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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Edward Gerard Stermer

ENTITLED Middle Morrowan Carbonate Cycles of the Arrow Canyon,

Clark County, Nevada

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science

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Middle Morrowan Carbonate Cycles of the Arrow Canyon
Clark County, Nevada

by

Edward G. Stermer

Thesis

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Degree of Bachelor of Science
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ABSTRACT

Five complete cycles of carbonate sedimentation occur in the Middle Morrowan in the Bird Spring Group, Arrow Canyon, Nevada. These five cycles consist primarily of shallowing-upward sequences which are interrupted by abrupt deepening events.

The New Eustatic model of cyclic sedimentation (Carozzi, 1986) provides the most effective explanation of this Middle Morrowan ciclicity. The Vail curve of eustatic sea level change (Vail et al., 1977) suggests that the entire Morrowan Series represents a transgression. This, however, is not reflected in the examined cycles. Goodwin and Anderson's (1985) model of Punctuated Aggradational Cycles can be applied to 3 of the five cycles but does not offer a complete explanation for the Middle Morrowan cyclicity at Arrow Canyon.

ACKNOWLEDGEMENTS

The author wishes to thank Dr. R. L. Langenheim Jr. for his guidance and supervision of this study. Many thanks to Richard Poskin for providing hours of geologic banter without which I would never have understood the true meaning of the word "scholar". The author also acknowledges the Department of Geology at the University of Illinois for support of this project.

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INTRODUCTION

Middle Morrowan strata of the Bird Spring Group at Arrow Canyon, Nevada, consist of a thick, almost completely exposed, conformable carbonate sequence. These rocks have been described in detail by V. A. M. Langenheim (1964) and C. P. Weibel (1982). The purpose of this study is to describe depositional cycles in this exposure and to compare them with existing models explaining late Paleozoic cyclicity. Vail curves (Vail *et al.*, 1977), Puncuated Aggradational Cycles (Goodwin and Anderson, 1985) and the New Eustatic model (Carozzi, 1986) all have been proposed to explain depositional cyclicity.

LOCATION

Arrow Canyon is at in the northeast end of the eastern most ridge of the Arrow Canyon Range, Clark County, Nevada (Figure 1). Most of this range is shown on the Arrow Canyon 15' Quadrangle (1958 ed) of the United States Geologic Survey. It is bounded by latitudes 36¦30'N. and 36¦45'N. and longitudes 114¦45'W. and 115¦00'W.

The canyon is about 50 miles northeast of Las Vegas (E 1/2, sec.11, S 1/2, sec.12, T14S, R64E, and SW 1/4, sec.7, T14S, R65E). From Las Vegas, the canyon can be reached via Interstate 15, travelling north to Glendale, and proceeding 11 miles northwest on Nevada state highway 168. Turn left on a paved secondary road and continue for about 0.4 miles until the intersection of a jeep trail on the right. Take the jeep trail past a refuse dump and continue 2 miles to the mouth of the canyon. The studied section begins approximately 0.5 miles past the canyon's mouth.

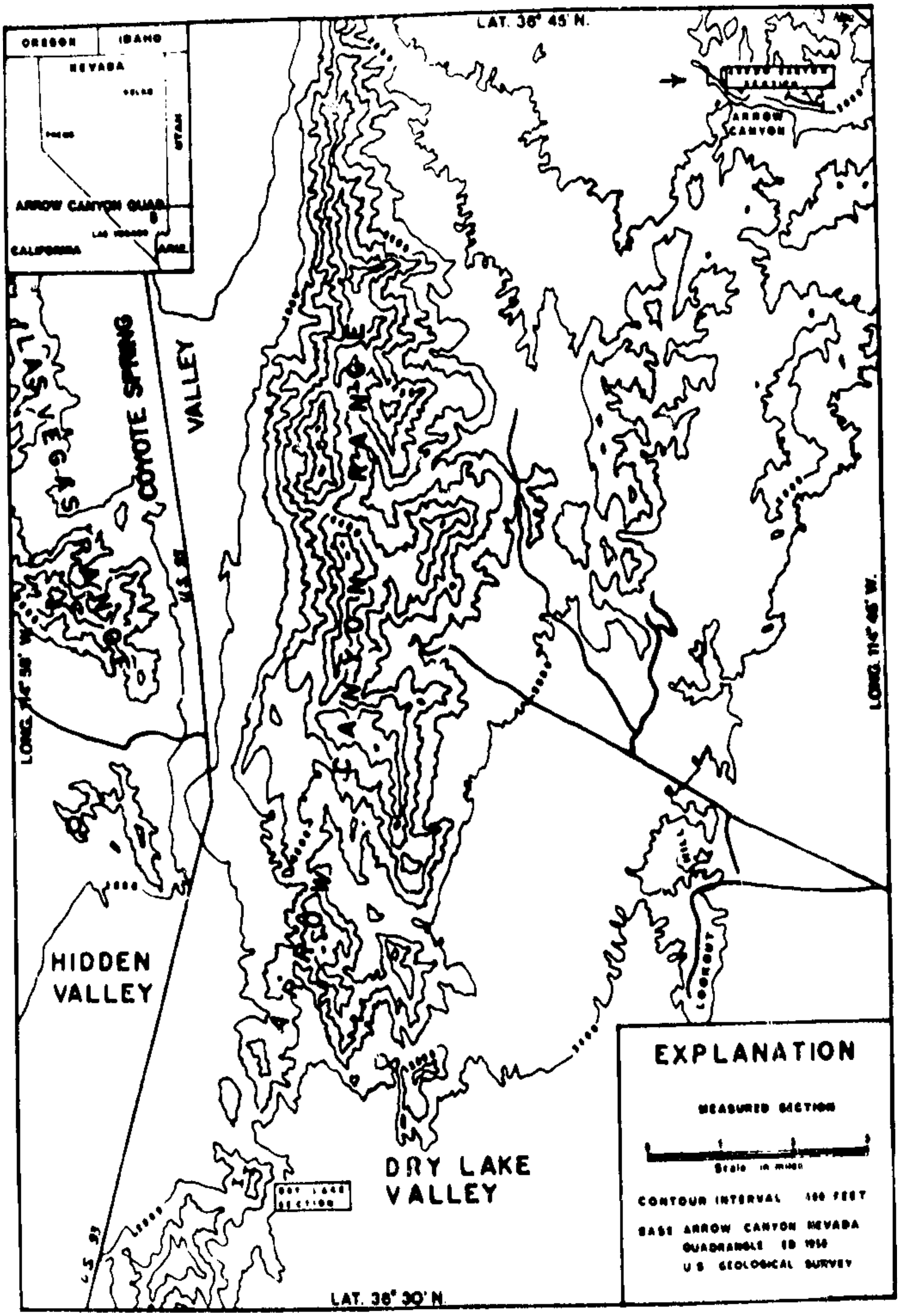

Figure 1. Location Map- Arrow Canyon is located in the northeast corner (Weibel, 1982).

GEOLOGIC SETTING

The Arrow Canyon Range is within the south-central portion of the Basin and Range Province. This area is characterized by north-south trending, blockfaulted mountains separated by broad, downfaulted valleys. The Arrow Canyon Range is composed entirely of Paleozoic rock units which were folded and thrust-faulted during the Nevadan Orogeny (late Jurassic - early Cretaceous). In the Miocene, blockfaulting began and produced the Arrow Canyon and other mountain ranges in the area. Arrow Canyon was eroded by a superimposed stream which eroded through the Tertiary and Quaternary alluvium and exposed the Paleozoic section.

The Arrow Canyon Range is divided into two main parts: the western main ridge and a series of lower foothills to the east. The eastern flank of the main range trends nearly parallel to the Arrow Canyon Syncline. The syncline's western limb forms the main ridge of the Arrow Canyon Range, exposing Ordovician to Mississippian strata, while it's eastern limb repeats the formations of the main ridge. The western flank of the main ridge is bounded by a steep, normal fault scarp separating the Las Vegas and Arrow Canyon Ranges (Longwell, et al, 1965). Arrow Canyon is in the eastern foot hills of the range.

Limestones of the Bird Spring at Arrow Canyon were deposited on the eastern edge of the Bird Spring Basin in the southern part of the Cordilleran Miogeosyncline (Rich, 1977). This miogeosyncline was characterized by Rich as a complex seaway with mobile segments and with marginal and possibly axial source areas. It was bounded by the Las Vegas-Wastch Line to the east and by the Antler Orogenic Belt to the west. The Bird Spring Basin was one of a series of isolated or interconnected basins in the Cordilleran Miogeosycline. Deposition in the Bird Spring Basin fluctuated with changes in sea level, basin size, and accumulation of sediment. In the Morrowan, the primary source of sediment in the Bird Spring Basin was the Antler positive element located just west of the basin. Wilson (1975) suggested that the Morrowan was a period of sea transgression after a study of the shelf deposits found in southern Nevada. Heath, Lumsden, and Carozzi (1967), however, have proposed that the Morrowan strata in Nevada represent 46 compete cycles of sea transgression-regression.

METHODS AND TECHNIQUES

Field work was conducted over a three day period from January 5 to January 8, 1989. A 321'6" section of strata approximately .5 miles from the mouth of the canyon was described and sampled. Individual stratal units were originally defined by V.A. Langenheim (1964) and are referred to by her VAL UNIT numbers. In the field, the VAL UNITS were subdivided based on changes in lithology, bedding, color, chertification, fossil content, and noticeable sedimentary structures. Examination was done macroscopically and with a handlens. Thicknesses were derived by referring to markers set up by AMOCO geologists at intervals of 1.5 meters. The markers are marked with an "A" followed by a serial number. The rock units described in this paper begin 1'7" above AMOCO marker A154 and end 1'6" above A88. Units between A154 and A114 were sampled on the canyon's north wall and units between A114 and A88 were sampled from the south wall.

GENERAL STRATIGRAPHY

Arrow Canyon exposes Mid-Mississippian through Permian strata which strike about N33E and dip 30-34} southeast. The rock units examined in this paper are in the Morrowan Series of the Early Pennsylvanian System.

All Morrowan rocks at Arrow Canyon are entirely within the Bird Spring Group. Glock (1929) first referred to the "Bird Spring Formation" while describing the strata in the Spring Mountain Range, Nevada. Hewett (1931) later placed the Bird Spring Formation within the Pennsylvanian System after examining it in great detail. Bissell (1962) was the first to recognize the Bird Spring Formation at Arrow Canyon. Later, Langenheim _et al_ (1962) elevated it to group status and subsequently divided the Bird Spring Group into five units, Bsa through Bse.

The Morrowan section described in this paper is all part of the Bsc unit. This unit is composed primarily of cherty limestone, ranging from fine to coarse grained. Brachiopods, bryozoans, and echinoderms are widespread while rugosa and Syringopora sp. occur in only a few beds. Castle (1967) and Micklin (1967) referred to the upper part of the Bsc unit as the Tungston Gap Chert Member of the Bird Spring Group due to its repetitive chert layers. Although this has not formally been proposed as a member, Langenheim and

Webster (1979) refer to it as a distinct unit of regional significance in the Arrow Canyon area.

The "marker limestone", a distinctive limestone unit, occurs within the examined section (Webster, 1969). It is referred to as Unit 1 (VAL# 49A, 48, 47, 46). The "marker limestone" contains many closely spaced, but distinct layers of chert which make it easy to identify in the field. In fact, it is recognizable over an area of several thousand miles and is useful in determining stratigraphic relationships in the region. At Arrow Canyon the "marker limestone" is approximately 100 feet thick.

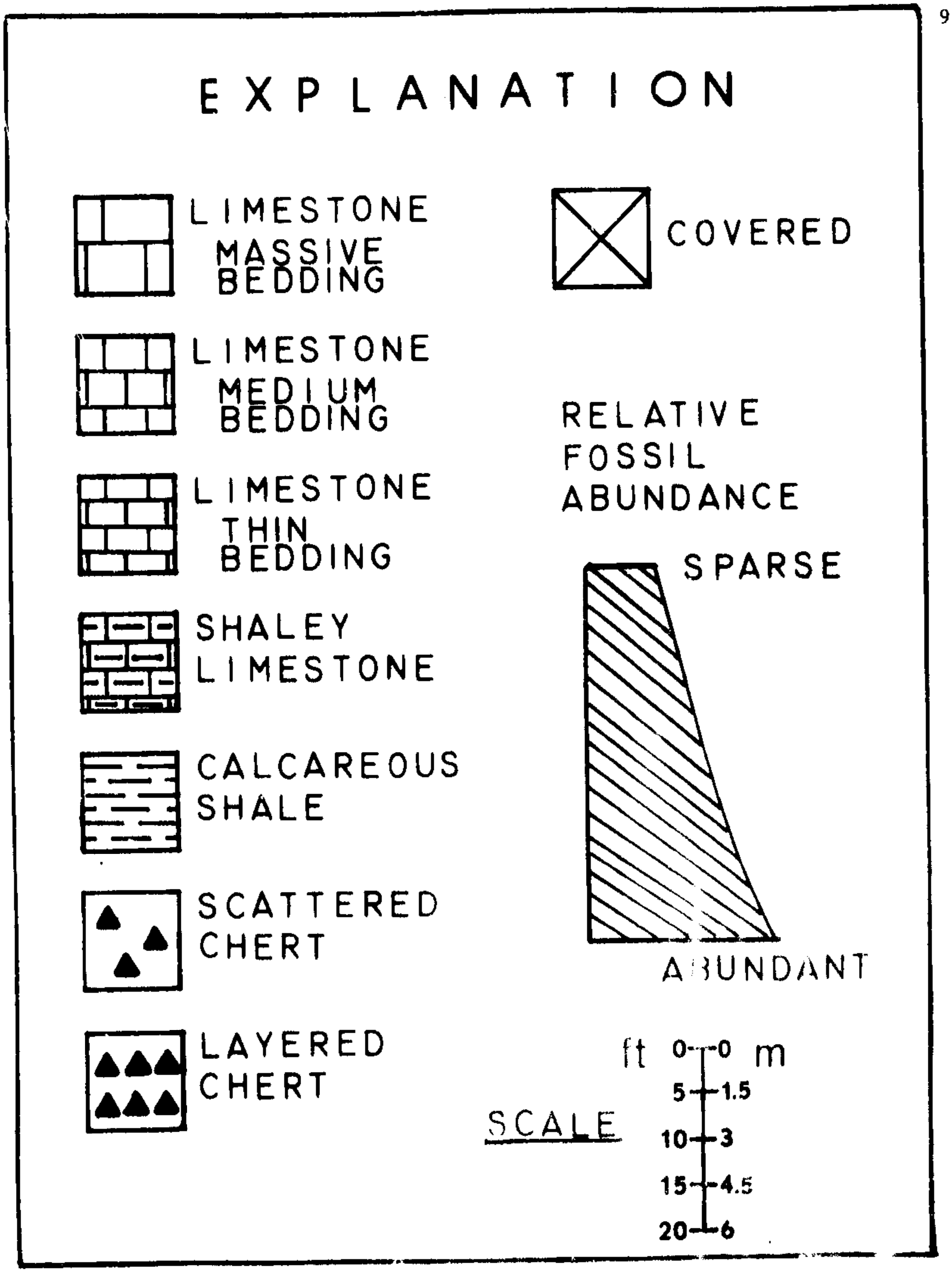

Figure 2. Explanation.

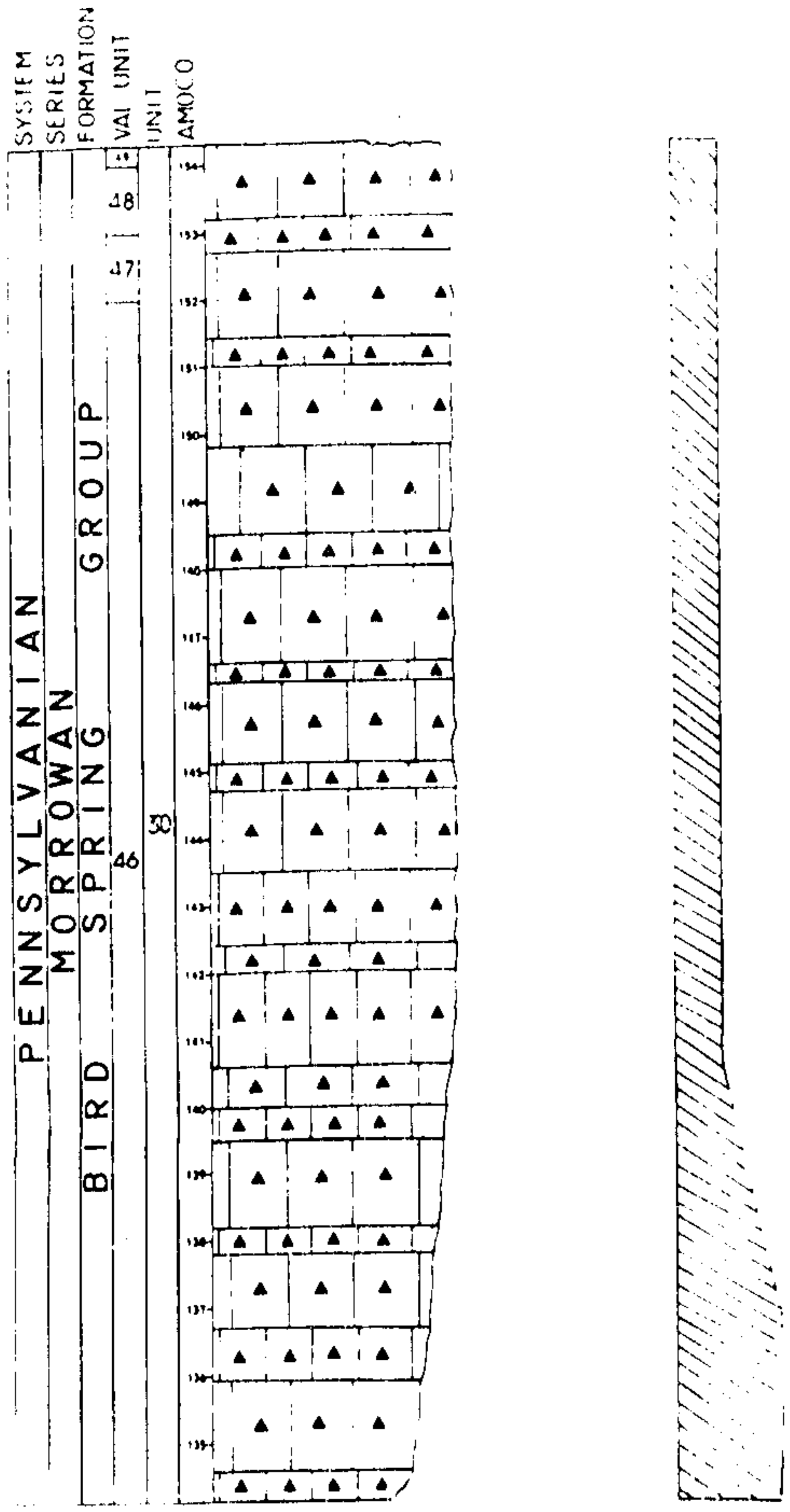

Figure 3 Stratigraphic Column

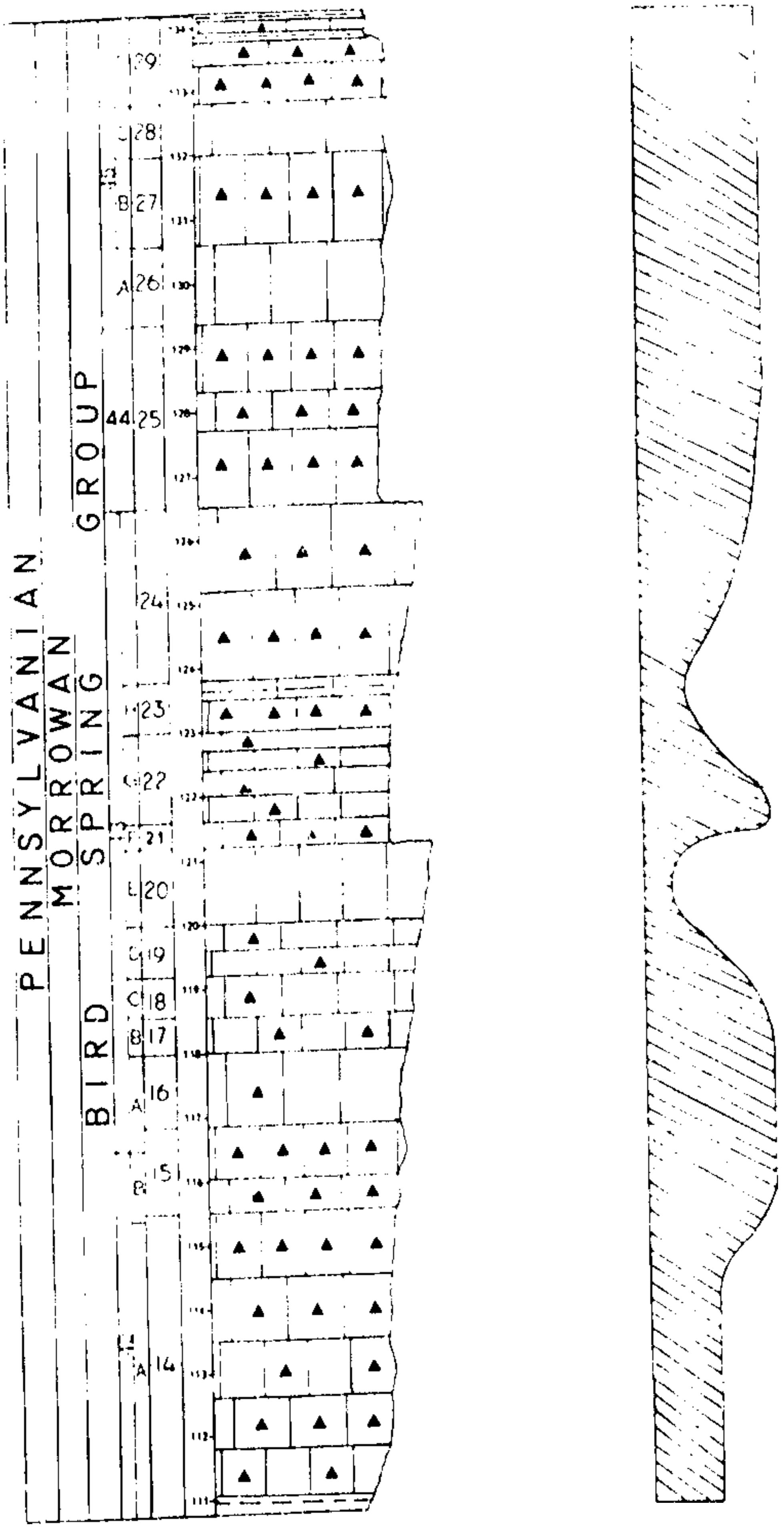

Figure 4. Stratigraphic Column

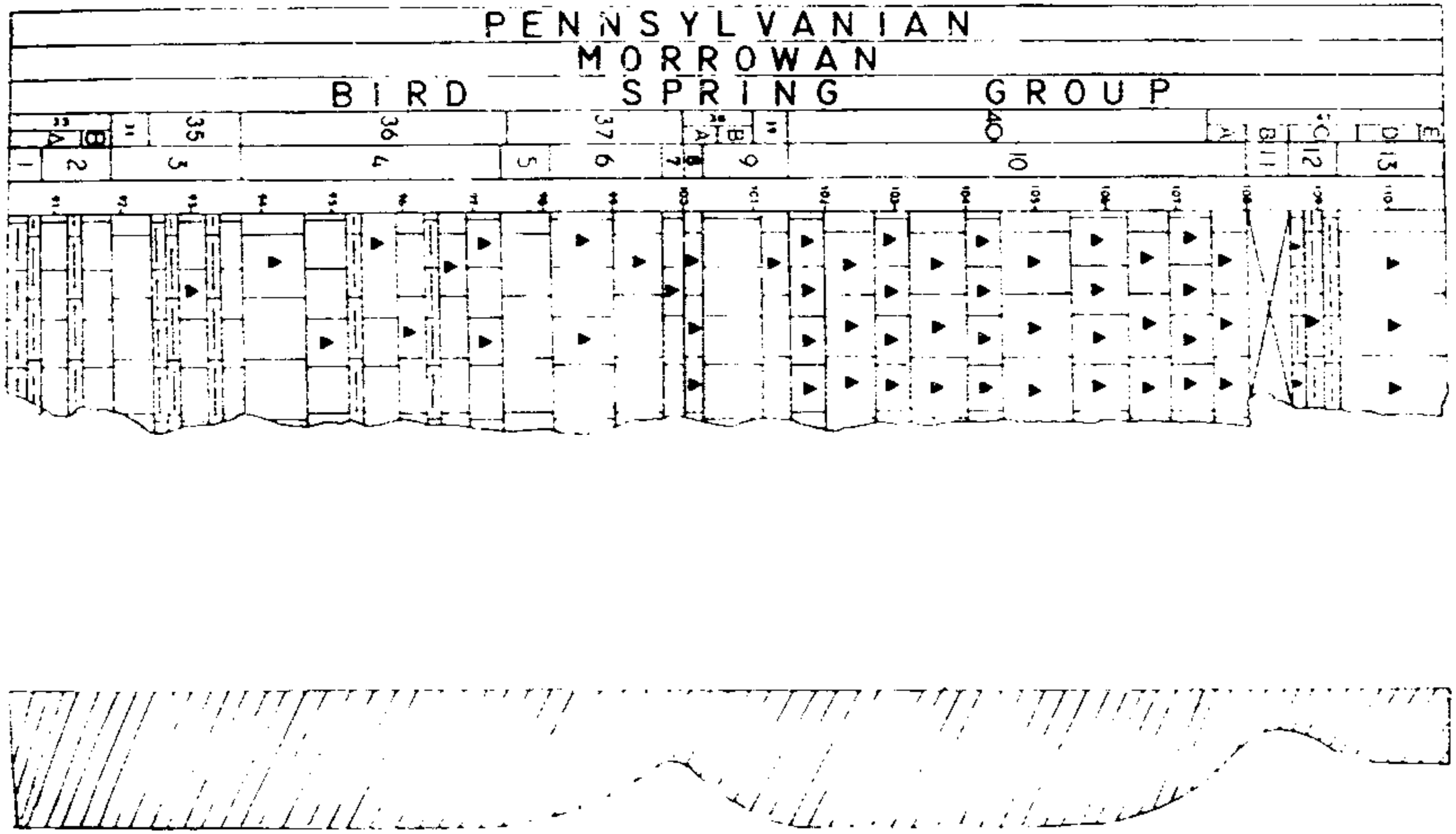

Figure 5. Stratigraphic Column

DETERMINATION OF CYCLES

5 complete cycles have been noted within the Morrowan strata described in this paper. Determination of the cycles is based on the microfacies studies of the Bird Spring Group by Heath, Lumsden and Carozzi (1967) and on the paleoenvironmental interpretation of the Syringopora species at Arrow Canyon by Weibel (1982).

Heath, Lumsden and Carozzi (1967) recognized 11 lithologic types at Arrow Canyon which they call microfacies groups. There are 5 quartz rich groups and 6 normal groups. The 5 quartz rich microfacies are limited to the Upper Morrowan and are absent in the described sequence. The normal microfacies consist of 6 groups, 0 - 5, defined as follows:

Microfacies 0- This limestone is fine grained and consists of thin to massive beds. The fresh surface is medium to dark gray which weathers light gray to tan. The rock lacks visible megafossils and fossil fragments but contains abundant chert nodules and layers.

Microfacies 1- This limestone occurs in thin to thick beds most of which are fairly resistant. The rock is fine grained and poorly fossiliferous. Fresh surfaces are primarily gray weathering to brown to light gray. Nodules and layers of chert are abundant.

Microfacies 2- This limestone is medium grained and occurs in thin to medium beds which are poorly resistant. The fresh surface is gray which weathers light gray to brown. Fossils include crinoid debris, brachiopods, and bryozoans. Chert is moderately abundant.

Microfacies 3- This limestone occurs in massive, resistant beds. It is coarse grained and chert is inconspicuous. Fresh surfaces are light to dark gray and crinoid debris, brachiopods, and bryozan are abundant throughout.

Microfacies 4- This limestone is medium to coarse grained and occurs in thin to massive beds. Fresh surfaces are gray but weather dark gray. The rock is fairly resistant and is very fossiliferous (crinoid debris, brachiopods and bryozoans). Veins of calcite are moderately abundant.

Microfacies 5- This medium grained limestone occurs in thin to medium beds. Oolites are abundant. The rock is resistant and chert is absent. Fresh surfaces are gray but weathers light gray. Crinoids and brachiopods occur where oolites are absent.

According to Heath, Lumsden and Carozzi (1967), each microfacies represents a different environment of carbonate deposition. Microfacies 0 corresponds to a low energy, deep water environment which grades upward to microfacies 5, a high energy, shallow water environment. Figure 6 shows the relationship between the distribution of the microfacies and the position of the wave base.

The syringoporids in units 15,16,17,21,26 and 27 also indicate the environment of deposition. Weibel (1982) associates the syringoporids with microfacies 1 and 2. The syringoporids found relatively undisturbed in growth position are associated with the quiet, deep waters of microfacies 1. Those found abraded and broken are related to microfacies 2, as would be expected with an increase in environmental energy.

The ideal microfacies cycle begins at 0, grades to 5, and then returns to 0. Based on this Heath, Lumsden and Carozzi (1967) propose that the Morrowan strata at Arrow Canyon consists of 46 complete cycles. Also, there is a general trend towards increasingly deeper and quieter conditions which lead them to conclude that the Morrowan represents a major transgression.

Figure 7 illustrates the cyclic nature of the described section. The 5 cycles were determined by assigning a

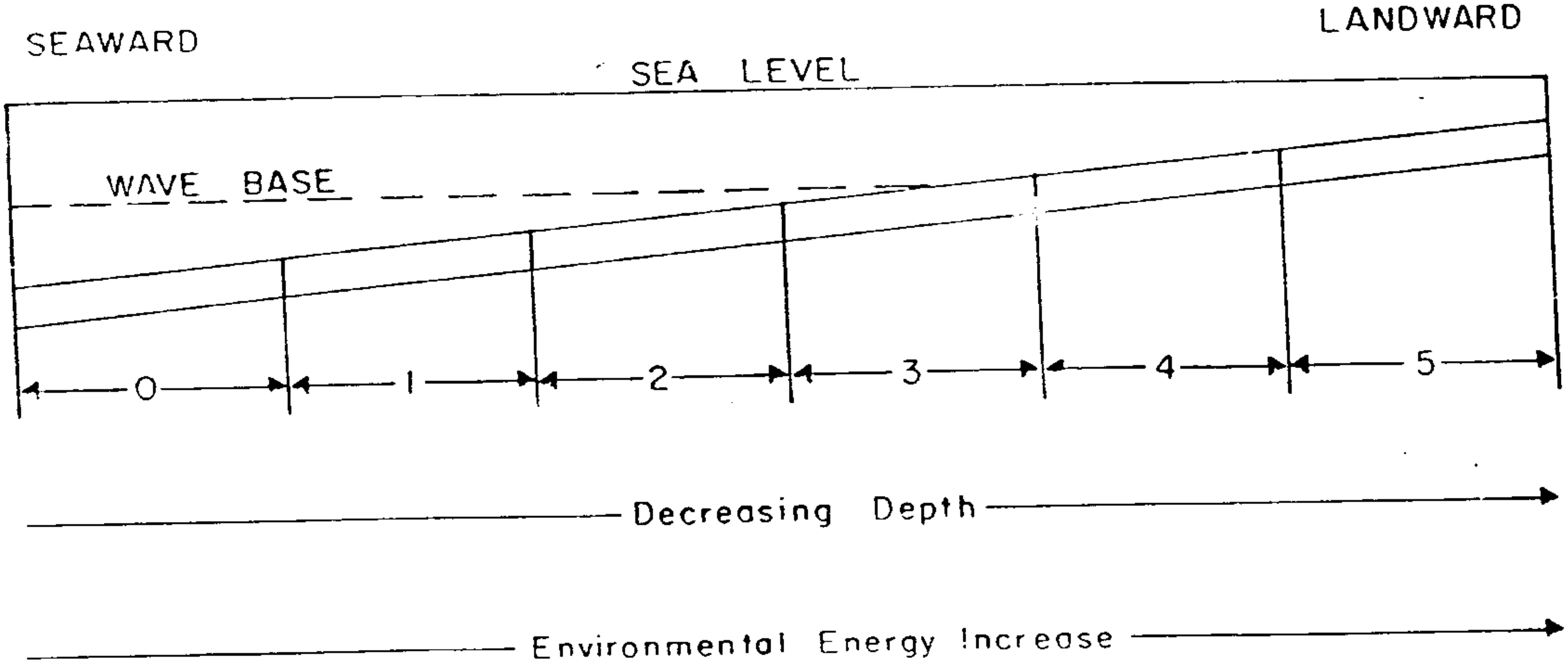

Figure 6. General horizontal interpretation of microfacies relationships. AFTER Heath, Lumsdem and Carozzi (1967).

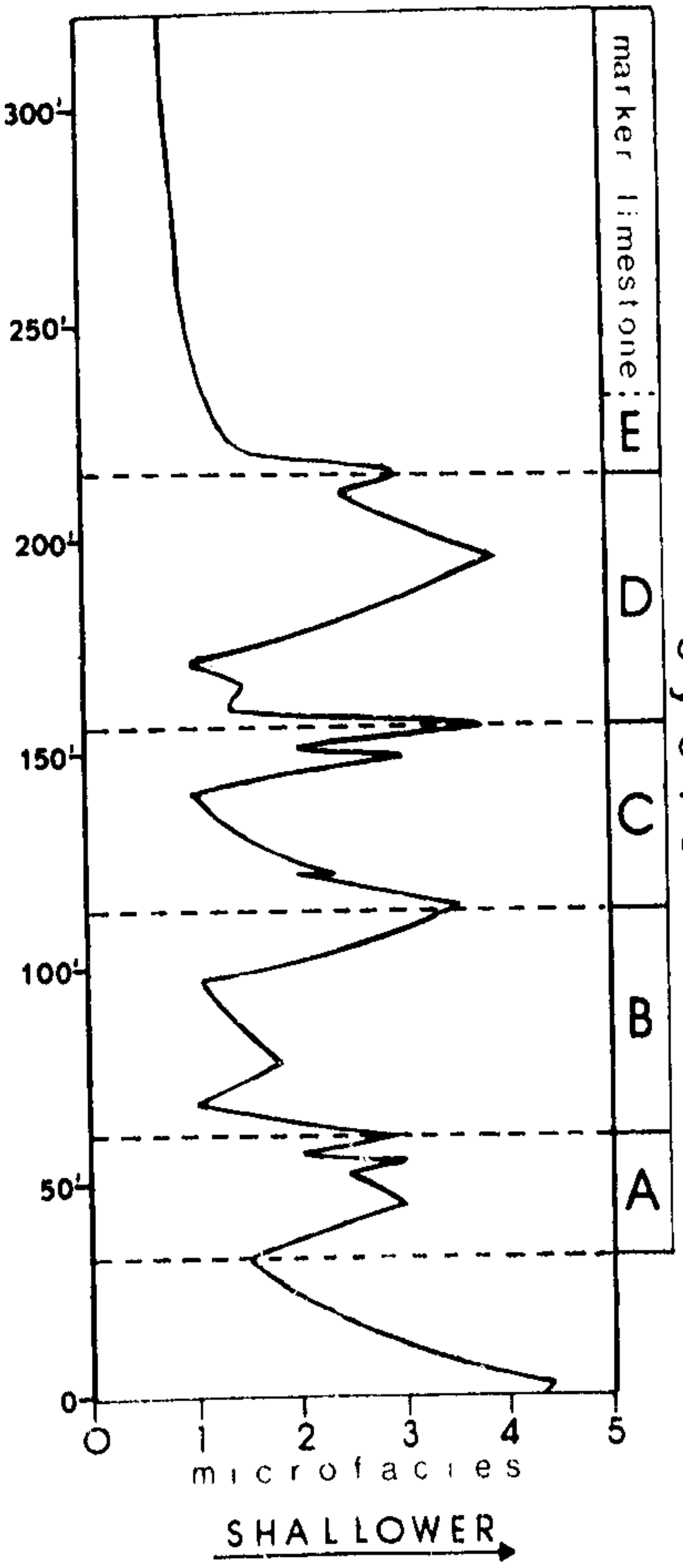

Figure 7. Correlation of units, microfacies and cycles.

microfacies group to each unit described in the field (Table 1). Cycle A begins at the base of unit 4 where it shallows to the environment of microfacies 3 and then fluctuates twice between microfacies 2 and 3 before terminating. Cycle B begins at the base of unit 10 where microfacies 1 appears abruptly. Depths then fluctuate as microfacies 2 and 1 alternate before rapidly shallowing to an environment between that of microfacies 3 and 4. Cycle C, which begins near the base of unit 16, shows a more symmetric pattern of deepening to the environment of microfacies 1 and then shallowing back to that of microfacies 4. Cycle D begins at the base of unit 20 where microfacies 1 appears abruptly. The depth then fluctuates back to the environment of microfacies 3 where the cycle terminates. Cycle E begins with a somewhat rapid shallowing and then recedes to an unusually long period of deep water deposition as expressed by the marker limestone.

UNIT	MICROFACIES	CYCLE
30	1	E
29	1-2	———
28	3	
27	2-3	
26	3	
25	4	D
24	1-2	
23	1	
22	1-2	
21	1	———
20	4	
19	2	
18	3	C
17	2	
16	1	
15	1-2	———
14	2-4	
13	3	
12	1	B
11	---	
10	1-2	———
9	3	
8	2	
7	3	A
6	2-3	
5	3	
4	2-1	———
3	2-3	
2	3-4	
1	4	

TABLE 1: Correlation of units, microfacies and cycles.

MODELS OF CYCLIC DEPOSITION

Many models have been proposed to explain the cyclic nature of sedimentary deposition. These include Vail curves (Vail et al., 1977), Puncuated Aggradational Cycles (Goodwin and Anderson, 1985), the eustatic model (Wilkinson, 1982; James, 1984), the autocyclic model (Ginsburg, 1971), and the new eustatic model (Carozzi, 1986).

Vail et al. (1977) recognized that cycles in the Phanerozoic can be correlated around the world indicating that they are based on eustatic sea level changes. Periods of transgression (rise in sea level) and regression (fall in sea level), which significantly alter the depositional environments, producing supercycles, cycles and paracycles, each of which successively represents a shorter period of time. Vail proposed that these cycles involve relatively long periods of sea level rise followed by fairly rapid drops in sea level. This pattern is not represented in the described section where, in all 5 cycles, thick sequences of coarse, shallow water sediments abruptly change to finer, deep water sediments followed gradually by shallow water deposits. Therefore, Vail's cycles of eustatic sea level changes can not be applied to the Middle Morrowan. However, as Heath, Lumsden and Carozzi (1967) indicated, the entire

Morrowan Series may represent a period of transgression and, therefore, would fit Vail's eustatic sea level model.

Goodwin and Anderson (1985) argue that the stratigraphic record consists of thin, basin-wide shallowing upward cycles separated by surfaces marked by abrupt change to deeper facies. These small-scale (1-5 meters thick) cycles are referred to as Punctuated Aggradational Cycles or PACs. This term refers to aggradational deposition during periods of base-level stability followed by geologically instantaneously base-level rises (punctuation events). Goodwin and Anderson estimate that PACs reoccur in 30,000 to 80,000 year intervals depending on the depositional environment. PACs have been documented in many stratigraphic sequences and, according to Goodwin and Anderson, apply to all sedimentary environments. Cycles B, C and D fit the PAC model of a gradually shallowing sequence abruptly terminated by rapid deepening. However, these 3 cycles do not conform to the PAC reoccurrence interval (1-5 meters). Cycles A and E do not depict a recognizable PAC sequence. Therefore, although some of the cycles fit the PAC depositional sequence, the Middle Morrowan cycles can not be adequately explained by the PAC hypothesis alone.

The eustatic model (Wilkinson, 1982; James, 1984) attempts to explain the shallowing-upward sequence of deposition postulated in the PAC hypothesis. It states that the rate of subsidence or the position of sea level changes periodically while the rate of carbonate sedimentation remains constant. A shallowing-upward sequence is deposited during periods of stable or slowly rising sea level. Deposition is then reduced or interrupted by a sudden surge of deeper water. Eventually, the sea will regain its stability and a new shallowing upward sequence will be deposited.

Previously, Ginsburg (1971) proposed the autocyclic model which asserts that the rate of sedimentation is controlled by the extent of the source area. During deposition, which, like the eustatic model, occurs in a stable or slowly rising sea, carbonate sediments are driven shoreward by wind and tidal processes to form a carbonate wedge. The fining-upward sequence is deposited as the wedge accumulates. This continues until deposition can no longer keep up with the subsidence rate thus disrupting sedimentation. Eventually, sea level rises above the carbonate wedge and a new cycle of deposition starts. The autocyclic model cannot be applied to the Middle Morrowan strata since the rocks at Arrow Canyon were deposited primarily in situ. This is indicated by the lack of channelling and cross bedding in the strata.

Both the autocyclic and the eustatic models of carbonate cyclicity directly does not conform to Vail's world-wide eustatic cycles. Vail's eustatic cycles consist of a slowly rising sea followed by a rapid shallowing while the carbonate cycles consist of a slow shallowing-upward phase followed by a rapid deepening (Figure 8).

The New Eustatic model, proposed by Carozzi (1986), attempts to resolve the Vail cycle/carbonate cycle discrepancy. Carozzi argues that carbonate cycles originate as a result of an interaction between global slow rises and raid falls of sea level and a rate of carbonate deposition which can outpace the sea level rise. Based on this, Carozzi (1986) states that two possibilities may be considered (Figure 9). First, the rate of carbonate productivity outpaces a slow rise in sea level. This produces a shallowing-upward sequence with an exposure zone and depositional hiatus near the top. Second, the rate of carbonate productivity increases with but never outpaces the slow rise in sea level. This produces a shallowing-upward sequence overlain with a thin sequence of non-sequential carbonate sedimentation or lag deposits. Both possibilities assume a constant rate of subsidence.

The New Eustatic model offers a possible explanation for the Middle Morrowan cyclicity. The Arrow Canyon strata shows no evidence of ever being exposed above sea level nor are there any depositional gaps in the Morrowan sequence. Therefore, the first possibility is ruled out. The second

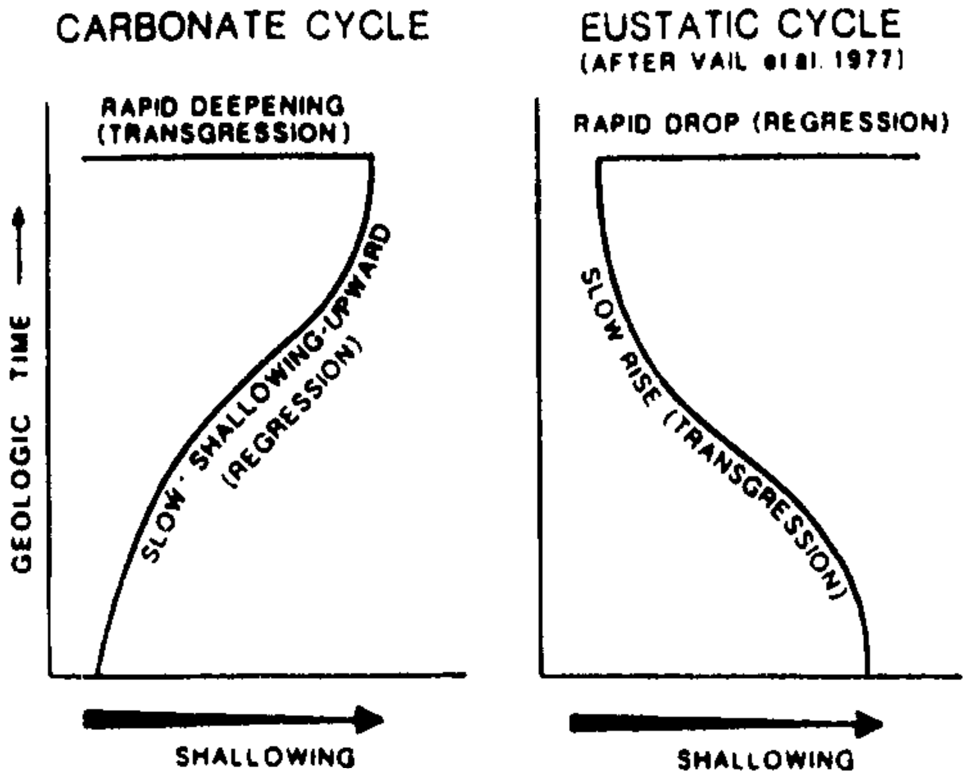

Figure 8. Apparent Dilemma Between Carbonate Cycle and Vail's Eustatic Cycle- Illustration of the apparent dilemma between carbonate cycle and Vail's eustatic cycle. (Carozzi, 1986)

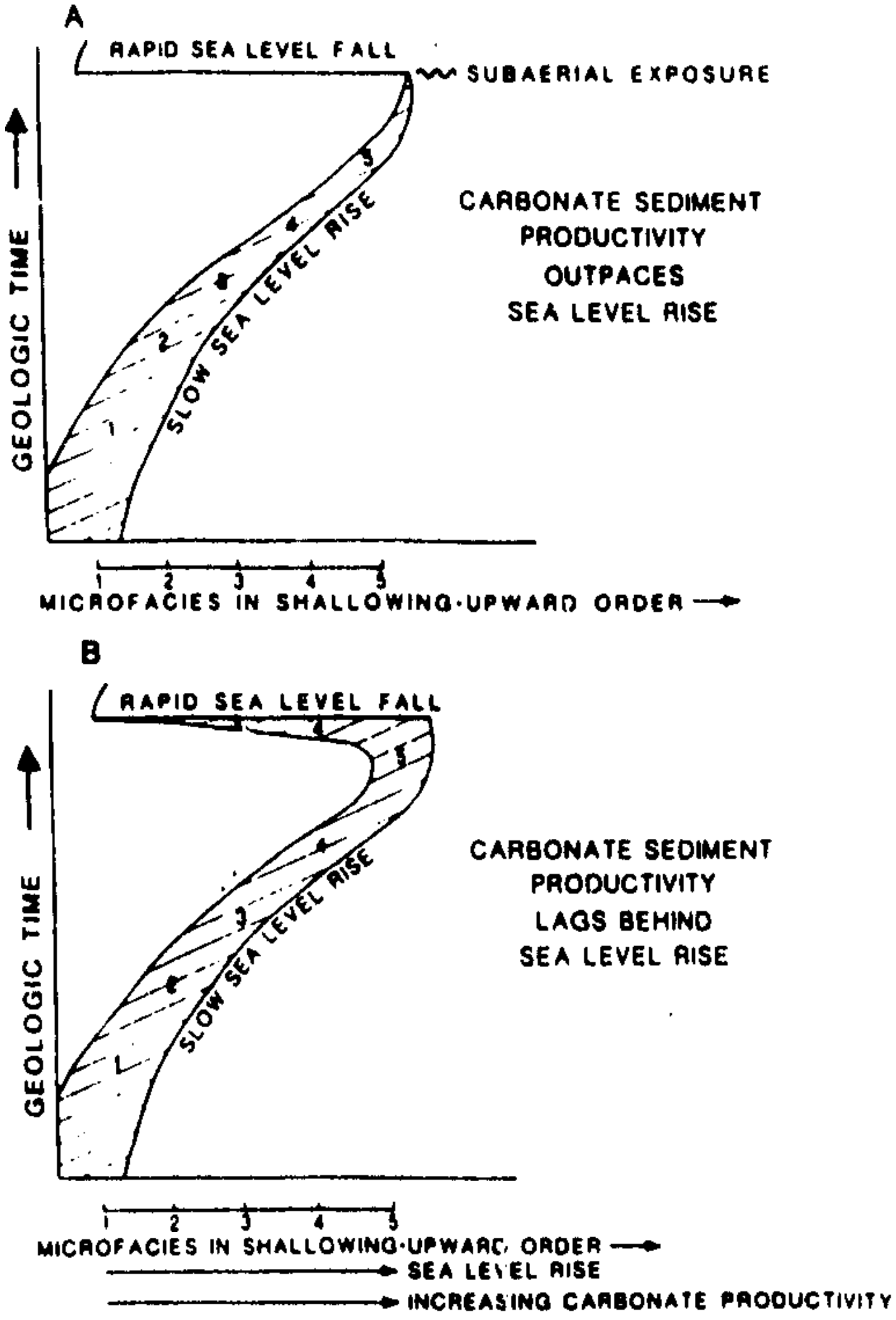

Figure 9. Two Types of Asymmetric Carbonate Cycles- Illustration of how the two major types of asymmetric carbonate cycles are generated during a eustatic slow sea level rise followed by a rapid sea level fall. (Carozzi, 1986)

possibility suggests that deposition could have been somehow restricted during the Morrowan thereby producing the irregular cyclic patterns in cycles A and E. Since Carozzi's model depends on eustatic sea level changes that occur on differing orders of magnitude, the second possibility can also explain the different orders of magnitude found in the described cycles. Therefore, the interaction of carbonate productivity and eustatic sea level changes found in Carozzi's second possibility offers the most complete explanation of the Middle Morrowan cyclicity.

DESCRIPTION OF UNITS

UNIT	THICKNESS	DESCRIPTION
30	99'7"	Limestone, fine grained; thin to massive bedding; gray weathering tan; abundant chert layers; NO fossils found; bench former--MARKER LIMESTONE. VAL# 46-49A A# 1'7" above 154 - 2' above 134
29	7'5"	Limestone, medium grained; medium bedding: some thin beds of shale found between limestone beds; light gray weathering dark gray; scattered nodules and several thin layers of chert; brachiopods, bryozoans, and echinoderm fragments. VAL# 45D A# 2' above 134 - 1' below 133
28	4'6"	Limestone, coarse grained; massive bedding; gray weathering light gray to brown; NO chert; calcite veins; echinoderm and brachiopod fragments. VAL# 45C A# 1' below 133 - 5" below 132
27	7'1"	Limestone, medium-coarse grained; massive bedding; dark gray weathering gray; 2 distinct layers of chert with scattered nodules through out; calcite veins; brachiopods and *Syringopora* sp. VAL# 45B A# 5" below 132 - 2'6" below 131
26	5'6"	Limestone, medium grained; massive bedding; ray weathering to tan; NO chert; calcite veins; brachiopods, bryozoans, and *Syringopora* sp. VAL# 45A A# 2'6" below 131 - 2' above 129

UNIT	THICKNESS	DESCRIPTION
25	14'3"	Limestone, coarse grained; medium to massive bedding; gray weathering tan; small chert nodules; calcite veins; brachiopods, bryozoans, and echinoderm fragments. VAL# 44 A# 2' above 129 - 2'8" below 127
24	14'	Limestone, fine grained; massive bedding; dark gray weathers gray; abundant scattered nodules and layers of chert; brachiopods and solitary rugosa; large calcite crystals; cliff former. VAL# 43I A# 2'8" below 127 - 1'10" below 124
23	3'5"	Limestone, fine grained; medium bedding; gray weathering dark gray; 2 distinct layers of chert; NO fossils found; 2 layers of silty limestone near top. VAL# 43H A# 1'10" below 124 - 123
22	6'9"	Limestone, fine-medium grained; medium-thin bedding; gray weathering light gray; abundant chert nodules concentrated near center of unit; fossil fragments found throughout; calcite veins. VAL# 43G A# 123 - 1'9" below 122
21	2'5"	Limestone, fine grained; massive bedding; gray weathering gray; thin layer of chert near top; abundant *Syringopora* sp. VAL# 43F A# 1'9" below 122 - 1' above 121

UNIT	THICKNESS	DESCRIPTION
20	7'	Limestone, fine grained; massive bedding; gray weathering to tan; NO chert; NO fossils; calcite veins; very fractured. VAL# 43E A# 1' above 121 - 6" below 120
19	3'6"	Limestone, medium grained; medium-thin bedding; dark gray weathering gray; very small chert nodules near center; sparse fossil fragments; thin silty layers interbedded with limestone. VAL# 43D A# 6" below 120 - 1' above 119
18	3'3"	Limestone, coarse grained; massive bedding; dark gray weathering light gray; small chert nodules; brachiopods and rugosae. VAL# 43C A# 1' above 119 - 2'3" below 119
17	3'	Limestone, coarse grained; massive bedding; gray weathering tan; small chert nodules; brachiopod fragments, *Syringopora* sp, and 2 layers of *Tschussovskonia* sp. (rugosae). VAL# 43B A# 2'3" below 119 - 118
16	6'5"	Limestone, fine grained; massive bedding; gray weathering light gray; large, irregular chert nodules concentrated in center; brachiopod fragments and *Syringopora* sp. VAL# 43A A# 118 - 1'3" below 117

UNIT	THICKNESS	DESCRIPTION
15	5'11"	Limestone, fine grained; medium bedding; gray weathering tan; 2 distinct layers of irregular chert; <u>Syringopora</u> sp and layer of rugosae; 3 thin beds of silty limestone interbedded with limestone. VAL# 42B A# 1'3" below 117 - 2'6" below 116
14	24'7"	Limestone, fine-coarse grained: fine near top, course near base; massive bedding; gray weathering tan; scattered and layered chert nodules; echinoderm fragments; some small, silty layers interbedded with limestone; 1'4" shaley layer near base. VAL# 42A-41E A# 2'6" below 116 - 1'2" below 111
13	5'2"	Limestone, medium grained; massive bedding; gray weathering tan; irregularly shaped chert nodules scattered throughout; silicified brachiopod shells; cliff former. VAL# 41D A# 1'2" below 111 - 2'2" above 109
12	4'2"	Limestone, fine grained; medium bedding; dark gray weathers tan; 3 chert layers composed of small nodules; few fossils found; interbedded with calcareous shale. VAL# 41C A# 2'2" above 109 - 2' below 109
11	3'	Covered; recessed VAL# 41B A# 2' below 109 - 108

UNIT	THICKNESS	DESCRIPTION
10	32'	Limestone, fine grained; thin-medium bedding; approximately 13 layers of nodular chert- also, large rounded chert nodules scattered though out; brachiopods and bryozoans; bench former. VAL# 40-41A A# 108 - 3' above 101
9	6'1"	Limestone, coarse grained; medium bedding; dark gray weathering gray; scattered chert nodules in upper 2/3 of unit; brachiopods. VAL# 38B-39 A# 3' above 101 - 1'11" above 100
8	1'7"	Limestone, medium grained; massive beds; gray weathering tan; scattered chert in upper portion; brachiopod shells at base. VAL# 38A A# 1'11" above 100 - 4' above 100
7	1'11"	Limestone, coarse grained; thin bedding; gray weathering light gray/tan; very small chert nodules scattered though out; abundant brachiopod shell fragments. VAL# 38A A# 4' above 100 - 7' below 100
6	8'7"	Limestone, fine-coarse grained; massive bedding; gray weathering tan; large-small chert nodules scattered throughout; brachiopods and echinoderm fragments; fractured. VAL# 37 A# 7' below 100 - 10" above 98

UNIT	THICKNESS	DESCRIPTION
5	3'1"	Limestone, coarse grained; medium bedding; dark gray weathering gray; NO chert; echinoderm fragments; interbedded with silty layers. VAL# 37 A# 10" above 98 - 2'9" above 97
4	20'	Limestone, fine grained; medium bedding; dark gray-black weathering gray; scattered chert nodules; well preserved brachiopods and echinoderms; localized thin shaley beds. VAL# 36 A# 2'9" above 97 - 2" below 94
3	9'3"	Limestone, coarse grained; thin-massive bedding; gray weathering light gray; scattered chert nodules; large echinoderm fragments and brachiopods; interbedded with shaley limestone. VAL# 34-35 A# 2" below 94 - 1'1" below 92
2	5'1"	Limestone, medium grained; medium bedding; dark gray weathering tan; NO chert; brachiopods, bryozoan, and echinoderms; recessed; shaley limestone bed near center. VAL# 33C A# 1'1" below 92 - 1' below 91
1	3'	Limestone alternating with shale; very thin bedding; gray weathering gray/green/red; NO chert; brachiopods and bryozoans; recessed. VAL# 33B A# 1' below 91 - 1'6" above 88

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