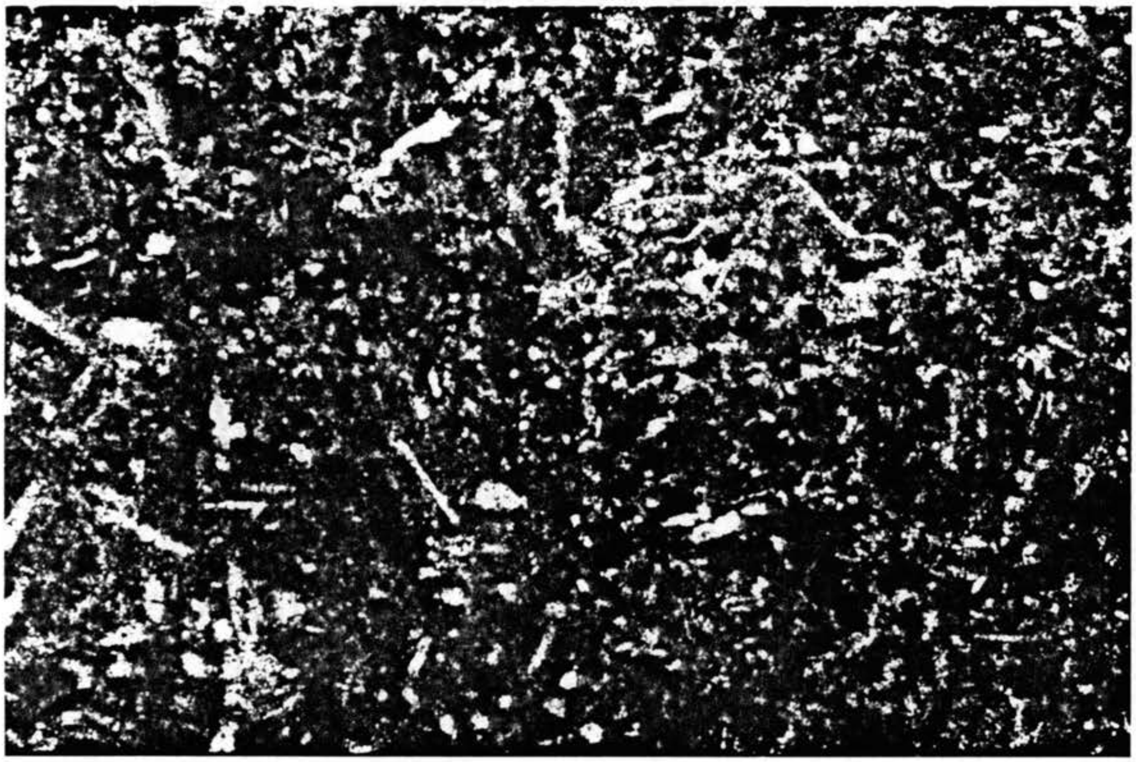


Figure 45. Sponge Spicules in a Peloidal Micrite (x 160)

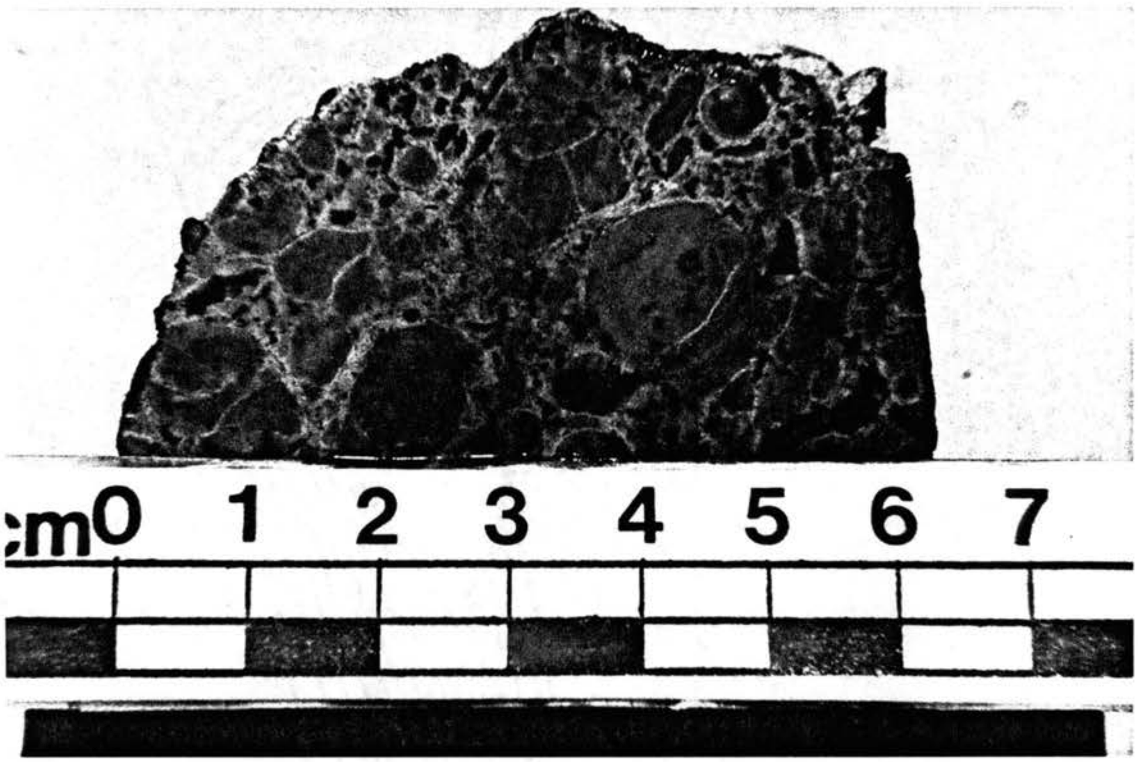



Figure 46. Oncolites and Rhyolite Clasts at the Unconformity Between the Fort Sill and Carlton Rhyolite Formations, Stumbling Bear Pass

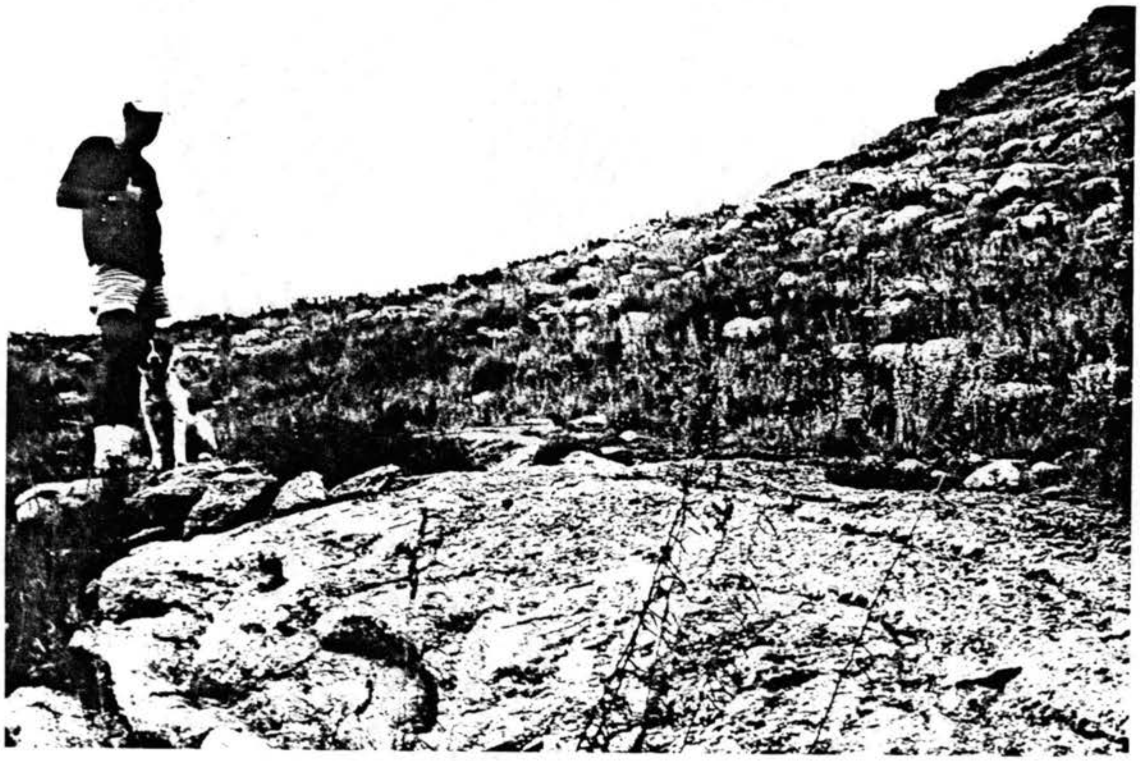


Figure 47. Algal Mounds in the Upper Massive Limestone Unit of the Fort Sill Formation, Bally Mountain

planar, crinkly, cryptalgal laminations of light gray micrite and fenestrae infilled with spar and baroque dolomite (Figure 48).

Rare stromatolites are found throughout the formation. Most stromatolites are horizontally laminated; many pass up into cylindrical, columnar forms. Laterally linked columns attain heights up to 254 mm (10 inches) with individual laminae up to 4 mm thick (Figures 49, 50, 51). Ooids, pellets, micrite, intraclasts, fossil hash and siliciclastics infill the areas between individual columns.

Trace Fossils

Peloids. Glauconitic peloids decrease up section and are rarely found in the massive upper limestone unit of the formation (Figure 42). Pellets vary in size from coarse silt (0.04 mm) to fine sand (0.125 mm). They range in abundance from 1% to 6% and commonly occur along pressure solution seams or associated with siliciclastic laminations.

Ovoid micrite pellets increase in abundance (1% to 35%) up section and range in size from coarse silt (0.06 mm) to medium sand (0.45 mm) (Figure 42). Because the pellets are well sorted, ovoid in shape and are found in association with fossil fragments, they are assumed to be fecal in origin.

Bioturbation. Horizontal burrows, most commonly found in finely laminated units, occur as orange weathered casts infilled by micrite and quartz silt. Burrows are approximately 1.5 cm in width (Figure 52).

Vertical burrows infilled by a dark reddish brown micrite are found only at the basal unconformity between the Fort Sill Formation and Carlton Rhyolite (Figure 53) (Stumbling Bear Pass, Chapter III).


Figure 48. Slabbed and Polished Algal Mound Dismicrite Showing Planar Crinkly Crypt Algal Laminations and Fenestrae Infilled with Sparite, Bally Mountain

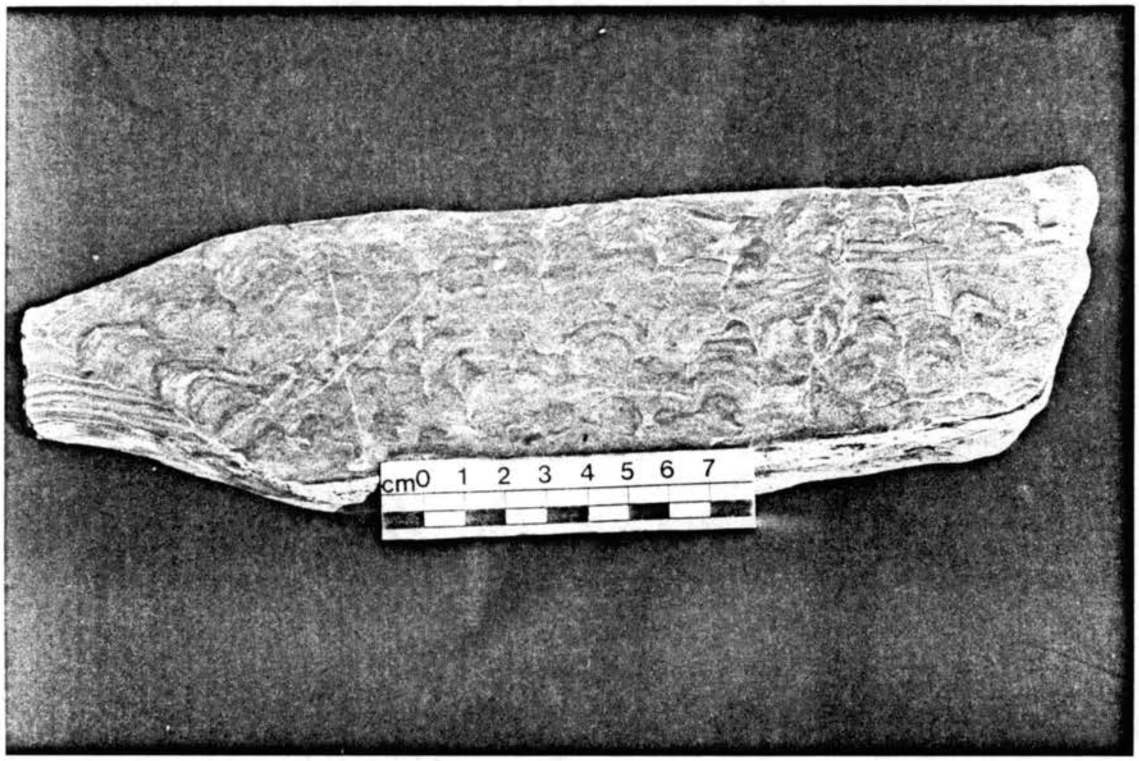



Figure 49. Fort Sill Formation Stromatolite Displaying Laterally Linked Hemispheroid Morphology

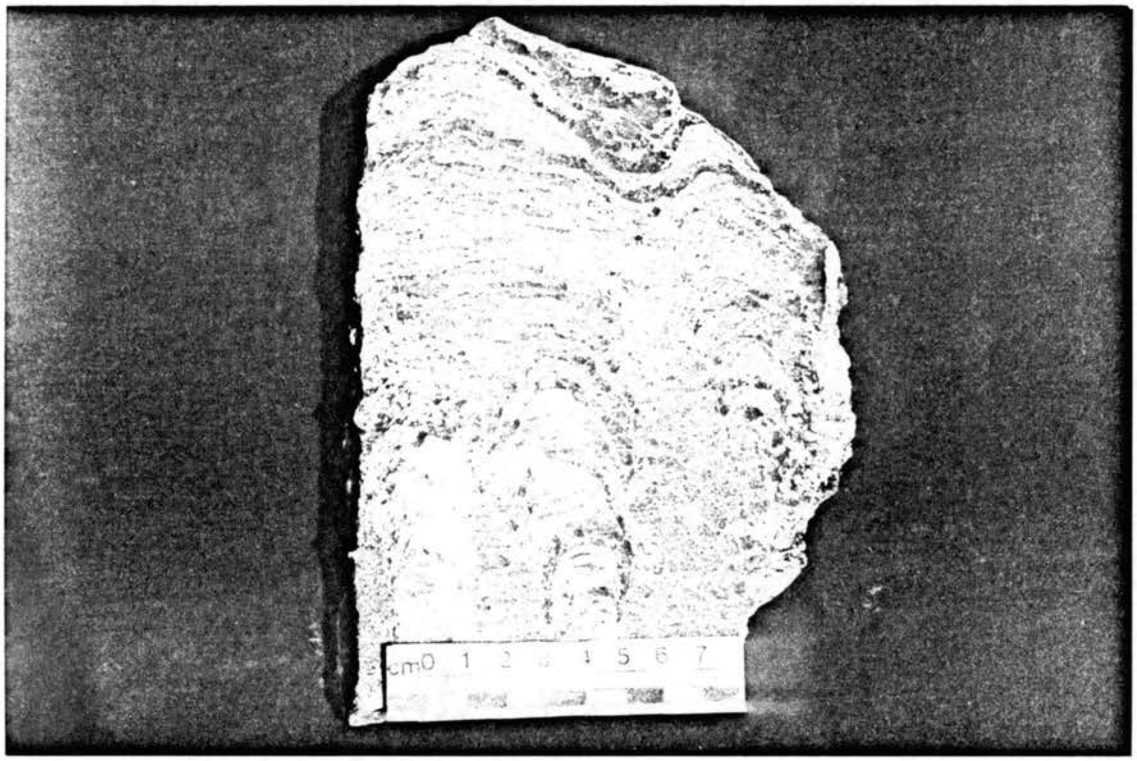


Figure 50. Fort Sill Formation Stromatolite. Vertically Stacked Hemispheroids Become Laterally Linked Up the Columns

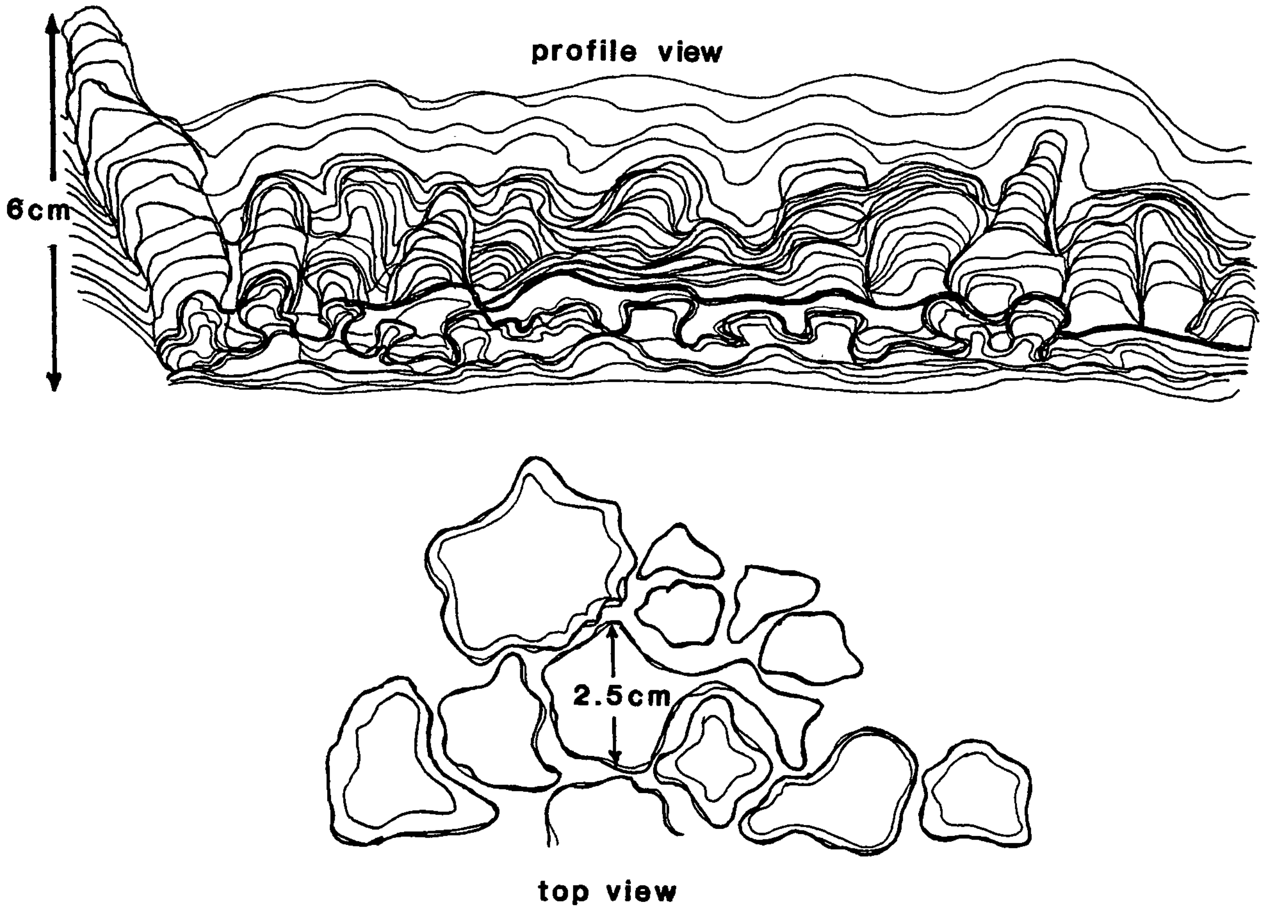



Figure 51. Sketch Showing Dimensions of Laterally Linked Hemisphiroid Morphology, Fort Sill Formation

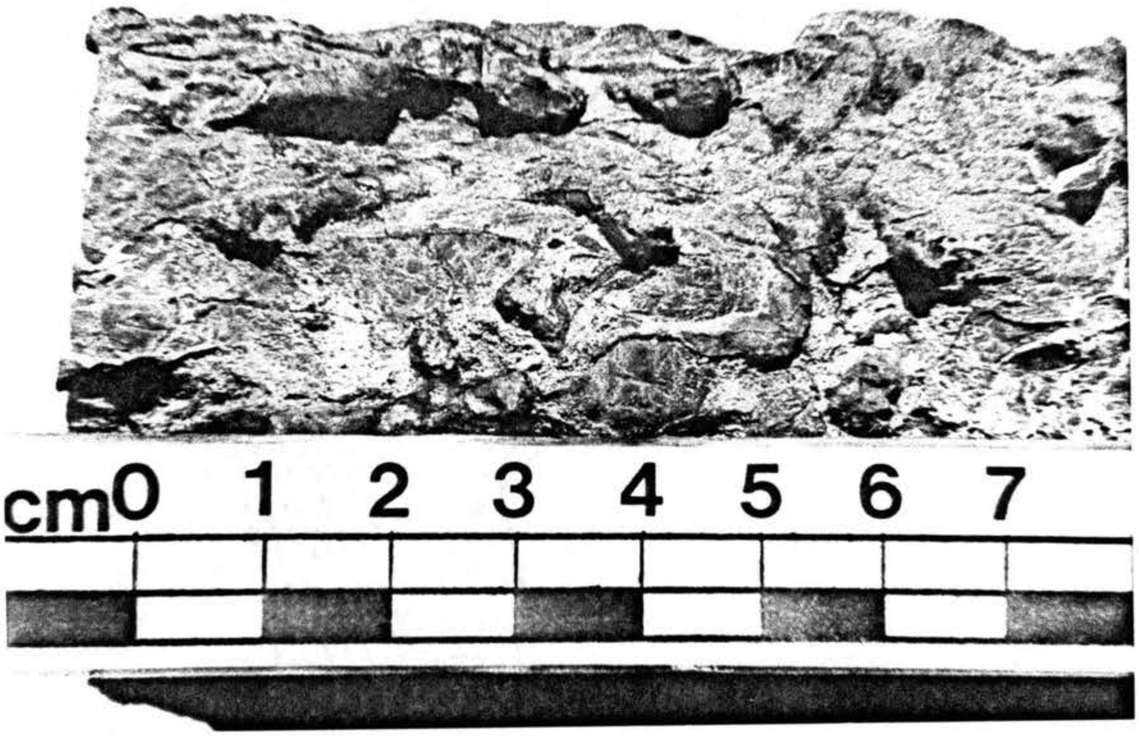



Figure 52. Horizontal Burrow Casts (Weathered Orange). Infill Consists of Micrite and Quart Silt Grains

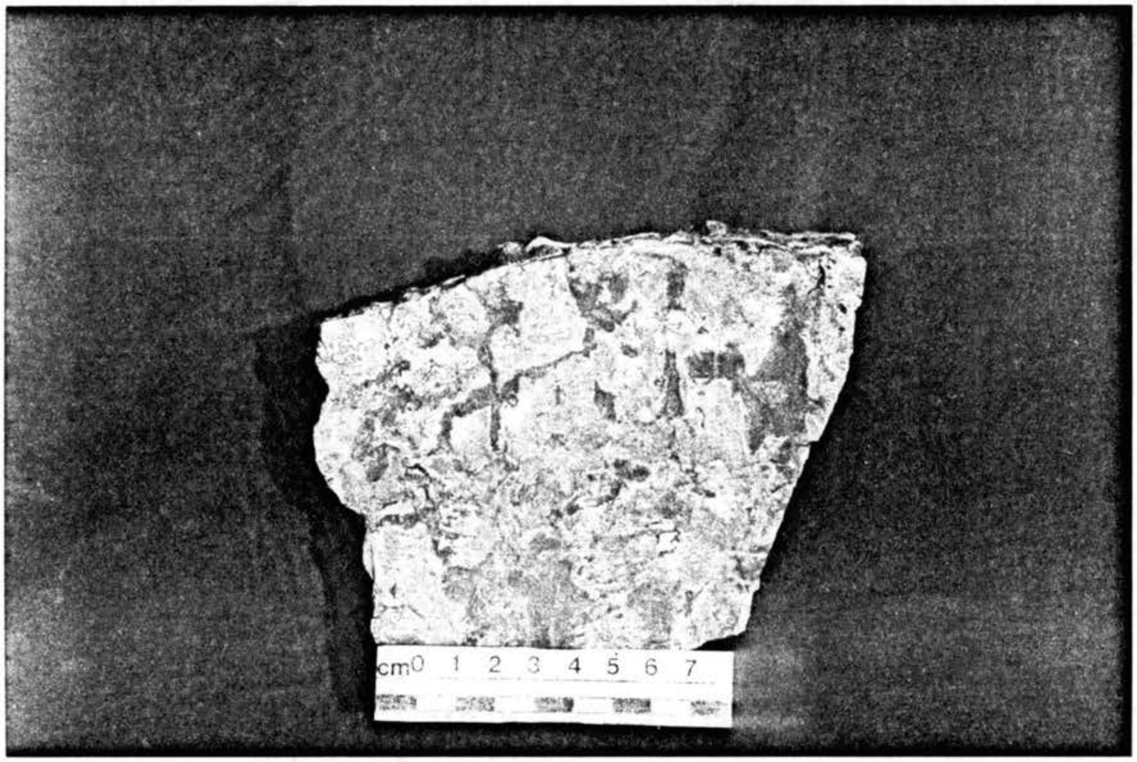



Figure 53. Vertical Burrows Infilled by Dark Reddish Brown Micrite. Found Near the Unconformity Between the Fort Sill and Carlton Rhyolite Formations, Stumbling Bear Pass

### Miscellany

Ooids. Ooids occur sporadically throughout the formation. They do not appear to form laterally persistent beds, but are dispersed as lenses in micritic, sparry and stromatolitic horizons. Most of these horizons are less than 2 cm thick.

Individual ooids range in size from 0.42 mm to 0.63 mm. Two basic internal structures are generally recognized in thin section (Tucker, 1981): radial and concentric. Most of the Fort Sill Formation ooids are of the radial variety. The nuclei are either pelmatozoan and trilobite fragments, or quartz grains. In some cases dolomitization (ferroan dolomite or ankerite) and micritization have destroyed the original structure of the ooids (Figures 54, 55).

Intraclasts. Intraclasts, consisting mostly of micrite and quartz silt, range in abundance from 0-10% (Figure 42). Rounded elongate clasts vary in size from 0.22 mm to 3.75 mm. They are associated most commonly with ooids, pellets and micrite cement. Occasionally clasts have been preferentially dolomitized and glauconitized (Figure 54).

## Authigenics

### Micrite

Micrite occurs most abundantly in fine laminations. It comprises from 1% to 55% (average 35%) of the total rock (Figure 56). The micrite may contain quartz and feldspar silt and occasional glauconite peloids. It is commonly found in intraclasts (producing wackestone and packstone

Figure 54. Ooids and Intraclasts in Spar Cement. Note Edge of Intraclast (i) is Replaced by Glauconite (x 80)

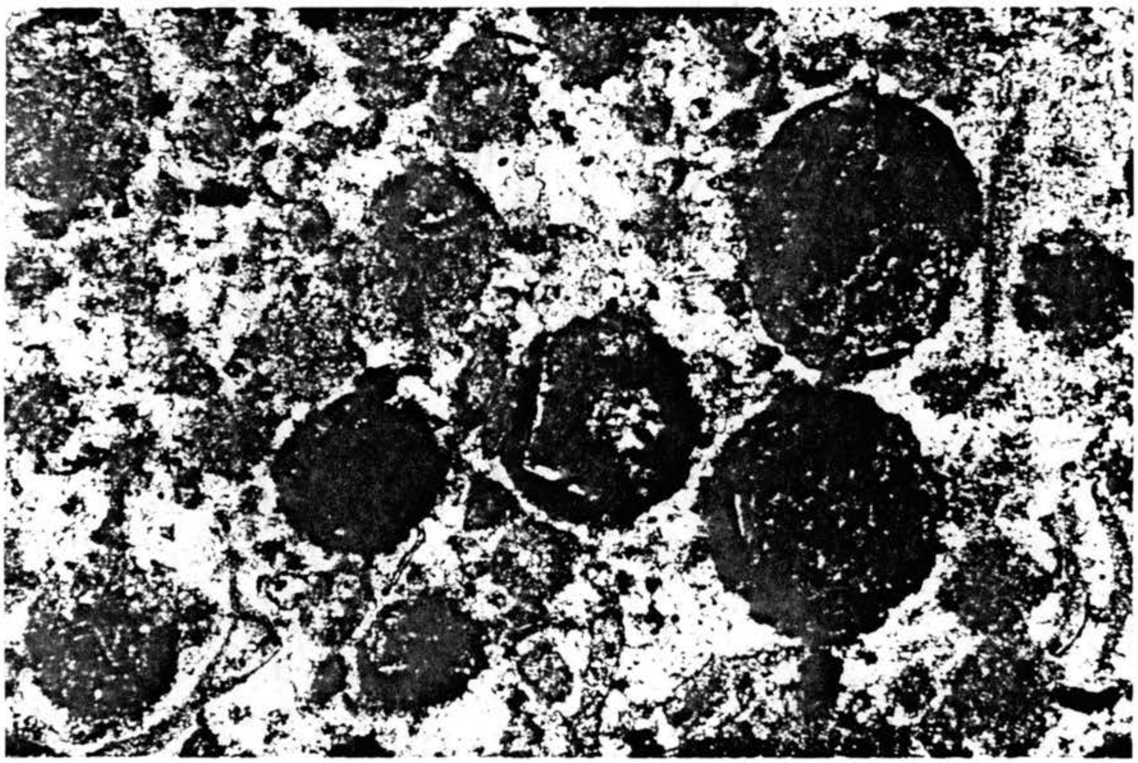


Figure 55. Ooids Replaced by Ferroan Dolomite in Sparry Cement (x 160)

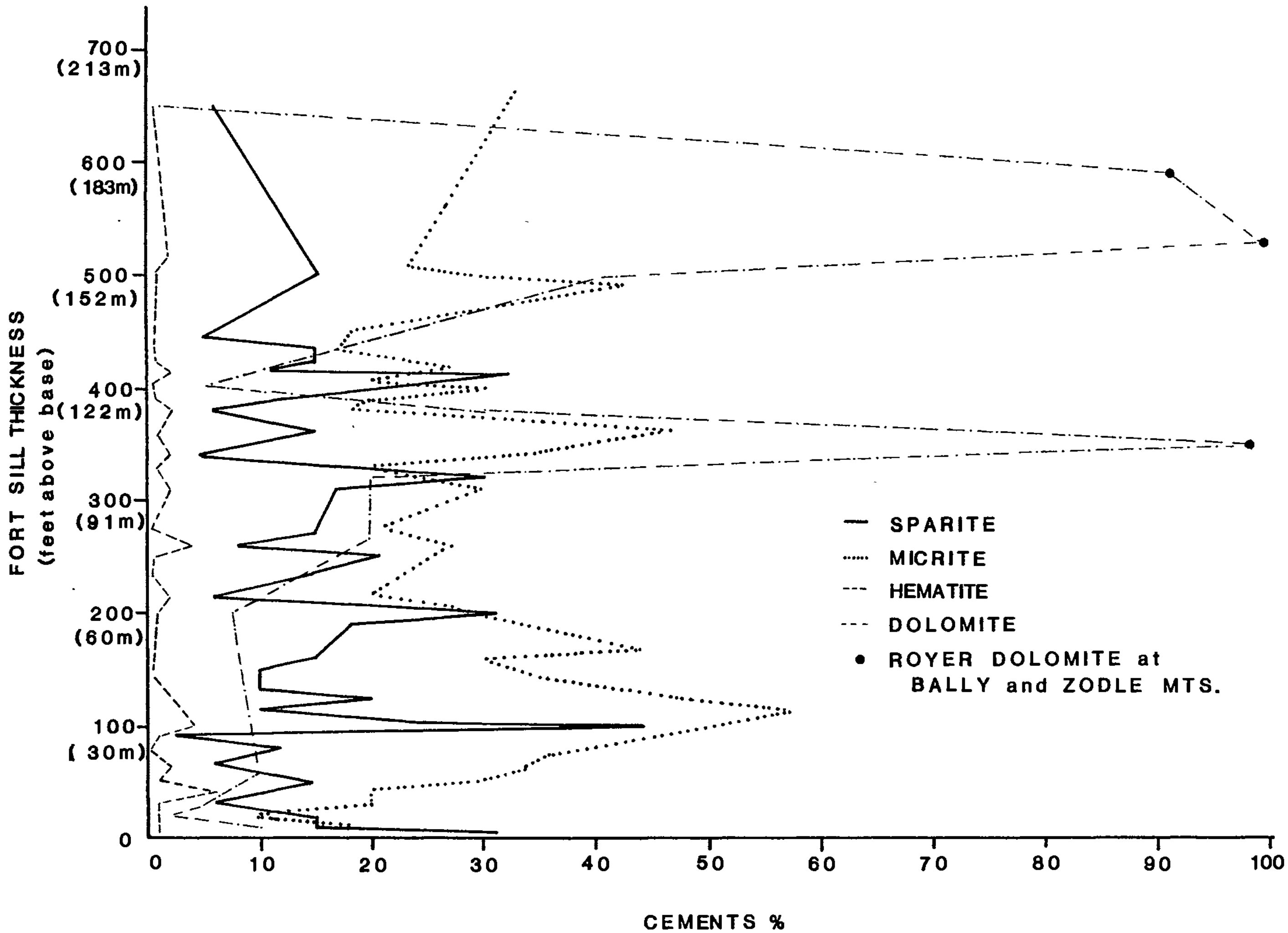



Figure 56. Variation in the Cements and Lime Mud Content in the Fort Sill Formation

textures). It has infilled burrows and appears to have been preferentially replaced by ferroan dolomite (ankerite).

### Sparite

Sparite decreases up section and ranges in abundance from 3% to 32%, (averaging 15%) of the total rock (Figure 56). It occurs most frequently as blocky euhedral sparite infilling vugs, fenestrae, shrinkage porosity and shelter porosity. It also commonly occurs as syntaxial overgrowths on pelmatozoan fragments. Sparite has etched and replaced quartz, feldspar and glauconite grains.

### Dolomite

Two varieties of dolomite occur in the formation:

1. ankerite occurs as zoned scattered rhombohedrons of uniform (0.30 mm across) size. The ankerite has preferentially replaced the micrite infilling burrows, micritic intraclasts and oolites. It is also found along pressure solution seams.
2. Baroque dolomite occurs as an interlocking mosaic of ferroan rhombohedrons containing some glauconite and quartz grains (Figure 56).

### Iron Minerals

Hematite and pyrite are found throughout the formation from trace amounts to 3%. Hematite is found lining vugs, coating grains, outlining burrows and as accumulations along pressure solution seams. Pyrite infrequently occurs as cubes up to 0.275 mm across.

## Related Sedimentary Features

### Laminations

Alternating laminations of siliciclastic siltstone (3.6 mm) and micritic limestone (5.0 mm) occur throughout the formation (Figure 57). Many laminated units are disrupted by bioturbation and stylotization (Figure 57). Pressure solution has occurred commonly between the two lithologies.

### Stylolites

Stylolites occur throughout the Fort Sill Formation. Thin section analysis reveals parallel sets of low amplitude (0.16 mm to 0.75 mm) microstylolites. Accumulations along the pressure solution seams consist of quartz and feldspar grains, hematite, silicified fossil fragments, phosphatic brachiopod fragments, glauconite and illite.

### Geopetal Voids

Geopetal voids are most commonly found as the result of arched trilobite and brachiopod fragments settling lengthwise and parallel to bedding. The fragments have entrapped and collected micrite. Fragments of this type and orientation have also created shelter porosity by preventing mud infiltration. In all cases this porosity as been infilled by drusy spar (Figure 43).

## Diagenesis in the Fort Sill Formation

The Fort Sill Formation has been subjected to uncomplicated and relatively minor diagenetic processes. Like the Honey Creek Formation,

Figure 57. Laminations of Silt Sized Siliciclastics and Micrite Disrupted by Bioturbation and Stylotization (x 80)

the Fort Sill Formation has been affected by both chemical and physical diagenetic processes.

The chemical processes include:

1. secondary authigenic precipitation
2. alteration, dissolution and replacement.

The principal physical processes are:

1. pressure solution
2. stylotization.

## Chemical Processes

### Secondary Authigenic Precipitation

Minerals recognized as secondary authigenic precipitants include calcite, silica and hematite.

Calcite. Calcite occurs as a secondary authigenic precipitant in the form of pore filling cement. Cement characterized by differing fabric types may be recognized as occurring in successive diagenetic phases.

The types of cements found in the Fort Sill Formation include syntaxial overgrowths, drusy spar, and anhedral equant spar.

Syntaxial overgrowths on pelmatozoan fragments,as previously discussed in Chapter IV, occur as an early phase of cementation in the paragenetic sequence of the formation. Initial cementation was often preceeded by the infilling of ossicle pores and the coating of grains by micrite envelopes (Figure 45).

Syntaxial cementation probably occurred relatively early in the freshwater phreatic-active zone (Figure 33) (Flügel, 1982).

Both drusy spar and anhedral spar probably formed relatively late in the diagenetic history of the formation. These types of spar are typical cements precipitated in either the meteoric phreatic zone or after deep burial (Figure 33) (Tucker, 1981).

Both types of cement are found most commonly filling pores, vugs, fractures, and shelter porosity. Complex, relationships between calcite and silica cements exist due to fluctuating pH of ground waters (Figure 58).

Silica. The secondary precipitation of silica as a cement was in the form of syntaxial overgrowths on detrital quartz grains and as minor pore-filling megaquartz and microquartz.

Overgrowths are commonly present in those laminae in which quartz is the main constituent. Such laminae occur mostly in the lower two-thirds of the formation. The main source of silica is either from the dissolution of quartz and feldspar as the result of pressure solution or from pH changes in the formation fluids.

Most of the pore-filling silica (which is very minor) exists in the form of anhedral megaquartz. Megaquartz represents the last phase of secondary silica precipitation (Figure 58).

Hematite. Hematite occurs both as grain coatings and as pore-filling cement. The main source of iron probably was derived from devitrified rhyolite. The decrease in hematite up section suggests that marine waters probably contained high concentrations of iron early in Fort Sill time as some of the Carlton Rhyolite paleohills were still directly exposed to transgressing seas. Hematite is indicative of oxy-

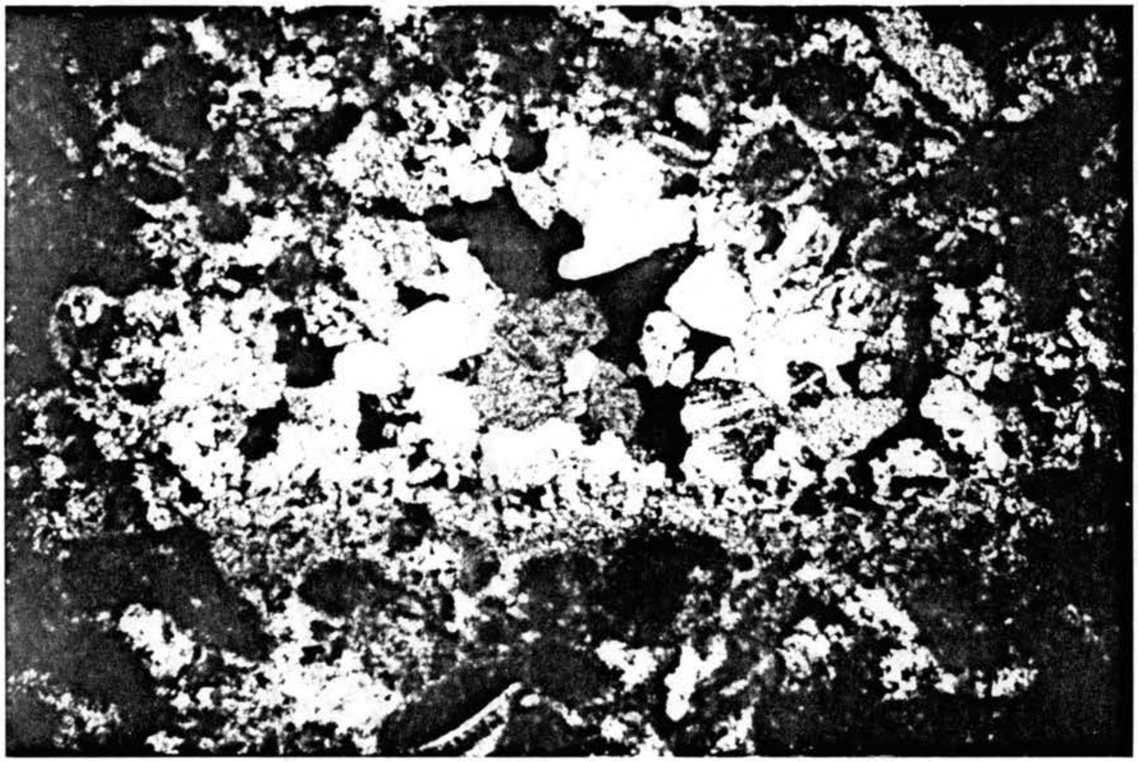


Figure 58. Alternating Drusy Spar and Anhedral Silica Cements Infilling a Fracture in an Oointrapelmicrite (x 80)

dizing conditions (Tucker, 1981) and is thought to have been precipitated early in the diagenetic history of the Fort Sill Formation.

### Alteration, Dissolution, Replacement

As in the Honey Creek Formation, evidence of alteration, dissolution, and the replacement of one mineral by another is common in the Fort Sill Formation.

The minerals and constituents affected by one or more of these processes are silica, glauconite, dolomite and calcite.

Silica. The replacement of calcitic brachiopods and pelmatozoan ossicles by silica probably occurred relatively early in the diagenetic history of the formation. It appears that silicification was initiated in the centers of pelmatozoan ossicles and brachiopod valves (Figure 43). This suggests that a local slightly acidic environment due to organic decay exsisted within or near the fossil fragments. The sources of silica probably included dissolved quartz grains and the siliceous sponge Hexactinellida, as both silicified fossils and siliceous sponges only occur in the upper massive unit of the Fort Sill Formation.

Glauconite. Partially glauconitized micritic intraclasts were found only in the lower unit of the Fort Sill Formation (Figure 54). Glauconitization probably occurred early in the paragenetic sequence. Glauconitized peloids, similar to those found in the Honey Creek Formation, occur in abundance at the base of the Fort Sill Formation, decreasing to negligible amounts up section. Glauconitization of both intraclasts and peloids is thought to have formed in the same manner as discussed in Chapter IV.

Dolomite. As noted previously, dolomite occurs in two forms in the Fort Sill Formation.

1. non-baroque (zoned)
2. baroque (zoned and unzoned).

Scattered zoned rhombohedrons have preferentially replaced burrow-filling micrite, micritic intraclasts, fossil filling micrite (gastropods) and are also found along pressure solution seams. Preferential dolomitization of micrite probably occurred early in the diagenetic history of the formation when ground water percolated through conduits consisting of semi-consolidated lime mud.

Pore-filling baroque dolomite, found within the Royer Dolomite, appears to have formed late in the diagenetic sequence of the formation. The original limestone of the Royer was probably dolomitized by the mixing of groundwater enriched in iron and magnesium. Cloyd (1984)has studied the timing and geochemistry of dolomitization in the Royer Dolomite.

Calcite. The dissolution and replacement of siliciclastics was observed throughout the formation. As stated previously, the complex interrelationships between silica and calcite were controlled by fluctuating pH and temperatures of the formation water. The timing of dissolution and replacement of siliciclastics by calcite appears to have taken place intermittently, but most probably is related to deep burial (Dapples, 1979).

### Physical Processes

#### Stylotization and Pressure Solution

Pressure solution and stylotization are the primary mechanical diagenetic processes that have affected the Fort Sill Formation, although it appears that these processes have affected the Fort Sill Formation less than the Honey Creek Formation. This may be due to the greater amount of siliciclastics in the latter as well as less overburden in the former. Comparison of amplitudes between the two formations reveal that in general lesser degrees of pressure solution exist in the Fort Sill Formation than in the Honey Creek Formation (the average amplitude for the Fort Sill is approximately 0.30 mm, the average amplitude for the Honey Creek is approximately 0.675 mm). Pressure solution probably occurred throughout the late diagenetic stage of the Fort Sill Formation.

Figure 59 is a paragenetic interpretation of the Fort Sill Formation. The figure depicts a general timing of diagenetic events as deduced from textural evidence.

## Environment of Deposition of the Fort Sill Formation

An environment of deposition is suggested for the Fort Sill Formation based on an analysis of constituents and sedimentary features and the application of basic uniformitarianism analogies. The results of this analysis are suggestive of a shallow water open marine environment. No modern analogy precisely parallels this ancient environment, but

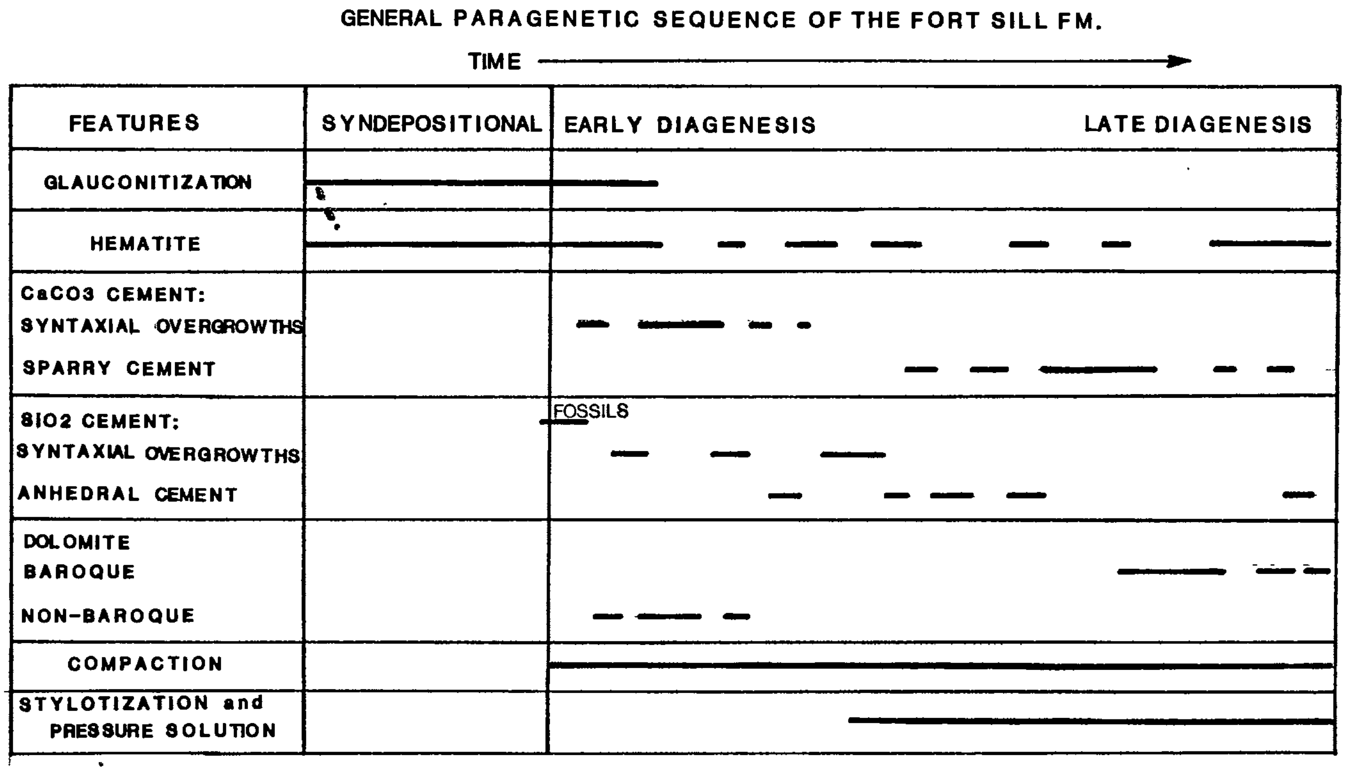



Figure 59. General Paragenetic Interpretation of the Fort Sill Formation

there is some similarity to the offshore environment of the Persian Gulf.

The Persian Gulf, a small shallow sea approximately 1000 km by 350 km, depicts a typical carbonate producing environment. Minimal seasonal influx of siliciclastic sediment is supplied by the Tigres, Euphrates and Karun Rivers. (Blatt, Middleton, Murray, 1980). The shallow Cambrian seas were apparently of greater areal extent than the Persian Gulf but were floored by sediments which show some parallels to the Fort Sill Formation environment - in particular a mix of siliciclastics and carbonate clastics.

## Overall Trends

The gradual change from a dominantly siliciclastic irregular shoreline to a highly productive carbonate shelf is represented by the transition from the Honey Creek Formation to the Fort Sill Formation. This is reflected by the gradual change in character of environmental indicators "up section."

The percentage of pelmatozoan fragments remains fairly constant throughout the Fort Sill Formation, although they are less common than in the Honey Creek Formation. Generally, Fort Sill Formation pelmatozoan fragments are dispersed throughout a matrix of micrite whereas the Honey Creek pelmatozoans were the principal constituent of coarse grained cross bedded sands. This change in depositional mode is suggestive of a decrease in wave or current energy.

The content of trilobites also remains fairly constant throughout the Fort Sill Formation. However trilobites also are less common than in the Honey Creek Formation.

Calcitic and phosphatic brachiopods clearly declined in abundance in the Fort Sill; no phosphatic brachiopods have been found in the upper quarter of the formation.

Stromatolites became more prolific particularly in the late Fort Sill time. Cyanobacteria successfully colonized large areas at this time and as a result, laterally persistent algal reefs and bioherms developed.

Sponges and gastropods initially colonized the area in the middle Fort Sill. Modern sponges require slight to moderate water agitation and slow sediment influx. Most modern gastropods inhabit waters less than 600 feet deep (Heckel, 1972). The occurrence of gastropods and sponges is supporting evidence suggestive of quiet water conditions.

An environmental indicator not found in the Honey Creek Formation is ooids. Typical modern ooids form in water supersaturated with calcium carbonate which is characterized by moderate to strong consistent agitation in depths from intertidal to 100 m (Heckel, 1972).

An increase in intraclasts and peloid content is obvious in the Fort Sill as compared to the Honey Creek. Both of these constituents are associated with oolites and stromatolites. This assemblage of sediments (most of which are grainstones) suggests an environment of considerable agitation (perhaps affected by storms) in an intertidal or shallow subtidal setting. The overall aspect of this facies resembles that of some marginal settings in the Persian Gulf, albeit they are not suggestive of lagoonal sediments.

A different facies, more common than the above, consists of laminated burrowed mudstones, wackestones, and packstones. By analogy with modern day settings, prolific horizontal burrows (Rhoads, 1967) may indicate a continuously submerged subtidal environment in which uniform conditions prevail. Such relatively low energy and stable conditions allow infaunal organisms to burrow to shallow depths and remain near the sediment surface.

An increase in the amount of micrite present clearly reflects the development of a prolific low energy carbonate producing environment. The low levels of hydrodynamic energy meant that there was little winnowing of sediment and as a result packstone and wackestone textures developed. The increase in carbonate productivity was accompanied by gradual cessation of siliciclastic input into the area.

Also reflecting a decrease in hydrodynamic energy is the predominance of fine parallel laminae of siliciclastic silt and micrite. The alternation of the two differing lithologies may be caused either by intermittent deposition (of one or both lithologies) or by changes in sediment provinance (Heckel, 1972).

## Environmental Synopsis of the Fort Sill Formation

The vast expanse covered by the transgressing Franconian sea and the shallow depths of water suggested by the foregoing sedimentary analysis, is compatible with increasingly weaker wave and current energy through time which may have resulted in a retarded rate of sorting of sediment into clearly defined facies belts. In general two lithological associations can be recognized and interpreted as follows:

1. in shallow subtidal and intertidal water depths, initially, local high energy oolitic sands accumulated as shoals. These shoals apparently stabilized and were then colonized by cyanobacteria resulting in stromatolitic development. Occasionally, storms

created high energy conditions which produced intraclasts and deposited ooids, peloids and intraclasts over the stromatolites. This facies is only found in the lower part of the formation.

2. Thinly bedded bioclastic carbonates interlaminated with siliciclastic siltstones were deposited in slightly deeper water seaward of the oolitic shoals. In this low-energy open marine environment, mostly below wave base a normal marine fauna of trilobites, brachiopods, pelmatozoans and (somewhat later) sponges and gastropods flourished. Glauconite possibly formed in this environment.

This scenario may be compared to the modern day Persian Gulf where the influx of siliciclastic sediments supplied by the Tigres, Euphrates and Karun Rivers is seasonal (Figure 60). Along the shore, intertidal zones are extensive and tidal flats are covered with cyanobacteria. Near shore, in very shallow water, lime mud accumulates along with fecal pellets. Patches of mud reflect decreased agitation on the protected lee sides of islands where wave base is not deep. Along the shallowest fringe of this zone are ooide shoals. In deep water, lime muds and glauconite form (reflecting low sediment influx) (Heckel, 1972).

In general, the Fort Sill Formation records the general decrease of siliciclastic input, probably due to the covering of the Honey Creek archipelago (Carlton Rhyolite Islands) and, as the transgression continued, increased the distance of the Slick Hills area from influent rivers (which, as noted previously, drained an area to the north). Fluctuating sediment supply occurred throughout the lower and middle limestone unit time. By upper massive unit time the supply of quartz silt and other siliciclastic sediment almost ceased. As a result the most prolific carbonate production during the whole of the Fort Sill

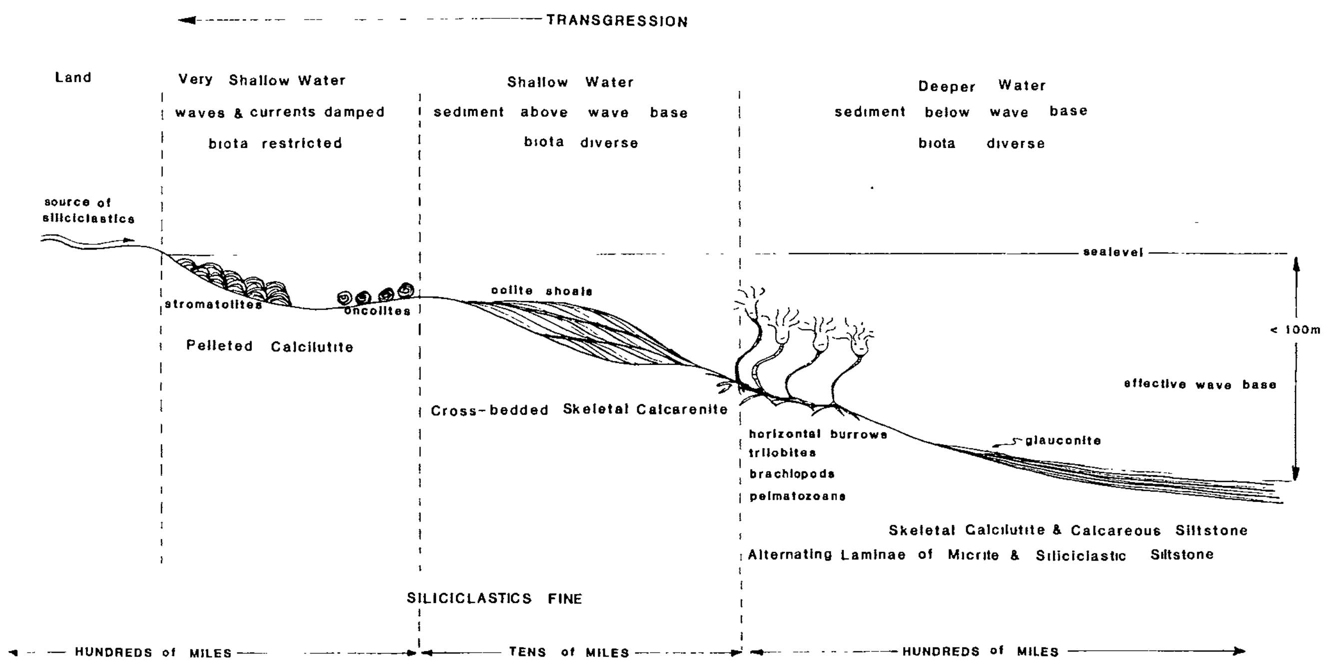



Figure 60. Diagrammatic Interpretation of the Environment of Deposition of the Fort Sill Modeled after the Persian Gulf (Modified from Heckel, 1972)

took place. One feature of note is the development of algal reefs and mounds at this time. These boundstones are not associated with ooids or intraclasts (as they were in the lower Fort Sill). It seems likely that the cyanobacteria colonized stable mud banks in a shallow sea which was little disturbed by major hydrodynamic energy. This calm scenario changed abruptly with deposition of the Signal Mountain Formation (Ditzell, 1984).

## CHAPTER VI

## SUMMARY AND CONCLUSIONS

The purpose of this study is to describe the sedimentary geology of the Cambrian Honey Creek and Fort Sill Formations. Specifically, this study presents an interpretation of the environments of deposition and the diagenetic histories of these Formations. The study area is located in the Slick Hills of southwestern Oklahoma.

The Honey Creek and Fort Sill Formations locally unconformably overly the Carlton Rhyolite. The unconformity records a major Franconian marine transgression. The paleogeomorphology of the Carlton Rhyolite during the Late Cambrian consisted of an archipelago of rocky rhyolite islands surrounded by shallow transgressing seas. This provided a setting that resulted in the Honey Creek and Fort Sill Formations onlapping hills of Carlton Rhyolite, thus creating an irregular unconformity. Facies recognized at the unconformity between the Honey Creek and Carlton Rhyolite Formations are interpreted to represent two coastal environments, an exposed coastline and a sheltered coastline.

The following constituents and sedimentary features were recognized in the Honey Creek Formation:

1. Siliciclastics: quartz, feldspar, rhyolite and minor amounts of zircon and muscovite in general decrease both in grain size and abundance up section.

2. Allochems: pelmatozoans, trilobites, brachiopods, phosphatic brachiopods, stromalolites, oncolites, and algae are the only fossils identified in the formation. Glauconatized pellets and horizontal burrows are found as trace fossils throughout the formation. Intraclasts occur in minor amounts.
3. Authigens: Sparite occurs as a cement in the form of syntaxial overgrowths, radiaxial fibrous, drusy and anhedral spar. Dolomite occurs both as zoned ferroan rhombohedrons and in the baroque crystal form. Micrite mostly occurs as internal sediment filling cavities, burrows, pore spaces and geopetals. Glauconite is found replacing rhyolite clasts, filling pelmatozoan pores and replacing pellets. Hematite coats grains and fills pore spaces. Pyrite occurs in trace amounts.
4. Related sedimentary features: laminations, bioturbation, stylolites, and geopetals are the most common sedimentary structures. Porosity is negligible.

The Honey Creek Formation has been affected by both chemical and physical diagenetic processes. The chemical processes include secondary authigenic precipitation of calcite, silica, glauconite, and hematite; and alteration, dissolution and replacement of rhyolite, glauconite, calcite, dolomite and silica. The principal physical processes are pressure solution and stylotization.

The environment of deposition of the Honey Creek Formation is interpreted as a shallow mixed siliciclastic/carbonate marine environment; gradually evolving from a dominantly siliciclastic irregular shoreline to a highly productive shallow carbonate shelf environment.

Three ad hoc stratigraphic units are recognized in the Fort Sill Formation:

1. lower limestone unit
2. middle silty limestone unit
3. upper massive bedded limestone unit

The following constituents were recognized in the Fort Sill Formation:

1. Siliciclastics: quartz, feldspar, rhyolite and muscovite occur in laminae interbedded with micrite laminae.
2. Allochems: pelmatozoans trilobites, phosphatic brachiopods, calcitic brachiopods, gastropods and sponge spicules, oncolites and stromatolites are the only fossils recognized in the formation. Micritic and glauconitic peloids are recognized as trace fossils. Ooids and intraclasts are most commonly found in association with stromatolites.
3. Authigens: micrite occurs most abundantly in laminae. Sparite occurs as anhedral spar, and drusy cement, filling vugs and fenestrae. Dolomite occurs as zoned rhombohedrons preferentially replacing micrite and in the baroque crystal form. Hematite coats grains and fills pores. Pyrite occurs in minor amounts.
4. Related Sedimentary features: laminations, stylolites, and geopetals are the most common sedimentary features. Porosity is negligible.

The Fort Sill Formation has been subjected to both chemical and physical diagenetic processes. Chemical processes include secondary authigenic precipitation of calcite, silica and hematite; and alteration, dissolution and replacement of silica, glauconite, dolomite and calcite. The principal physical processes include pressure solution and stylotization.

The environment of deposition of the Fort Sill Formation is interpreted as a shallow water open marine environment.

The transition from the Reagan Sandstone to the Honey Creek Formation records a gradual change from siliciclastic and glauconitic shallow marine sedimentation to a carbonate sand-dominated shelf. The upward passage from the Honey Creek Formation into the Fort Sill Formation records a gradual change from a carbonate sand dominated shelf to a carbonate mud dominated shelf.

REFERENCES CITED

Bain, Foster, H, 1900, Geology of the Wichita Mountains: Geological Society of America Bulletin, Vol. 11, p. 127-144.

Bathurst, R. G. C., 1959, The cavernous structure of some Mississippian stromatactis reefs in Lancashire, England: Journal Geology, 67, p. 506-521.

Blatt, Harvey, 1982, Sedimentary Petrology: San Francisco, W. H. Freeman and Company, 630 p.

Blatt, Harvey, Gerrard Middleton, and Raymond Murry, 1980, Origin of Sedimentary Rocks: Prentice Hall, New Jersey, 782 p.

Chase, W. Gerald, E. A. Frederickson, and William E. Ham, 1956, Resume of the Geology of the Wichita Mountains, Oklahoma: in Petroleum Geology of Southern Oklahoma, Amer. Assoc. Petro. Geol., Vol. 1, p. 35-55.

Cloud, Preston, 1955, Physical limits of glauconite formation: Bull. Amer. Assoc. Petrol. Geol., Vol. 39, p. 484-491.

Cloyd, Kelly and Mary B. Rafalowski, 1984, Ankerite at the boundary between the Cambrian Reagan Sandstone and Honey Creek Formation, southwestern Oklahoma: Oklahoma Geology Notes, Okla. Geol. Survey, Vol. 44, No. 3, p. 92.

Cloyd, Kelly, 1984, The development of dolomite in Lower Paleozoic strata in the Slick Hills of southwestern Oklahoma: Unpub. M. S. Thesis, Oklahoma State University.

Comstock, T. B., and W. F. Cummins, 1889, A preliminary report on the geology of the central mineral region of Texas: Texas Geological Survey, 1st Ann. Report, p. 319-328.

Dapples, E. C., 1979, Diagenesis in Sediments and Sedimentary Rocks: Elsevier, Amsterdam, 579 p.

Decker, C. E., and C. A. Merritt, 1928, Physical characteristics of the Arbuckle Limestone: Oklahoma Geological Survey Circ 15, 55 p.

Decker, C. E., 1933, Early Paleozoic stratigraphy of the Arbuckle and Wichita Mountains: Tulsa Geological Society Digest, Vol. 2, p. 55-57.

Decker C. E., 1939a, Two Lower Paleozoic Groups, Arbuckle and Wichita Mountains, Oklahoma: Bull. Geol. Soc. America, Vol. 50, No. 8, pp. 1311-1322.

Decker, C. E., 1939b, Progress report on the classification of the Timbered Hills and Arbuckle Groups of Rocks, Arbuckle and Wichita Mountains, Oklahoma: Okla. Geol. Survey, Circ. 22, 62 p.

Decker, Charles, E. 1939, Contact of Honey Creek and Reagan Formations with igneous rocks in Arbuckle and Wichita Mountains, Oklahoma: Amer. Assoc. Petro. Geol. Bull., Vol. 23, No. 7, p. 1094-1098.

Ditzell, Curtis, 1984, The sedimentary geology of the Signal Mountain Formation as exposed in the Slick Hills of southwestern Oklahoma: Unpub. M. S. Thesis, Oklahoma State University.

Donovan, R. N., 1984, Recent developments in the Wichita Mountains: 18th Annual GSA Meeting Field Trip, Richardson Texas, 101 p.

Donovan, R. N., 1982, Geology of Blue Creek Canyon Wichita Mountains Area: Okla. Geol. Survey Guidebook 21, p. 65.

Evamy, B. D. and D. J. Shearman, 1965, The Development of overgrowths from echonoderm fragments: Sedimentology, Vol. 5, p. 211-233.

Farmillo, Alfred William, 1943, A lithological and field study of the Royer Formation and the overlying & underlying formations: Unpublished M. S. Thesis, University of Oklahoma.

Farrow, George E., Allen Henry, N. Akpan Etieben, 1984, Bioclastic carbonate sedimentation on a high-latitude, tide-dominated shelf: Northeast Orkney Islands, Scotland: Journal of Sedimentary Petrology, Vol. 54, No. 2, p. 373-382.

Flügel, Erik, 1982, Microfacies Analysis of Limestones: Springer-Verlag, New York, 633 p.

Fox, Charles, 1958, The Honey Creek Formation of the Wichita Mountains, Oklahoma: Unpub. M. S. Thesis, University of Oklahoma.

Frederickson, E. A., 1948, Upper Cambrian Trilobites from Oklahoma: Journal of Paleontology, Vol. 22, No. 6, p. 798-803.

Frederickson, E. A., 1948, Upper Cambrian Trilobites from Oklahoma: Journal of Paleontology, Vol 22, p. 798-803.

Frederickson, E. A., 1948, Clarification of Upper Cambrian Stratigraphy in Oklahoma: Amer. Assoc. Petro. Geol. Bull., V. 32, No. 7, p. 1349-1352.

Frederickson, E. A., 1949, Trilobite fauna of the Upper Cambrian Honey Creek Formation: Journal of Paleontology, V. 23, No. 4, p. 341-363.

Gebelein, Conrad, 1976, Open marine subtidal and intertidal stromatolites (Florida, the Bahamas and Bermuda), in Developments in Sedimentology 20, Stromatolites, Elsevier, New York, 790 p.

Gilbert, M. and R. N. Donovan, Ed., 1982, Geology of the eastern Wichita Mountains and southwestern Oklahoma: Oklahoma Geological Survey Guidebook 21, 160 p.

Gould, C. N. and C. E. Decker, 1925, Index to the stratigraphy of Oklahoma: Oklahoma Geological Survey Bull. 35, p. 11-14.

Habicht, J. K. A., 1979, Paleoclimate, Paleomagnetism, and Continental Drift: Amer. Assoc. Petro. Geol. Studies in Geology No. 9, Tulsa, Oklahoma, p. 31.

Ham, W. E. and J. L. Wilson, 1967, Paleozoic epeirogeny and orogeny in the Central U. S.: American Journal Science, Vol. 265, p. 332-407.

Harlton, B. H., 1964, Surface and subsurface subdivisions of Cambro-Orodovician carbonates of Oklahoma: Tusla Geol. Soc. Digest, Vol. 32, p. 38-42.

Havens, John S., 1977, Reconnaissance of the water resources of the Lawton Quadrangle, southwestern Oklahoma: United States Geological Survey.

Heckel, Philip H., 1972, Recognition of Ancient Shallow Marine Environments, in S. E. P. M. Spec. Publ. No. 16, 340 p.

Hoffman, M. G., 1930, Geology and petrology of the Wichita Mountains: Okla. Geol. Survey Bull. 52, 83 p.

Hoffman, H. J., 1969, Attributes of stromatolites: Geol. Surv. of Canada Paper 69-39, p. 1-58.

Howell, J. V., 1922, Notes on the Pre-Permian Paleozoics of the Wichita Mountain Area: Amer. Assoc. Petro. Geol. Bull., Vol. VI, No. 5, p. 421-422.

Howell, B. F., et al., 1944, Correlation of the Cambrian Formations of North America: Bull. Geol. Soc. America, Vol. 55, p. 993-1003.

Kendall, A. C., M. E. Tucker, 1973, Radiaxial fibrous calcite: A replacement after acicular carbonate: Sedimentology Vol. 20, p. 365-389.

Logan, B. W., and V. Semeniuk, 1976, Dynamic metamorphism; processes and products in Devonian Carbonate rocks, Canning Basin, Western Australia: Geol. Soc. Australia Spec. Publ. 6, 138 p.

Longman, Mark W., 1980, Carbonate diagenetic textures from near surface diagenetic environments: Am. Assoc. Petr. Geol. Bull., Vol. 64, No. 4, p. 461-487.

Nelms, Jerry, 1958, The Fort Sill Formation of the Wichita Mountains, Oklahoma: Unpub. M. S. Thesis, University of Oklahoma.

Odin, G. S., A. Matter, 1981, De glauconiarum origine: Sedimentology, Vol. 28, p. 611-641.

Park, W. C., E. H. Shot, 1968, Stylolites: their nature and origin: Journal of Sedimentary Petrology 38, p. 175-191.

Ragland, Debbie, R. N. Donovan, 1984, A Sedimentological and paleoenvironmental analysis of the Early Ordovician Cool Creek Formation of southwestern Oklahoma: In Press.

Reading, H. G., 1978, Sedimentary Environments and Facies: Elsevier, New York, 569 p.

Rhoads, D. C., 1967, Biogenic reworking of intertidal and subtidal sediments in Barnstable Harbor and Buzzards Bay, Mass.: Jour. Geology, Vol. 75, p. 46-476.

Sanderson, David J., R. Nowell Donovan, 1974, The vertical packing of shells and stones on some recent beaches: Journal of Sedimentary Petrology, Vol. 44, p. 680-688.

Shumard, George G., 1853, Remarks on the general geology of the country passed over when exploring the sources of the Red River: U. S. 32nd Congress, 2nd Session, Sen. Ex. Doc. 54, p. 179-195.

Stitt, James, 1971, Late Cambrian and Earliest Ordovician trilobites, Timbered Hills & Lower Arbuckle Groups, western Arbuckle Mountains, Murray County, Oklahoma, in Cambrian-Ordovician trilobites western Arbuckle Mountains, Okla. Geol. Survey Bull. 110, 83 p.

Stitt, James H., 1977, Late Cambrian and Earliest Ordovician Trilobites Wichita Mountains Area, Oklahoma: Okla. Geol. Survey Bull. 124, p. 79.

Stitt, James, 1978, Biostratigraphy and depositional history of the Timbered Hills and Lower Arbuckle Groups, Western Arbuckle Mountains, Oklahoma, in Regional Geology of the Arbuckle Mountains, Oklahoma, Okla. Geol. Survey Bull. 125, 61 p.

Taff, J. A., C. N. Gould, E. O. Ulrich, 1901, Work of the USGS: preliminary report on the Geology of the Arbuckle and Wichita Mountains: USGS Prof. Paper No. 31, p. 53.

Taff, J. A., 1902, Preliminary report on the geology of the Arbuckle and Wichita Mountains: USGS Prof. Paper No. 31, p. 40.

Taff, J. A., 1904, Preliminary Report on the Geology of the Arbuckle and Wichita Mountains: USGS Prof. Paper No. 31, p. 51-81.

Tsegay, Teklab, 1983, The sedimentary geology of the Reagan Formation (Upper Cambrian) of the Blue Creek Canyon, Slick Hills, southwestern Oklahoma: Unpub. M. S. Thesis, Oklahoma State University.

Tucker, M. E., 1981, Sedimentary Petrology: John Wiley and Sons, New York, 252 p.

Ulrich, E. O., 1911, Revision of the Paleozoic System: Bull. Geol. Soc. America, Vol. 22, Pl. 27, p. 281-680.

Ulrich, E. O., 1927, Fossiliferous boulders in the Ouchita Caney Shale and the age of the shale containing them: Okla. Geol. Survey Bull. 45, p. 28-31.

Ulrich, E. O., 1932, Preliminary description of the Honey Creek, Fort Sill, Royer, and Signal Mountain Formations of Oklahoma: Bull. Geol. Soc. America, Vol. 43, No. 3, p. 742-747.

Vaughan, T. W., 1899, Geologic notes on the Wichita Mountains, Oklahoma and Arbuckle Hills, Indian Territory: Amer. Geologist, Vol. 24, p. 44-45.

Walkden, G. M., J. R. Berry, 1984, Syntaxial overgrowths in muddy crinoidal limestones: cathodoluminescence sheds new light on an old problem: Sedimentology 31, p. 251-267.

# APPENDIX A

## ANALYSIS OF REPRESENTATIVE THIN SECTIONS FROM THE HONEY CREEK AND FORT SILL FORMATIONS

## ZODLETONE MOUNTAIN

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| ZT-1 (HC) | 3 | | | | | 25 | | | | | 35 | 7 | 5 | | 5 | | | | 20 | | | hematite fills pore space |
| ZT-2 (HC) | 1 | 15 | 5 | | | 20 | | | | | 30 | 8 | 5 | | 6 | | | | 10 | | | hematite fills pore space |
| ZT-3 (HC) | | | | | | 30 | | | | | 45 | 5 | 15 | | 5 | | | | | | | |
| ZT-4 (FS) | | 3 | 7 | | | 3 | 5 | | | | 25 | 5 | | | 10 | 42 | | | TR | | | bioturbated |
| ZT-3B(FS) | | | | | | 15 | | | | | 45 | 10 | 10 | TR | | | | | | | | matrix of illite 20%, quartz overgrowths |
| ZT-6 (FS) | 1 | 18 | 3 | | | | 1 | | | | 25 | 10 | 10 | | 15 | 7 | 7 | | 3 | | | Fe dolomite zoned |
| ZT-7 (FS) | 1 | 20 | 5 | | | 1 | 10 | | | | 15 | | 2 | | 10 | 36 | | | TR | | | bioturbated |
| ZT-8 (FS) | 2 | 15 | 10 | | | TR | 20 | | | | 10 | 3 | 5 | | 10 | 24 | | | 1 | | | pelmats filled w/ chalcedony |
| ZT-9 (FS) | | 15 | 5 | | | | 10 | | | | 5 | 2 | | | 15 | 48 | | | | | | bioturbated |
| ZT-10 (FS) | | 5 | 2 | | | | 10 | 40 | | | 3 | | | | 35 | 5 | 10 | | | | | Fe dolomite replaces ooids |
| ZT-11 (FS) | | 35 | 3 | | | | | | 30 | 5 | 3 | | | | 7 | 17 | 10 | | | | | Fe dolomite replacing micrite |
| ZT-12 (FS) | | | 3 | | | | 20 | | 20 | | | | | | 15 | 42 | TR | | | | | some styolites contain Fe dolomite |
| DFS-12(FS) | | | | | | | | | | | | | | | | | 100 | | | | | baroque dolomite |
| DFS-2T | | | | | | | 25 | | 15 | | 15 | | | | 10 | 10 | 23 | | 2 | | | zoned rhombs of Fe dolomite, laminated |

# BALLY MOUNTAIN

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| B-1 (HC) | 3 | | | | | 15 | | | | | 10 | 3 | | | | | 67 | 1 | 1 | | | Fe dolomite-Baroque |
| B-2 (HC) | 1 | 35 | 8 | | | 6 | | | | | 30 | 8 | 2 | | 3 | 4 | | | 3 | | | Quartz overgrowths, laminated |
| B-6 (HC) | 2 | | | | | 15 | | | | | 20 | 4 | 3 | | 56 | | | | | | | laminated |
| B-7 (FS) | | | | | | | 6 | 55 | 8 | | | | | | 31 | | | | | | | |
| B-8 (FS) | 1 | 12 | 10 | | | | 15 | | 10 | | 13 | 5 | 4 | | 14 | 6 | 10 | | TR | | | Fe dolomite Baroque Bioturbated |
| B-9 (FS) | 1 | 10 | 12 | | | 3 | 10 | | 7 | | 25 | 3 | 5 | TR | 24 | | | | | | | Quartz overgrowths |
| B-10 (FS) | | 2 | 3 | | | | 5 | 55 | 10 | | | | | | 25 | | | | | | | |
| B-11 (FS) | 1 | 10 | 12 | | | 3 | | | | | 15 | | | | 10 | 46 | | | | | | Micrite & includes peloids |
| B-12 (FS) | 1 | 8 | 10 | | | 2 | | | 7 | | 8 | 2 | | | 8 | 54 | | | | | | Micrite & includes peloids, Bioturbated |
| B-13 (FS) | TR | 5 | | | | | 5 | | 15 | | 16 | 4 | | | 31 | 15 | 8 | | 1 | | | Fe dolomite, laminated |
| B-14 (FS) | | 7 | 8 | | 2 | 1 | 10 | | 6 | | 15 | 2 | | | 10 | 38 | | | 1 | | | Bioturbated |
| B-15 (FS) | | 6 | | TR | 8 | 1 | 10 | | 12 | 3 | 5 | 2 | | | 23 | 5 | 20 | 2 | | | 3 | Brach infilled w/ chalcedony Fe dolomite, baroque |
| B-16 (FS) | | | 1 | | | | 20 | 35 | 6 | | 5 | 2 | 1 | | 30 | | | | | | | |
| B-18 (RD) | | | | | | | | | | | 2 | | | | | | 98 | | | | | Baroque, coarse dolostone |
| B-19 (RD) | | | | | | | | | | | | | | | | | 91 | | | | | Remaining % = porosity baroque |
| B-20 (FS) | | 10 | 8 | | | TR | 30 | | | | 10 | 2 | | | 6 | 32 | 2 | | TR | | | Bioturbated |
| Bally Agal Mound | | | | | | | | | | | | | | | | | | | | | | |

# BLUE CREEK CANYON #1

| Sample | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| BC-1 (HC) | | | | | | 5 | | | | | 10 | | 2 | | 5 | | 71 | | 10 | | | Baroque Dolomite |
| BC-35 (HC) | 1 | 60 | 2 | | 3 | | | | | | 3 | | 6 | | 25 | | | | | | | |
| BC-4 (HC) | 4 | 66 | 10 | | | 10 | | | | | 5 | | | | | | | | 5 | | | Sparite included w/ pelmat % (as overgrowths) |
| BC-5 (HC) | | 20 | 8 | | | 3 | 10 | | 6 | | 20 | | | | | 28 | | 2 | | | | |
| BC-6 (HC) | 5 | 52 | 10 | | | 10 | 3 | | | | 10 | 2 | 5 | | | | | | 3 | | | Sparite included w/ pelmat % (as overgrowths) |
| BC-7 (HC) | 2 | 30 | 3 | | | 10 | | | | | 25 | 10 | 5 | | 12 | | | | 3 | | | Hematite fills pore space, laminated |
| BC-8 (HC) | 5 | | | | | 7 | | | | | 55 | 15 | 4 | | 13 | | | 1 | | | | Quartz overgrowths |
| BC-9 (HC) | 1 | | | | | 5 | | | | | 65 | 15 | 3 | TR | 10 | | | | 1 | | | Quartz overgrowths |
| BC-10 (HC) | 3 | 30 | 2 | | | 10 | | | | | 20 | 10 | 5 | | 18 | | | | 2 | | | laminated/alternating carbs & detritals |
| BC-11 (FS) | 1 | 15 | 5 | | | 3 | 20 | | | | 25 | 7 | 2 | | 14 | 6 | | | 2 | | | bioturbated |
| BC-12 (FS) | 2 | | | | | 5 | | | | | 45 | 8 | 6 | TR | 32 | | | | 2 | | | Quartz overgrowths |
| BC-13 (FS) | | 9 | 7 | | | | 15 | | | | 12 | 2 | | | 10 | 45 | | | | | | |
| BC-14 (FS) | 1 | | | | | | 40 | | | | 10 | 3 | | | 20 | 26 | | | TR | | | laminated, bioturbated |
| BC-15 (FS) | | | | | | 10 | | | | | 69 | 15 | 6 | TR | | | | | TR | | | Quartz overgrowths |
| BC-16 (FS) | 1 | 10 | 7 | | 6 | 20 | | | 10 | | 15 | 3 | | | 20 | 7 | | 1 | | | | bioturbated |
| BC-17 (FS) | 1 | 6 | 7 | | 3 | 25 | | | 10 | | 15 | 3 | | | 10 | 20 | | | TR | | | |

# BLUE CREEK CANYON #1 (Continued)

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Blauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| BC-18 (FS) | | 10 | 6 | | | | 15 | | 5 | | 8 | 2 | | | 11 | 18 | 25 | | | | | Dolomite replaces micrite in burrows Fe dolomite, some dolomite zoned |
| BC-20 (FS) | | 6 | 5 | | | | | | | | 1 | | | | 10 | 52 | 20 | | | | | Chalcedony, fills pelmats, bioturbated zoned Fe dolomite |
| BC-21 (FS) | | 5 | 7 | | | | 25 | | | | 10 | | | | 17 | 30 | 5 | | | | | Bioturbated |
| BC-22 (FS) | | 5 | 4 | | | | 20 | | | | | | | | 10 | 18 | 40 | | | | | Baroque dolomite, fibrous $CaCO_3$, fill vugs |
| BC-23 (FS) | | 7 | 4 | 2 | 16 | | 20 | 3 | | | 7 | | | | 10 | 30 | | | 1 | | | Bioturbated, pelmatazoan overgrowths very rounded |
| BC-24 (FS) | | 12 | 7 | | 3 | | | 20 | 15 | | 5 | | | | 13 | 23 | | | 2 | | | Dolomite selectively replaces intraclasts (% included with intraclasts) |

## STUMBLING BEAR PASS

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| SB-1 (HC) | 1 | 74 | 5 | | | 2 | | | | | 10 | 1 | 2 | | 5 | | | | | | | Overgrowths on pelmats |
| SB-FS oncolite | | | | | | | | 30 | | | 3 | | 25 | | | 42 | | | TR | | | Oncolite/nucleous of rhyolite |
| SB-10 FS | 1 | 20 | 12 | | | 2 | | | | | 15 | 6 | | | 15 | 18 | 10 | | 1 | | | Fe dolomite |
| SB-20 FS | 1 | 10 | 7 | | | 5 | | | 15 | 3 | 25 | 4 | 2 | | 15 | 10 | 2 | | 1 | | | intraclasts glauconotized, bioturbated |
| SB-30 FS | | 10 | 9 | | | 1 | 25 | | | | 25 | 3 | | | 6 | 20 | 5 | 1 | 1 | | | laminated, bioturbated |
| SB-40 FS | 1 | 19 | 12 | | | | 15 | | 6 | | 10 | | | | 11 | 20 | | | 6 | | | bioturbated |
| SB-50 FS | TR | 10 | 8 | | | 1 | | | 10 | | 20 | 5 | | | 15 | 30 | | | 1 | | | bioturbated |
| SB-65 FS | 1 | 18 | 15 | | | 3 | | | 4 | | 12 | 2 | 3 | | 6 | 34 | | | 2 | | | |
| SB-72 FS | | 8 | 10 | | | 2 | 20 | | | | 10 | 2 | | | 12 | 36 | | | TR | | | bioturbated |
| SB-90 FS | | 15 | 12 | | | 4 | | | | | 15 | 3 | 2 | | 3 | 45 | | | 1 | | | bioturbated |
| SB-100 FS | 2 | 12 | | | | 6 | | | | | 25 | 5 | 2 | | 44 | | | | 4 | TR | | quartz overgrowths |
| SB-114 FS | | 10 | 7 | | | 3 | | | | | 12 | 1 | | TR | 10 | 57 | | | | | | pellet % included w/micrite % |
| SB-124 FS | 1 | 8 | 6 | | | 1 | | | | | 26 | | | TR | 10 | 47 | | 1 | | | | pellet % included w/micrite % bioturbated |
| SB-133 FS | | 8 | 6 | | | 3 | 15 | | 10 | | 15 | 2 | | | 10 | 31 | | | | | | |
| SB-148 FS | | 10 | | | | 1 | 24 | | | | 30 | 4 | 1 | | 10 | 20 | | | TR | | | laminated, bioturbated |
| SB-150 FS | 1 | 8 | 6 | | | 2 | | | 15 | | 20 | 2 | | | 3 | 43 | | | TR | | | |
| SB-160 FS | | 13 | 10 | | | 1 | | | | | 15 | 2 | | | 15 | 44 | | | | | | bioturbated, dismicrite |

## STUMBLING BEAR PASS (Continued)

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| SB-200 FS | | 15 | 8 | | | 1 | 10 | | 10 | | 8 | 2 | | | 18 | 27 | | | 1 | | | feldspar overgrowth |
| SB-215 FS | 1 | 10 | | | | 2 | | | 6 | | 30 | 5 | 3 | | 6 | 20 | | | 2 | | | laminated, pellet % included w/micrite % |
| SB-235 FS | 1 | 8 | | | | 3 | 25 | | | 6 | 15 | 5 | | | 15 | 22 | | | TR | | | Brach filled w/chalcedony |
| SB-250 FS | TR | 8 | 6 | 5 | | 1 | 30 | | 4 | | 10 | 2 | | TR | 14 | 20 | | | TR | | | bioturbated |
| SB-257 FS | TR | 6 | 4 | 1 | | 3 | 12 | | | | 30 | 5 | | | 8 | 27 | | | 4 | | | bioturbated |
| SB-275 FS | | 15 | | 1 | | | 20 | | | 15 | 10 | 2 | | | 15 | 22 | | | TR | | | Brachs filled w/chalcedony laminated |
| SB-310 FS | | 10 | 6 | 3 | | 4 | | | | | 20 | 5 | 3 | | 17 | 30 | | | 2 | | | laminated, bioturbated |
| SB-330 FS | | 4 | | 4 | | 1 | 35 | | | 6 | 10 | 2 | | | 17 | 20 | | | 1 | | | Brachs filled w/chalcedony, bioturbated |
| SB-342 FS | 1 | 10 | | 2 | | 1 | | | | | 30 | 10 | 3 | | 5 | 35 | | | 2 | | | laminated |
| SB-358 FS | | 8 | 3 | | | 2 | 20 | | 7 | 10 | 15 | 4 | 2 | | 15 | 13 | | | 1 | | | laminated, bioturbated, brachse pelmats replaced by chalcedony |
| SB-379 FS | | 10 | 3 | | | | 10 | | 10 | | 8 | 2 | | | 6 | 18 | 30 | | 2 | | | pelmat filled w/chalcedony, Fe dolomite |
| SB-391 FS | | 8 | | 1 | | | 25 | | 20 | 5 | 6 | 2 | 1 | | 12 | 20 | | | 1 | | | pelmat & brach filled w/chalcedony |
| SB-403 FS | | 8 | 6 | | | | 15 | | | | 15 | 3 | 1 | | 32 | 20 | | | TR | | | |
| SB-415 FS | | 5 | | 1 | | | 10 | | | | 35 | 10 | | | 10 | 27 | | | 2 | | | laminated |
| SB-425 FS | | 15 | 2 | | | | 20 | | 10 | | 10 | 3 | 1 | | 15 | 23 | | | 1 | | | |
| SB-432 FS | | 5 | 2 | 1 | | | 40 | | 15 | | 3 | 2 | | | 15 | 17 | | | | | | bioturbated |
| SB-440 FS | | 6 | 5 | 2 | | | 40 | | 15 | | 4 | 2 | | | 8 | 18 | | | TR | | | bioturbated, pelmat filled w/chalcedony |
| SB-442 FS | | 15 | 8 | 2 | | | 10 | | | | 4 | 10 | 1 | | 10 | 35 | 8 | | 3 | | | Fe dolomite, bioturbated |
| SB-445 FS | | 15 | 10 | | | | 15 | | 15 | | 10 | 3 | 2 | | 5 | 15 | 10 | | | | | Fe dolomite selectively replace micritic intraclasts |

# BLUE CREEK CANYON #2

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Dolomite | Pyrite | Hematite | Organics | Chalcedony | |
| 10 (HC) | | 25 | 2 | | | 3 | | | | 10 | | | 4 | | 56 | | | | | | | Hematite surrounds grains |
| 20 (HC) | | 20 | 2 | | | 1 | | | | | 4 | | 1 | | 50 | 20 | | | 2 | | | Chalcedony fills brachs |
| 30 (HC) | 1 | 25 | 5 | | | 7 | | | | | 15 | | | | 37 | 5 | | | 5 | | | |
| 40 (HC) | 2 | 10 | 20 | | | 5 | | | | | 10 | 2 | | | 23 | 25 | | | 3 | | | |
| 50 (HC) | | 7 | 10 | | | 10 | | | | 3 | 20 | 8 | | | 30 | 10 | | | 2 | | | |
| 60 (HC) | | | | | | 10 | | | | | 35 | 15 | TR | TR | 40 | | | | | | | |
| 72 (HC) | | | | | | 15 | | | | 2 | 32 | 20 | | | 29 | | | | 2 | | | Quartz strained |
| 80 (HC) | | | | | | 10 | | | | 2 | 32 | 15 | 3 | | 37 | | | | 1 | | | Quartz overgrowths |
| 92 (HC) | 5 | | | | | 15 | | | | TR | 25 | 10 | | | 43 | | | | 2 | | | laminated |
| 100 (HC) | 2 | 20 | 5 | | | 5 | | | | 3 | 8 | 2 | | | 53 | 2 | | | TR | | | some fibrous $CaCO_3$ cement |
| 113 (HC) | 1 | 10 | 8 | | | 8 | | | | 4 | 10 | 1 | | | 55 | | | | 3 | | | |
| 121 (HC) | | | | | | 10 | | | | 3 | 40 | 8 | | | 38 | | | | 1 | | | |
| 130 (HC) | | 25 | 3 | | | 10 | | | | 1 | 15 | 5 | | | 39 | | | | 2 | | | laminated |
| 140 (HC) | 1 | 25 | 3 | | | 6 | | | | | 25 | 5 | 3 | | 37 | | | | 5 | | | laminated |
| 160 (HC) | 1 | 3 | | | | 10 | | | | 2 | 30 | 10 | 5 | | 39 | | | | | | | Quartz overgrowths |
| 170 (HC) | 5 | | 2 | | | 10 | | | | 1 | 25 | 10 | | | 47 | | | | | | | laminated |

## BLUE CREEK CANYON #2 (Continued)

| Samples | Composition (%) | | | | | | | | | | | | | | | | | | | | | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Allochems | | | | | | | | | | Detritals | | | | | | | | | | | |
| | Phosphatic Brachs | Pelmatazoans | Trilobites | Sponge Spics | Gastropods | Glauconite | Peloids | Ooids | Intraclasts | Brachiopod | Quartz | Feldspar | Rhyolite | Muscovite | Sparite | Micrite | Eolomite | Pyrite | Hematite | Oganics | Chalcedony / | |
| 190 (HC) | 3 | 2 | | | | 12 | | | | 5 | 38 | 8 | | | | | | | TR | | | |
| 200 (HC) | | | | | | 5 | | | | | 75 | 20 | TR | | | | | | TR | | | Quartz overgrowths, obliterates porosity |
| 205 (HC) | | 5 | | | | 15 | | | | | 25 | 20 | 7 | | 22 | | | 3 | 3 | | | Quartz overgrowths |
| 230 (HC) | 3 | 25 | | | | 2 | | | | | 20 | 15 | 5 | | 29 | | | 1 | TR | | | |
| 250 (HC) | 1 | 20 | 7 | | | 5 | | | | | 25 | 15 | 2 | | 24 | | | | 1 | | | pseudomatrix of glauconite along stylolites |
| 270 (HC) | | | | | | 3 | | | | | 70 | 20 | 5 | TR | | | | | | | | 2% illite as matrix quartz overgrowths |
| 280 (HC) | | 7 | 5 | | | 1 | 25 | | | | 25 | 5 | | | 15 | 17 | | TR | TR | | | bioturbated |
| 290 (HC) | | 20 | 2 | | | 2 | 20 | | | 5 | 20 | 5 | | | 13 | 13 | | | | | | bioturbated |
| 300 (FS) | TR | 15 | 10 | | | TR | 10 | | | | 20 | 5 | | | 10 | 30 | | | TR | | | bioturbated |

VITA

Mary Beth Rafalowski

Candidate for the Degree of

Master of Science

Thesis: THE SEDIMENTARY GEOLOGY OF THE LATE CAMBRIAN HONEY CREEK AND FORT SILL FORMATIONS AS EXPOSED IN THE SLICK HILLS OF SOUTHWESTERN OKLAHOMA

Major Field: Geology

Biographical:

Personal Data: Born in Columbus, Ohio, November 30, 1958, the daughter of Paul Henry Rafalowski and Catherine Ann Rafalowski.

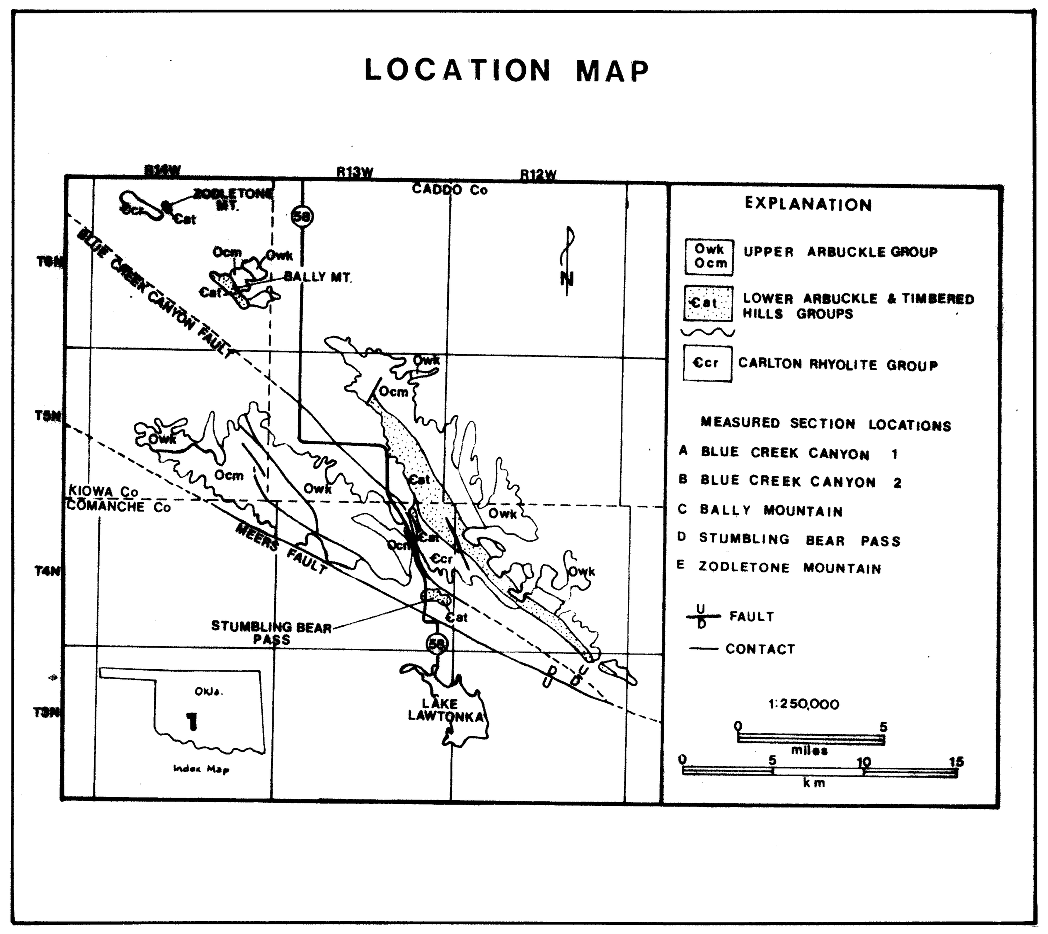
Education: Graduated from Glen Oak High School, North Canton, Ohio, June 6, 1977; received Bachelor of Science Degree in Geology and Mineralogy at the Ohio State University in March, 1982; completed the requirements for the Master of Science Degree at Oklahoma State University in December, 1984.

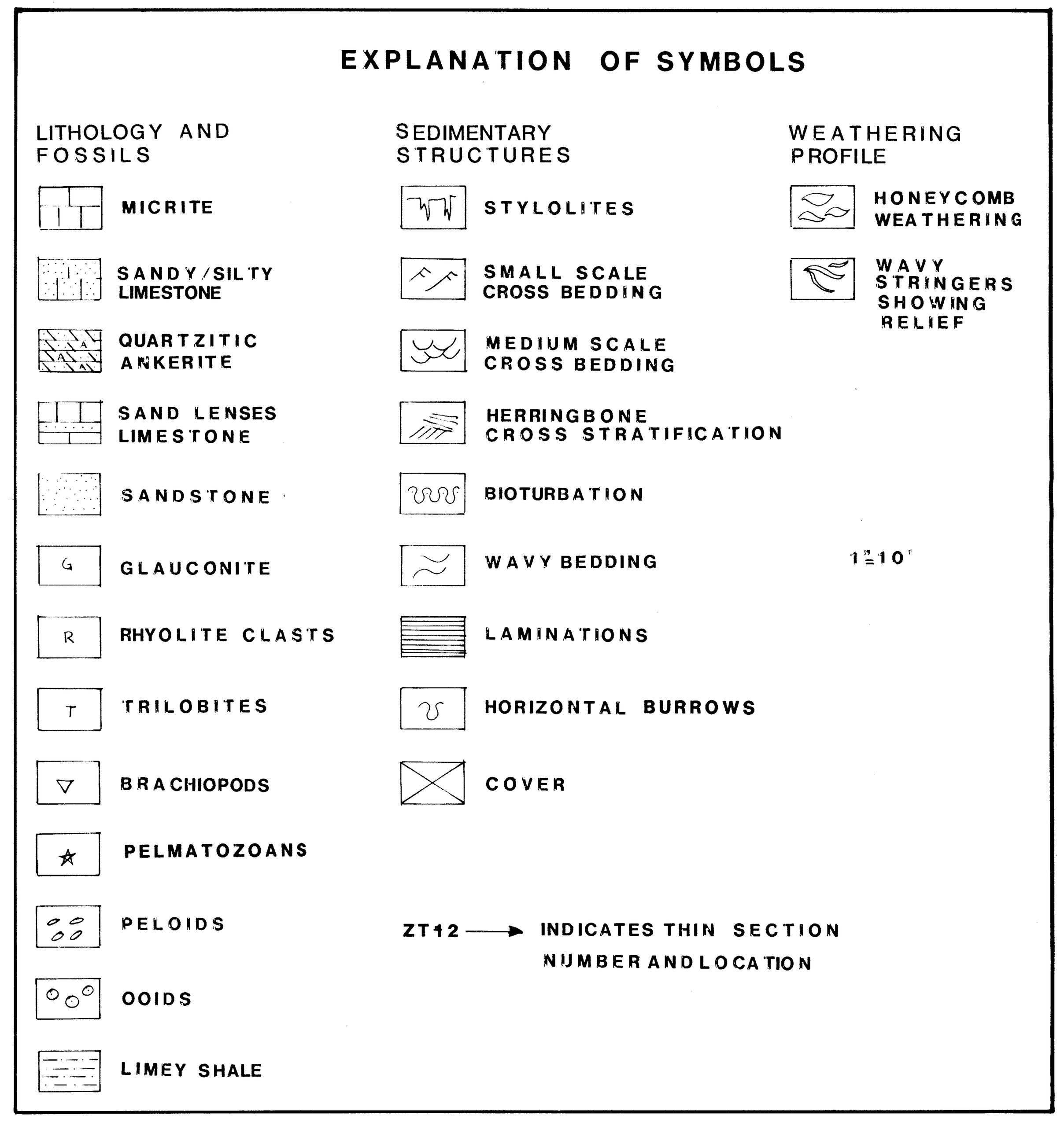
Professional Experience: Geologic Intern, Ohio Geological Survey Columbus, Ohio, Summer 1980; Student Research Assistant, Ohio State University, 1979-1982; Geologic Cartographer, Leslie Oil and Gas, Columbus, Ohio, Spring 1982; Structural Field Research Assistant, Southern California, Summer 1981; Teaching Assistant, Oklahoma State University Geology Field Camp 1984; Graduate Teaching and Research Assistant and thin section preparator, Oklahoma State University August 1982-October 1984; Member of Phi Kappa Phi; Member American Association of Petroleum Geologist; Member Association of Women Geoscientists.

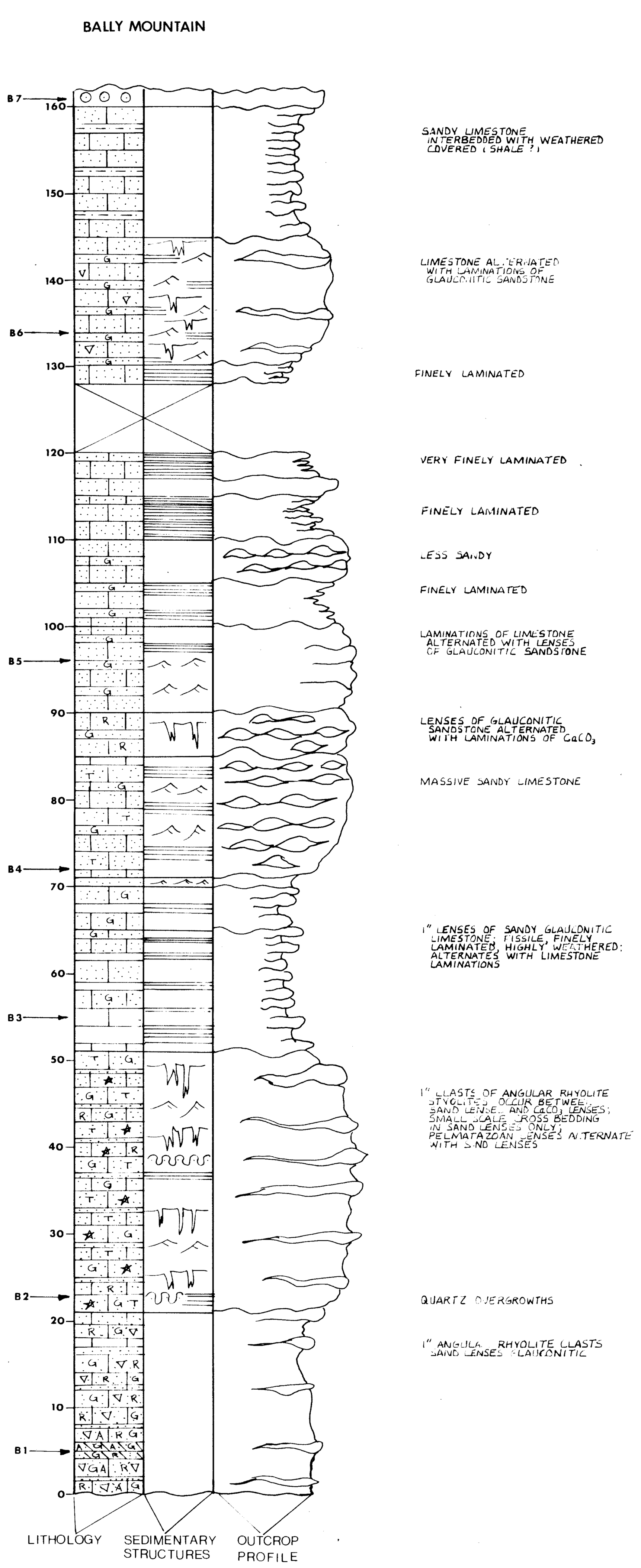
# PLATE I

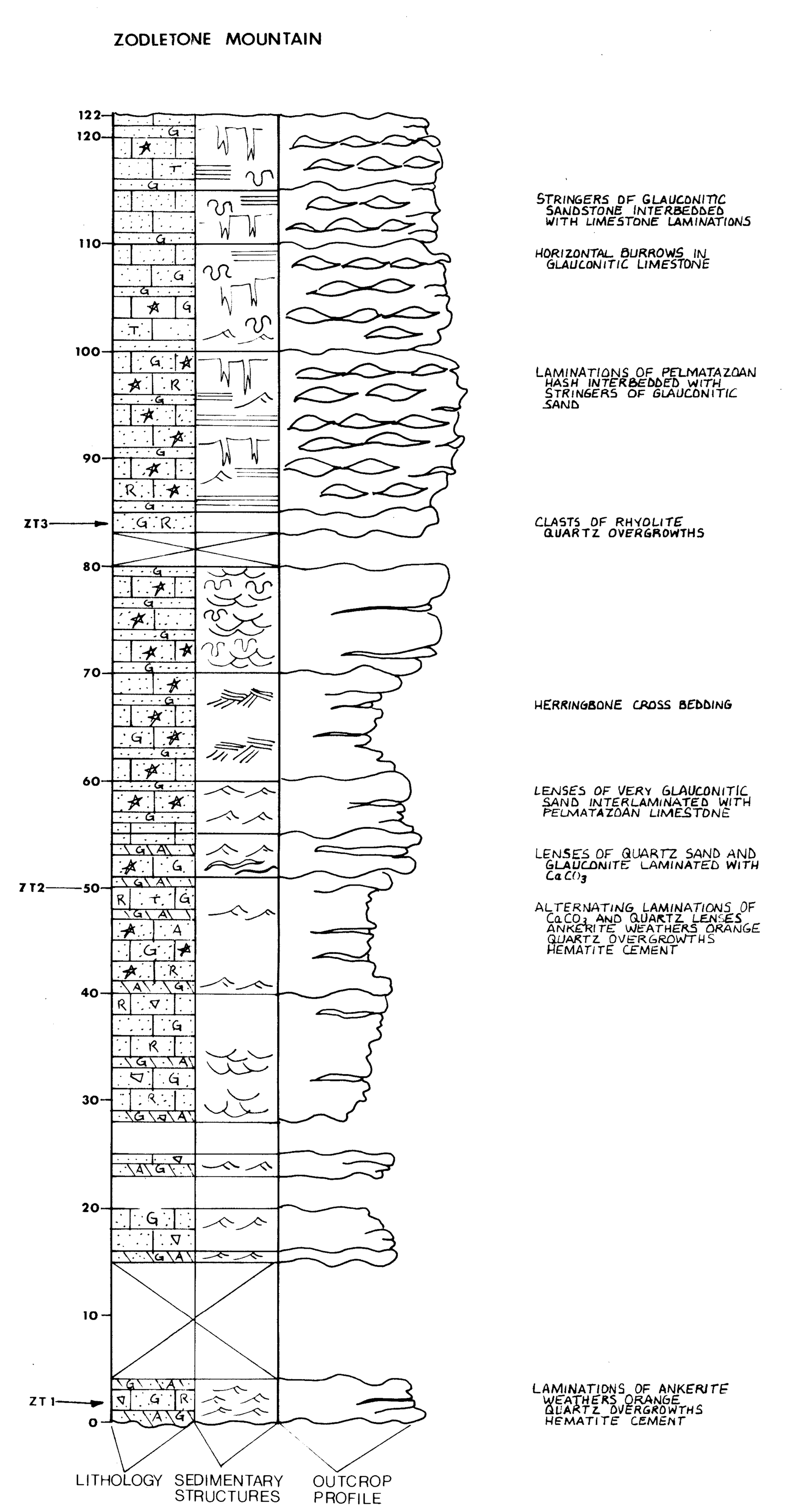
## MEASURED SECTIONS OF THE LATE CAMBRIAN HONEY CREEK FORMATION

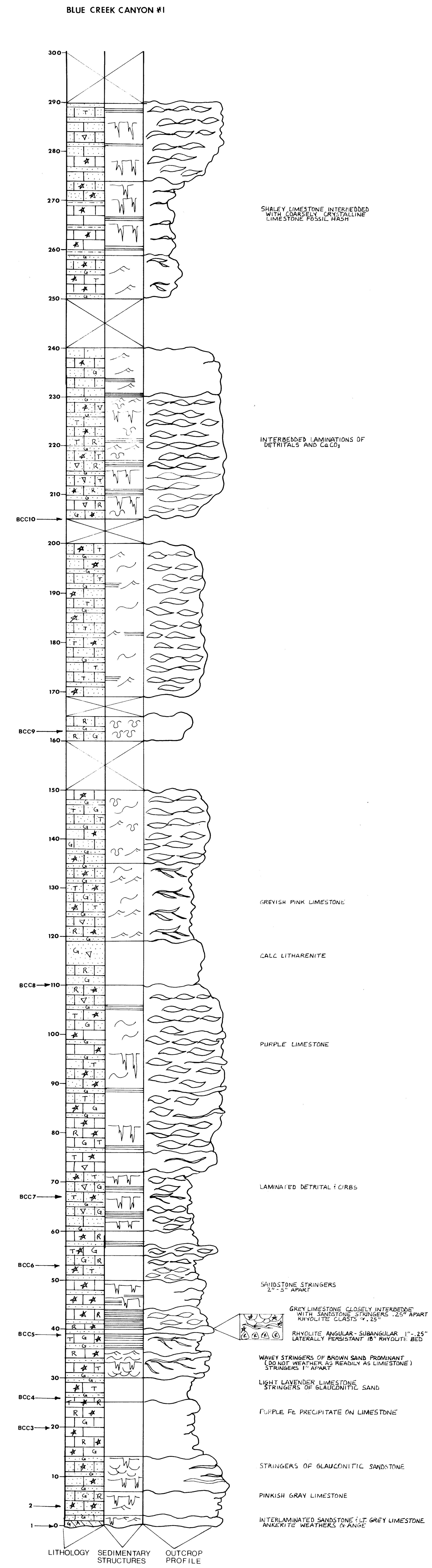
## SLICK HILLS, SOUTHWESTERN OKLAHOMA

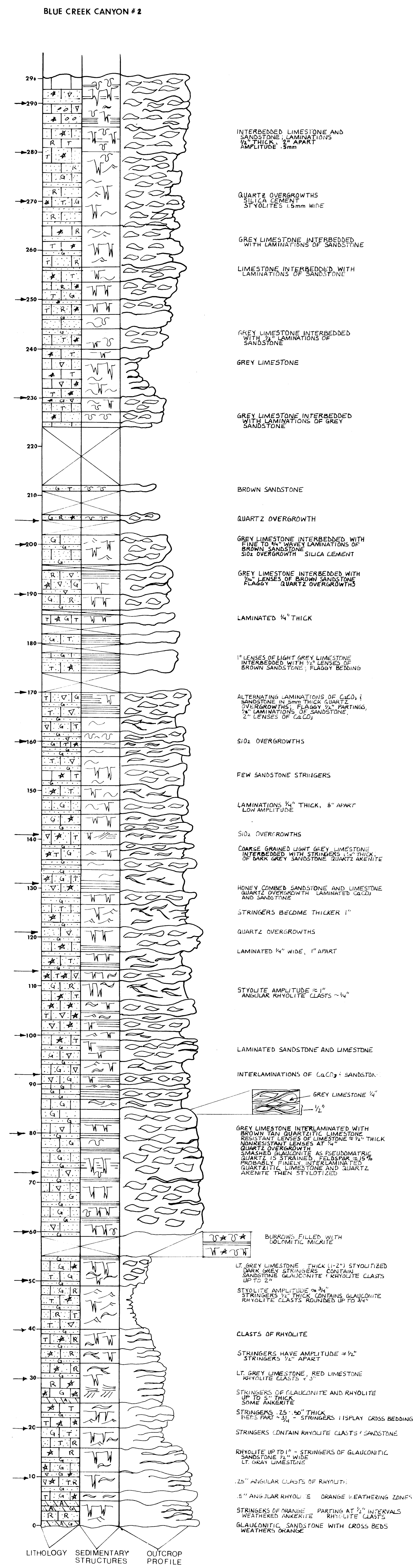


# PLATE II

## MEASURED SECTIONS OF THE LATE CAMBRIAN FORT SILL FORMATION

## SLICK HILLS, SOUTHWESTERN OKLAHOMA