FIELD TRIP TO THE SOUTH CENTRAL NEWARK BASIN FOR THE MEETING OF DOSECC MARCH 7, 1992

Field Trip Leaders
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SCHEDULE

Stop #	Formation	duration	time
travel		1:30	8:30AM to 10:00 AM
1	Prallsville Mb. of Stockton	0:35	10:00 AM to 10:35 AM
travel		0:15	10:35 AM to 10:50 AM
2	Middle Lockatong	0:45	10:50 AM to 11:35 AM
travel		0:25	11:35 AM to 12:00 PM
Lunch		1:30	12:00 PM to 1:30PM
travel		0:25	1:30 PM to 1:55 PM
3	Mb.C of Passaic	0:30	1:55 PM to 2:25 PM
travel		0:10	2:25 PM to 2:35PM
4	Passaic Formation near Border Fault	0:35	2:35 PM to 3:10 PM
travel		1:15	3:10 PM to 4:25PM
5	Orange Mt. Basalt	0:20	4:25 PM to 4:45 PM
travel		0:45	4:45 PM to 5:30PM

INTRODUCTION

The purpose of this field trip is to compare outcrops of the Newark basin (Figures 1 and 2) to the recently collected Newark basin cores. Outcrops in the sub-basins in which the cores were collected (with the exception of Martinsville # 1) are not suitable for a field short field trip. Therefore, we will visit the classic localities along the Delaware River, which have been the subject of so many guidebooks. In this case, however we can directly compare the cores with the outcrop. The similarity between the cores and the outcrops are remarkable because the two main areas in which they occur are in different sub-basins that were active during sedimentation, and are presently separated by 25 to 55 km. This brief guidebook is based largely on text and figures culled with modification from Olsen et al. (1989) that includes the work of many authors. Complete attribution and references in this guidebook can be found in that source.

STOP 1: QUARRY IN PRALLSVILLE MEMBER OF STOCKTON FORMATION, STOCKTON, NJ

(Adapted from Olsen and Schlische (in Olsen et al., 1989, pp. 89-90)

Highlights:

- *Basal fluvial portion of basin fill with large upward fining cycles.*
- *Correlates with lower part of Princeton # 1 core.*

The Stockton Formation comprises the oldest fill in the Newark rift basin and it is almost entirely fluvial. The Skeuse family quarry in upper part of the Prallsville Member of the Stockton Formation exposes about 60 m of section and begins about 760 m above the base of the formation (Figure 4) (Van Houten, 1969, 1980). We will examine a 18 m section in the most recently active part of the quarry. The interval exposed in the quarry probably correlates with from 2700 to 3500 ft in the Princeton # 1 core (Figure 5).

Thick (~15 m) fining upward cycles are obvious at these outcrops (Figure 3), which consist of, from the bottom up: 1) pebbly trough cross bedded sandstone at base passing upwards into sandy compound cross-bed sets - units tend to be kaolinized and have small to large siltstone rip-up clasts; 2) thick interval of well sorted sandstone with climbing ripple cross lamination and planar lamination with bioturbation and siltstone partings increasing up section; 3) climbing ripple to massive siltstone with intense bioturbation by *Scoyenia* and roots, and slickensided dish structures. The 18 m section exposed in the part of the quarry we will visit (main quarry - Figure 4) exposes almost a complete cycle plus the basal portion of a succeeding cycle.

The sequence of structures in these fining-upward sequences are consistent with large, perennial meandering or anastamosing river deposits. In addition, lateral accretion surfaces of point bars are suggested by the lateral fining of cross-bedded structures in the up-dip direction. The large river systems implied by these outcrops are incompatible with a closed basin model for the Newark basin (Smoot, 1985) and indicate an open basin for this part of the basin's history. This is in accord with the predictions of the basin filling model outlined by Schlische and Olsen (1990) and Olsen and Schlische (1988a-d), and every basin in the Newark rift system has a similar basal through-draining fluvial unit.

This is a particularly good place to see the two main mutually perpendicular joint sets characteristic of the Newark basin (Figure 4). Such regional joint sets are characteristic of extensional systems with one set (NE-striking) being perpendicular to the extension direction and tending to be parallel with most of the Jurassic age dike sets in the Newark basin. The NW-striking set parallels the axes of fold systems in the basin, and may be related to the overall bending and downwarping of the Newark basin as a result of variable slip on the border fault system.

STOP 2: MIDDLE LOCKATONG FORMATION AT BYRAM, NJ

Highlights:

- *Example of deepest water facies in Newark basin, classic field locality of cyclic Lockatong lacustrine strata.*
- *Extremely close correlation with Nursery # 1 core.*

Exposed along the east side NJ 29 and along the ravine at its north end are more than 400 m of middle Lockatong Formation (Figure 6), which represents a shallower portion of the “deep lake” stage of the Newark rift. In this basin the lacustrine interval is characterized by extremely exaggerated lake level cycles that always have a phase showing signs of complete desiccation. These cycles were originally described by Franklyn Van Houten in the 1960’s, and these are the exposures on which he based most of his interpretations. These are also the lacustrine exposures most often seen by visiting geologists, although they are becoming increasingly overgrown in recent years. This outcrop correlates to the section cored in Nursery # 1 from 1280 to 2300 ft (Figure 7).

About 99% (405 m) of this outcrop section consists of fine calcareous mudstone and claystone with the remaining 1% (5 m) consisting of very fine sandstone. These exposures include the Ewing Creek, Byram, Skunk Hollow, and Tohicken members. McLaughlin's (1944) "First Thin Red" makes up the upper part of the Skunk Hollow Member and the "First Thick Red" makes up the upper part of the Tohicken Member.

These outcrops are typical of the middle and upper Lockatong Formation, with the deepest water stages of the Lockatong sequence being lower in the formation.

Fourier analysis of this depth-ranked section done in 1984 (Figure 6) and calibration by varve-based sedimentation rates and radiometric time scales show the main thickness and time periodicities typical of both the Lockatong and Passaic formations in this part of the basin. All of the periodic components predicted by the Milankovitch theory of climate change for monsoonal equatorial regions are present in the power spectrum. More details on this stop are provided in the Olsen et al. (1989) guidebook (pp.86-89).

STOP 3: BASAL PASSAIC FORMATION: MEMBER C AT DEVILS TEA TABLE

Highlights:

• *Red mudstone of lower Passaic Formation still showing characteristic cyclical pattern.*

• *Correlates with 2150 to 2300 in the Titusville # 1 core.*

The transition from Lockatong to Passaic Formation is marked by an increase in proportion of red massive mudstones over gray. The cyclical pattern remains intact through the transitions and through the entire Passaic Formation, however, the frequency with which deep lakes appeared was waning. These outcrops are stratigraphically the lowest in this part of the basin in which red rather than gray massive mudstones are dominant. The section illustrates the facies typical of much of the shallow lake phase of the Newark basin section, and it is similar to often desiccated, but still, lacustrine phases in other rift lakes as well.

Exposed along the east side NJ 29 are about 100 m of lower Passaic Formation (Figure 8) showing the classic cyclical alternation of thin black and gray shales and mudstones and much thicker packages of red mudstone. This outcrop section is amazingly similar to the section cored in Titusville # 1 from 2150 to 2300 ft. Outcrops on the southwest side of Devils Tea Table and Cains Run are of the gray and black portions of Member C, the stratigraphically lowest of many putatively 400,000 year cycles in the Passaic Formation. The dominant lithology in the gray beds is a massive mudcracked mudstone (breccia fabric) deposited in a playa. However, gray and black more fissile mudstones deposited in perennial lakes occur about every 5-7 m, outlining the same kind of cyclicity seen in the underlying Lockatong Formation (Stop 2). The thick sequence of red mudstones higher in Member C still follows this pattern, although the gray and black units are replaced by fissile red or purple siltstones.

Many gray and red massive mudstones at this locality are cut by dish-shaped, concave-upward clay-lined surfaces with radial slickenlines. These "dish structures" were described by Van Houten (1964, 1969) and interpreted as a possible gilgai-type soil feature (Van Houten, 1980). A mechanical analysis of these structures suggests they are coulomb fractures produced in relatively rigid, but not lithified, mud by more or less isotropic expansion in a three-dimensional analogue of Davis *et al.*'s (1983) "bulldozer" model for the development of thrust faults in accretionary wedges. The volume increase was probably due to eolian deposition of mud in desiccation cracks followed by rewetting. Because the bed was confined laterally, it fractured along listric, dish-shaped faults and compensated for increased volume by increasing in thickness. As a mechanical consequence of volume increase, the dish-structures are probably not specific to any particular environment in larger sense, but could be indicative of a limited range of environments in a particular basin setting such as the basal Passaic.

STOP 4: PEBBLE BLUFF, NEAR MILFORD, NJ

Highlights:

- *Interbedded conglomerates and lacustrine strata near the border fault.*
- *Correlates with from about 1900 to 2400 ft in the Rutgers # 1 core and from 30 to 300 ft in the Titusville # 2 core.*

These outcrops [described by Van Houten (1969, Stop 6; 1980, Stop 1) and Arguden and Rodolpho (1987), Olsen *et al.* (1988 and 1989)] consist of thick sequences (> 20 m) of red conglomerate and sandstones alternating with cylindrical black, gray, and red mudstone and sandstone. Dips average 10-15° NW, and there several faults, down-throwing to the east, between the largest outcrops. The gray beds seen in Figure 10 appear to be the basal Perkasie member. The outcrops shown in Figure 10 correlate with 2280 to 2320 ft in the Rutgers # 1 core and from 30 to 110 ft and are the facies equivalent of those fine grained strata near the border fault. The entire suite of outcrops at Pebble Bluffs span the intervals from about 1900 to 2400 ft in the Rutgers # 1 core and from 30 to 300 ft in the Titusville # 2 core (0 to 30 ft not cored in the latter).

Conglomerates at Pebble Bluffs occur in three basic styles. 1) Poorly-bedded boulder-cobble conglomerate with pebbly sandstone interbeds. Matrix rich conglomerates are in places matrix-supported. These appear to define lenses that are convex-upward and bounded by the largest clasts at their edges and tops. These lenses appear to be debris flow lobes, in which some of the matrix may have been partially washed out by rain during periods of non-deposition. If correctly identified, the flow lenses are typically less than 30 cm. thick and less than 5 m wide, similar to debris flows formed on mid to lower portions of steep fans. Pebbly sandstone and muddy sandstone include "trains" of isolated cobbles often oriented vertically. These cobble trains represent thin, low viscosity debris flows that are stripped of their matrix by shallow flash-flood streams. The sandstones appear to be broad, shallow stream deposits that may include hyperconcentrated flow as indicated by flat layering defined by the orientation of granules.

2) Well-defined lenticular beds of pebble-cobble conglomerate separated by pebbly muddy sandstones with abundant root structures. The conglomerate beds are channel-form with abundant imbrication. Some internal coarsening and fining sequences are consistent with longitudinal bars (Bluck, 1982). Finer grained deposits resemble less incised channels and overbank deposits. There are some hints of thin debris flow sheets. Abundant root structures filled with nodular carbonate (caliche?) suggest soil development.

3) Grain-supported cobble-pebble conglomerate with sandy matrix. Granules and coarse sand show a high degree of sorting suggestive of wave reworking of finer fractions (LeTourneau and Smoot, 1985). These are associated with the gray and black shales and oscillatory-rippled sandstones in the Van Houten cycles of the Perkasie at this locality.

Laterally continuous black and gray siltstones and claystones within division 2 of Van Houten cycles (Figure 10) contain pinch-and-swell laminae, abundant burrows, and rare clam shrimp. These perennial lacustrine deposits are clearly the coarser facies of strata represented in the more central Newark basin, such as seen in the Titusville and Rutgers cores. These lakes were evidently deep enough to transgress over the relief caused by the toes of alluvial fans, as represented by the debris flow deposits at this outcrop.

STOP 5: ORANGE MT. BASALT, WEST ORANGE, NJ.

Highlights:

- *Columnar jointing in a very thick individual flow of a giant flood basalt.*
- *Correlates with 860 to 1120 ft in the Martinsville # 1 core.*

When this road cut was constructed in 1969, this was the deepest federally financed highway cut east of the Mississippi River (Manspeizer, 1980). The road cut is about 33 m high and exposes a nearly complete section of the lowest flow of the Orange Mt. Basalt (Figure 12). Unusual curved patterns of columnar joints are present in the cut, described as chevrons, oblique and reverse fans, and rosettes. This flow overlies the red mudstones and sandstones of the uppermost Passaic Formation, which contains the Triassic-Jurassic boundary. This same flow was cored in the Martinsville # 1 core from 848 to 1121.5 ft (the section in the core that correlates with the outcrop is from 860 to 1120 ft).

This outcrop is the type section of the Orange Mountain Basalt (Olsen, 1980a,b), which was referred to as the First Watchung Basalt in older literature. The Orange Mountain is an HTQ basalt (Puffer and Lechler, 1980) which at this exposure shows a complete, beautifully exposed Tomkeieff (1940) sequence almost exactly comparable to Long and Woods (1986) Type III flows. The thin (6 m) lower colonnade is fine-grained with large columns, the entablature is thick (35 m) with very well developed curvi-columnar jointing, and the upper colonnade (10 m) is massive with poorly developed columns.

The largest fault at this exposure strikes N05°E, dips 80°E, and does not visibly offset subhorizontal joints, suggesting that it is a predominantly strike-slip fault (Schlische, 1985). Another fault with a 25-cm-wide breccia and gouge zone strikes N30°E and dips 70°NW. Although slickensides suggest that the last slip on the fault was predominantly strike-slip, this fault may have originated as a normal fault during NW-SE extension. Several minor slickensided surfaces mostly reactivated cooling joints show evidence of an earlier period of predominantly dip-slip and a later period of strike-slip (Schlische, 1985).

Mineralization of cavities in the basalt at this outcrop consists mostly of zeolites, while in the Martinsville # 1 core copper mineralization is prevalent. This difference in mineralization is typical of the northern and southern parts of the Watchung Syncline, respectively. In the southern Watchung syncline, copper mines were developed along the upper and lower contacts of this basalt formation, while in the north, spectacular zeolite assemblages are more common. According to Cummins (1988 and pers. comm.) the origin of both the copper and the zeolites was from low-temperature, oxidizing, connate brines circulating through the vast volume of red mudstones and sandstones that dropped some of their solutes on contact with the reducing basalt. The low temperature of these fluids is demonstrated by the preservation of liquid hydrocarbons in vesicles in the basalt and in the overlying Feltville Formation as seen in the Martinsville # 1 core and outcrops, and by studies of organic maturity in the immediately surrounding sediments (Pratt et al, 1986). The zeolites in this basalt are thus not the result to thermal metamorphism as sometimes assumed.

The Orange Mountain Basalt, as well as the other basalt formations of the Newark Supergroup are apparently correlatable at the 20,000-year level from at least northern Massachusetts to central Virginia, based on geochemistry and Milankovitch cycle correlations. Based on the detailed cyclostratigraphy, the entire extrusive and associated intrusive event (which includes the Palisade Sill) lasted only about 600,000 years (Olsen et al., submitted). The remarkable correlation of the flow sequences and their amazing geochemical homogeneity over such long distances poses major challenges for theories of tholeiitic melt production and intrusion theories.

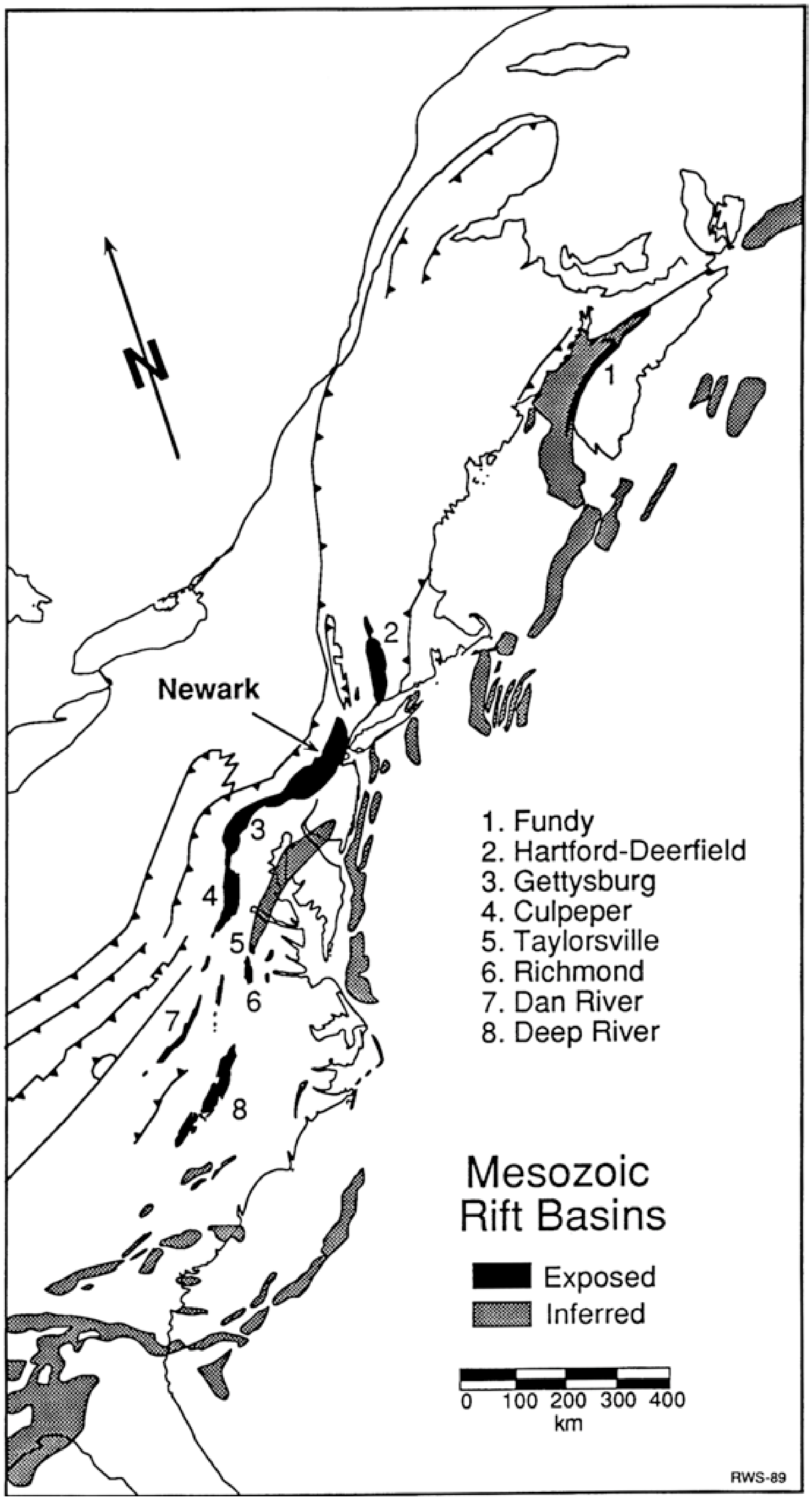

N
Newark
1
2
3
4
5
6
7
8
1. Fundy
2. Hartford-Deerfield
3. Gettysburg
4. Culpeper
5. Taylorsville
6. Richmond
7. Dan River
8. Deep River
Mesozoic
Rift Basins
Exposed
Inferred
0 100 200 300 400
km
RWS-89

Figure 1.

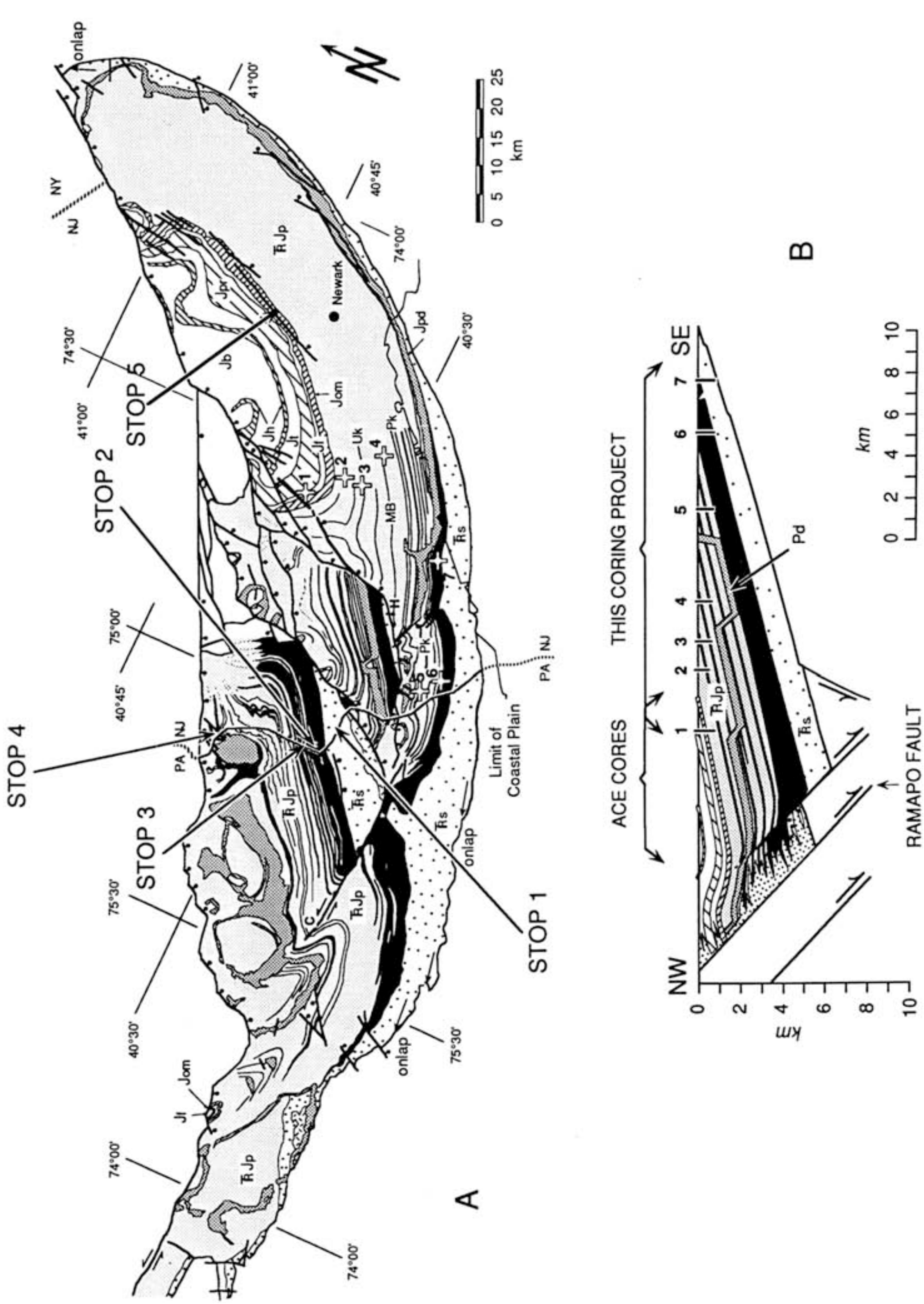
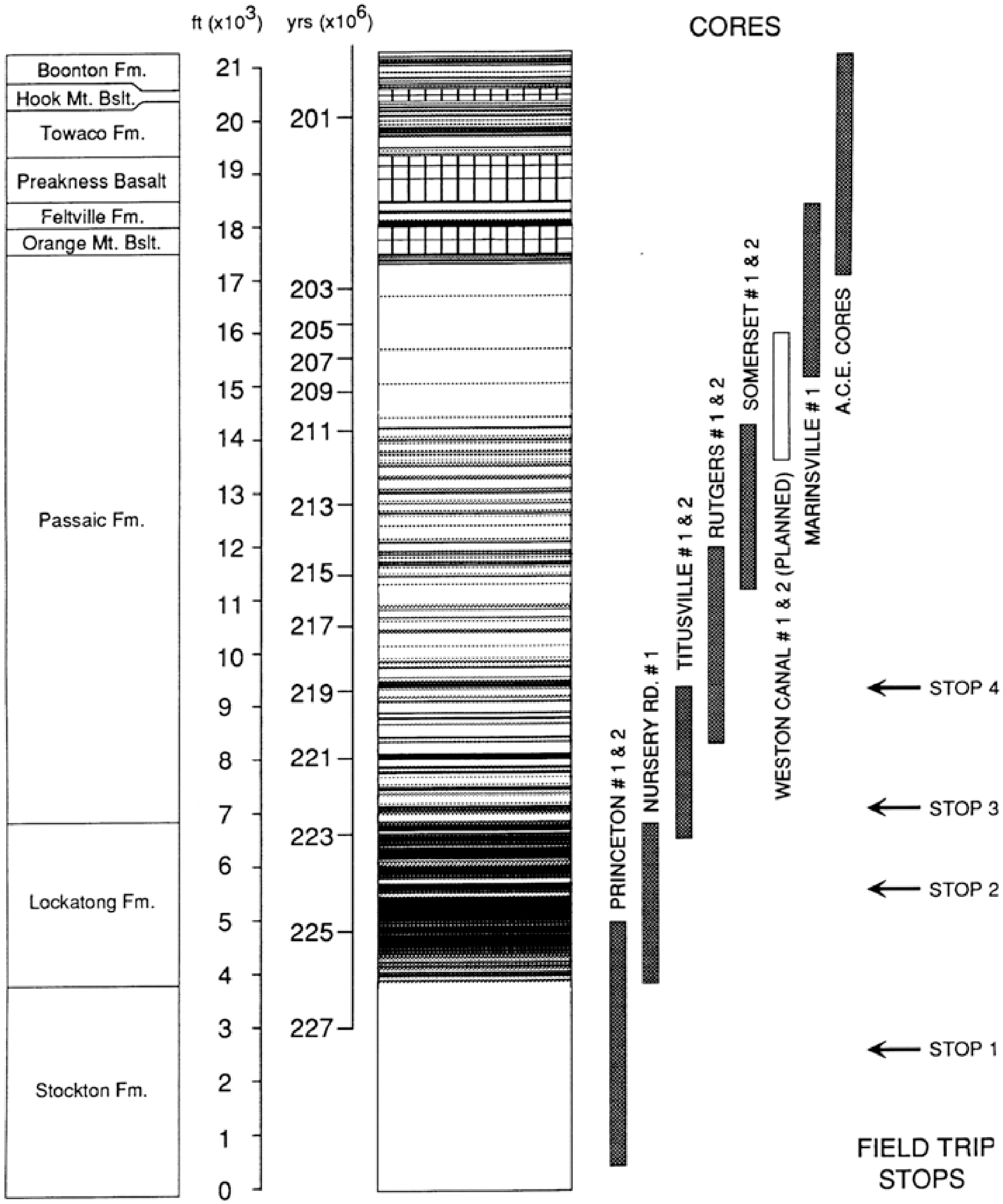

A
B
STOP 1
STOP 2
STOP 3
STOP 4
STOP 5
Newark
NY
NJ
PA
Limit of Coastal Plain
onlap
RAMAPO FAULT
ACE CORES
THIS CORING PROJECT
NW
SE
km
0 5 10 15 20 25
km
Pd

Figure 2.



ft (x10^3)
yrs (x10^6)
CORES
Boonton Fm.
Hook Mt. Bslt.
Towaco Fm.
Preakness Basalt
Feltville Fm.
Orange Mt. Bslt.
Passaic Fm.
Lockatong Fm.
Stockton Fm.
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
201
203
205
207
209
211
213
215
217
219
221
223
225
227
PRINCETON # 1 & 2
NURSERY RD. # 1
TITUSVILLE # 1 & 2
RUTGERS # 1 & 2
SOMERSET # 1 & 2
WESTON CANAL # 1 & 2 (PLANNED)
MARINSVILLE # 1
A.C.E. CORES
STOP 4
STOP 3
STOP 2
STOP 1
FIELD TRIP STOPS

Figure 3

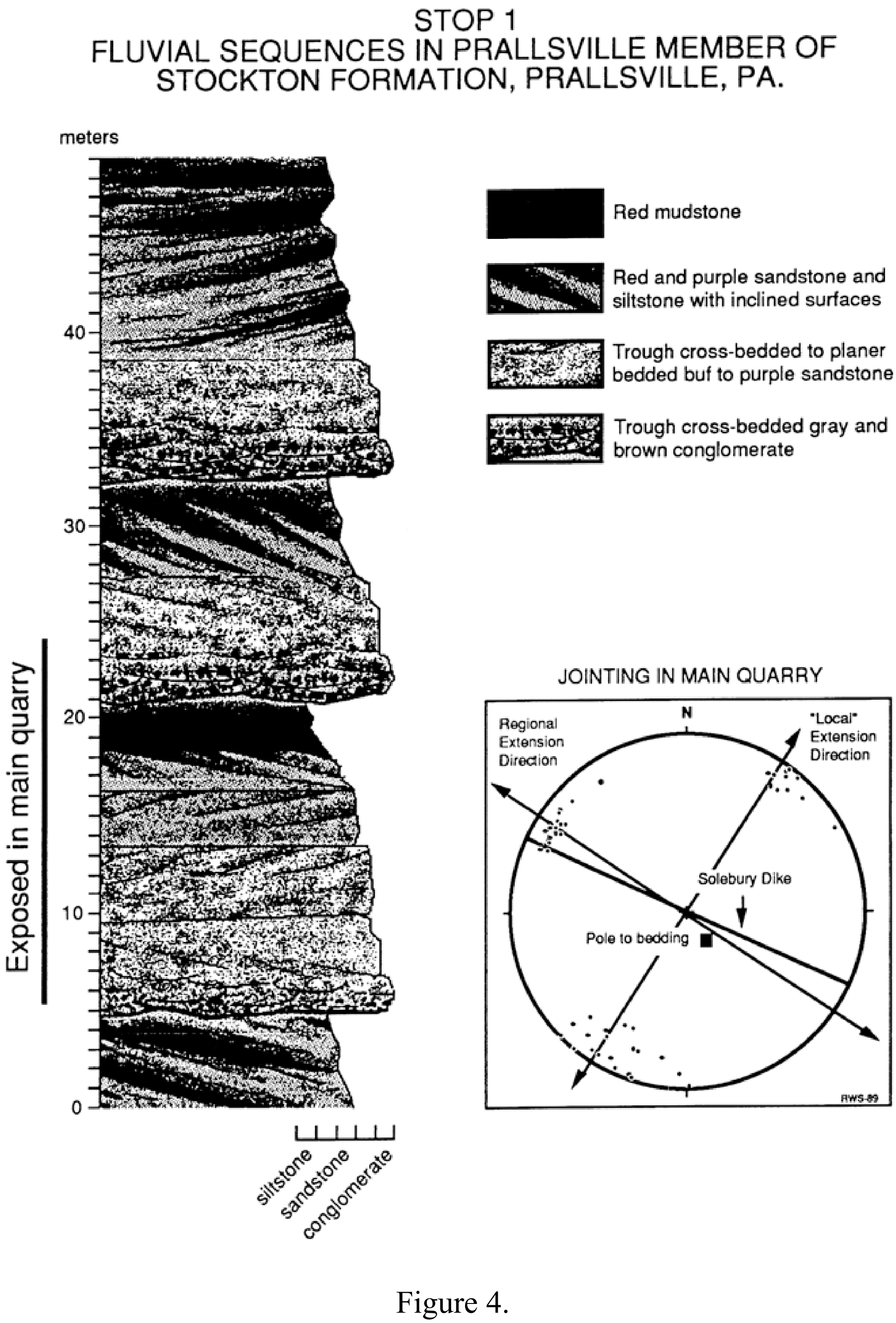

STOP 1
FLUVIAL SEQUENCES IN PRALLSVILLE MEMBER OF
STOCKTON FORMATION, PRALLSVILLE, PA.
meters
40
30
20
10
0
Exposed in main quarry
siltstone
sandstone
conglomerate
Red mudstone
Red and purple sandstone and siltstone with inclined surfaces
Trough cross-bedded to planer bedded buf to purple sandstone
Trough cross-bedded gray and brown conglomerate
JOINTING IN MAIN QUARRY
N
Regional Extension Direction
"Local" Extension Direction
Solebury Dike
Pole to bedding
RWS-89

Figure 4.

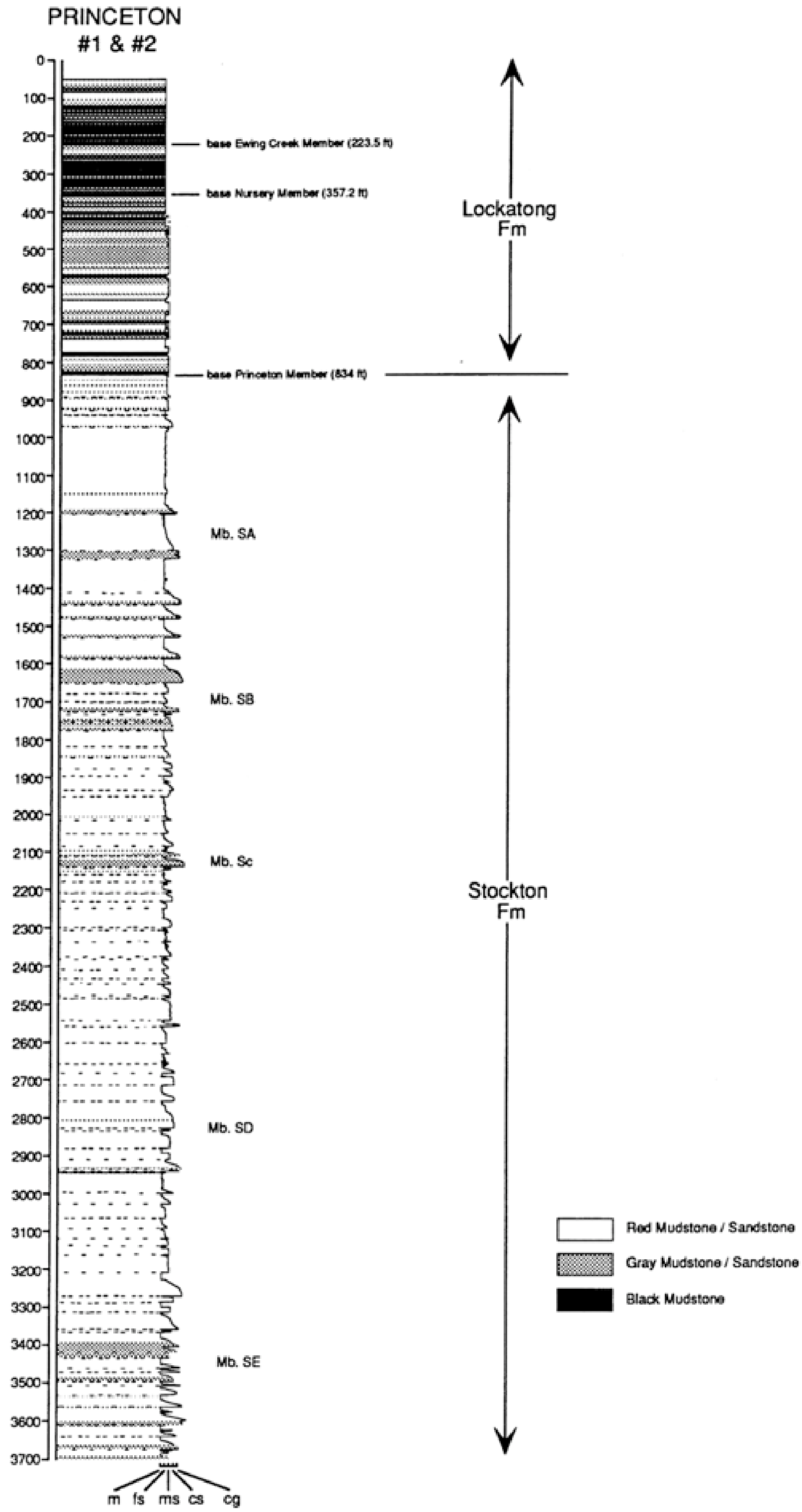

PRINCETON
#1 & #2
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
base Ewing Creek Member (223.5 ft)
base Nursery Member (357.2 ft)
base Princeton Member (834 ft)
Lockatong
Fm
Mb. SA
Mb. SB
Mb. Sc
Mb. SD
Mb. SE
Stockton
Fm
Red Mudstone / Sandstone
Gray Mudstone / Sandstone
Black Mudstone
m
fs
ms
cs
cg

Figure 5.

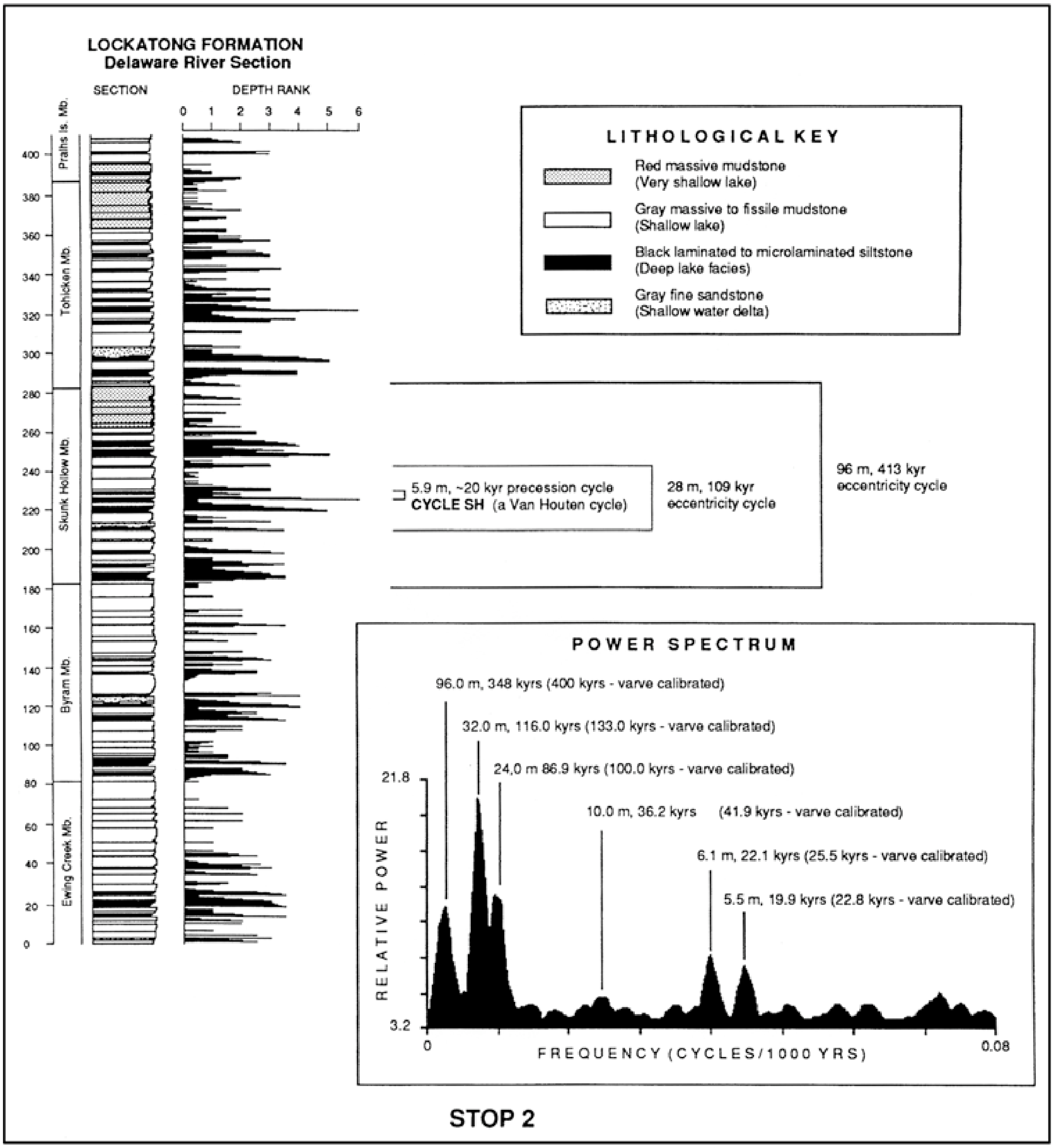


Figure 6: Measured section of Lockatong Formation at Byram along the Delaware River with depth ranks and power spectrum derived from them. Power spectrum yields periods in thickness that are converted to time by assigning the two high-frequency peaks to an average period of 20,000 years. Periods in parentheses are based on varve-calibration with an accumulation rate of 0.24 mm/yr. Adapted from Olsen (1986).

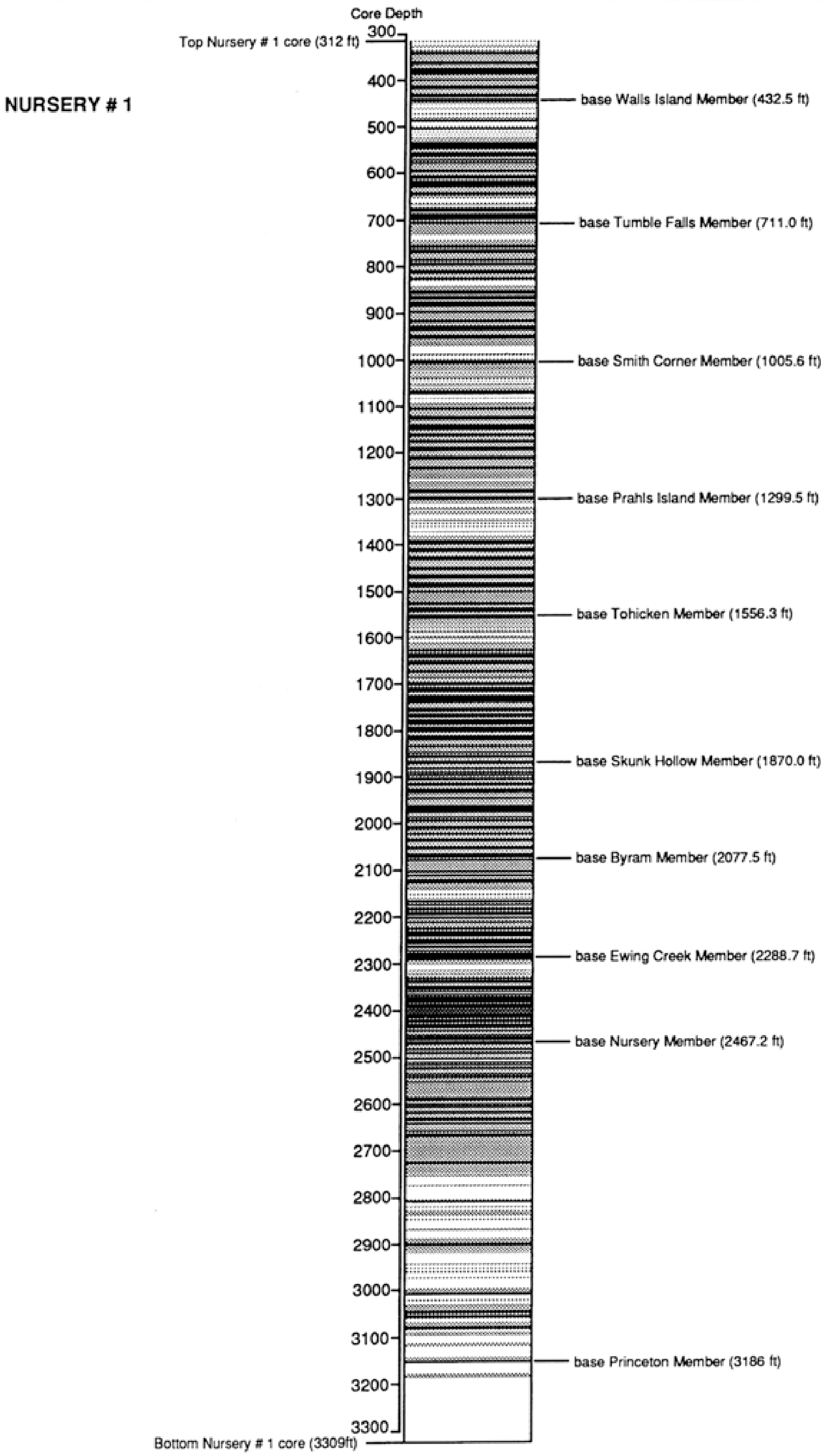

NURSERY # 1
Core Depth
Top Nursery # 1 core (312 ft)
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
Bottom Nursery # 1 core (3309ft)
base Walls Island Member (432.5 ft)
base Tumble Falls Member (711.0 ft)
base Smith Corner Member (1005.6 ft)
base Prahls Island Member (1299.5 ft)
base Tohicken Member (1556.3 ft)
base Skunk Hollow Member (1870.0 ft)
base Byram Member (2077.5 ft)
base Ewing Creek Member (2288.7 ft)
base Nursery Member (2467.2 ft)
base Princeton Member (3186 ft)

Figure 7.

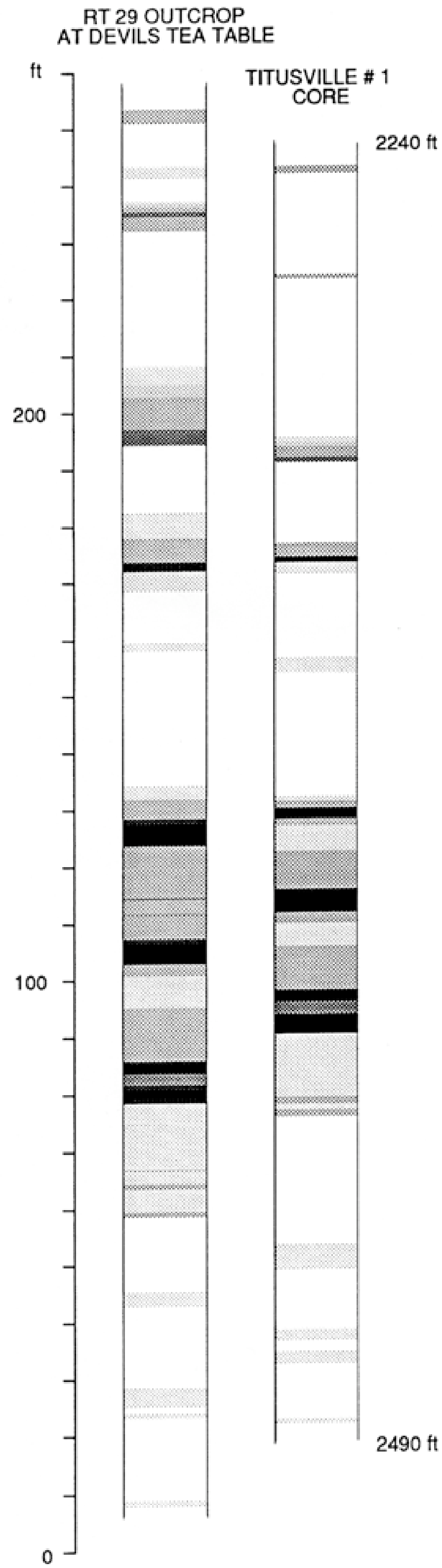

RT 29 OUTCROP
AT DEVILS TEA TABLE
ft
200
100
0
TITUSVILLE # 1
CORE
2240 ft
2490 ft

Figure 8.

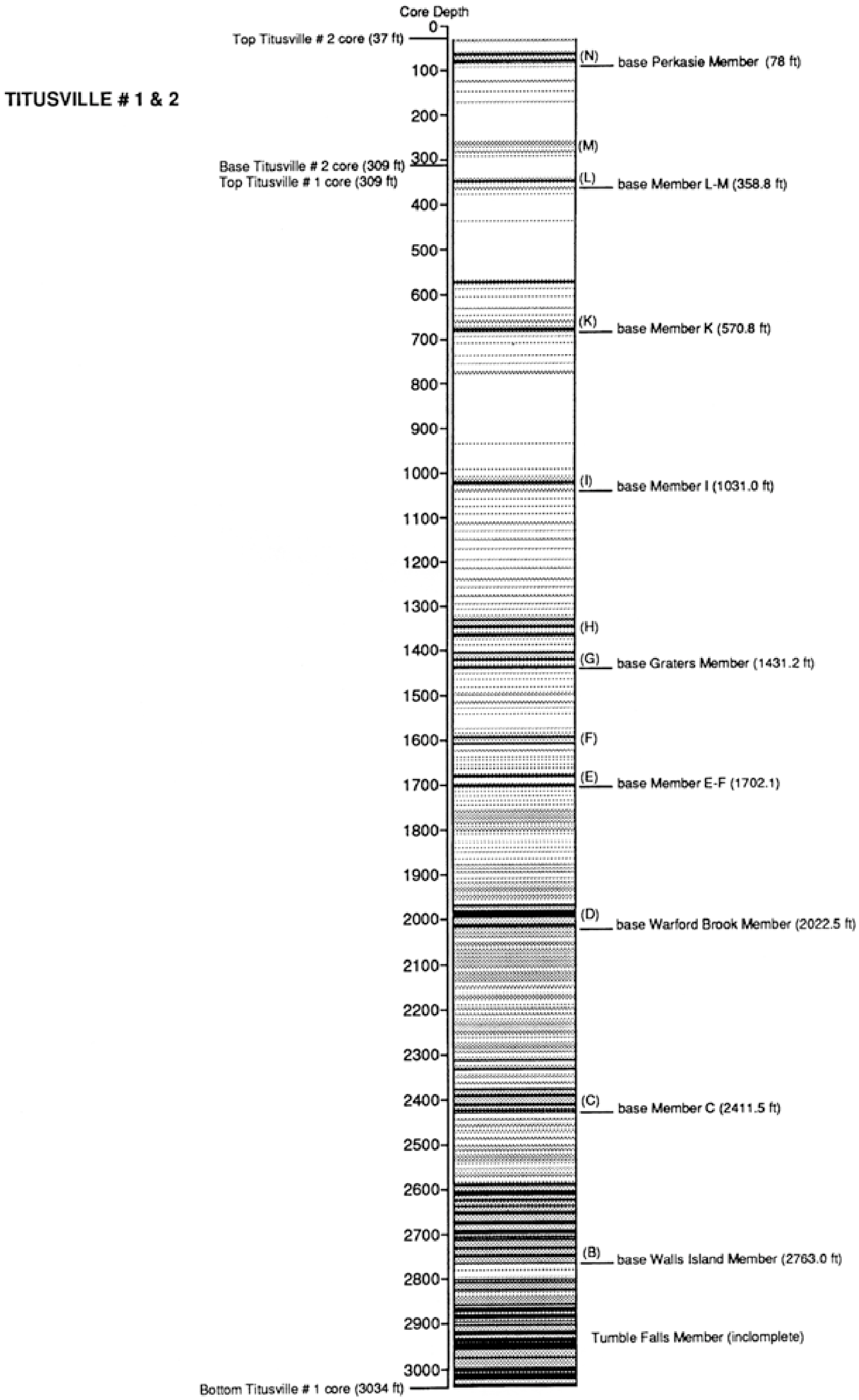

TITUSVILLE # 1 & 2
Core Depth
Top Titusville # 2 core (37 ft)
Base Titusville # 2 core (309 ft)
Top Titusville # 1 core (309 ft)
Bottom Titusville # 1 core (3034 ft)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
(N) base Perkasie Member (78 ft)
(M)
(L) base Member L-M (358.8 ft)
(K) base Member K (570.8 ft)
(I) base Member I (1031.0 ft)
(H)
(G) base Graters Member (1431.2 ft)
(F)
(E) base Member E-F (1702.1)
(D) base Warford Brook Member (2022.5 ft)
(C) base Member C (2411.5 ft)
(B) base Walls Island Member (2763.0 ft)
Tumble Falls Member (inclomplete)

Figure 9.

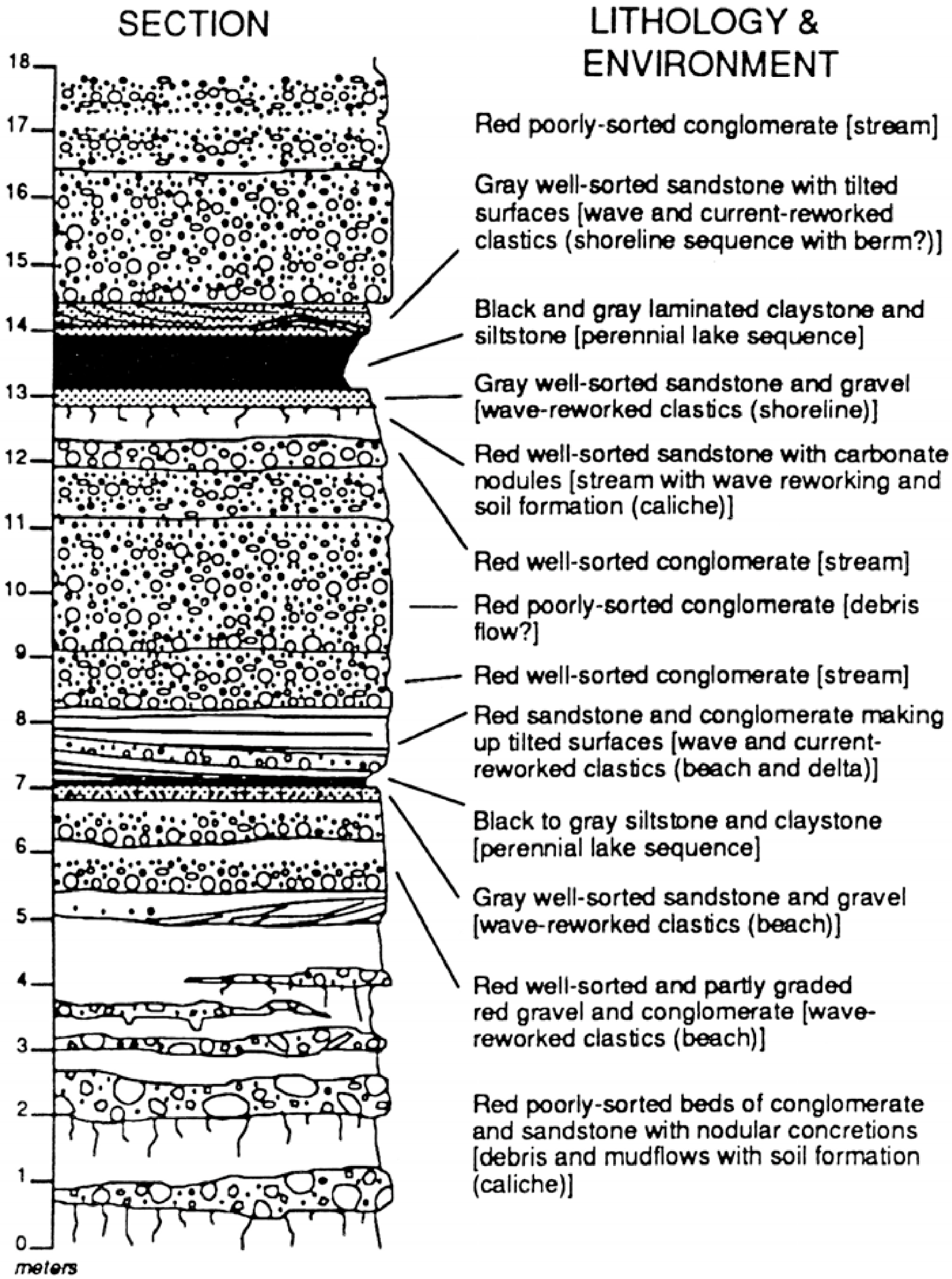


Figure 10: Measured section of the Passaic Formation (lower part of the Perkasie Member) at Stop 4 showing the alternation of alluvia and lacustrine deposits (after Olsen et al., 1986).

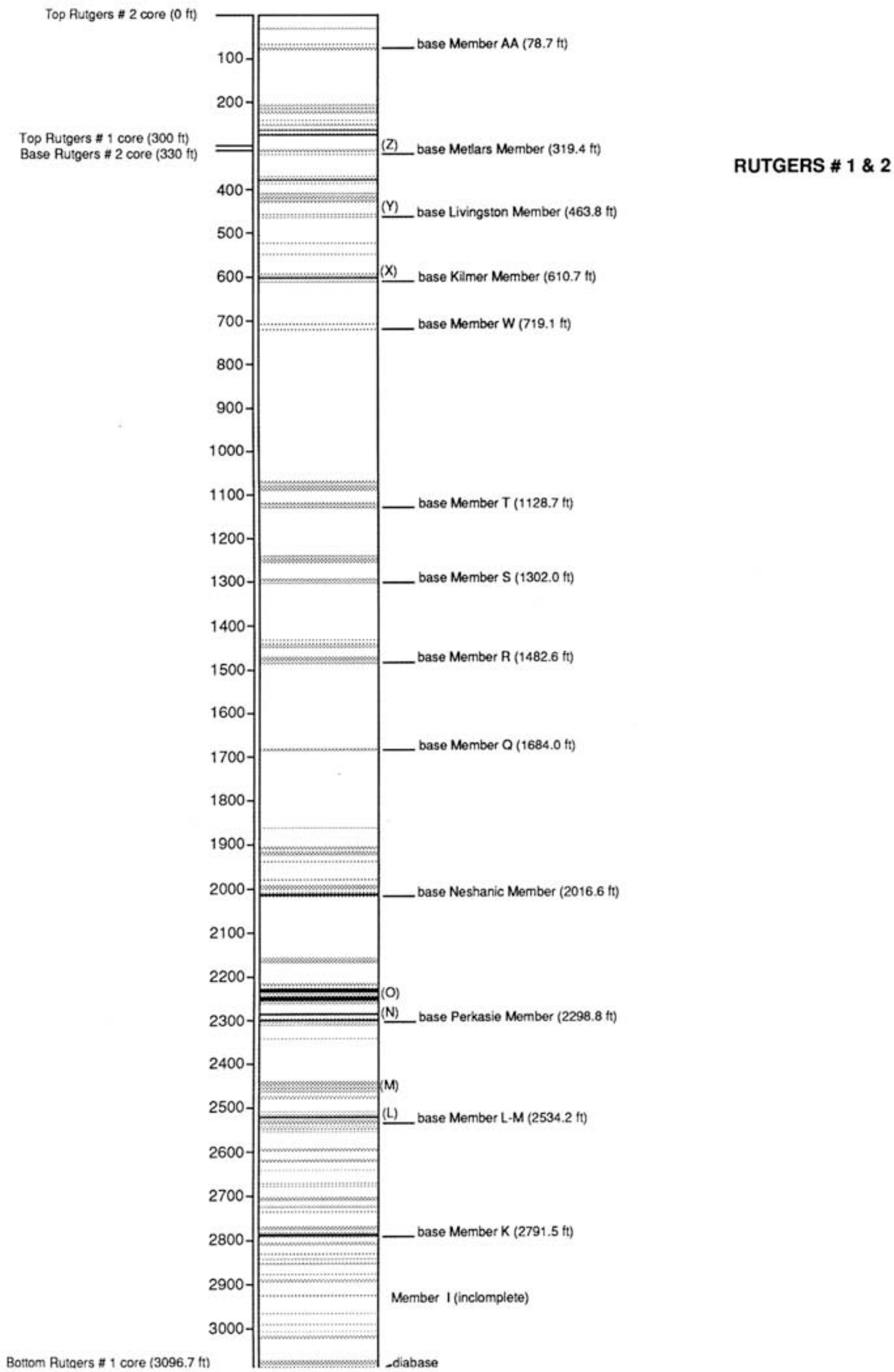

RUTGERS # 1 & 2
Top Rutgers # 2 core (0 ft)
Top Rutgers # 1 core (300 ft)
Base Rutgers # 2 core (330 ft)
Bottom Rutgers # 1 core (3096.7 ft)
100
200
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
base Member AA (78.7 ft)
(Z) base Metlars Member (319.4 ft)
(Y) base Livingston Member (463.8 ft)
(X) base Kilmer Member (610.7 ft)
base Member W (719.1 ft)
base Member T (1128.7 ft)
base Member S (1302.0 ft)
base Member R (1482.6 ft)
base Member Q (1684.0 ft)
base Neshanic Member (2016.6 ft)
(O)
(N) base Perkasie Member (2298.8 ft)
(M)
(L) base Member L-M (2534.2 ft)
base Member K (2791.5 ft)
Member I (inclomplete)
diabase

Figure 11.

Figure 12: Type section of the Orange Mountain Basalt along interstate Rt. 280 in East Ornage, N.J. Traced from a composite of a continuous series of photographs (from Olsen, 1980a).