Newark Basin – View from the 21st Century

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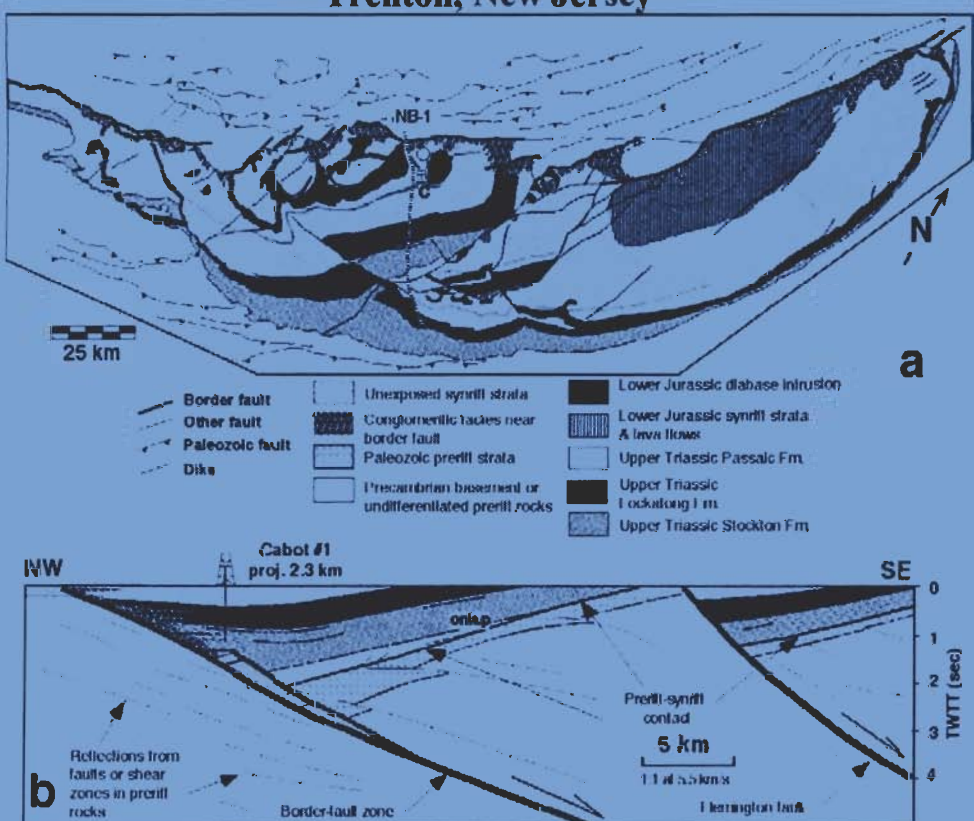

P. E. Olsen, J. P. Smoot, and J. H. Whiteside, 2005,
Stop 2. Upper Member L-M and Perkasie Member of the Passaic Fm., Pebble Bluff, Milford, NJ.
p. 125-133.

Stop 2. Upper Member L-M and Perkasie Member of the Passaic Fm. Pebble Bluff, Milford, NJ.

P. E. Olsen, J. P. Smoot, and J. H. Whiteside

Latitude and Longitude: (aprox.) 40°34.60'N, 75°08.27'W
Stratigraphic Unit: Passaic Formation
Age: Norian; ~215 Ma
Main Points:

1. Passaic Formation near border fault and coarse facies of interval at Stop 1.
2. Milankovitch cyclicity, and deeper water units extending into conglomeratic facies
3. Comparision to central basin facies
4. Fossiliferous outcrops
5. Reptile footprint faunules

These outcrops (Fig. 1), also described by Van Houten (1969, 1980), Arguden and Rodolpho (1986), Olsen and Flynn (1989), and Olsen et al., 1989) are less than 2.4 km to the southeast from the border fault and consist of thick sequences (>20 m) of red conglomerate and sandstones alternating with cyclical black, gray, and red mudstone and sandstone. Dips average 10-15° NW, and there several faults, downthrowing to the east, between the largest outcrops. These outcrops are part of the cyclical and quasiperiodic lacustrine to fluvial succession of the central Newark basin in which lake depth responded profoundly to Milankovitch climate forcing (Olsen, 1996; Olsen and Kent, 1996; Olsen and Kent, 1999). The thickest gray beds at this stop (see Figures 1 and 2) are the Perkasie Member, marking a 405 ky McLaughlin cycle within the wetter part of a 1.75 m.y. modulating cycle (P2) and a wetter part of a 3.5 m.y. Laskar cycle (La4). The red conglomerates in the lower parts of the section are the coarse lateral equivalents of the red mudstones seen at Stop 1.

The Perkasie Member consists of Van Houten cycles and compound cycles showing the same pattern as the Lockatong (Olsen, 1986; Olsen and Baird, 1986). It consists of two sequential 100 ky) year cycles, each containing two well developed ~20 ky Van Houten cycles and weakly developed red and purple Van Houten cycle, succeeded upwards by red clastics (Figure 2). McLaughlin named the lower set of gray beds member N and the upper member O, which I have renamed short modulating cycle N and O, respectively. Underlying strata at these outcrops comprise the drier parts of member L-M, and these are largely conglomeritic at this site.

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. At this locality, this style of conglomerate occurs in the upper part of member M-L.

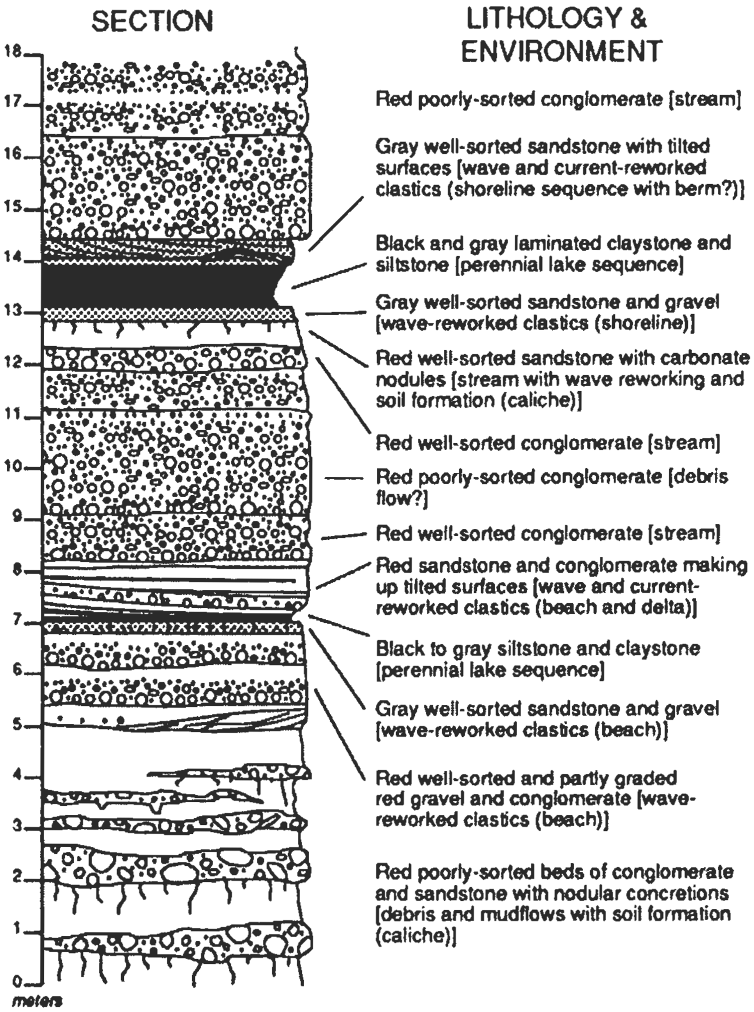

Figure 1 Measured section of the Passaic Formation at Pebble Bluff, Stop 2, showing the interfingering of debris flow, shoreline, and perennial lake deposits. (Olsen et al., 1989).

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 suggest soil caliche. Again these types of conglomerates are here almost entirely within member L-M although some occur in the gay parts of the Perkasie Member.

3) Grain-supported cobble-pebble conglomerate with sandy matrix. Granules and coarse sand show high degree of sorting suggesting wave reworking of finer fractions

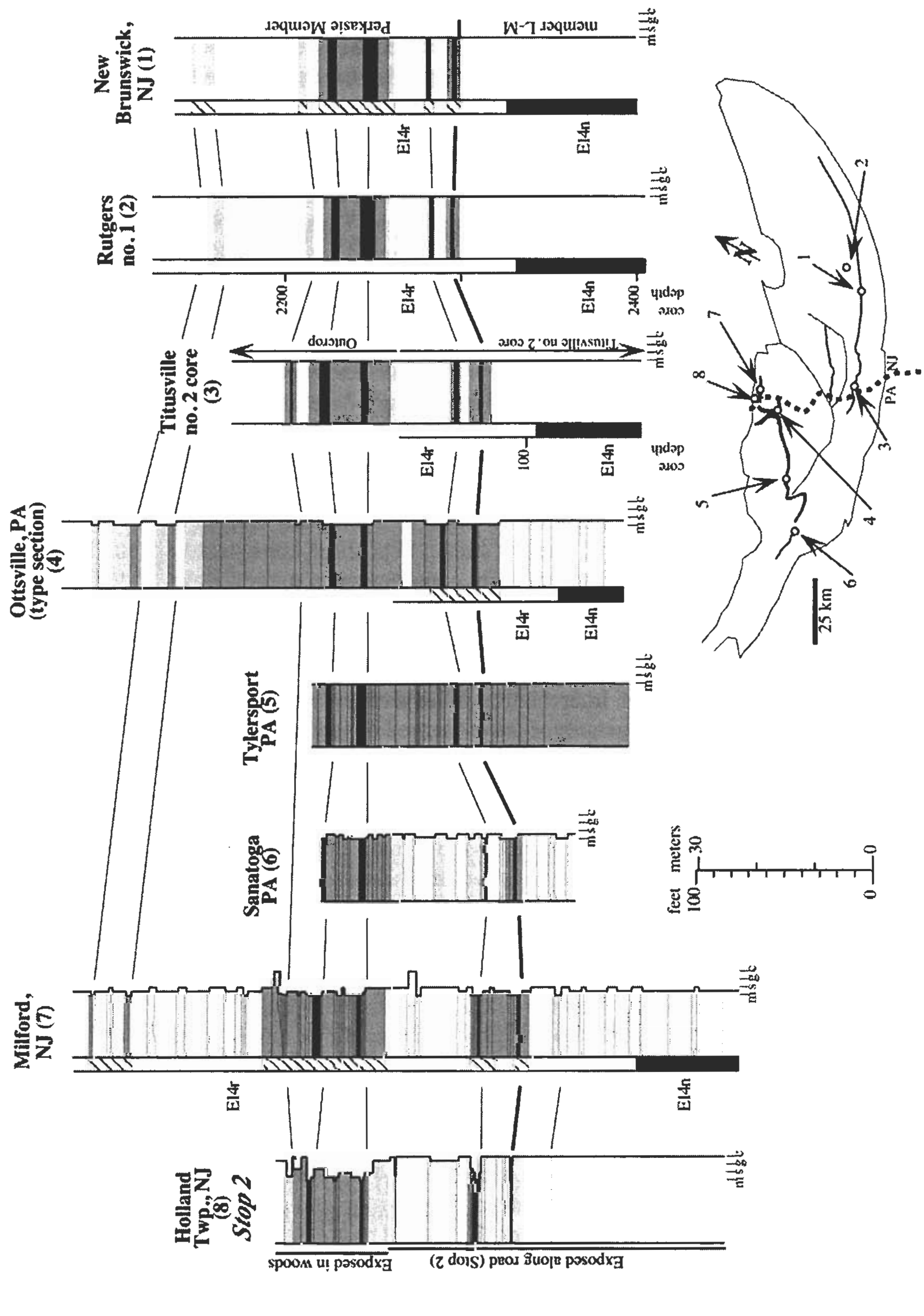
New Brunswick, NJ (1)
Rutgers no. 1 (2)
Titusville no. 2 core (3)
Ottsville, PA (type section) (4)
Tylersport PA (5)
Sanatoga PA (6)
Milford, NJ (7)
Holland Twp., NJ (8) Stop 2
Perkasie Member
member L-M
E14r
E14n
core depth
2200
2400
100
Outcrop
Titusville no. 2 core
Exposed in woods
Exposed along road (Stop 2)
feet meters
100 30
0 0
25 km
PA
NJ
1
2
3
4
5
6
7
8

Figure 2. Lateral correlation of the lower part of the Perkasie Member in outcrops and cores. Locations of sites are: 1, Rt. 18, New Brunswick, NJ ; 5, NE extension, PA Turnpike, Tylersport, PA; 6, quarry, Sanatoga, PA; 7, road outcrops in and near Milford, NJ; 8, Pebble Bluff, Holland Township, NJ (Stop 2) (from Olsen et al., 1996). For lithologies: white represents red; light gray, represents purple; gray, represents gray; and black, represents black. For magnetic polarity: black is normal and white is reverse.

The central basin facies of the Perkasie Member, consisting largely of fine-grained playa deposits is remarkably devoid of fossils. However, at localities such as these, closer to the border fault, fossils of many kinds are actually quite common. This we believe to be due to two factors: 1) desiccation patterns; and 2) variability of accumulation rate. In the central facies of the Newark basin the Passaic (and Lockatong) are profoundly mud dominated. On the flat playas during dry phases of Van Houten cycles, the high frequency of wetting and drying events produce a desiccation breccia fabric that destroys most trace and aquatic fossils. Second, and probably more importantly, the accumulation rate in the center of the Newark basin was probably extremely even with a precompaction rate of only 1 mm or so a year. Such evenness of accumulation means that remains of plants or animals are not buried quickly enough to remove them from the high recycling rate part of the terrestrial ecosystem. In contrast, closer to the border fault, accumulation rates were much more erratic both vertically and horizontally. This is evident from the scale of individual deposition events, which is both on average larger and more erratic near the border fault than at the center of the basin. Hence, there is a much higher potential for swift burial and escape from ecosystem recycling

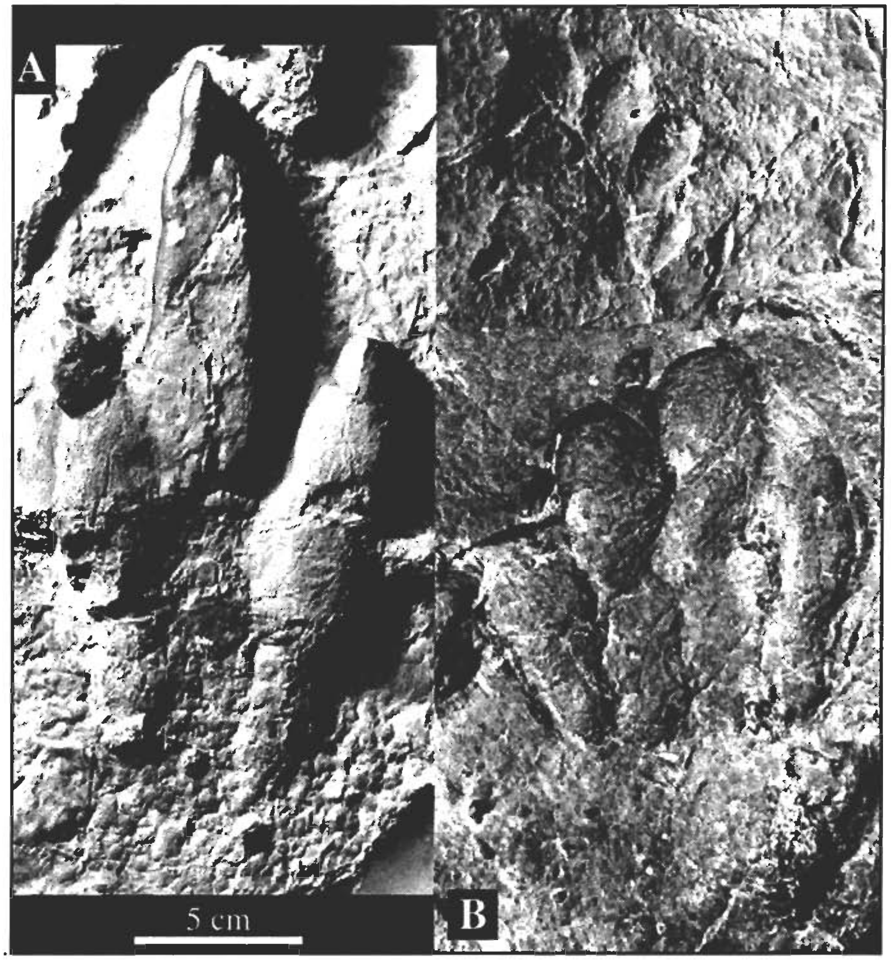

Figure 3. Examples of tracks from the Smith Clark Quarry, Perkasie Member, Milford, NJ: A, *Atreipus sulcatus*; B, *Brachychirotherium parvum*. From Baird (1957).

At this particular outcrop, complete fossil specimens are rare but nearby outcrops have produced a wealth of material. The nearby abandoned Smith Clark quarry is such an example. The Smith Clark Quarry was in operation in the late 19th to 20th century and was developed to quarry flagstones from exposures of the short modulating cycle O of the Perkasie Member (Drake et al., 1961) of the Passaic Formation at Milford, NJ (Figure 2). The gray footprint-producing horizons in the Smith Clark Quarry have produced the types and much associated material of *Atreipus milfordensis*, *A. sulcatus* (Baird, 1957; Olsen and Baird, 1986), *Brachychirotherium parvum* (Hitchcock, 1889), *B. eyermani* (Baird, 1957), *Apatopus lineatus* (Bock, 1952a), and *Rhynchosauroides hyperbates* (Baird, 1957), as well as examples of *Grallator parallelus* (Baird, 1957), *Rhynchosauroides brunswickii* (Baird, 1957), "*Coelurosaurichnus* sp." (Olsen and Baird, 1986), and an uncertain tridactyl form (Baird, 1957) (Figure [i]). Associated gray sandstones have produced an important megafossil plant assemblage and a probable phytosaur tooth (Newberry, 1888; Bock, 1969; Axsmith et al., 2004; Gallagher, pers.

comm.) including *Glyptolepis playsperma* and *G. keuperiana* (Cornet, 1977), *G. delawarensis* (Bock, 1969), *Pagiophyllum* spp., (?) *Cheirolepis munsteri*, *Clathropteris* sp., and *Equisetites* spp. The interesting, unique specimen of the plant fossil *Ginkgoites miliordensis* Bock, 1952b (ANSP uncatalogued), from the Smith Clark quarry, was destroyed on loan in 1974 (Spamer, 1988), so comparisons cannot now be satisfactorily made regarding its relationship to other fossil plants. Axsmith et al. (2004) have recently reviewed this floral assemblage. An isolated serrated tooth has also been found (by Andrew Ballet) in exposed gray sandstone relatively high in the section at the quarry (W. Gallagher, pers. comm.). The serrated tooth is comparable to the rear teeth of heterodont phytosaurs, but is not diagnostic at a lower taxonomic level than Phytosauria. Other teeth and bones could certainly be found.

At a nearby outcrop along Mill Road on the north side of Hackihokake Creek to the northeast, purplish and red footprint bearing beds of the Van Houten cycle overlying the gray beds of short modulating cycle O have produced *A. millordensis*, the type of *Chirotherium lulli* (Bock, 1952a; Baird, 1954), cf. "*Coelurosaurichnus* sp." (a different form than previously mentioned), and numerous small *Grallator* (PU 19910). Nearby exposures have also yielded clam shrimp in short modulating cycle O.

What is important about these particular footprint assemblages, is that on the whole, it is very similar to the assemblages from Lyndhurst, NJ (?Kilmer Member) which is about 3 m.y. younger and an assemblage from the lower Lockatong that is about 7 m.y. older (Olsen and Flynn, 1989), demonstrating very slow rates of faunal change through the Late Triassic.

As mapped by Ratcliffe et al. (1986) on the basis of surface geology, drill cores, and a Vibroseis profile, the border fault in this area is a reactivated imbricate thrust fault zone dipping 32°SE. Core and field data reveal Paleozoic mylonitic fabrics of ductile thrust faults in Precambrian gneiss and early Paleozoic dolostone overprinted by brittle cataclastic zones of Mesozoic normal faults which form the border fault system of this part of the Newark basin (see Stop 1).

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