PUNCTUATED AGGRADATIONAL CYCLES IN THE THACHER MEMBER OF THE MANLIUS FORMATION, HUDSON VALLEY REGION, NEW YORK

A Thesis Submitted
to the Temple University Graduate Board

---

in Partial Fullfiment
of the Requirement for the Degree

MASTER OF ARTS

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by

Lawrence J. Saraka

November 1984

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A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Arts in Geology, College of
Arts and Science, Temple University
Philadelphia, Pennsylvania
November 1984

Peter W. Goodwin ---------------------- Nov. 19, 1984
Dr. Peter W. Goodwin — Date

Edwin J. Anderson ---------------------- Nov. 19, 1984
Dr. Edwin J. Anderson — Date

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Dedication

This thesis is dedicated to my parents with love. Through their guidance and understanding I was able to attain this goal.

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ABSTRACT

In the Hudson Valley region the Thacher Member of the Manlius Formation consists entirely of PACs, thin shallowing-upward cycles separated by correlative sharp non-depositional surfaces. Vertically, within each PAC, facies represent aggradational shallowing; laterally adjacent facies in each PAC represent contiguous paleoenvironments. Between PACs facies change abruptly at PAC boundaries in response to rapid episodic base-level rises.

This small-scale stratigraphic framework permits detailed paleoenvironmental analysis of specific facies with respect to depth and lateral position relative to other facies. In this analysis, the Manlius Formation consists of 11 PACs each of which contains variable but coeval subtidal facies in its lower portion and intertidal or supratidal facies in the upper portion.

In previous studies (e.g. Laporte, 1967), the assumption of a gradualistic model of stratigraphic accumulation resulted in the conclusion that the Manlius Formation comprised a disordered facies mosaic in which any facies could occur at any time. In contrast, this analysis, which assumes episodic stratigraphic accumulation at a small scale, has produced a highly ordered interpretation. Specifically, the PAC approach indicates that facies patterns were controlled by abrupt allogenic events (base-level rises) followed by sedimentary aggradation resulting in a series of correlative PACs containing predictable facies patterns.

INTRODUCTION

Lithofacies of the Manlius Formation, Lower Devonian Helderberg Group of New York state (figures 1 and 2), have been interpreted to represent deposition in a restricted lagoon (Rickard, 1962). According to Laporte (1967), three subenvironments, subtidal, intertidal, and supratidal, existed contemporaneously within the lagoon. Westward transgression of Manlius facies through time did not result in a progressive migration of parallel bands of supratidal, intertidal, and subtidal facies, as would be expected with gradual water deepening. Instead, facies repeatedly shifted laterally due to continuous fluctuations of environmental conditions. The result of these lateral migrations of facies is a complex facies mosaic that is lacking a consistent internal motif.

In contrast, application of an episodic model of stratigraphic accumulation to the Manlius Formation has revealed a highly ordered facies pattern. Specifically, the PAC approach indicates that facies patterns were controlled not by irregular lateral migration of coexisting paleoenvironments but by abrupt allogenic events followed by sedimentary aggradation resulting in a series of correlative PACs containing predictable facies patterns (Saraka and Goodwin, 1984).

According to the Hypothesis of Punctuated Aggradational Cycles (Goodwin and Anderson, 1980), most stratigraphic accumulation occurs episodically as thin (1-5 meters thick)

Figure 1:
Map of New York state illustrating the
Helderberg outcrop belt and study localities.

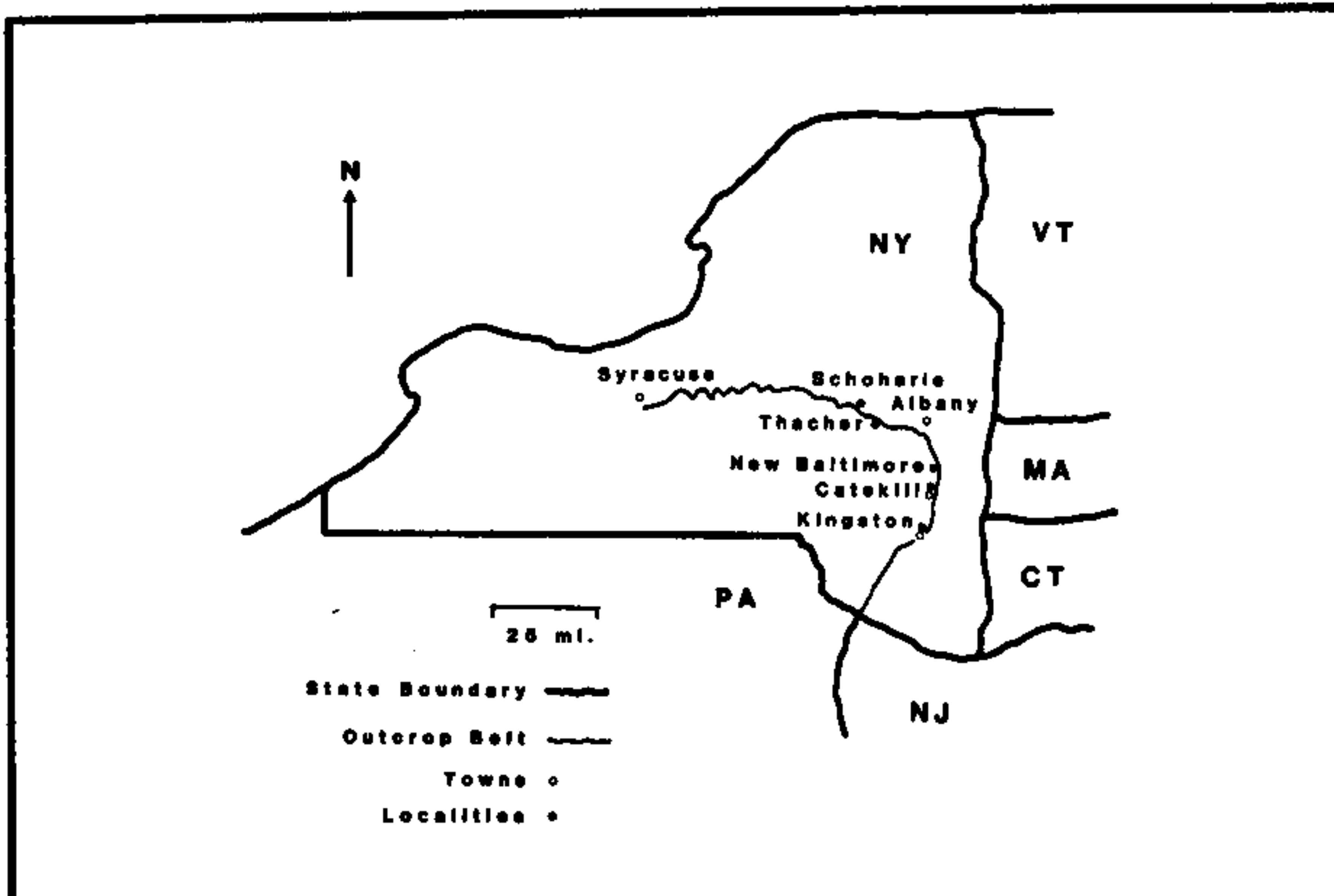
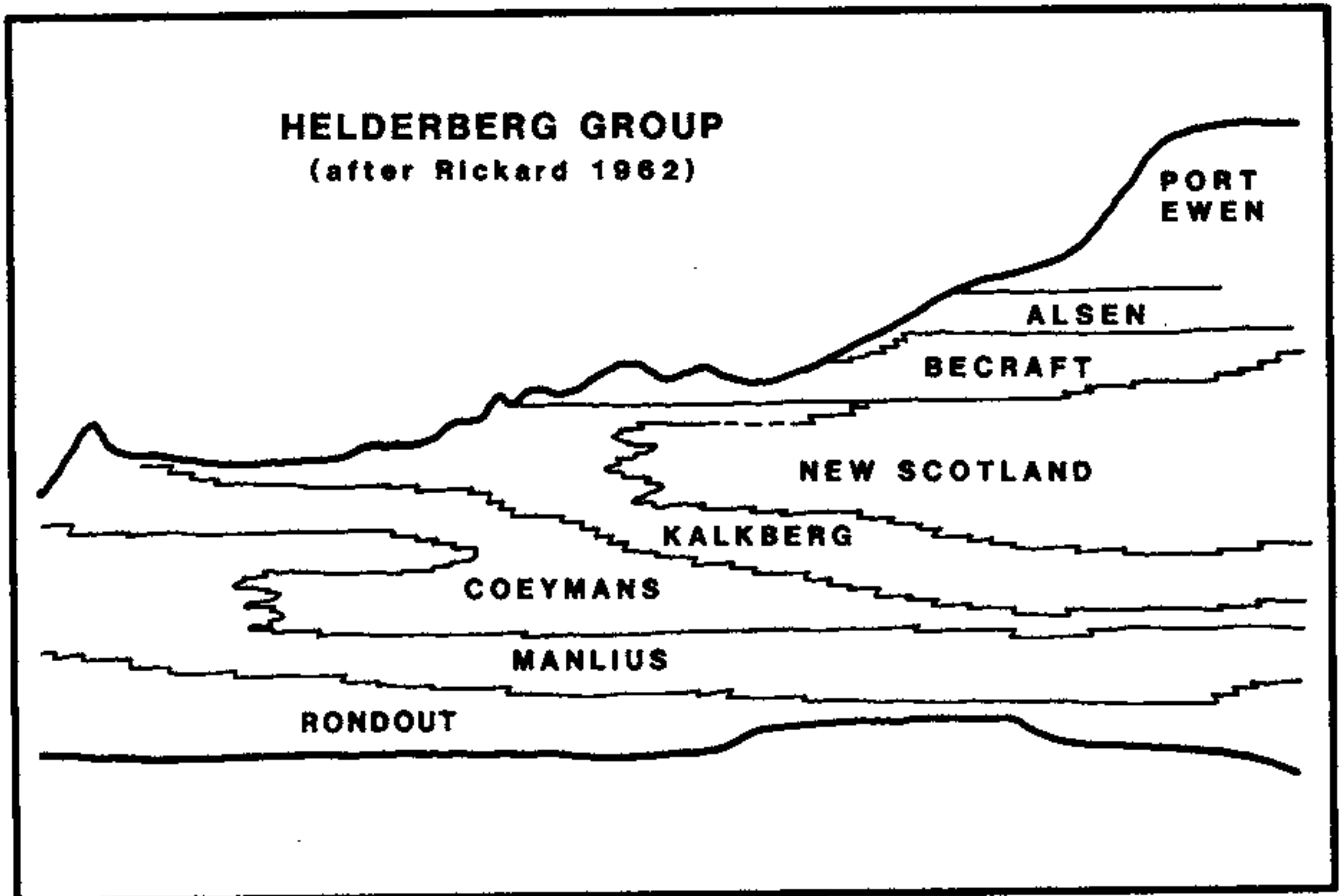

N
NY
VT
Syracuse
Schoharie
Albany
Thacher
New Baltimore
Catskill
Kingston
MA
CT
PA
NJ
25 mi.
State Boundary
Outcrop Belt
Towns
Localities

Figure 2:
Stratigraphic framework of the Helderberg Group in eastern New York state (after Rickard, 1962)


HELDERBERG GROUP
(after Rickard 1962)
PORT EWEN
ALSEN
BECRAFT
NEW SCOTLAND
KALKBERG
COEYMANS
MANLIUS
RONDOUT

shallowing-upward cycles (PACs) separated by sharply defined non-depositional surfaces. The non-depositional surfaces are created by geologically instantaneous base-level rises. Deposition, which occurs during periods of relative base-level stability, produces gradational facies changes within a PAC. Furthermore, the hypothesis predicts that facies change between PACs is abrupt in response to geologically sudden punctuation events. If the fundamental tenets of the PAC Hypothesis are correct, a single PAC should be traceable as a thin, time-stratigraphic unit throughout a basin of deposition. Therefore, the Manlius Formation should consist entirely of PACs which are correlative throughout the study area.

Purpose and Objectives

This study is an attempt to apply the Hypothesis of Punctuated Aggradational Cycles to the paleoenvironmental analysis of the Thacher Member of the Manlius Formation in the Hudson Valley region of New York.

In order to accomplish this purpose it is necessary to satisfy the following objectives: 1) to demonstrate that the Thacher Member of the Manlius Formation is completely divisible into PACs; 2) to correlate individual PACs among localities; 3) to interpret specific facies, within each PAC, with respect to depth and lateral position relative to other facies; 4) to reconstruct the paleoenvironmental and paleogeographic setting for each Thacher PAC; and 5) to interpret Manlius depositional history as an intermittent series of episodic base-level rises separated by longer periods of base-level stability.

Previous Work

In his analysis of Helderberg stratigraphy, Rickard (1962) recognized the Lower Devonian Manlius Formation as the oldest formation in the Helderberg Group (figure 2). Stratigraphic occurrence of the Manlius Formation, in eastern New York, is above the Rondout Formation and below the Coeymans Formation. Manlius facies in western New York are interpreted to be younger than eastern Manlius facies and a portion of the western Manlius Formation (Olney Member) is interpreted to be laterally equivalent to the Coeymans Formation (Dayville Member), in the east.

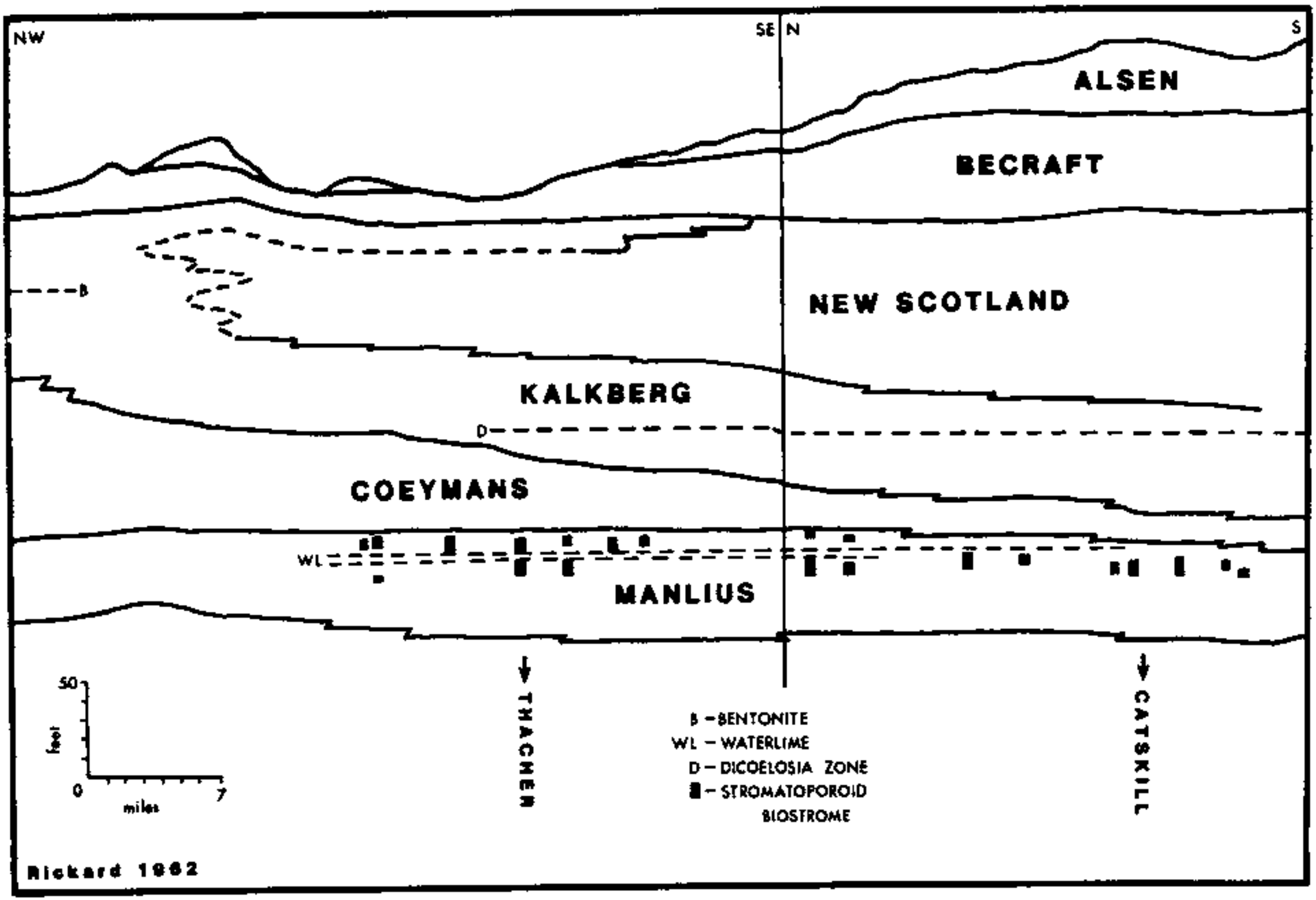
Rickard (1962) identified five primary facies that can be distinguished within the Helderberg Group. The superposition of these facies, from bottom to top, are dololutite, calcilutite, calcarenite, cherty calcisiltite, and argillicalcisiltite. In tracing one of his interpreted stratigraphic horizons, Rickard suggested that a traverse normal to the Helderberg shore exhibits the contemporaneous existence of the same facies sequence and that this facies sequence represents a complete lagoon-reef-neritic environmental sequence. This vertical and lateral relationship of facies occurrence apparently illustrates the validity of the law of the correlation of facies (Rickard, 1962). The law of the correlation of facies (Walther's Law) is stated as "only those facies and facies areas can be superimposed primarily which can be observed beside each other at the present time" (Middleton, p. 979, 1973).

Rickard's conclusions on Helderberg stratigraphy were based upon his interpretation of eight "time lines" (figure 3). Prior to his study, geologists considered each formation of the Helderberg Group to be comtemporaneous throughout its extent. However, Rickard concluded that Helderberg facies (formations) transgressed time lines (Rickard, 1962). These eight biostratigraphic and lithostratigraphic horizons, which suggest time lines, indicate that the Helderberg formations are time-transgressive not time-stratigraphic, and that these formations could have existed contemporaneously in an advancing sea.

Finally, Rickard (1962) recognized, among the eight time lines, two kinds of chronologically significant horizons within the Manlius Formation. They are the waterlime beds, and the stromatoporoid biostrome horizons. The thinness and distinctiveness of these units suggest that each was deposited during practically the same time. Rickard utilized these horizons as time lines to conduct stratigraphic correlations and establish the stratigraphic framework for the five members that comprise the Manlius Formation.

Laporte (1967) conducted a sedimentologic analysis of the Manlius Formation in an attempt to explain the depositional dynamics that governed facies distribution throughout the Manlius Sea. Through detailed paleontologic

Figure 3:
Rickard's (1962) lithostratigraphic and biostratigraphic time horizons utilized in the correlation of the Helderberg Group.


NW
SE
N
S
ALSEN
BECRAFT
NEW SCOTLAND
KALKBERG
COEYMANS
MANLIUS
D
WL
50
feet
0
miles
7
THACHER
CATSKILL
β – BENTONITE
WL – WATERLIME
D – DICOELOSIA ZONE
– STROMATOPOROID BIOSTROME
Rickard 1962

and lithologic analysis, and comparison with Recent carbonate analogues, Laporte concluded that the Manlius Formation is neither homogeneous nor randomly variable. Instead, Laporte's facies analysis indicated that the Manlius Formation is comprised of three characteristic facies: supratidal; intertidal; and subtidal (table 1). According to Laporte, these facies represent environments which were slightly above, at, or slightly below sea-level respectively.

Laporte utilized the term "facies" to refer to the particular lithologic and paleontologic characteristics of a specific sedimentary layer or sequence. These facies "usually refer to 'some areally restricted part of a designated stratigraphic unit' where environmental conditions causing facies differentiation are stable for a sufficient length of time so that the resultant facies are clearly manifest from one place to another" (Laporte p. 77, 1967).

Analysis of individual localities revealed that, in a vertical sequence, the three dominant Manlius facies were often repeated. Assuming the fundamental tenets of Walther's Law, Laporte suggested that environments shifted laterally and, therefore, changed vertically as a result of continuous fluctuations of environmental conditions. He further argued that the vertical repetition of supratidal, intertidal, and subtidal facies, at a given locality, indicates that facies did not simply transgress westward as a linear facies sequence. Instead, each of these three facies was present in patchy areas throughout a shallow,

Table 1:
Lithologic and paleontologic description of Manlius facies and an interpreted stratigraphic analogue (after Laporte, 1967).

FACIES	LITHOLOGY	PALEONTOLOGY	RECENT ANALOGUE	SOURCE
SUPRATIDAL	*Dolomitic laminated mudstone mud cracked, birds eye fenestrae, (Dolomitic micrite and pelmicrite)*	*Fossils scarce algal laminae, ostracods, some burrows*	*Supratidal areas in Florida Keys and Andros Island*	*Shinn and Ginsburg, 1964; Shinn et. al., 1965;*
INTERTIDAL	*Interbedded pelletal carbonate muds and calc-arenites, some intraclasts and mud cracks, (Pelmicrite and biopelsparite)*	*Types few but individuals are abundant ostracods, tentaculitids, stromatolites*	*Intertidal and just below tidal level in Florida Keys and Andros Island*	*Ginsburg, 1960; Logan et. al., 1964;*
SUBTIDAL	*Pelletal carbonate muds and "reefy" biostromes, medium to massive-bedded, (Biopelmicrudite and biolithite)*	*Types relatively abundant and diverse stromatoporoids, rugose corals, brachiopods, ostracods, gastropods*	*No Recent analogue but ancient analogue recognized in Devonian Pillara Formation of Australia*	*Read, 1973;*

restricted sea during Manlius deposition. Occurrence and lateral migration of the three environments resulted in a complex facies mosaic that lacked a consistent internal motif.

Laporte's analysis of the Manlius Formation (1967) is important in understanding and interpreting carbonate facies and their environments of deposition. However, failure to conduct stratigraphic correlations between individual localities may have resulted in a misrepresentation of the paleoenvironmental framework that comprised the Manlius Formation.

Goodwin and Anderson (1980), and Anderson and Goodwin (1978) proposed a new hypothesis for sediment accumulation in the rock record. According to the Hypothesis of Punctuated Aggradational Cycles, most stratigraphic accumulation occurs as thin (1-5 meters thick), time-stratigraphic shallowing-upward cycles (PACs) bounded by surfaces of non-deposition (figure 4). This small-scale time-stratigraphic framework, which assumes episodic accumulation of sediment, enables precise stratigraphic correlations (figure 5) and detailed paleoenvironmental/paleogeographic analyses.

Busch (1981) and Lee (1981) conducted PAC analyses of the Olney and Elmwood Members of the Manlius Formation in central New York. Both authors have documented the occurrence of small-scale, shallowing-upward cycles (PACs) throughout the entire Olney-Elmwood interval. Occurrence

Figure 4:
Diagramatic representation of a single, shallowing-upward, Punctuated Aggradational Cycle (after Anderson and Goodwin, 1980).

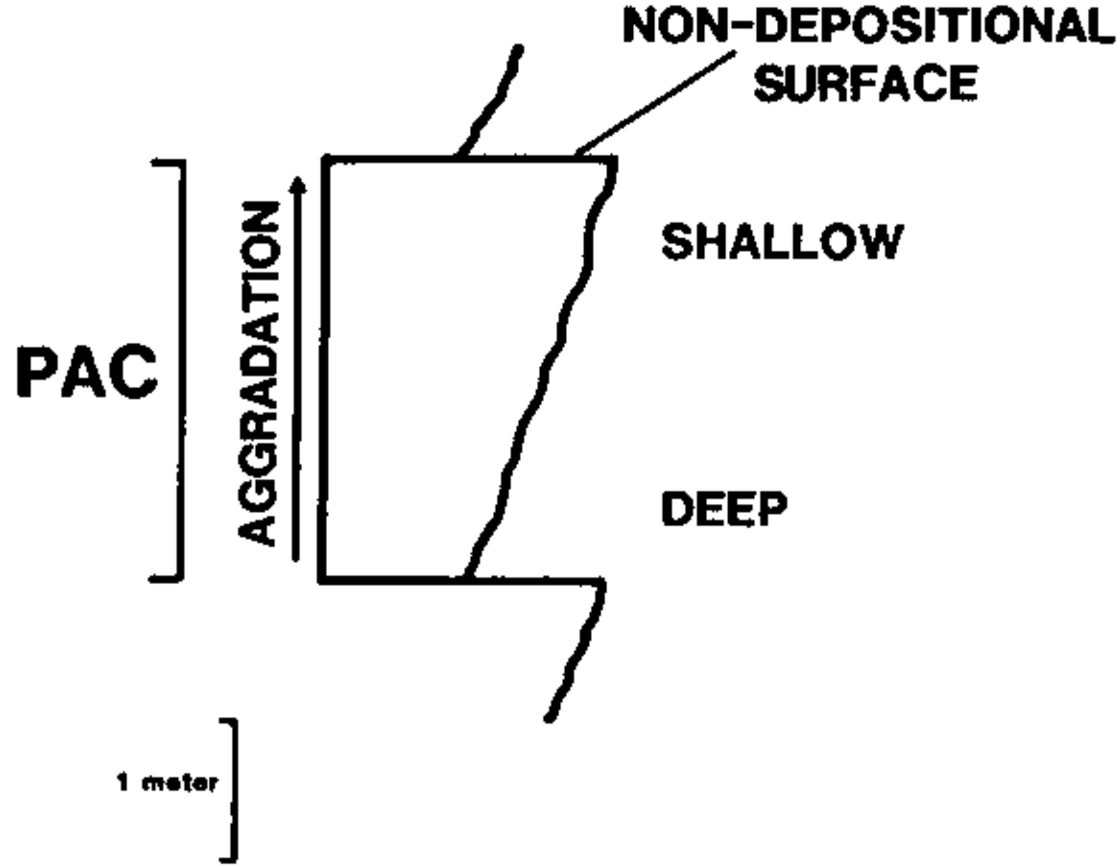
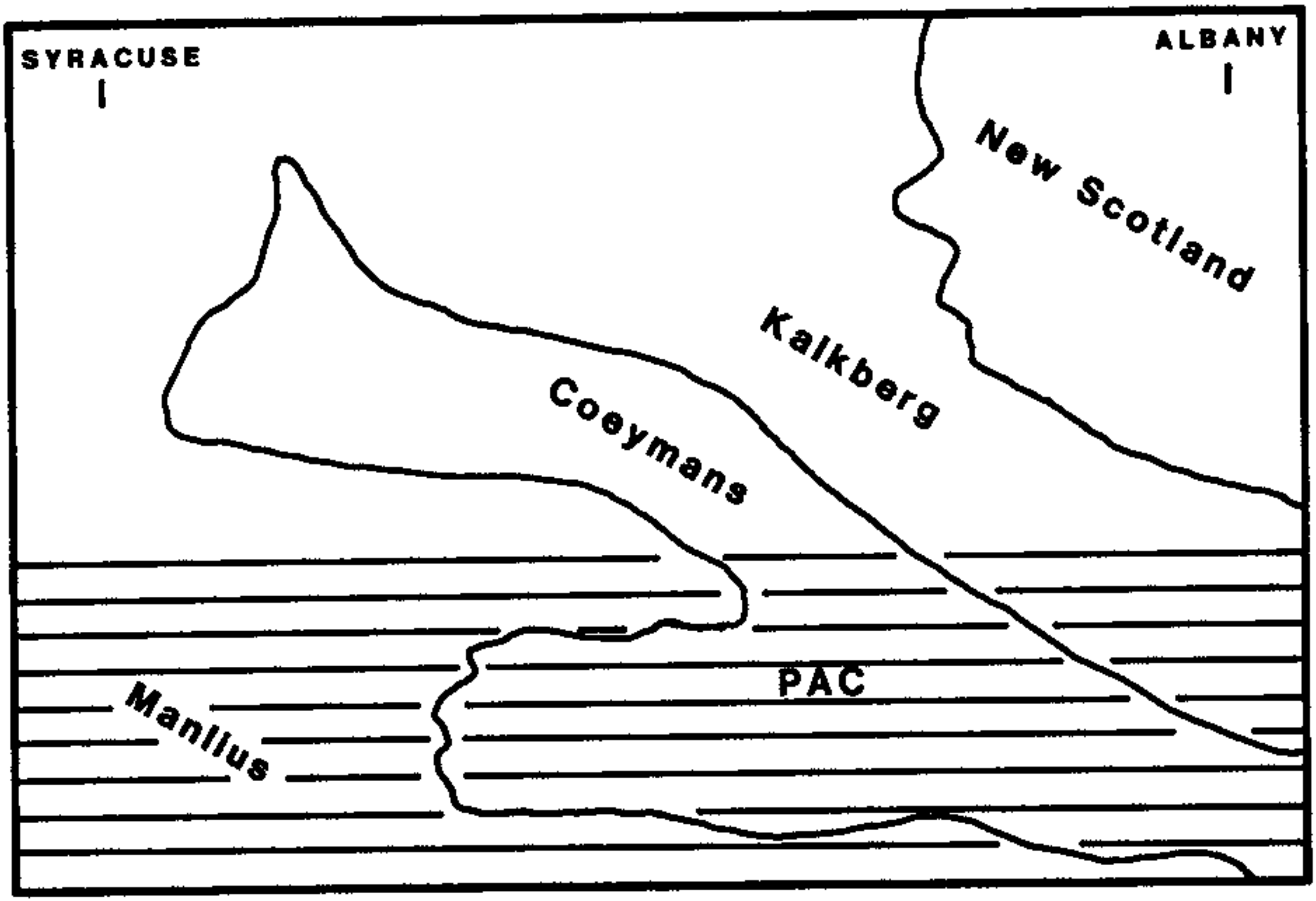

NON-DEPOSITIONAL
SURFACE
SHALLOW
DEEP
PAC
AGGRADATION
1 meter

Figure 5:
Illustration of the time-stratigraphic, Punctuated Aggradational Cycles compared to traditional, stratigraphic formations (Anderson and Goodwin, 1980).



SYRACUSE
ALBANY
New Scotland
Kalkberg
Coeymans
PAC
Manlius

of PACs in Olney-Elmwood facies indicates that facies distribution throughout the entire Manlius Formation may occur as an ordered response to allogenic mechanisms followed by sedimentary aggradation.

The Hypothesis of Punctuated Aggradational Cycles has been applied to the late Cayugan and Helderbergian rocks of New York by Anderson and Goodwin, and current and previous students. Intervals of study are described in stratigraphic order: Binnewater Sandstone (Buggey, 1984); Rondout Formation (Osborn, 1983); Manlius Formation (Hudson Valley) Saraka, Goodman (1984); Coeymans-Kalkberg Formations (Sobieski, 1984); Kalkberg Formation and Dicoelosia epibole (Connor, 1983); and New Scotland Formation (Side, 1984). Although these studies include great variation in environments of deposition, from clastic and carbonate tidal environments to carbonate basin deposits, the depositional motif for all units remains the same. All researchers have documented complete division of their respective intervals into PACs.

Methods

Field work for this study was conducted during the summer of 1983. Sixteen localities, from Kingston to Schoharie, New York, a straight-line distance of approximately 55 miles, were analyzed (figure 1). Most outcrop locations and locality numbers are from Rickard (1962); those that are not are from more recent exposures.

MANLIUS PACS

Introduction

Application of the PAC Hypothesis to the Manlius Formation in the Hudson Valley region reveals complete division of the interval into thin, shallowing-upward, time-stratigraphic units. At each locality the Manlius section consists entirely of small-scale shallowing-upward cycles each of which exhibits all of the characteristics of PACs in vertical section. Recognition of the number of PACs, the relative size of deepening events, and PAC thickness, allows for correlation of individual PACs among localities. Once these stratigraphic correlations have been established, it is possible to conduct a detailed paleoenvironmental and paleogeographic interpretation of Manlius facies. Thus this limited test of the PAC Hypothesis consists of three steps: 1) recognition of PACs in columnar sections; 2) correlation of PACs among localities; and 3) paleoenvironmental interpretation of lateral facies patterns within correlative PACs.

PACs in Columnar Section

At South Catskill, the Thacher Member of the Manlius Formation is completely divisible into PACs. Each of the 10 PACs that comprise the 47 foot thick Thacher Member exhibits a shallowing-upward motif and is bounded by sharp surfaces of non-deposition (figure 7). The gradual shallowing-upward transition of facies within these PACs

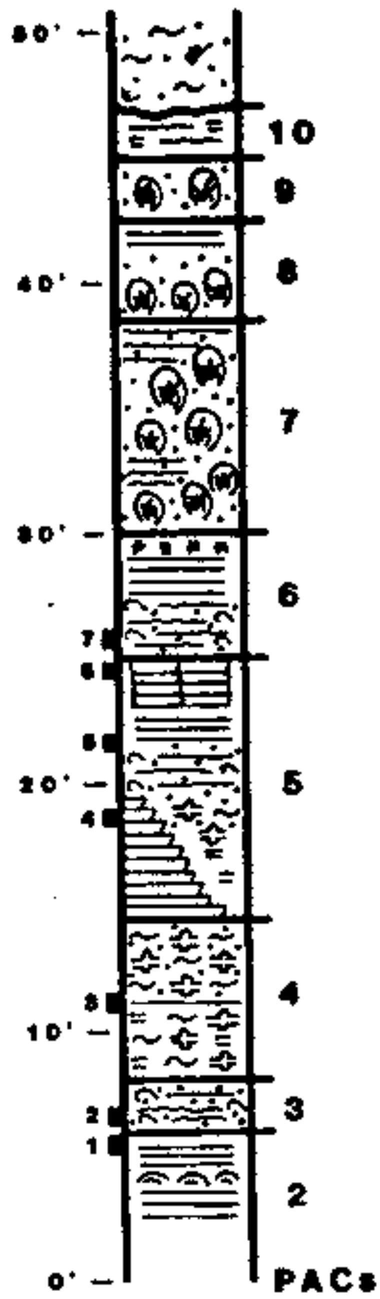
Figure 6:
Legend for all stratigraphic columns included in this study.

LEGEND FOR STRATIGRAPHIC COLUMNS

- Dolomite
- Mudcracked laminites
- Algal laminites
- Ostracod calcarenites
- Bedded calcarenites
- Calcarenites with shale interbeds
- Lime ribbons
- Birdseye fenestrae
- Cross beds
- Nodular, bioturbated beds
- Domal stromatolites
- Thrombolitic algae
- Bryozoans
- Gypidula
- Stromatoporoids
- ■ Rock samples

Numbered PACs comprise Thacher Member

Figure 7:
Measured stratigraphic column of locality 43 (South Catskill). Thacher PACs, bounded by non-depositional surfaces (horizontal lines), are indicated by numbers on the right side of column.



S. CATSKILL

suggests that sediments accumulated gradually during periods of base-level stability. The boundaries that occur between PACs are interpreted to be a result of geologically instantaneous sea-level rises which are represented in the rock record by sharp surfaces across which facies change abruptly to deeper environments.

Throughout the Hudson Valley region two types of PACs commonly occur within the Thacher Member, single-environment PACs and multiple-environment PACs. Both types of PACs are composed of a limited number of facies that are interpreted to represent the following depositional environments: subtidal; low intertidal; and high intertidal to low supratidal (table 2). Because Manlius facies at this locality contain both single-environment and multiple-environment PACs and all depositional environments are represented, South Catskill is chosen as a representative column for all Hudson Valley localities.

Single-environment PACs are defined as those PACs that consist entirely of facies that occur within a depositional environment. It is important to note that although only one general environment is present within these PACs, gradational vertical facies change indicates shallowing of that environment by aggradation.

At South Catskill, PAC 4 is an example of a single-environment PAC. The entire interval ($6\frac{1}{2}$ feet) consists of bioturbated, thin-bedded, fine-grained calcarenites and shale interbeds. An upward gradation of facies is observed within the calcarenites. Each successive calc-

Table 2:
Outcrop description, Folk classification, and environmental interpretation of commonly occurring Thacher facies.

FACIES	OUTCROP DESCRIPTION	FOLK CLASSIFICATION	ENVIRONMENTAL INTERPRETATION
LAMINITES	*mm thick beds; carbonate muds, dolomite, dolomitic shales; algal laminites, ostracods; lithoclasts, birdseye fenestrae, mud crack; weathers massive*	*fossiliferous micrite, dismicrite dolomitic rhombs*	*high intertidal low supratidal*
OSTRACOD CALCARENITE	*cm-mm thick beds, often discontinuous fine-grain calcarenite; ostracods, domal stromatolites, bryozoans, brachiopods; bedding thickness thins upward; weathers massive*	*biopelmicrite*	*low intertidal*
NODULAR BIOTURBATED BEDS	*variable bedding thickness; shaley calcarenites, shale interbeds; gastropods, brachiopods, ostracods, stromatoporoids; burrowed; weathers nodular*	*biopelmicrite*	*subtidal*
LIME RIBBONS	*thin-bedded (less 10 cm), laterally persistent; carbonate muds; "storm" interbeds contain ostracods, brachiopods, tentaculitids*	*micrite biosparite*	*subtidal*
BEDDED CALCARENITE	*thick-bedded (greater 10 cm), calc-arenites, shale interbeds; gastropods, brachiopods (Strophomenids), bryozoans, stromatoporoids, rugose corals*	*biopelsparite*	*subtidal*
STROMATOPOROID FACIES	*variable thickness; stromatoporoids dominate (biostromal), "reefy" debris; gastropods, some thrombolitic stromatolites*	*biolithite biopelsparite*	*subtidal*

arenite bed exhibits a decrease in shale content and a decrease in effects due to bioturbation (figure 8). Thin-section analysis reveals alternations of fossiliferous micrite beds and shale drapes. Primary fossil constituents of the fossiliferous micrite beds are gastropod and ostracod fragments (figure 9). Random orientation of micritic lithoclasts in nodular beds suggests intermittent periods of bioturbation (figure 10). Interpretation of outcrop and thin-section data indicates that PAC 4 was deposited in a subtidal environment. Furthermore, the gradual decrease in shale content and increase in carbonate abundance from the base to the top of PAC 4 demonstrate that sediments were shallowing upward and accumulating under stable base-level conditions. A deepening event (PAC 4-PAC 5 boundary) prevented shallowing to the intertidal environment thereby producing a wholly subtidal PAC (figure 8).

Like its upper boundary, the lower boundary of PAC 4 is marked by a surface of non-deposition. The lower surface (8 foot mark, figure 7) corresponds to an abrupt facies change from the laminated calcarenites of PAC 3 to the thin-bedded, bioturbated, shaley calcarenites of PAC 4. Thin-section analysis across this boundary (figure 11) reveals an abrupt lithofacies change from biopelmicrites (PAC 3) to nodular, fossiliferous micrites (PAC 4). Interpretation of facies directly above and below the surface suggests an abrupt change of environments from intertidal deposits to subtidal deposits initiated by an abrupt

Figure 8:
Field photograph of PAC 4 at South Catskill (locality 43). The single-environment, subtidal PAC is embraced by the arrows (PAC stick is 4 feet long).

Figure 9:
Thin-section photonegative showing the fossil constituents of the nodular beds of PAC 4 (scale is 1 cm).

Figure 10:
Thin-section photonegative showing extensive bioturbation within the nodular beds of PAC 4 (scale is 1 cm).

Figure 11:
Thin-section photonegative of abrupt facies change across a PAC boundary; biopelmicrites of PAC 3 (figure 11a) change abruptly to nodular, fossiliferous micrites of PAC 4 (figure 11b).

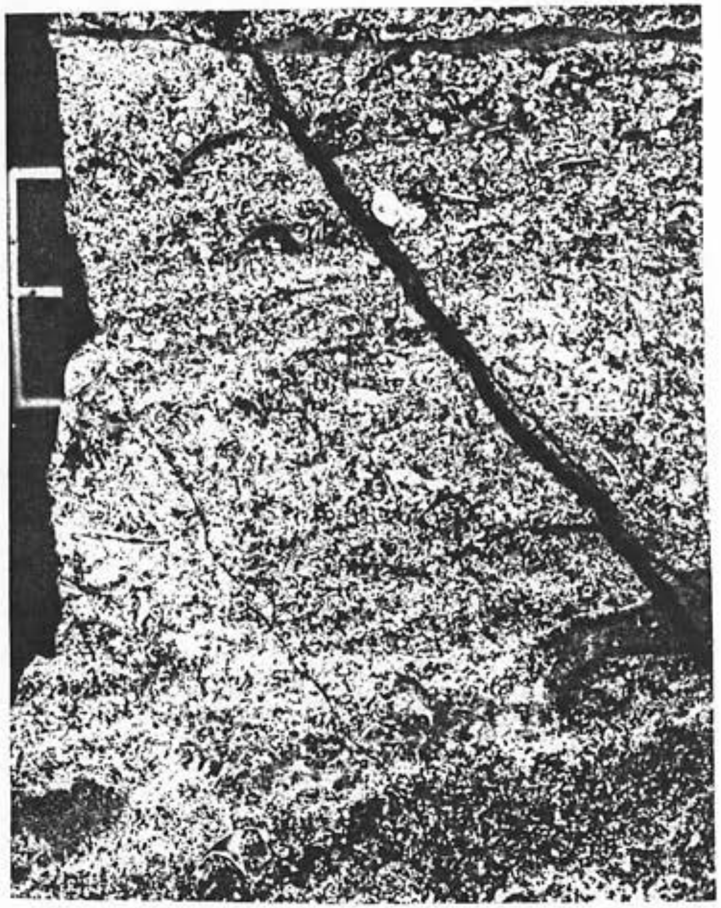


figure 11a

figure 11b

relative rise of sea-level.

Another example of a single-environment PAC is PAC 3 which is interpreted as a wholly intertidal PAC (figure 7). PAC 3 (2 feet thick) consists entirely of laminated calcarenites that weather as a massive unit (figure 12). Bedding thickness decreases upward suggesting that tidal effects gradually increased as shallowing continued through the intertidal environment. Thin-section analysis of this facies reveals that the calcarenite is a biopelmicrite containing bryozoan, brachiopod and ostracod fragments, calcispheres and abundant pellets in a micrite-rich matrix (figure 13). The orientation of these carbonate grains into laminae suggests that sediments were continually affected by current activity. Relative abundance of pellets and micrite matrix suggests that current washing was kept to a minimum. Faunal representation in thin-section indicates open marine conditions of good circulation and near normal salinity. Therefore, this facies is interpreted to represent deposition in a low intertidal environment.

Multiple-environment PACs exhibit a more pronounced shallowing-upward motif than that observed in single-environment PACs. Stable base-level conditions and sufficient sediment accumulation rates produced rock units that represent shallowing through more than one depositional environment.

PAC 5 represents a multiple-environment PAC that contains a complete (subtidal through low supratidal)

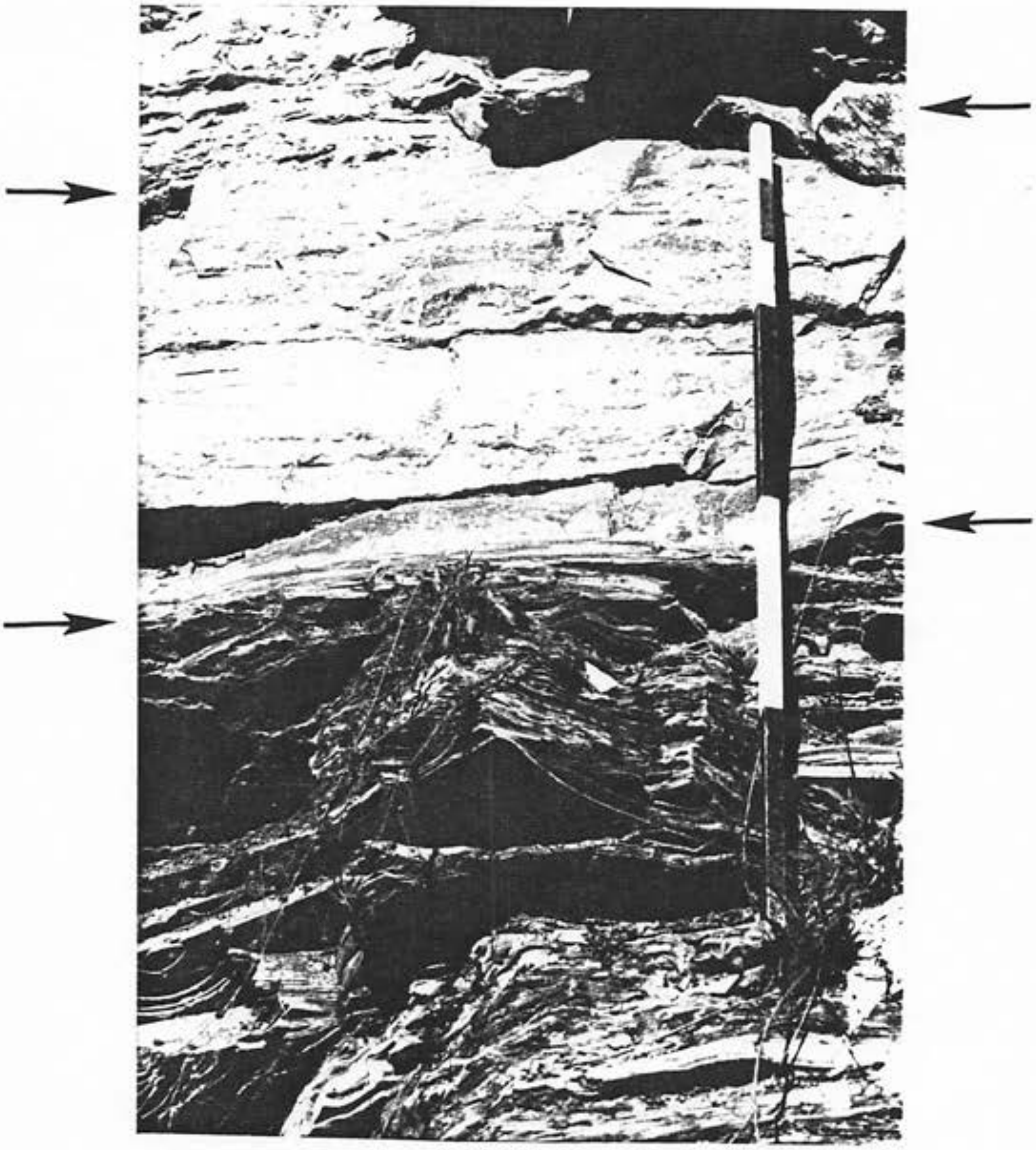


Figure 12:
Field photograph of PAC 3 at South Catskill (locality 43). The single-environment, low intertidal PAC is embraced by the arrows (PAC stick is 4 feet long).

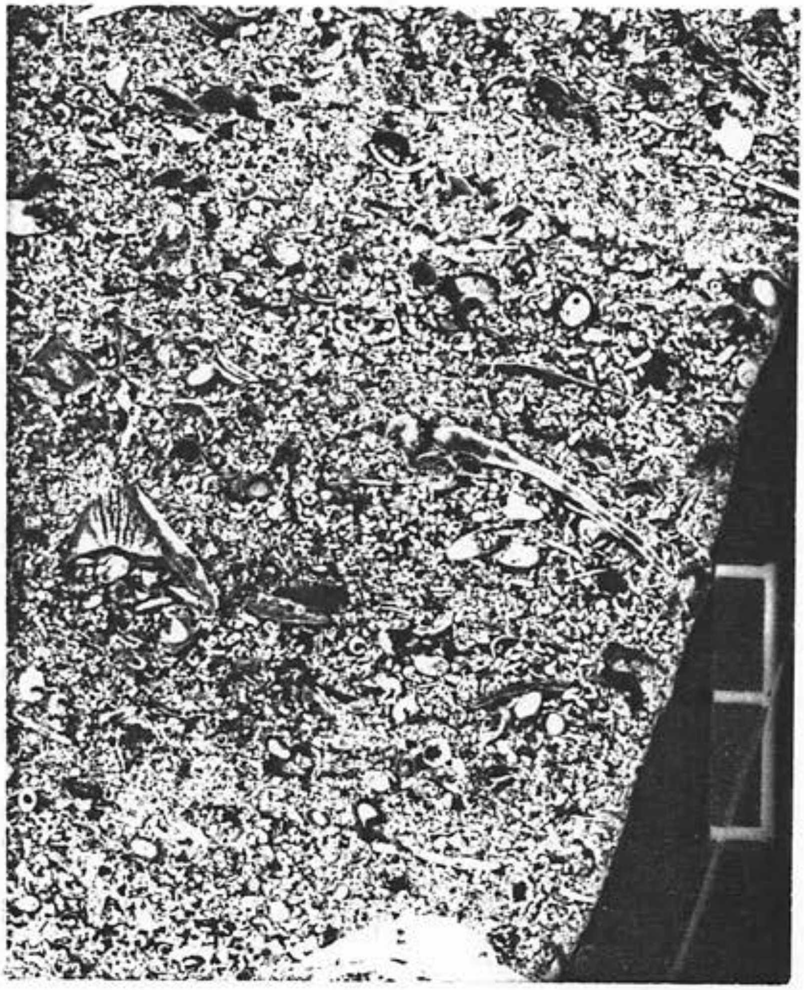


Figure 13:
Thin-section photonegative showing the various faunal constituents of the "ostracod" calcarenites (scale is 1 cm).

shallowing-upward motif (figure 14) suggest that the punctuation event which produced the PAC 4-PAC 5 boundary was large enough to create subtidal conditions. Subtidal facies grade upward into laminated calcarenites, characteristic of the low intertidal environment. Occurrence of mud-cracked, cryptalgal stromatolites, rich in birdseye fenestrae indicates that aggradation continued into the low supratidal environment (figure 15).

A fundamental tenet of the Hypothesis of Punctuated Aggradational Cycles is that a stratigraphic interval is totally divisible into PACs, small-scale (1-5 meters thick) shallowing-upward cycles separated by sharply defined non-depositional surfaces traceable throughout a basin of deposition (Anderson and Goodwin, 1978). Analysis of PAC 3, PAC 4, and PAC 5 reveals this pervasive pattern of sediment accumulation. In all three instances each depositional unit (PAC) is bounded by sharp surfaces across which facies change is abrupt in response to relative water depth increases. Furthermore, facies within individual PACs exhibit a gradational shoaling; shallowing-upward patterns are observed in both single and multiple-environment PACs.

Construction of a relative water depth curve for the column at South Catskill yields a graphic representation of the events which produced this series of PACs (figure 16). Instantaneous base-level rises, sedimentation rates and subsidence rates are incorporated into the relative water depth curve. Instantaneous base-level rises are illustrated

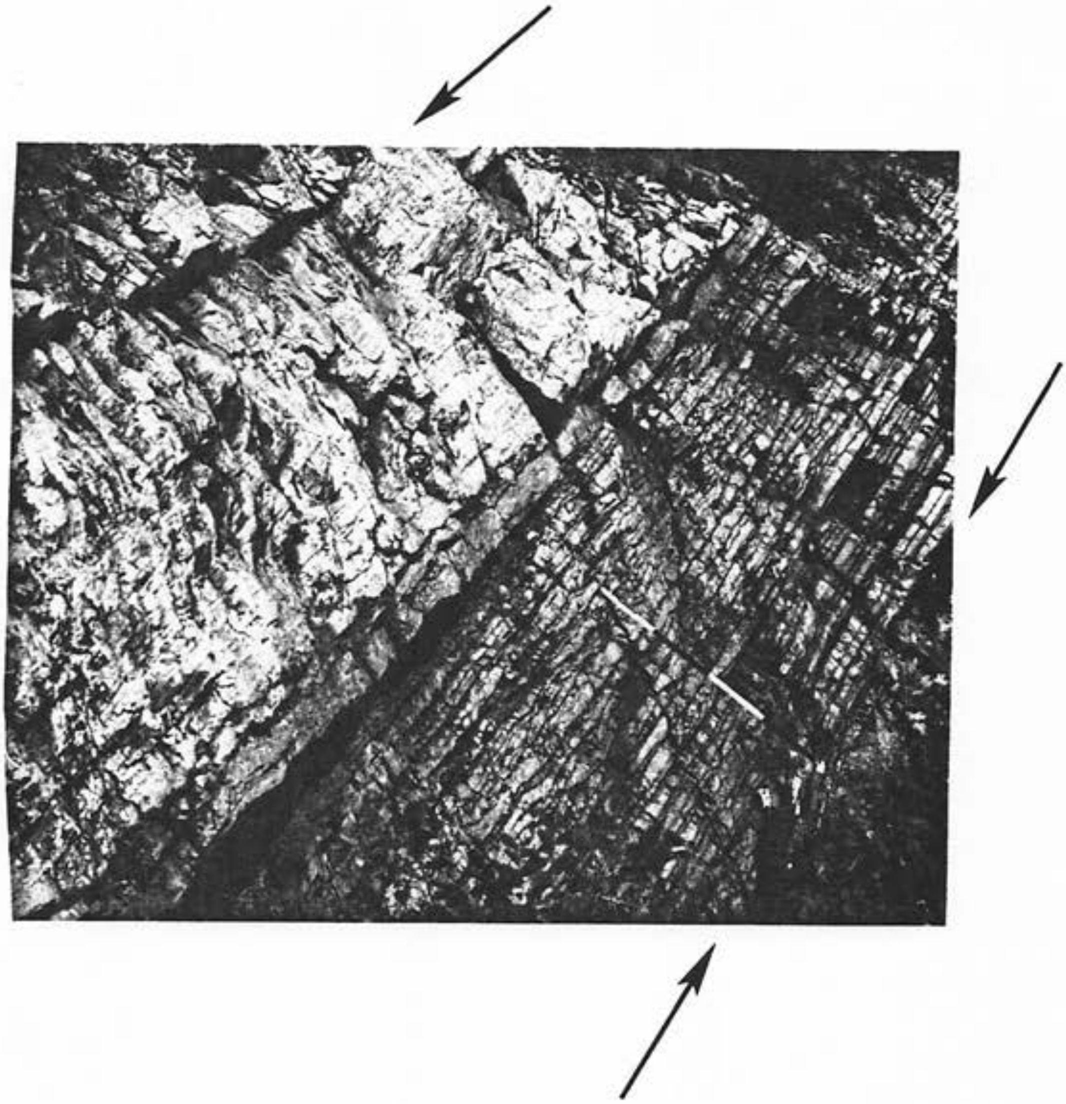


Figure 14:
Field photograph of PAC 5 at South Catskill (locality 43). This multiple-environment PAC contains a complete (subtidal lime ribbons through supratidal cryptalgal stromatolites) shallowing-upward motif. PAC 5 is embraced by the arrows (PAC stick is 4 feet).

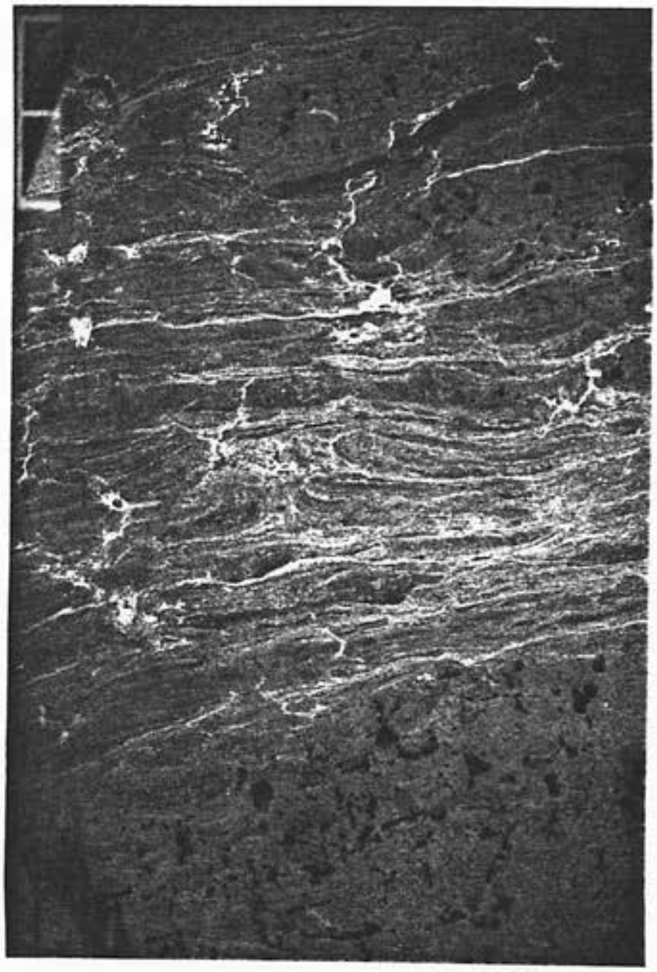
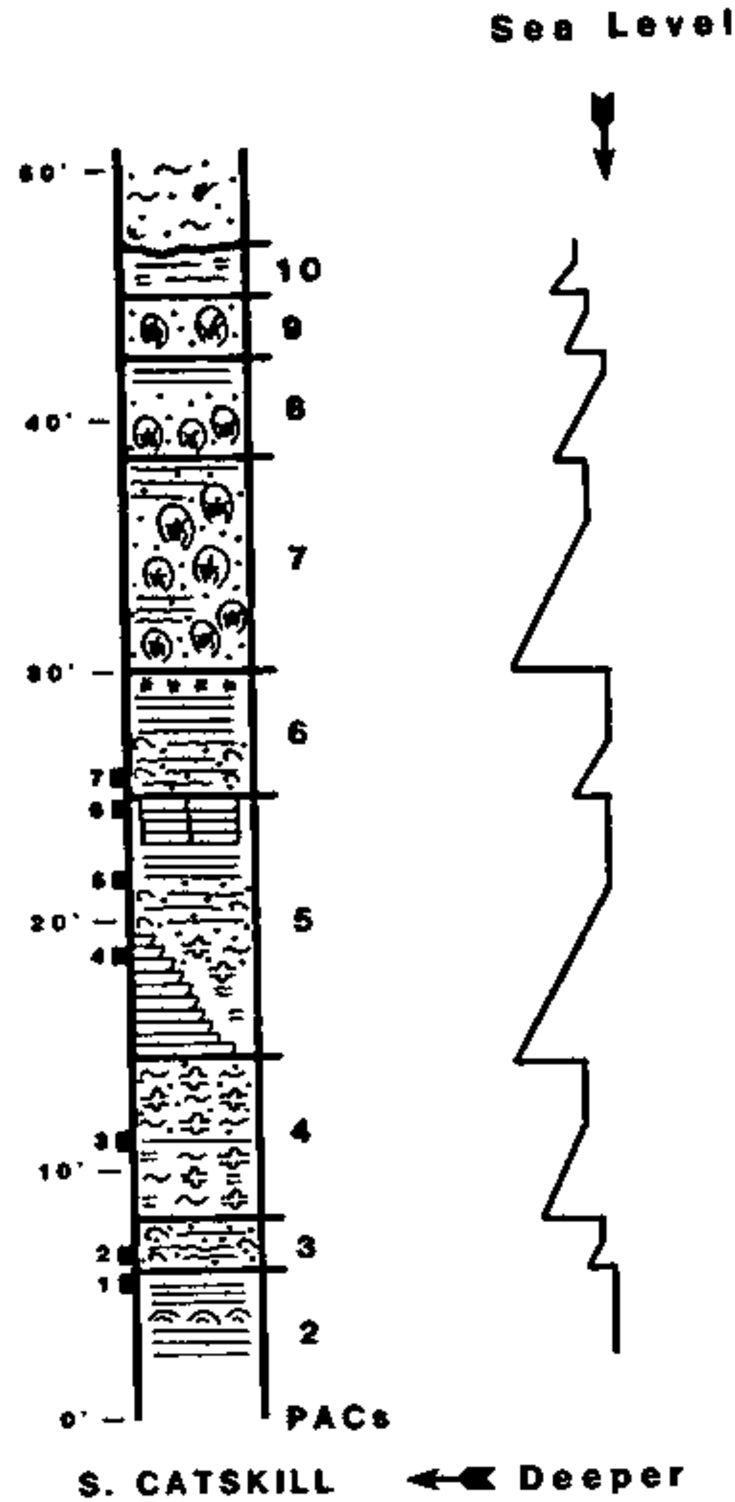


Figure 15:
Thin-section photonegative showing the cryptalgal stromatolites and birdseye fenestrae that comprise the supratidal facies of PAC 5 (scale is 1 cm).

Figure 16:
Measured stratigraphic column of locality 43 (South Catskill). Interpreted relative water depth curve is constructed from depositional patterns observed at South Catskill.


Sea Level
60'
40'
30'
20'
10'
0'
10
9
8
7
6
5
4
3
2
PACs
S. CATSKILL
Deeper

by horizontal lines; the relative magnitude of each base-level rise is indicated by the amount of left lateral shift of the curve. Shallowing by aggradation during base-level stability is illustrated by the diagonal portions of the curve. Each PAC is assumed to have been affected by ongoing subsidence during deposition (suggested by thick accumulation of similar lithologies); the vertical portion of the curve illustrates the estimated amount of sedimentation in each PAC attributed to subsidence.

Because PACs are theoretically basin-wide in extent, correlative sequences of PACs at different localities should have been produced by the same sequence of events. Therefore, water depth curves of these columnar sections should be comparable. Independently constructed curves should provide an additional criterion for establishing detailed correlations. Comparison of relative water depth curves from South Catskill and Thacher Park (25 miles apart) indicates that the depositional patterns recorded at each locality were produced by the same seuqence of events (figure 17). Since the same sequence of events can be identified between the two localities, it is possible to correlate individual events and therefore, individual PACs between localities (figure 18).

PAC Correlations

In order to use PACs in paleoenvironmental and paleogeographic reconstructions it is necessary to establish detailed correlations of Thacher PACs throughout the Hudson

Figure 17:
Measured stratigraphic column of locality 59 (Thacher Park). Interpreted relative water depth curve is constructed from depositional patterns observed at Thacher Park.

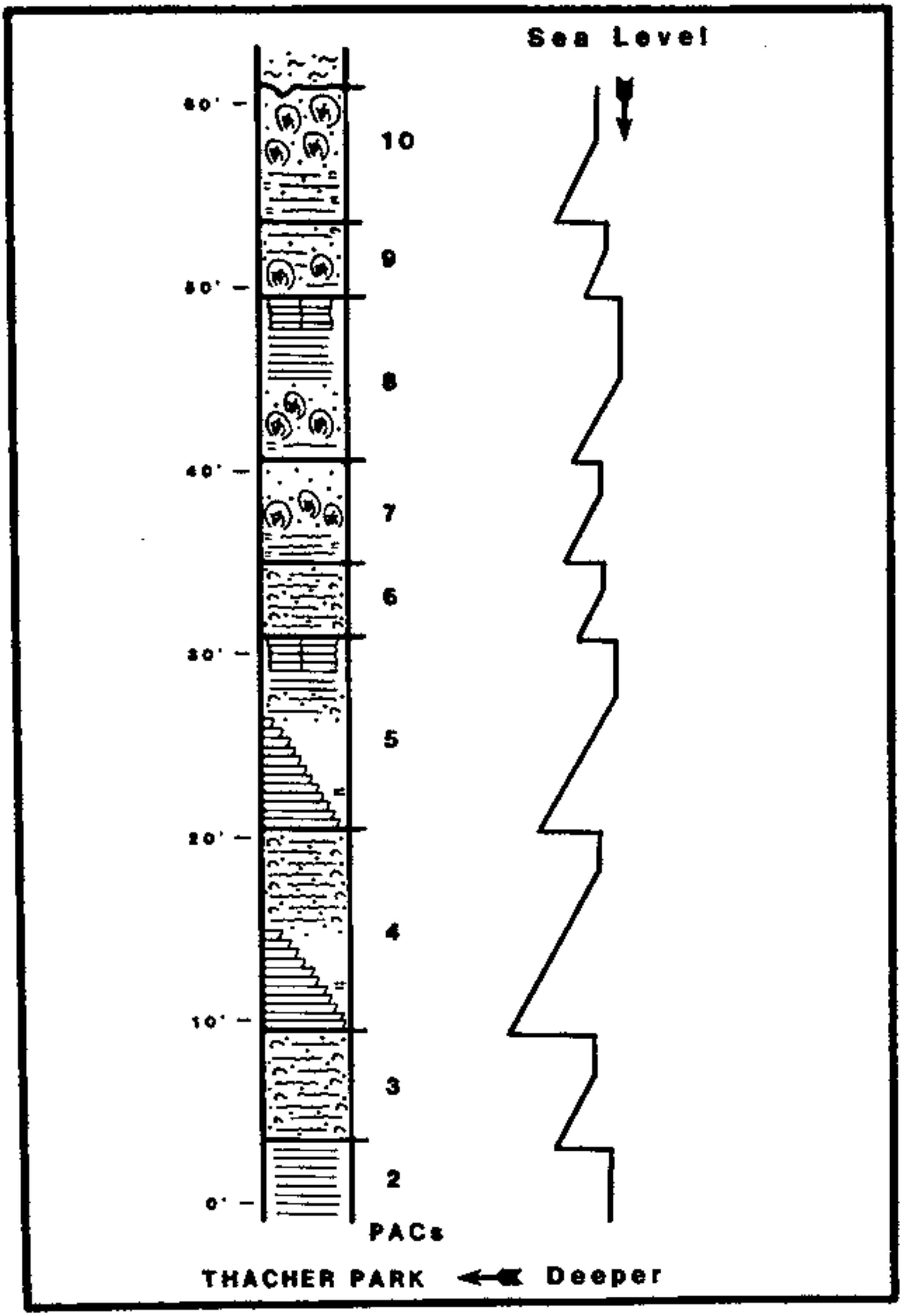
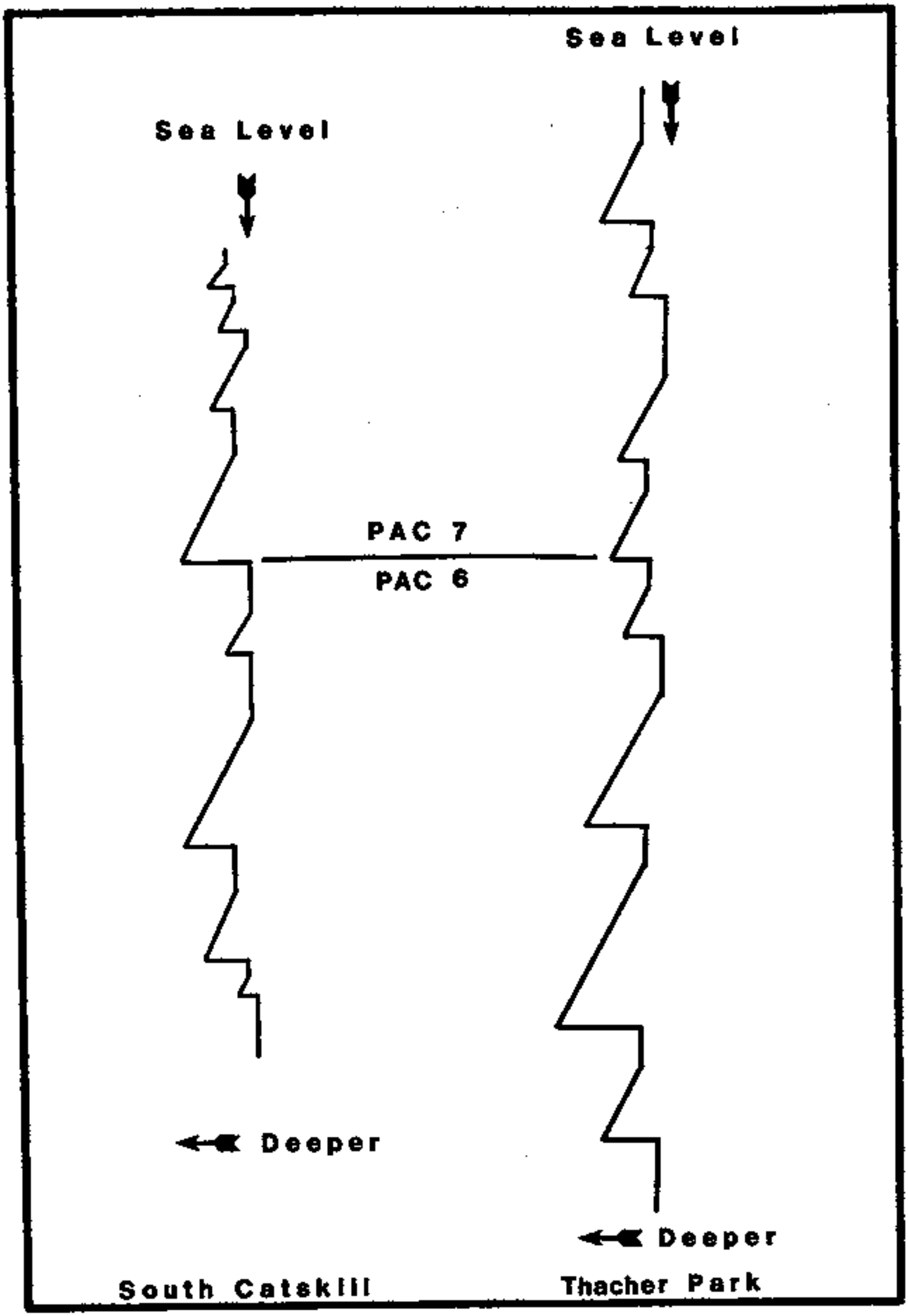

Sea Level
60'
50'
40'
30'
20'
10'
0'
10
9
8
7
6
5
4
3
2
PACs
THACHER PARK
Deeper

Figure 18:
Correlation of depositional events from South Catskill and Thacher Park by use of relative water depth curves.


Sea Level
Sea Level
PAC 7
PAC 6
Deeper
Deeper
South Catskill
Thacher Park

Valley. According to Goodwin and Anderson (manuscript) the PAC approach to chronologic correlation is a multi-dimensional process based upon the following methods: 1) tracing of PACs between closely spaced sections; 2) matching PAC sequences (deepening or shallowing) between closely spaced sections; and 3) correlating large punctuation events. In this study, correlations within the Thacher Member have been established by combining the first and third methods of PAC correlation.

Fundamental to this study is the third method of correlation, matching large punctuation events. According to Goodwin and Anderson "such events produced major facies changes in all paleoenvironments throughout the basin and are therefore represented by well-defined surfaces at most localities" (p. 32, manuscript). Examples of two major punctuation events that occur within the Thacher Member are the PAC 3-PAC 4 boundary and the PAC 6-PAC 7 boundary.

Because major punctuation events often produce major facies changes throughout a basin of deposition, they are utilized as time-stratigraphic data. The PAC 6-PAC 7 boundary is utilized as the stratigraphic datum for this study. This datum, the PAC 6-PAC 7 surface, marks the most dramatic change of facies within the Thacher Member. Specifically, it marks a change from low intertidal laminated calcarenites or high intertidal/low supratidal cryptalgal laminites to subtidal stromatoporoid and shale-rich calcarenites. Generally, it marks an overall change in depositional environments from primarily low intertidal and high intertidal/low supratidal PACs (below the PAC 6-PAC 7 boundary) to primarily subtidal PACs (above the PAC 6-PAC 7 boundary). This datum may be traced for a distance of 100 kilometers through 10 localities (figures 19-25).

The PAC 3-PAC 4 boundary is a surface representing another deepening event which can be utilized as a check on the correlations that are based upon the PAC 6-PAC 7 datum. Like the PAC 6-PAC 7 boundary, the PAC 3-PAC 4 boundary is traceable throughout the study area and represents a major facies change at all localities.

Utilization of the first method of correlation, tracing of PACs between closely spaced sections, provides a mechanism by which it is possible to correlate smaller-scale punctuation events and, therefore, individual PACs among localities. Because facies changes over short distances are generally minor, it is possible to trace individual PACs by conducting lithologic and faunal comparisons. Also, incorporation of the relative water depth curve into the first method of correlation will aid in determination of stratigraphic positioning.

Correlation of the PAC 5-PAC 6 boundary illustrates how minor punctuation events are correlated among localities. At South Catskill (figure 7) the PAC 5-PAC 6 boundary is marked by an abrupt change from the mud-cracked, cryptalgal stromatolites of PAC 5 to the laminated calcarenites of PAC 6. Lateral comparison of facies between closely spaced

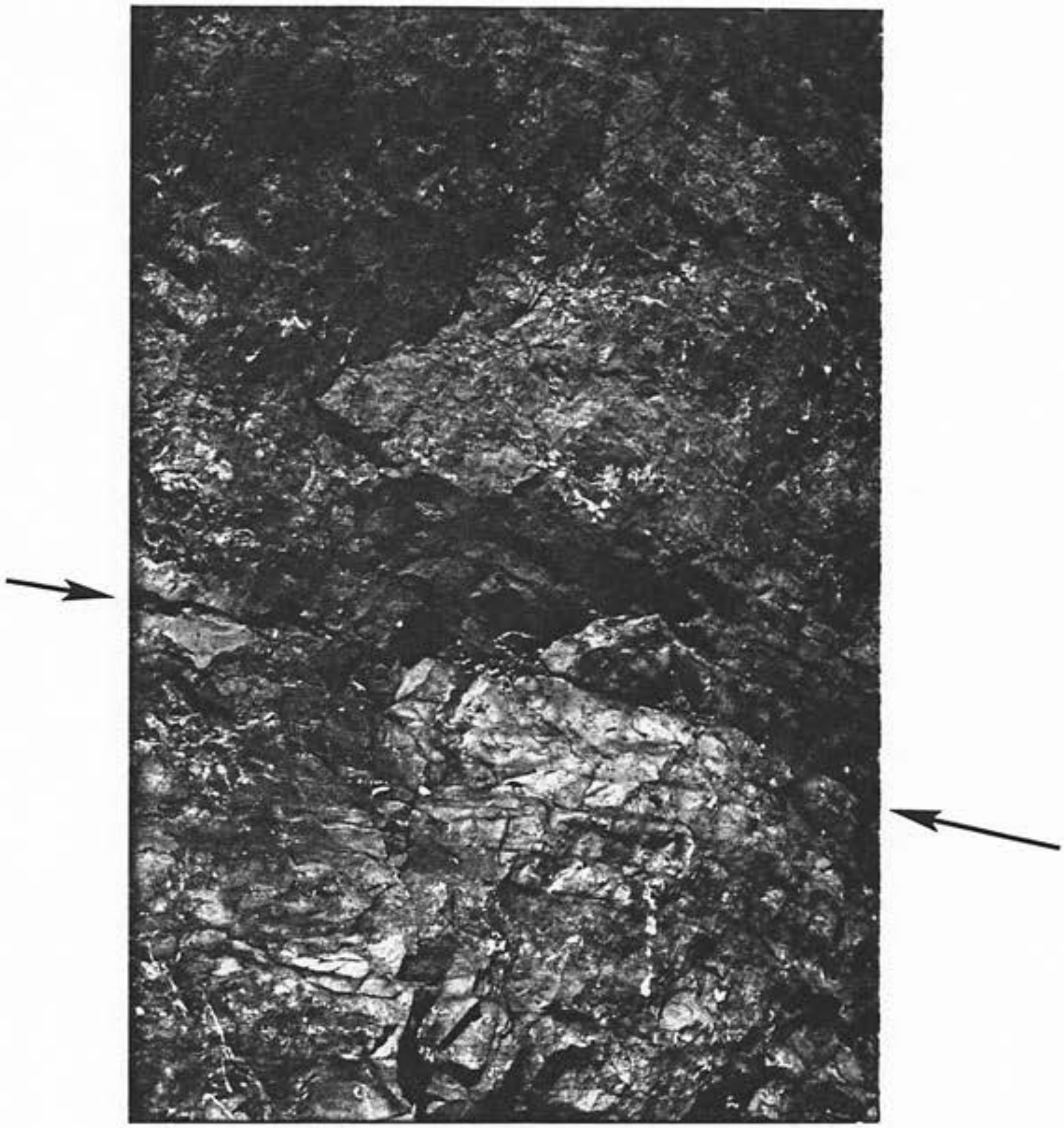


Figure 19:
Close-up of the PAC 6-PAC 7 boundary at East Kingston (locality 25). Lens cap rests on the surface that marks the abrupt change from bedded calcarenites to biostromal stromatoporoids.

Figure 20:
Close-up of the PAC 6-PAC 7 boundary at South Catskill (locality 43). Lens cap rests on the boundary.

Figure 21:
Close-up of the PAC 6-PAC 7 boundary at North Catskill (locality 44-B). Note the similarities of this contact with the same contact at South Catskill. Lens cap rests on the boundary.