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

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ENTITLED THE BASAL CALLVILLE LIMESTONE IN THE MORMON MOUNTAINS,

VIRGIN GORGE, AND VIRGIN MOUNTAINS

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

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# The Basal Callville Limestone in the Mormon Mountains, Virgin Gorge, and Virgin Mountains

By

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## ABSTRACT

Study of the basal Callville Limestone from northwest to the southeast shows that these rocks are a part of a geosyncline and its adjacent shelf deposited in a Pennsylvanian sea. The northwestern most regions are composed of cylical limestones, silty limestones and sandstones. This area has accumulated thick sequences of these cyclical limestones. The southeastern most regions are composed mainly of limestones with virtually no clastic material. The large amount of clastic detritus and fossil hash in these rocks lends to support the idea that this was a region of rapid deposition and high energy.

## ACKNOWLEDGMENTS

I would like to thank Dr. R. L. Langenheim for his time, advice, and assistance throughout the preparation of this report and my undergraduate career. A special thanks to my field partners Jack Yarnold and Bill Verkaik for their help and companionship during the research, Cindy Shroba for her patience when answering questions and Sandra Marquez for her companionship during the writing of this report.

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# INTRODUCTION

The Callville Limestone is believed to have been deposited on the shelf margin adjacent to the Cordilleran miogeocline. The clastic source was northwest of this region is evidenced by the abundant clastic material in the northwestern most measured section. The adjacent shelf was to the southeast as indicated by obvious thinning of the Callville Limestone and absence of clastic materials.

The purpose of this report is to add to the previous studies of the Callville with detailed descriptions of the rocks and their fossils.

## PRIOR INVESTIGATIONS

A number of workers have investigated the Callville Limestone in the southeastern Nevada-northwestern Arizona region. There have been detailed studies of the regional structure done by Wernicke (1984) and Seager (1970). General regional stratigraphy was done by Langenheim and Schulmeister (1987), McNair (1951), Moore (1972), Reeside (1922), and Steed (1980). Each of these workers has examined the general lithology of the Callville Limestone.

## METHODS

Field work was accomplished in this region in January, 1987. Section measurement of the AT&T section located in the Mormon Mountains was done by Jacob's staff and in the Virgin Gorge and Virgin Mountains by tape and Brunton Compass. Section measurement was completed under the supervision of Dr. Ralph Langenheim, Jr. and in cooperation with Jack Yarnold and Bill Verkaik. Samples were collected from selected units and thin sectioned. These samples were then described lithologically and fossil content was noted. These three sections were correlated based upon similar lithology and fossil content.

## LOCATION

The AT&T section (Figure 1, local 1) is located in the Mormon Mountains at 741880m E, 4087740m N Universal Transverse Mercator (UTM) Zone 11 from the Davidson Peak Nevada Quadrangle, Lincoln County Nevada. This point is located in the middle of the transverse on the west side of a north-northwest trending ridge. The transverse was perpendicular to the trace of the bed starting in the upper most Monte Cristo to the ridge including the prominent red bed unit. The Virgin Gorge section (Figure 1, local 2) is located in the NW/c SW SW SE of section 16, T.41N, R.16W also 249160m E, 4092600m N UTM Zone 12 from the Mountain Sheep Spring Quadrangle, Mohave County, Arizona. The Virgin Mountain section (Figure 1, local 3) is located in the SW/c NW NW SE of section 27, T.38N, R.16W also 768000m E, 4061560m N UTM Zone 11 from the Hen Spring Nevada-Arizona Quadrangle, Mohave County, Arizona.

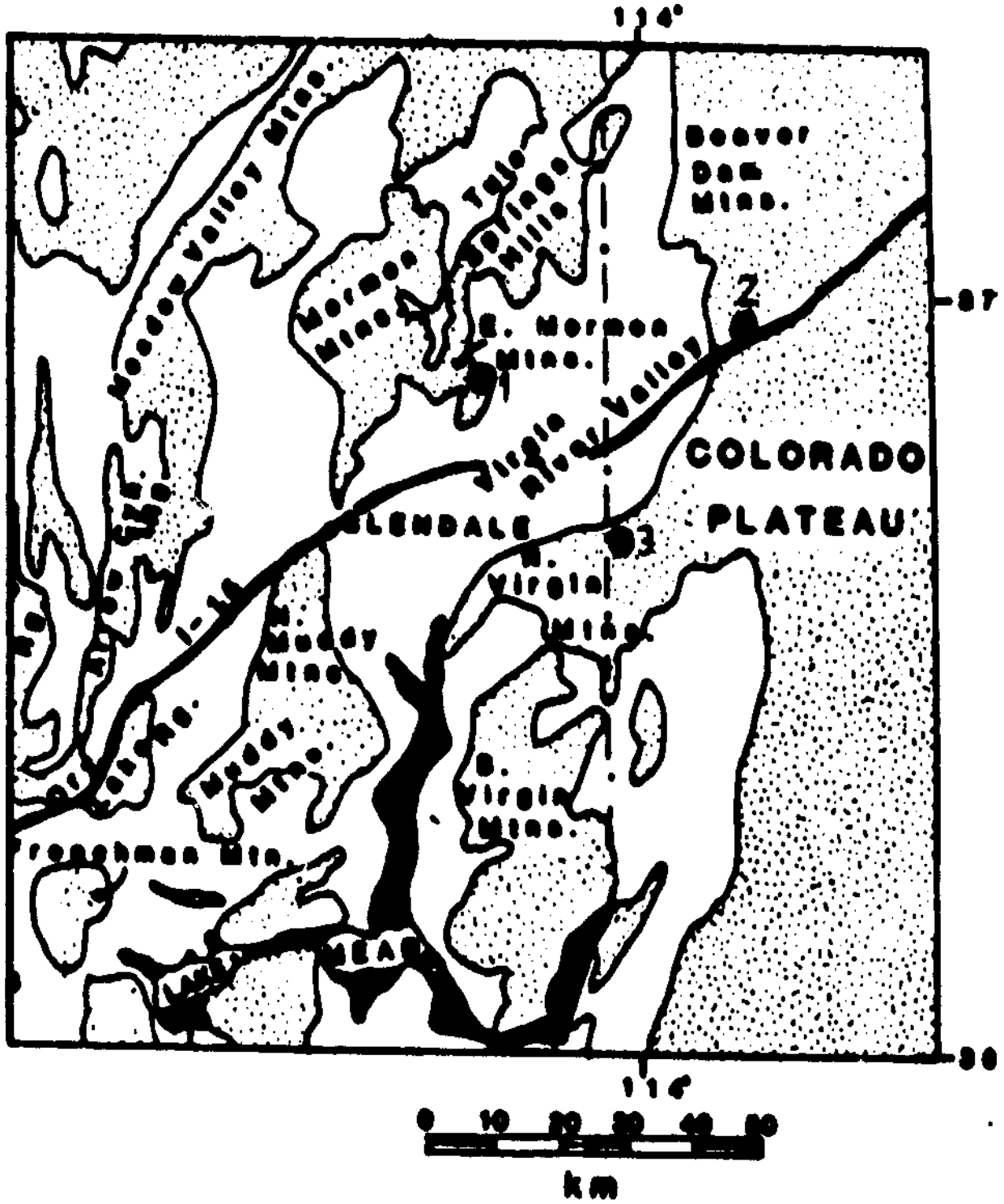



Figure 1: Regional location map. Locale 1: Mormon Mountains(Al&I). Locale 2: Virgin Gorge. Locale 3: Virgin Mountains.

## STRATIGRAPHY

Detailed descriptions of each unit are in appendix I. The lower 1/3 of the AT&T section (Figures 2-4) consists of cycles of limestone and calcareous sandstone. The remaining 2/3 is semi-cyclic limestone interrupted by a few units of silty limestone. The later cyclicity is most noted in the lower most part and upper most part of the remaining 2/3 of the section. This section is well exposed and fairly complete. The cyclicity of the limestone with the other rock types gives evidence of the small changes in detrital supplies due to geologic activities and general environments of deposition. This is the only area in which red beds were found, they are thought to have been deposited during the westward regression of the late Pennsylvanian-early Permian. Chert is scattered throughout the entire column but is confined to specific units.

The Virgin Gorge section (Figure 5) is approximately 1/2 as thick as the AT&T section. These rocks also show cycles of silty limestone, sandstone, and limestone. However, this sequence contains less sandstone, and limestone. No chert was noted in the Callville Limestone at this locale and there was no cross bedding within the sandstone.

The Virgin Mountains column (Figure 6) is thinner than that in tne Virgin Gorge and is composed entirely of limestone with a very few grains of quartz visible under a microscope.

# EXPLANATION

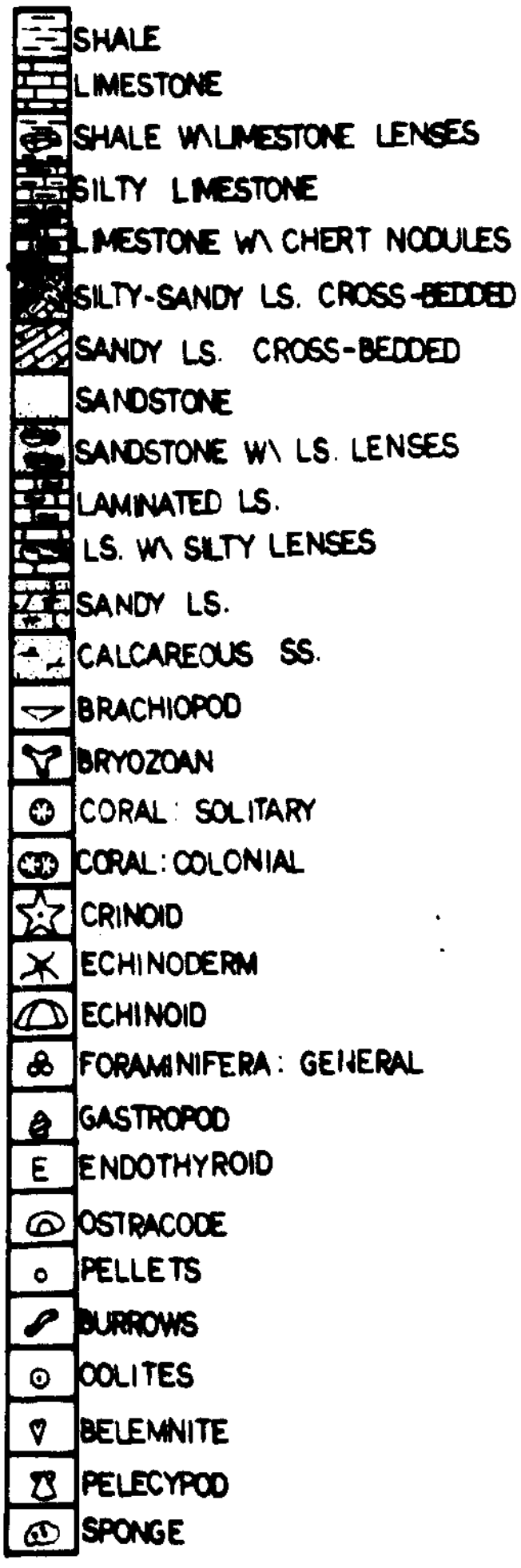



Figure 2

# A T & T

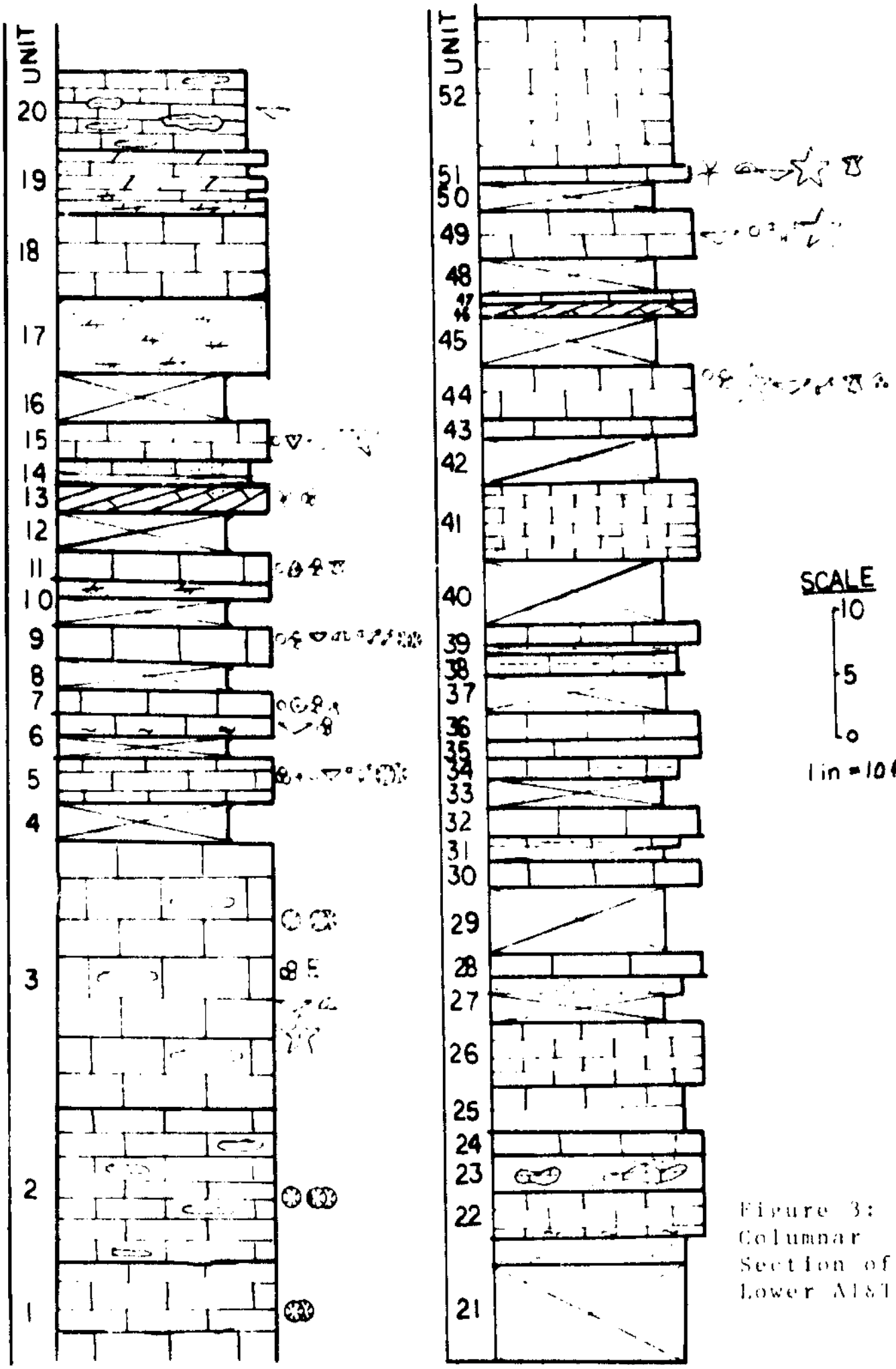
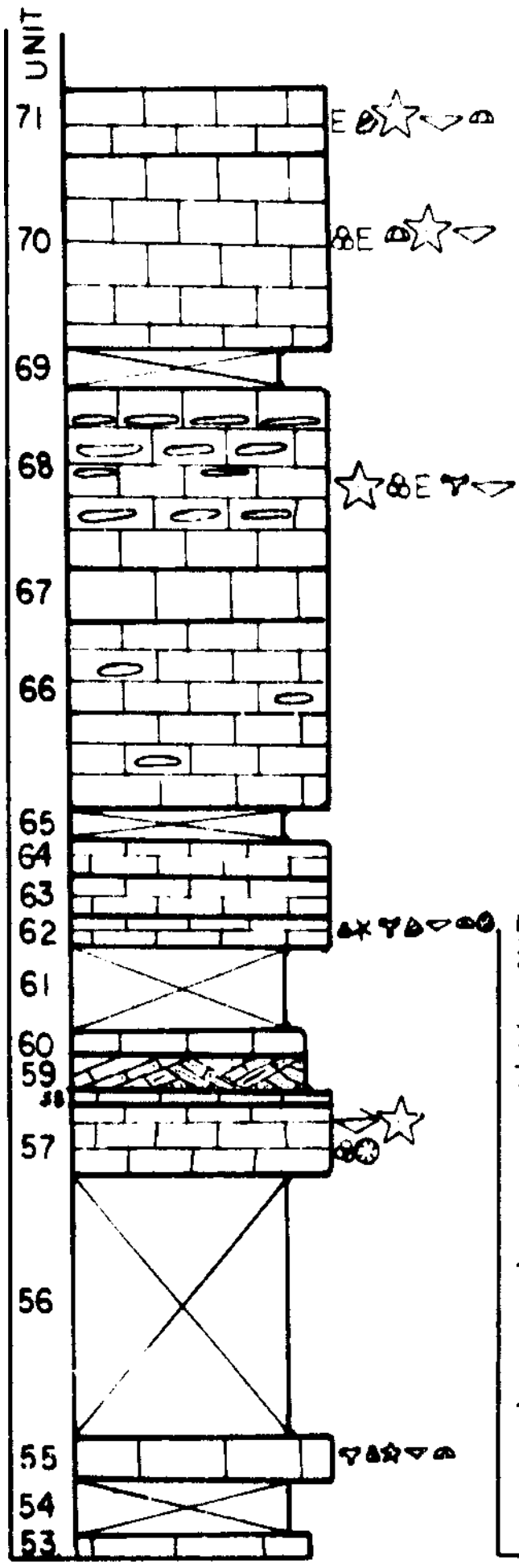
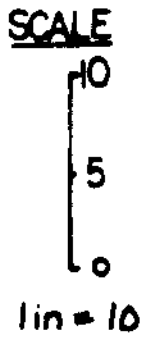



Figure 3: Columnar Section of Lower AT&T.

# A T & T



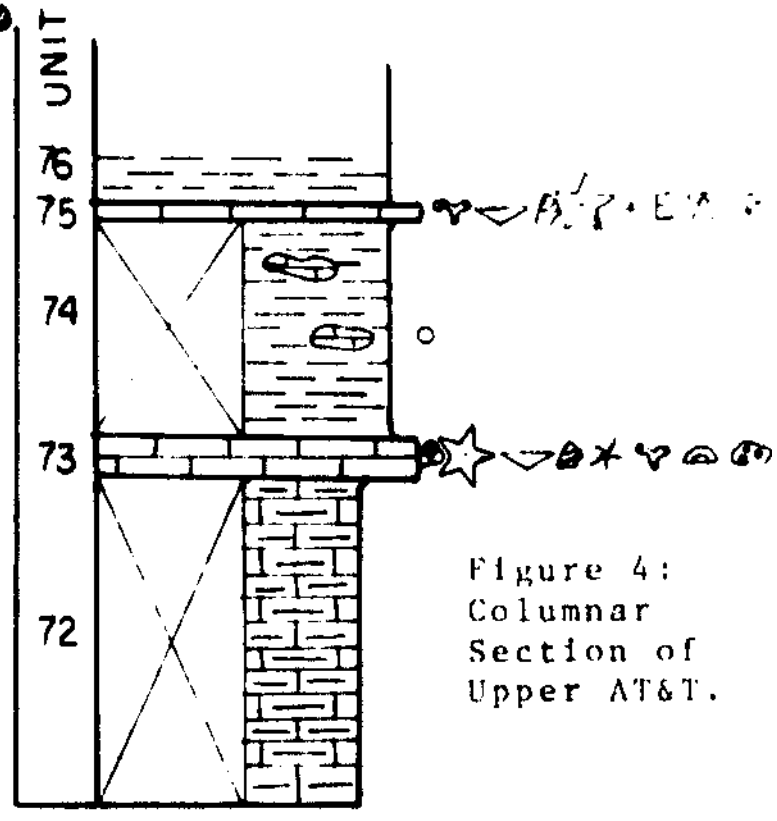




Figure 4: Columnar Section of Upper AT&T.

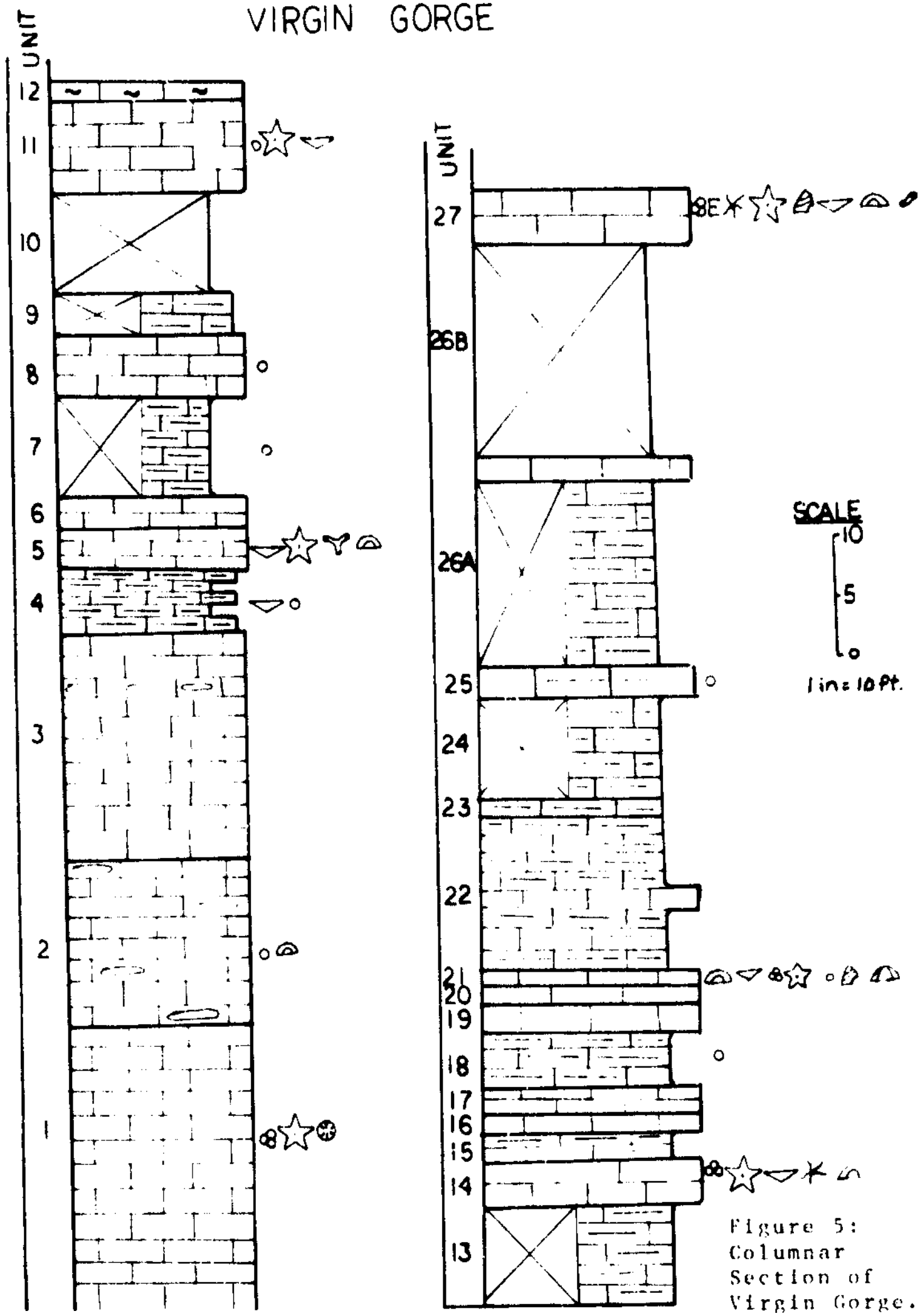


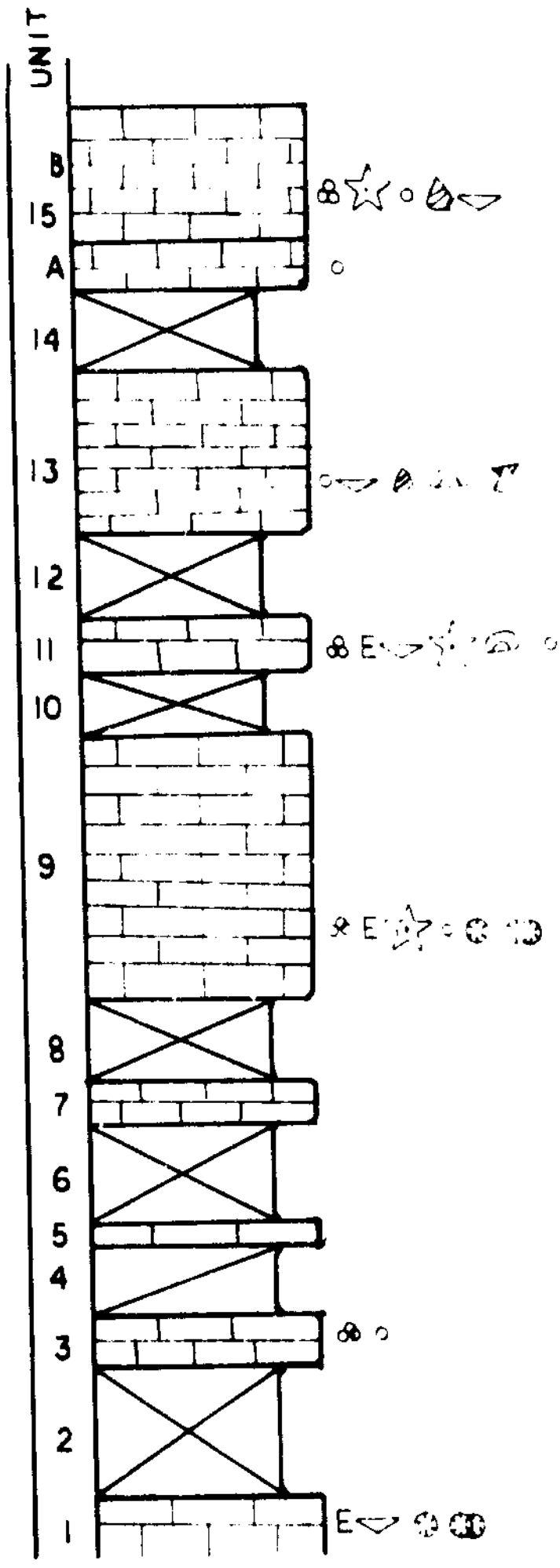

Figure 5: Columnar Section of Virgin Gorge.

There appears to be no obvious cyclicity within this sequence. Unit 9 contains chert and most units appear to be massive with no apparent bedding.

Appendix II contains detailed descriptions of thin sections from each of these three areas. The AT&T locality has colonial corals at the bottom of the column and solitary corals are scattered throughout. The majority of the fossils noted in these thin sections are fragments, or most of the samples are a fossil hash. Many endothyroid foraminifera occur and much of the limestone is pelletoid. The sandstone samples contain subangular quartz grains and lack fossils or their fragments, indicating deposition close to the clastic source. On a macroscopic scale, the Ca`lville Limestone is not abundantly fossiliferous, just a few isolated productids and corals were noted in the field.

The Virgin Gorge samples contain much pelletoid material and the fossils are mostly hash. There were several types of endothyroid foraminifera found in these rocks which were the only complete fossils. The sandstone units contain subangular quartz grains, which indicates that the amount of clastic material from the source either increased considerably or else the clastic source was closer to this area. Some of the fossils from the Virgin Gorge appear partially filled with mud, indicating that burial was slow. Also the high degree

# VIRGIN MOUNTAINS




SCALE
10
5
0
1 IN=10 FT.

Figure 6: Columnar Section of Virgin Mts.

of fragmentation suggests that these remains underwent considerable transport before deposition.

The Virgin Mountains samples contain much pelletoid material as well as fossil hash. The only non-fragmented fossils are various types of endothyroid foraminifera. Some units contain very few quartz grains which had to be carried far from the source or this area is assumed to be most distant from the clastic source. Occurrence of scattered quartz grains can be attributed to current action or to an increased supply of detrital materials. The entire section appears to be entirely limestone.

Correlation of these sections (Figure 7) is based primarily upon lithologic similarities on both the microscopic and macroscopic scale. Fossil content was used to aid in the correlation when lithology alone proved inconclusive. The amount of clastic material decreases significantly between the Mormon Mountains (AT&T) and the Virgin Gorge sequences.

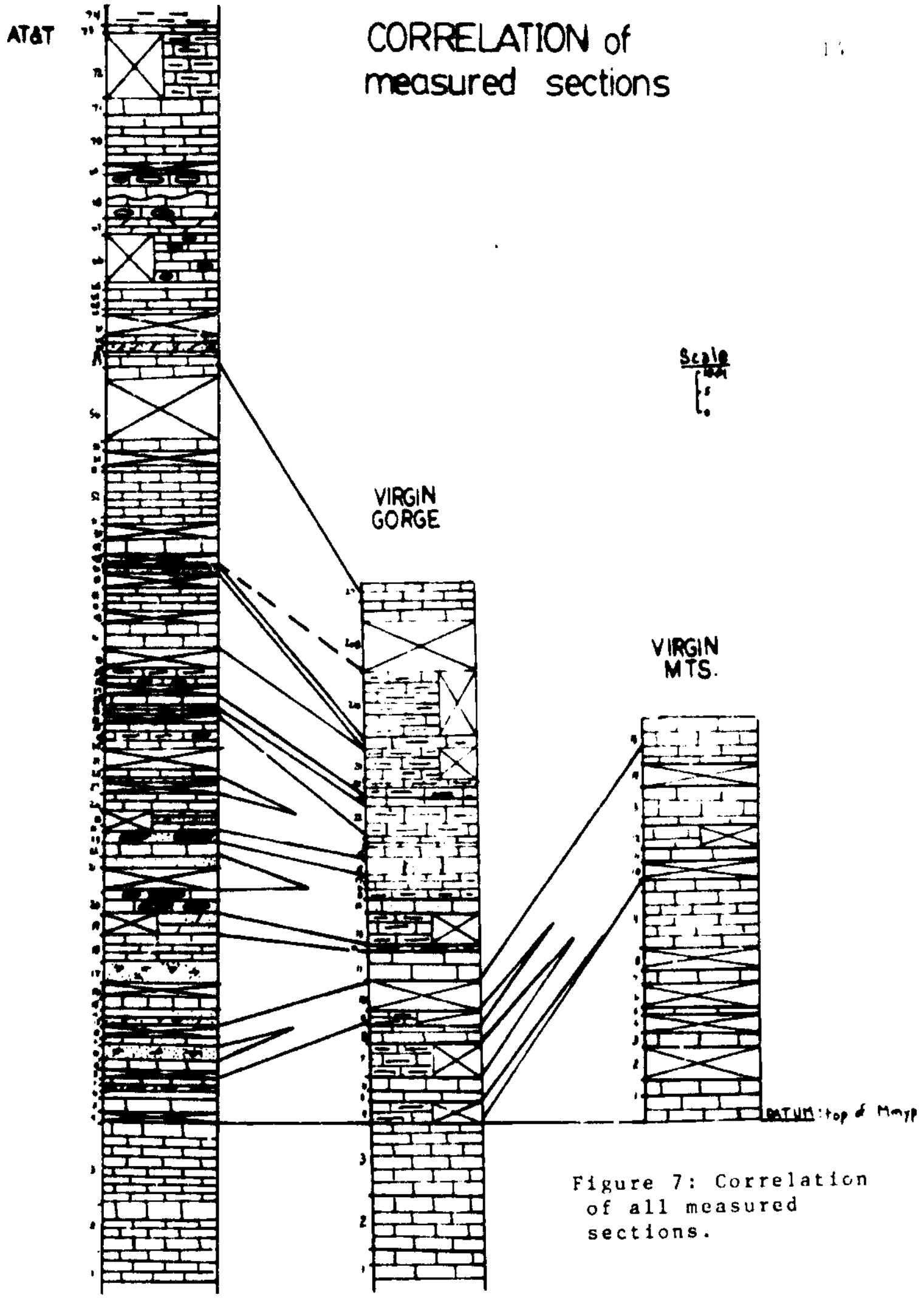



Figure 7: Correlation of all measured sections.

# CONCLUSIONS

Thinning of the basal Callville from the AT&T section to the Virgin Mountain section reflects an approach to the shelf-geosynclinal margin. Increase in detrital content in the direction of the AT&T section suggests a geosynclinal source to the northwest.

Endothyroid foraminifera in all three sections indicate a Morrowan age. Rocks directly below the Callville belong to the Yellowpine Limestone, which is of Meramecian age. Thus Chesterian rocks are absent. To the northwest, the Chesterian Indian Springs Formation bridges the hiatus and the Surprise Canyon Formation, of the same age, fills channels cut into the uppermost Redwall Limestone in the western part of the Grand Canyon.

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# APPENDIX I

## LITHOLOGIC DESCRIPTION OF MEASURED SECTIONS

AT&T Section

| Unit | Sample | Thickness(ft) | Description |
|---|---|---|---|
| 76 | | -- | Covered for rest of slope traverse E for at least 20 yards. Lots of red silty debris. |
| 75 | AT75 | 0.5 | Coarse grained limestone, gray-brown weathering gray, single layer. |
| 74 | AT74 | 11.5 | Covered. Talus of yellow, rusty and red silty claystone, scattered outcrops of same unit, scattered ls, nodules. |
| 73 | AT73 | 2.0 | Medium-coarse grained limestone, reddish-brown weathering gray. |
| 72 | | 17.0 | Covered. Deep soil-chips of yellow, silty ls.-red siltstone. |
| 71 | AT71 | 4.0 | Medium grained limestone, lt. gray weathering slightly darker gray, beds 2 ft. thick, crinoidal, AT71 from middle. |
| 70 | | 12.5 | Medium grained limestone, lt. gray weathering lt. gray, massive cliff former without apparent consistent bedding, no chert. |
| 69 | | 2.6 | Covered |

AT&T Section

| Unit | Sample | Thickness(ft) | Description |
|---|---|---|---|
| 68 | AT69 | 11.5 | Medium grained limestone, crinoidal, lt. gray weathering gray, rusty chert nodule .5' x 4'-5'. 3' above base in a double layer about 1' thick. Additional more irregular layer 5' above base. AT69 at 6" above base. Additional chert layer 1.5-4.5 ft. below top. |
| 67 | | 3.5 | Very fine grained limestone, lt. gray weathering buff, single layer massive, shattered. |
| 66 | AT66 | 12.0 | Very fine grained limestone, black weathering buff irregular nodules of rusty chert. AT66 3.5' above base. |
| 65 | | 2.0 | Covered |
| 64 | | 2.4 | Very fine grained limestone, gray weathering bleached gray, becoming more coarse grained at top. |
| 63 | | 2.4 | Limestone same as unit 62--merge units. |
| 62 | AT62 | 2.0 | Medium grained limestone, dark gray to black weathering gray, beds 2"-6" thick, unsilicified fossils |

AT&T Section

| Unit | Sample | Thickness (ft) | Description |
|---|---|---|---|
| | | | including solitary rugosans, calcarenites. AT62 near top. |
| 61 | | 5.5 | Covered |
| 60 | | 1.5 | Fine-medium grained limestone, gray weathering lt. gray, chips of rusty weathering silty limestone. |
| 59 | | 2.4 | Silty-sandy limestone, weathers rusty with very fine grained limestone interlaminated. Very prominent rust band, cross-bedded. |
| 58 | | 0.5 | Very fine grained limestone, gray weathering gray, thin slabby beds 2", covered in part. |
| 57 | AT57 | 3.0 | Medium grained limestone, gray weathering gray, single bed, small solitary corals--not silicified, AT57 near top. |
| 56 | | 18.3 | Covered with a 2' limestone bed approximately 2' from top of unit, otherwise deep soil. |
| 55 | AT55 | 2.5 | Medium-coarse grained limestone, gray weathering gray, single ledge. AT55 near top. |
| 54 | | 3.7 | Covered |

AT&T Section

| Unit | Sample | Thickness (m) | Description |
|---|---|---|---|
| 53 | AT54 | 1.5 | Very fine grained limestone, gray weathering yellow-pink, rubbly. |
| 52 | | 11.5 | Covered with rubble of very fine grained red and yellow weathering calcilutite. |
| 51 | AT51 | 1.5 | Fine-medium grained limestone, gray weathering lt. gray, upper part medium grained and lower part calcilutite. AT51 from base. |
| 50 | | 2.0 | Covered |
| 49 | AT49 | 3.5 | Fine-medium grained limestone, gray weathering gray-brown-gray, two beds; large productids in upper layer. (lower layer is unit 35 of JCY) AT49 at top. |
| 48 | | 2.8 | Covered |
| 47 | | 0.5 | Very fine grained limestone, gray weathering gray, gradational basal contact. |
| 46 | | 1.2 | Fine-medium grained, sandy limestone, weathers rusty, cross-bedded. |
| 45 | | 3.8 | Covered |

AT&T Section

| Unit | Sample | Thickness (ft) | Description |
|---|---|---|---|
| 44 | AT44 | 4.0 | Fine-medium grained limestone, gray weathering buff to brown, prominent layer-massive or in two equal beds. |
| 43 | | 1.5 | Very fine grained limestone, gray weathering gray. |
| 42 | | 3.0 | Covered |
| 41 | AT41 | 6.0 | Very fine grained limestone, gray weathering lt. gray, slabby beds 6" thick. |
| 40 | | 5.0 | Covered |
| 39 | | 2.0 | Fine grained limestone, gray weathering brown-gray, rusty streaked silty beds to 8". |
| 38 | | 1.7 | Silty limestone, weathers rusty. |
| 37 | | 3.0 | Covered |
| 36 | | 2.0 | Very fine grained limestone, gray weathering gray, single bed. |
| 35 | | 1.2 | Limestone |
| 34 | | 1.5 | Chertified, silty limestone, rusty weathering. |
| 33 | | 2.3 | Covered |
| 32 | | 2.0 | Fine-medium grained limestone, gray weathering gray, well defined ledge. |

AT&T Section

| Unit | Sample | Thickness | Description |
|---|---|---|---|
| 31 | | 2.0 | Covered, upper foot chertish, silty limestone. |
| 30 | | 2.0 | Very fine grained limestone, gray weathering gray, well defined double bed, no fossils apparent. |
| 29 | | 5.0 | Covered |
| 28 | | 1.8 | Very fine grained limestone, gray weathering gray, well defined bed, no fossils apparent. |
| 27 | | 3.7 | Covered--upper 1/3 sandstone, gray weathering rust. |
| 26 | | 5.0 | Very fine--fine grained limestone gray weathering gray, no fossils apparent. |
| 25 | | 3.5 | Covered--upper 1/2 limestone, lower 1/2 sandstone. |
| 24 | | 1.5 | Very fine grained limestone, gray weathering gray, mottled, small dark subspherical black bodies in bed at top about 1/4" diameter. |
| 23 | | 3.0 | Fine-medium grained sandstone, lt. gray weathering rust, "clots" of gray weathering sandy lenses enclosed. |

AT&T Section

| Unit | Sample | Thickness(') | Description |
|---|---|---|---|
| 22 | | 3.5 | Very fine grained limestone, gray weathering lt. gray, faintly laminated bed as much as 1 ft. thick, no fossils. |
| 21 | | 9.5 | Covered--sandstone in upper part to North. |
| 20 | | 6.0 | Very fine grained limestone, lt. gray weathering lt. gray, scattered rusty chert, silty lenses, definite isolated productids. |
| 19 | | 5.0 | Covered and scattered outcrops of rusty weathering to lt. gray sandstone or sandy limestone, faintly laminated cross-bedded. |
| 18 | | 6.5 | Very fine-fine grained limestone, gray weathering lt. gray, mottled in part, beds 1-2 ft. thick, no fossils. |
| 17 | | 5.5 | Calcareous sandstone or arenaceous carbonate, lt. gray weathering tan to rusty at top. |
| 16 | | 4.0 | Covered |
| 15 | AT15 | 3.0 | Medium grained limestone, gray weathering gray, single massive bed, no fossils noted. |

AT&T Section

| Unit | Sample | Thickness(ft) | Description |
|---|---|---|---|
| 14 | | 2.0 | Covered--top most foot limestone, medium grained, lt. gray, somewhat sandy and poorly consolidated. |
| 13 | AT13 | 2.0 | Sandstone or calcareous sandstone, weathering tan to rusty, laminated and cross-bedded, essentially a single layer. |
| 12 | | 3.0 | Covered |
| 11 | AT12 | 2.1 | Limestone weathering gray beds 6"-1', faintly laminated, no fossils noted. |
| 10 | AT10 | 3.7 | Lower 2/3 covered, sandy limestone or calcareous sandstone, medium gray weathering tan to rusty, beds 4" +. |
| 9 | AT9 | 2.5 | Very fine grained limestone, gray weathering gray, lithostrotinid type corals. |
| 8 | | 2.5 | Covered |
| 7 | AT7 | 1.6 | Very fine grained limestone, dark gray weathering gray, single bed, no fossils noted. |

AT&T Section

| Unit | Sample | Thickness(ft) | Description |
|---|---|---|---|
| 6 | AT6 | 3.4 | Very fine grained limestone, gray weathering lt. gray (lighter than units above and below), laminated with clots of dark limestone, upper contact convoluted. Lower 1/2 covered. |
| 5 | AT5 | 3.4 | Limestone, weathers lt. gray, 3 equal beds in unit sparsely fossiliferous-phaceloid coral, coralliledea. |
| 4 | | 3.0 | Covered |
| 3 | AT3 | 20.5 | Very fine grained limestone, black weathering dark gray beds 1-3 ft. thick, parallel bedding, coralline fauna scattered throughout, lithostratinoids, phaceloid corals, syringoporiod, solitary rugosans, some beds mottled, very few isolated rusty chert nodules. |
| 2 | | 12.0 | Very fine grained limestone, black weathers lt. gray to rusty, single massive layer considerably bleached alteration. Phaceloid coral, lithostratinoid solitary coral, |

AT&T Section

| Unit | Sample | Thickness(ft) | Description |
|---|---|---|---|
| | | | syringoporoid, scattered rusty chert nodules black on fresh and in part replacing coral heads, corals and chert form a layer (biostrome) 5.0 ft. above base. |
| 1 | | 7.8 | Very fine grained limestone, dark gray weathering medium gray with a slight purplish cast--not prominent. Rillanstein weathering, beds 1.5-2.0 ft. thick. Lithostrotionid corals, syringoporoids, colonies of both more than 1.0 ft. across on exposure, corals near top of unit more or less in same stratigraphic position, no biostrome, no chert. |

Total Thickness 327.3 ft.

Virgin Gorge Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 27 | G27 | 4.7 | Medium grained limestone, gray weathering gray, beds 4' thick, prominent ledge maker--measured indirectly. |
| 26B | | 18.0 | Covered |
| 26A | | 17.1 | Covered with talus of silty limestone, buff--scattered outcrops possible, no signs of red beds. Top 2' limestone similar to unit 27. |
| 25 | G25 | 2.5 | Fine to medium grained silty limestone, brown--gray weathering rust, single 2' layer. |
| 24 | | 8.2 | Covered with talus of silty limestone, buff, scattered outcrops of same off line of section. |
| 23 | | 1.4 | Fine-medium grained silty limestone, olive gray weathering rust, single layer. |
| 22 | | 12.9 | Covered with talus of buff and rusty silty limestone, single bed massive gray limestone about 1.5' thick projects into middle of interval. |

Virgin Gorge Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 21 | G21 | 1.3 | Very fine to fine grained limestone, gray weathering gray, single layer--Straparollus. |
| 20 | | 1.3 | Very fine grained limestone, gray weathering gray, slabby beds. |
| 19 | | 2.7 | Very fine to fine grained limestone, gray weathering gray, massive layer. |
| 18 | G18 | 4.1 | Fine grained limestone silty limestone, olive gray weathering rust, massive bed. |
| 17 | | 2.1 | Very fine grained limestone, light gray weathering gray, thin slabby beds. |
| 16 | | 1.7 | Very fine to fine grained limestone, gray weathering gray, single layer. |
| 15 | | 2.7 | Very fine grained silty limestone, weathering rusty, massive. |
| 14 | G14 | 3.4 | Very fine to fine grained limestone, gray weathering dk. gray, gray single 1.5' bed at base, 1' slabby limestone with crurithyris. |
| 13 | | 8.2 | Covered with rusty weathering silty limestone. |

## Virgin Gorge Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 12 | | 1.3 | Fine grained limestone, gray weathering gray, faintly laminated beds. |
| 11 | G11 | 7.5 | Fine to medium grained limestone, gray weathering gray, single ledge 3.5'--rusty buff at base. |
| 10 | | 8.2 | Covered. |
| 9 | | 3.5 | Covered with talus of silty limestone, gray weathering rust. |
| 8 | G8 | 5.1 | Very fine grained limestone, gray weathering somewhat lighter, 4' ledge. |
| 7 | G7 | 8.2 | Covered with talus of very fine grained silty limestone, olive gray weathering rusty. |
| 6 | | 2.6 | Very fine to fine grained limestone, gray-dk. gray weathering gray. |
| 5 | G5 | 3.3 | Very fine grained limestone, gray weathering gray, beds as much as 6" thick, slabby. |
| 4 | G4 | 5.3 | Covered on tape line, rusty weathering silty limestone off line section. |

Virgin Gorge Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 3 | | 18.5 | Very fine to fine grained limestone, gray weathering gray, ledges as much as 2' thick, minor cover, 6" chert layer at 14', no fossils noted. |
| 2 | G2 | 13.8 | Fine to medium grained limestone, gray weathering gray and rusty, beds 6"-2'--scattered chert masses, all thin 2"-4" layers chert--weathering rusty. |
| 1 | G1 | 23.5 | Very fine grained limestone, gray weathering gray, beds as much as 4' thick, 2.5' bed in top unit with rugose corals. |

Total Thickness 193.1 ft.

## Virgin Mountains Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 15 | 15A | 12.2 | Very fine grained limestone, lt. gray weathering lt. gray to white, parallel bedding, no chert or silification. Basal 1'8" limestone very fine grained, gray weathering lt. gray--single bed (V15A). Fossils from upper Limestone, spirifers, productids. Upper 9' very fine grained limestone (V15B). |
| | 15B | | |
| 14 | | 5.4 | Covered |
| 13 | V13 | 10.3 | Limestone weathers gray to rusty buff, chert free, single massive bed, no fossils apparent single massive 4' bed at top. |
| 12 | | 5.6 | Covered with blocks of similar limestone, possibly some in place. |
| 11 | V11 | 3.3 | Very fine grained limestone, gray weathering gray, beds approx. 1.25' thick, rock appears homogeneous, no chert. |
| 10 | | 4.5 | Covered |

## Virgin Mountains Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| 9 | V9 | 17.3 | Very fine-fine grained limestone, gray weathering gray, beds 6"-2-3'/irregular beds of rusty weathering whole chert. Syringoporida, scarce Phaceloid corals, solitary rugose. Sequence from base up: ls. 1.7', chert 1.4', ls. 1', chert 6", ls. 1.5', chert 6", ls. 1', chert 8", ls. 2', V9 from top. |
| 8 | | 5.8 | Covered |
| 7 | | 2.6 | Very fine-fine grained limestone, gray weathering gray-purple exposed. |
| 6 | | 6.9 | Covered |
| 5 | V5 | 1.5 | Very fine-fine grained limestone, gray weathering gray, single bed. |
| 4 | | 4.5 | Covered |
| 3 | V2 | 3.5 | Very fine-fine grained, massive limestone |
| 2 | | 8.5 | Covered |
| 1 | V1 | -- | Resting on massive limestone ledge in excess of 10', apparently |

## Virgin Mountains Section

| Unit | Sample | Thickness (ft.) | Description |
|---|---|---|---|
| | | | continuous with Mmcyp. Syringo-poroid, small rugose, no lithostrotionids noted. |

Total Thickness 91.9 ft.

# APPENDIX II

## THIN SECTION DESCRIPTIONS

AT&T Section

| Slide # | Unit | Description |
|---|---|---|
| AT75 | 75 | Many large calcite crystals, fossils fragmented, bryozoans, mollusk, brachiopod, sponge, gastropod, grapestones crinoid, brachiopod spine, echinoderm fragment foraminifera (Endothyroid), quartz crystals, large calcite crystals. |
| AT74 | 74 | Pelletal limestone with little calcite cement, no obvious fossils--very obscure, seems to be laminated (cross bedded) on a small scale, definite texture difference. |
| AT73 | 73 | Many fossil fragments with calcite matrix, foraminifera bryozoan fragments, ostracodes, crinoids, sponge fragments brachiopod spines, gastropod, echinoderm fragments. |
| AT71 | 71 | Densely packed with bio-fragments, foraminifera (Endothyroid), gastropods, large calcite crystals, crinoid, brachiopod fragments, echinoid fragments, fine grained calcite matrix. |
| AT70 | 70 | Abundant foraminifera (globigerina, milioid, Endothyroid), echinoid fragments, crinoid, brachiopod spines and fragments, some calcite crystals in muddy matrix. |

AT&T Section

| Slide # | Unit | Description |
|---|---|---|
| AT69 | 68 | Poorly sorted, fragmented bioclasts, large angular calcite crystals, crinoids, foraminifera (Endothyroid, biserial), bryozoans, brachiopod fragments, calcite matrix, heavily populated with bioclasts. |
| AT66 | 66 | Very fine grained calcite crystals with grain to grain contacts, subangular to angular, some quartz grains, large calcite veins, no visible fossils. |
| AT62 | 62 | Ostracodes, echinoderm, foraminifera (nummulites, globigerina) bryozoans, gastropods, brachiopod fragments, calcite veins, very fine dark matrix, most shells are highly fractured. |
| AT57 | 57 | Brachiopod-foraminifera fossil hash (miliolid, globigerina), crinoid, brachiopod spines and fragments, much calcite has grown about these structures. |
| AT55 | 55 | Abundant bryozoans, echinoid spines and plate fragments, foraminifera (globigerina), large calcite grains, somewhat vuggy, crinoid, brachiopod, a few quartz crystals, mostly grain to grain contacts. |

AT&T Section

| Slide # | Unit | Description |
|---|---|---|
| AT54 | 53 | Quartz very fine grained, well sorted, possible plagioclase grains, red color, no fossils. |
| AT51 | 51 | Poorly sorted, fossils are very fragmented in a cryptocrystalline mud-like cement. A few large calcite crystals, foraminifera (Endothyroid) echinoderm fragments, pelecypod, ostracode, brachiopod spines, crinoids. |
| AT49 | 49 | Brachiopod, calcite veins, seems to be 98% pellets, a few large calcite crystals, bryozoans fragments, crinoid, very fine grained calcite cement. |
| AT44 | 44 | Many pellets in calcite matrix, sponge fragments crinoid, gastropod, foraminifera, pelecypods that are mud filled, brachiopod fragments, worm tubes. |
| AT41 | 41 | Very fine grained mud with no fossils, calcite filled veins. |
| AT15 | 15 | Pelletal limestone with some quartz grains, belemnite, crinoid, calcite filled veins, brachiopod fragments. |
| AT13 | 13 | Quartz sandstone in muddy matrix, grains are subangular, few opaque grains, echinoderm fragments, foraminifera. |

AT&T Section

| Slide # | Unit | Description |
|---|---|---|
| AT12 | 11 | Foraminifera, gastropod, pelecypods, fairly pelletal and "muddy" calcite filled pores, fossils are obscured. |
| AT10 | 10 | Quartz sandstone, angular-subangular grains, no fossils noted red material--grains of opaques. |
| AT9 | 9 | Pelletal limestone that has many fossils and fragments, foraminifera (globigerina, miliolid), brachiopid fragments, echinoid fragments, bryozoan, worm tubes. |
| AT7 | 7 | Extremely sharp boundry between a fossil packed and a relatively unfossiliferous, crypto-crystalline muddy calciferous matrix, pelletal with a few quartz grains, echinoderm fragments, foraminifera. |
| AT6 | 6 | Grain to grain contacts, subangular grains, calcite microcrystalline grains, calcite veins, very fine grained, fairly well sorted, brachiopod spines, foraminifera (Agglutinated, miliolid). |
| AT5 | 5 | Foraminifera, echinoderm fragments, a few large calcite grains mainly pellets, brachiopod, bryozoan, quartz grains, calcite grains, very fine mud like matrix. |

## AT&T Section

| Slide # | Unit | Desctiption |
|---|---|---|
| AT3 | 3 | Subangular, point contact, bioclastic, calcite cement, biosparite, foraminifera (miliolid, Endothyroid), brachiopod spines and fragments, ostracodes, crinoids. |

Virgin Gorge Section

| Slide # | Unit | Description |
|---|---|---|
| G27 | 27 | Fossils are "hash" with a few large fossils. Most structures have been erased during replacement, calcite veins, very fine mud matrix, styolites, Echinoderm, crinoid, gastropod, foraminifera (miliolid, globigerina, Endothyroid), dolomite grains, brachiopod fragments, ostracode, worm tube. |
| G25 | 25 | Very fine grained mud-like matrix with quartz grains, Darker pelletal areas, no fossils, muddy sandstone. |
| G21 | 21 | Fine grained mud matrix with fossils and fragments, calcite crystals, echinoid spine, brachiopod fragments, foraminifera (milioid), ostracode, crinoid, many pellets. |
| G18 | 18 | Quartz grains of varying size in mud-like matrix and pellets no fossils noted, muddy sandstone. |
| G14 | 14 | Very fine grained mud fossil hash, ostracode, quartz grains, crinoid, foraminifera (globigerina), brachiopod, large calcite crystals, echinoderm. |
| G11 | 11 | Medium grained calcite and pellets, fossil hash, quartz grains, crinoid, brachiopod, calcite veins, replacement makes the fossils impossible to see. |

## Virgin Gorge Section

| Slide # | Unit | Description |
|---|---|---|
| G8 | 8 | Fine grained mud-like matrix with fossils and fragments, calcite veins that cross, fossil hash, pellets, fossils not recognizable due to recrystallization, quartz grains. |
| G7 | 7 | Very fine grained pelletic quartz sandstone, rounded grains, burrowing, very fine calcite matrix, no fossils. |
| G5 | 5 | Very fine grained mud-like matrix, fossil hash, ostracode, dolomite grains, brachiopod, crinoid, fossils are somewhat filled with mud matrix, bryozoan, large calcite crystals and veins. |
| G4 | 4 | Very fine quartz grains surrounded by mud-like matrix, sandy mud, brachiopod, the fossils are not easily seen or discernable, there are not many found here, pellets. |
| G2 | 2 | Many calcite filled veins that cross each other, very fine grained mud-like matrix, some fragmented fossils, ostracode, not many fossils and they are difficult to recognize, pellets. |
| G1 | 1 | Medium grained limestone with large calcite veins. Foraminifera (milioid), calcite grains are subangular and some mud-like matrix is |

## Virgin Gorge Section

| Slide # | Unit | Description |
|---|---|---|
| | | found, most grains have grain to grain contact, crinoid much replacement, not many fossils apparent. |

Virgin Mountains Section

| Slide # | Unit | Description |
|---|---|---|
| V15B | 15 | Very fine grained calcareous mud with many small pellets and very few fossils, quartz grains, foraminifera (miliolid, globgerina), crinoid, gastropod. |
| V15A | 15 | Many large pellets that have crystals of calcite that have grown between them, almost mud like, no fossils. |
| V13 | 13 | Matrix is hash of many fine pellets and fossil fragments, mollusk fragments gastrapod. brachiopod, ostracode. |
| V11 | 11 | Foraminifera (miliolid, globgerina, Endothyroid), brachiopod: fragments, spines, crinoid, ostracode, pelletal with quartz grains. |
| V9 | 9 | Foraminifera (miliolid, Endothyroid), crinoid, calcite crystals in a pelletal fine grained mud. |
| V5 | 5 | Very fine grained calcite crystals with grain to grain contacts with very few rounded quartz grains. |
| V2 | 3 | Pelloidal limestone with calcite cement, foraminifera (miliolid), very few fossils, few subangular quartz grains. |

## Virgin Mountains Section

| Slide # | Unit | Description |
|---|---|---|
| V1 | 1 | Matrix of fine mud, brachiopod, foraminifera (Endothyroid), many fossil fragments, large calcite crystals. |