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STOP 3: TRIANGLE BRICK QUARRY

LEADERS: Paul Olsen and Phillip Huber

Introduction

Extensive exposures of Durham sub-basin sedimentary rock in the Triangle Brick Co. Quarry comprise a world-class locality for late Triassic continental vertebrates and invertebrates, as well as an excellent view of Durham sub-basin fluvio-lacustrine strata. The purpose of this stop is to examine the stratigraphy, depositional environments, and overall context of rich fossil assemblages.

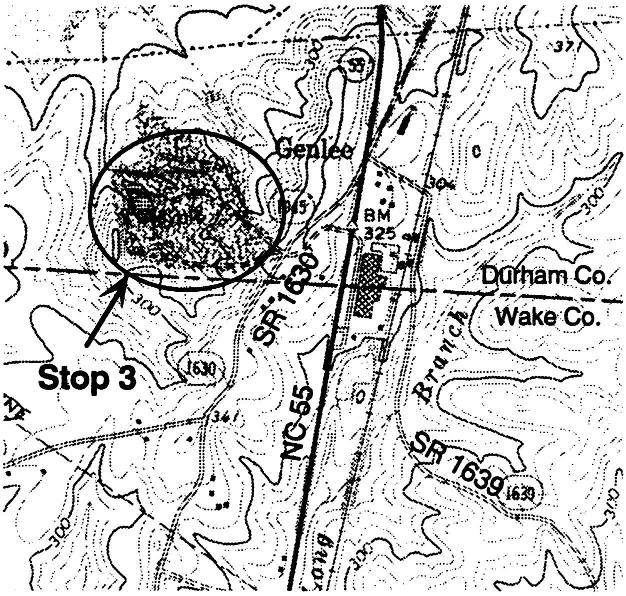


Figure 3-0. Location of Stop 3 on the Green Level quad.

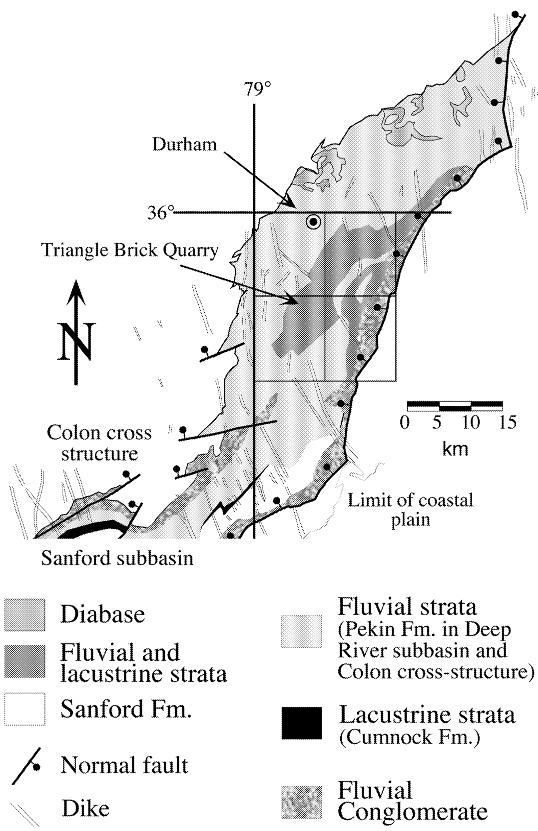


Figure 3-1. Map of the Durham sub-basin of the Deep River basin showing the position of the Triangle Brick Company quarry. The four 7.5-minute quads, from upper left clockwise: Durham Southwest, Durham Southeast, Cary, and Green Level. Map is modified from Bain and Harvey (1977) and Olsen et al. (1991).

Location

The quarry is located in the northeast corner of the Green Level 7.5' quadrangle at 35°52'09" latitude and 78°53' 67" longitude in the village of Genlee, Durham County, North Carolina (Figures 3-0, 3-1). It is situated in the south central part of the Durham sub-basin, on a weakly defined ridge that trends NE-SW, parallel with the regional strike. The soft red and purple mudstones exposed in the quarry are used mostly for making brick. Permission must be sought from the main office prior to visiting.

Stratigraphic Position

Exposures in the main quarry are located in the mudstone facies of Lithofacies Association II of Hoffman and Gallagher (1989) (Figure 3-2). The low strike ridge containing the quarry runs for at least 8 km to the north and nearly identical strata (including the lacustrine sequence) have been found on Ellis Road in Durham indicating considerable lateral continuity for this interval. The relationship of these strata to the better known sequence in the Sanford sub-basin is still poorly resolved (see below).

Lithological Sequence

The main quarry exposes about 60 m of red, purple, and gray fissile to bioturbated massive mudstones interbedded with gray, brown, and red arkosic sandstones (Figure 3-3). The upper half of the sequence consists of fissile red to gray-green fissile mudstones interbedded with bioturbated massive mudstone and arkosic sandstones arranged in a pattern reminiscent of cyclical lacustrine sequences in other Newark Supergroup basins (Olsen, 1986; 1997). At the scale of the outcrop, at least, each fissile mudstone bed is laterally persistent with little lithological change (Olsen, et al., 1989). The lowest fissile mudstone is particularly fine-grained and well laminated and contains a rich invertebrate assemblage (Figures 3-3, 3-4). The lower half of the exposed sequence consists of red to purple bioturbated massive mudstone with lenticular arkosic sandstones and several caliche-bearing horizons (Coffee and Textoris, 1997) with occasional articulated to fragmentary reptile skeletons.

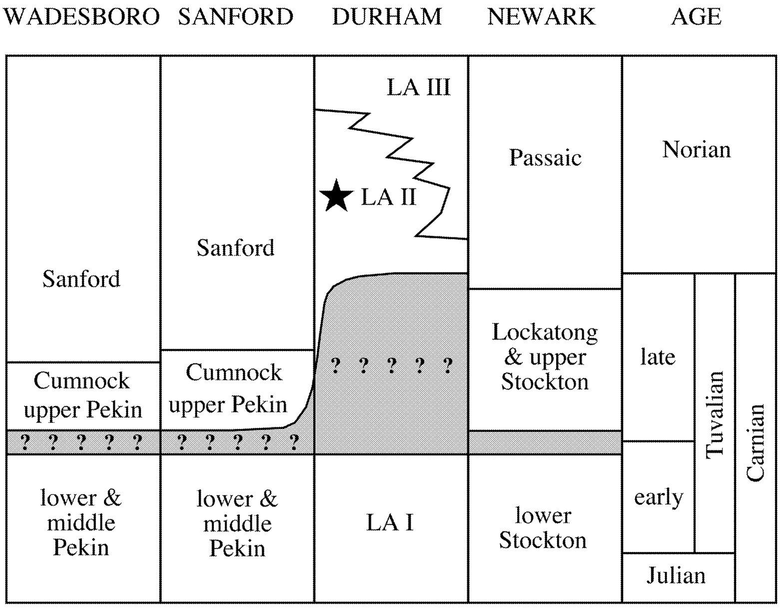


Figure 3-2. Correlation of units within the Deep River basin with the Newark basin section (NY, NJ, PA) and the European standard ages. The gray area represents a hiatus caused by a syn-rift unconformity between tectonostratigraphic sequence II and III, seen in the Newark, Richmond, Taylorsville, and Fundy basins of the Newark Supergroup and the Argana basin of Morocco (Olsen, 1997) and hypothesized in the Deep River basin largely based on vertebrate biostraigraphy. Star shows the position of the Triangle brick Company quarry.

Biota, Depositional Environments and Paleoecology

The Triangle Brick Quarry is a world-class locality for both continental invertebrates and vertebrates, particularly reptiles (Renwick, 1988; Gore and Renwick, 1987; Olsen et al., 1989, Olsen, 1977; Good and Huber, 1995) (Figure 3-4). At least three fossil assemblages can be recognized in three distinctive facies: 1) fissile clay-rich mudstones, 2) channel and shoreline lags, and 3) bank and overbank deposits with reptile skeletons (Table 3-1).

Fissile clay-rich mudstones

The fissile, laterally persistent mudstones in the upper part of the section contain abundant ostracodes and clam shrimp. The lowest fissile mudstone also produces rare fragmentary plants, unionid and myalinid clams (Good and Huber, 1995), articulated crayfish, abundant fragmentary to articulated fish, occasional reptile (phytosaur) teeth, and abundant coprolites. The enigmatic burrow *Scoyenia*, occurs throughout the fissile mudstone.

Particularly unusual is the occurrence of cambarid crayfish (Figure 3-4). When these were first found (Olsen, 1977), they were thought to be clytiopsid decapods. However, Hasiotis (personal communication) has determined that they are true crayfish and members of the extant family, the Cambaridae. The crayfish occur mostly as articulated, reddish, compressions, often poorly preserved. Some, however, are well preserved and show considerable surface detail (Figure 3-4). The occurrence of these crayfish in association with the burrow *Scoyenia,* as well as the morphology of the burrow itself suggested to Olsen (1977) and Olsen et al. (1989) that *Scoyenia* was the product of crayfish. Hasiotis and Dubiel (1993), however, have shown that crayfish from the Chinle Formation produce a burrow type very unlike that of *Scoyenia*, and suggests instead that the latter was produced by a burrowing beetle. The argument is of some significance, because *Scoyenia* is the most abundant ichnofossil in the Newark Supergroup and the burrower must have been of considerable ecological importance. The preservation of *Scoyenia* in the crayfish-bearing fissile mudstone is exceptionally fine (Figure 3-4) and should allow for a exceptionally detailed description of its morphology.

The sequence of specific lithologies and fossils within this interval (Figure 3-3) is distinctive and maintained throughout the quarry, however, the upper part of the sequence is variably cut out by overlying sandstones, and the lower part is cut by bedding parallel faults that frequently disturb the most fossiliferous units. Overall, the

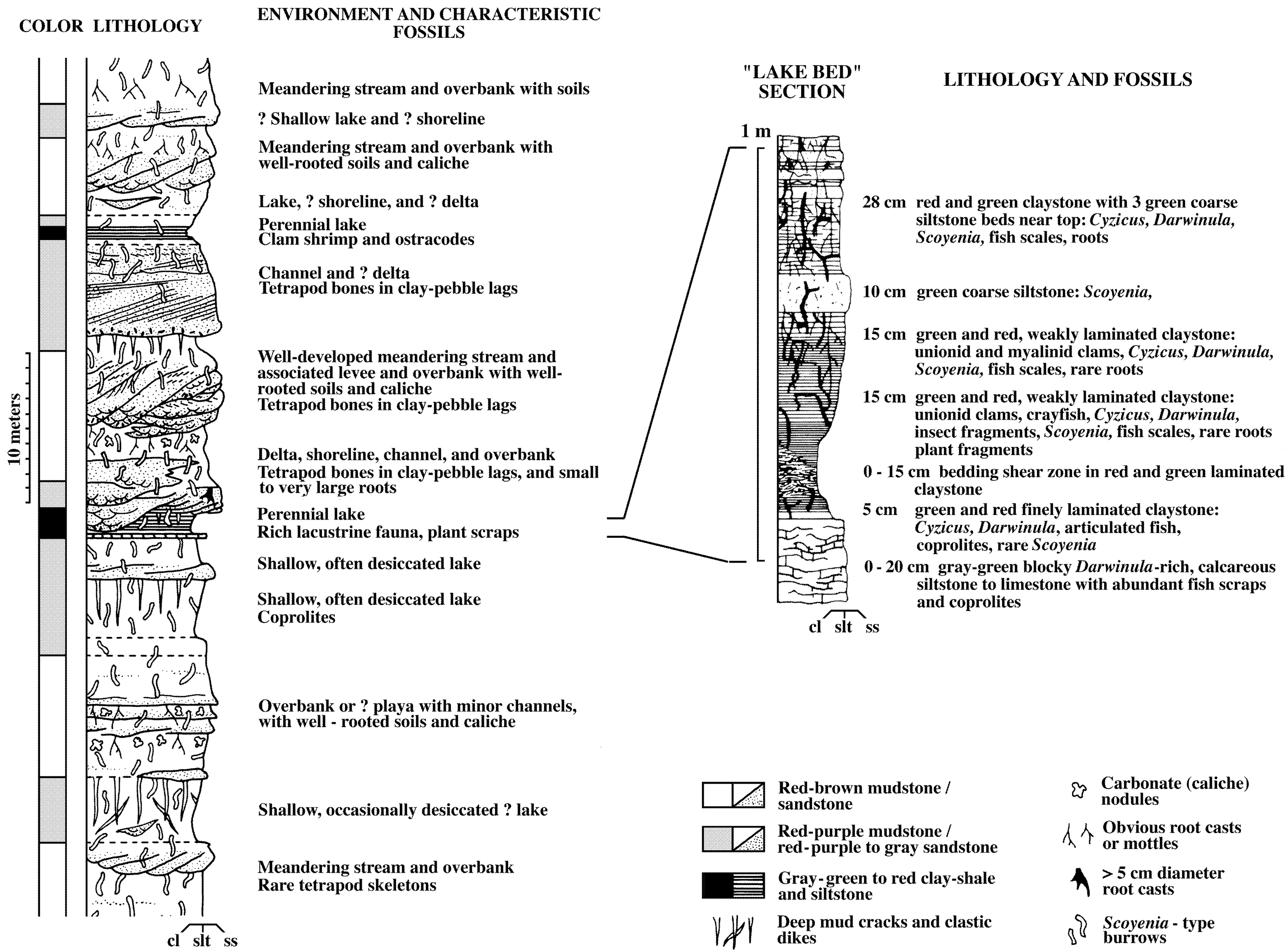


Figure 3. Section exposed at the Triangle Brick Co. Quarry. Modified from Olsen (1977) and Olsen et al. (1989, 1991).

sequence is reminiscent of that seen within individual Van Houten cycles of other parts of the Newark Supergroup (Olsen, 1986; Olsen et al., 1989). Specifically, this mudstone sequence has an abrupt transition upward from what appears to be a wave-winnowed lag (see below) into finely laminated fine mudstone with occasional partly articulated fish suggestive of a low oxygen environment. This gives way upward to a progressively less well-laminated mudstone, with a biota indicating higher degrees of oxygenation (e.g., mollusks) and eventual emergence (i.e., roots). This kind of sequence in contemporaneous deposits in other parts of the Newark has been interpreted as a lake level cycle responding to climate changes. Gore and Renwick (1987) and Renwick (1988) interpret this sequence as a small flood plain lake that filled with mud. However, at the scale of the outcrop, there is so little lateral change in this sequence that the lake must have been at least several times the area of the quarry. In addition, the discovery of a very similar unit in the same stratigraphic position with a nearly identical assemblage some 8 km away suggests the lake may have been quite large indeed.

Channel and shoreline lags

The base of the most fossiliferous fissile shale at the quarry (Fig. 3-3) has an ostracode-rich calcareous mudstone and limestone bed. This unit lies upon massive mudstones and suggests a transgressive shoreline lag deposit.

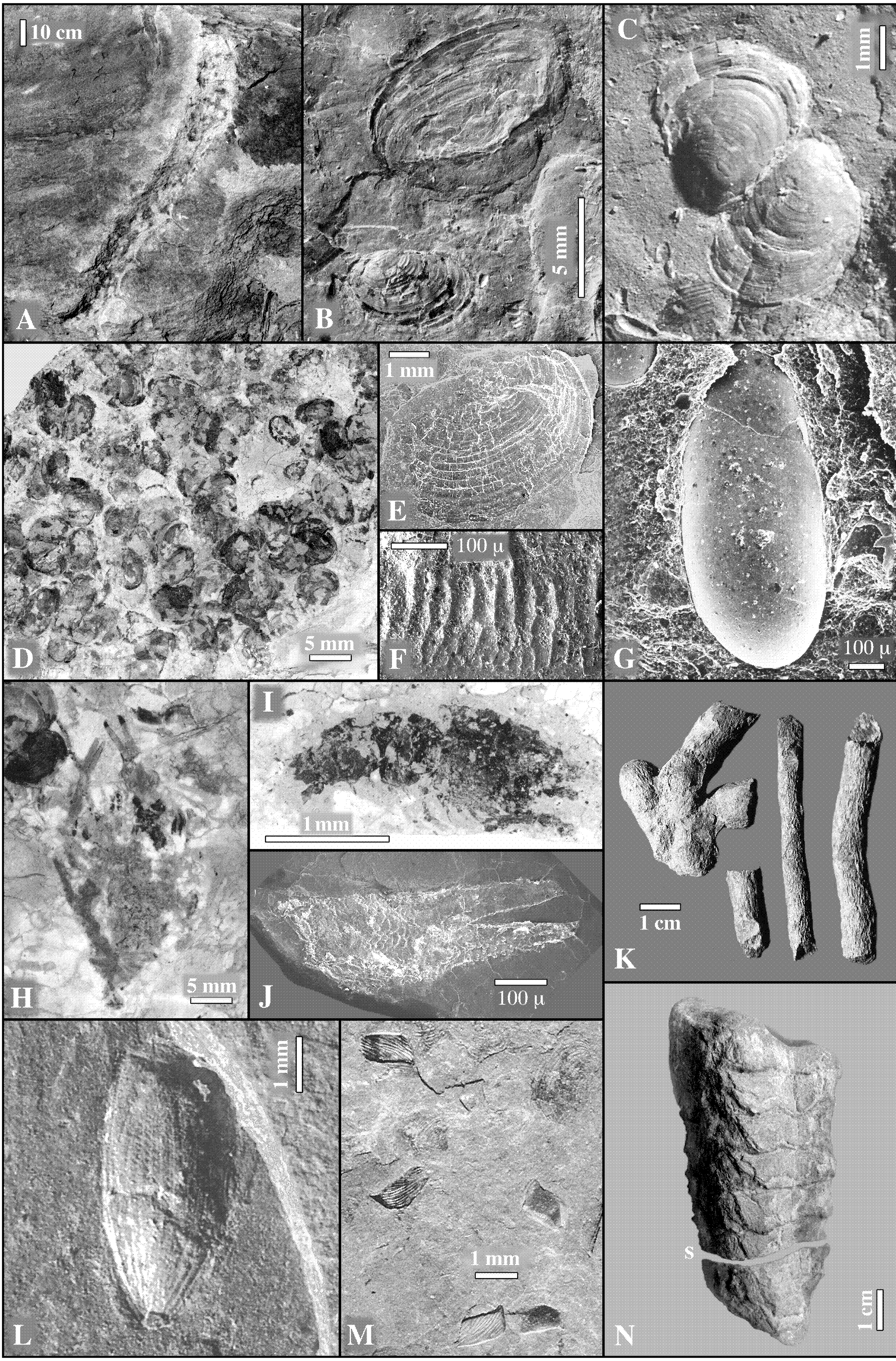
The sandstones interbedded with more massive bioturbated mudstones in the upper half of the quarry section often contain beds of intraformational conglomerate (channel lags) with isolated bones and teeth, mostly of phytosaurs. A single metoposaurid intercentrum was found in one of these intervals. One associated, very fragmentary phytosaur skeleton has been found in a moved block of yellow-weathering gray sandstone. It seems likely that the partial articulated skeleton of the armored aetosaur *Aetosaurus* (=*Stegomus*; Fig. 3-4N) described by Parker (1966) and Lucas et al. (1997) comes from these sandstones as well, although it is possible that the specimen came from a bank deposit (see below). The sandstones have also produced one particularly large tap root, plausibly of a cycadeoid (Fig. 3-4A). These massive mudstones and interbedded sandstones appear to be fluvial in origin and likely were produced by anastamosing streams, with extensive muddy banks.

Bank and overbank deposits

Reptile material has also been recovered from one lenses of muddy sandstone low in the quarry sequence. The unit was directly laterally adjacent to a red-to-cream-colored lenticular sandstone. Although extensive bioturbation and subsequent excavation precludes a detailed analysis of small-scale sedimentary structures, the overall arrangements suggests a levee or crevasse splay sequence next to a channel. The massive mudstones themselves adjacent to and interbedded with the coarser deposits are intensively burrowed by *Scoyenia* and locally contain abundant roots.

Coffey and Textoris (1997) have described moderately developed calcite horizons in presumed overbank deposits about

Figure 3-4. (facing page) Representative fossils from the Triangle Brick Co. Quarry, all but A and N from the main "lake bed" fissile mudstone (see Figure 3-3). A) large tap root plausibly of a cycadeoid from a channel sandstone; B) a unionid clam cast (above) and an isolated valve of the clam shrimp *Cyzicus* (below) along with numerous much smaller darwinulid ostracodes; C) the two calcitic valves of what is apparently a myalinid clam and darwinulid ostracodes; D) numerous clam shrimp (*Cyzicus* spp.); E) scanning electron photomicrograph of single valve of the clam shrimp *Cyzicus* sp.; F) detail of ornamentation between growth lines seen in E showing superb preservation; G) beautifully preserved ostracode valve (*Darwinula* sp.); H) nearly complete cambarid crayfish (note claws in upper part of photo) and clam shrimp (upper left); I) cambarid crayfish carapace missing claws, tail is to left; J) scanning electron photomicrograph of single cambarid crayfish claw showing sculpture; K) Scoyenia burrow, removed from matrix (note branching burrows, one with a rounded termination); L) isolated beetle elytron (wing cover); M) dissociated scales of the palaeoniscoid fish *Turseodus*; N) partial tail of *Aetosaurus* (=*Stegomus*) sp. with the characteristic amour plates - possibly from a channel sandstone.



10 cm
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B
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L
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s
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TABLE 3-1: Fossils from the Triangle Brick Company quarry (modified from Olsen et al., 1989).

- PLANTS
    - Sphenophytes
        - Equisetales (horsetails)
            - *Neocalamites* sp.
            - *Equisetales* sp.
    - Pteridophytes
        - Filicales (ferns and fern-like organisms)
            - *Cladophlebis* sp.
    - Coniferophytes
        - Coniferales (conifers)
            - *Pagiophyllum* sp.
- ANIMALS
    - Mollusks
        - Pelecypoda
            - Unionidae
                - undetermined aragonitic clams
            - Myalinidae
                - undetermined calcitic clams
    - Arthropods
        - Crustacea
            - Diplostraca (clam shrimp and water fleas)
                - *Cyzicus* sp.
                - ?*Palaeolimnadia* sp.
            - Ostracoda
                - *Darwinula* spp.
            - Decapoda
                - Cambarid crayfish
                - ?*Scoyenia* sp.
            - Insecta
                - Coleoptera ('beetles)
                    - undetermined fragments
            - undetermined large, arthropod fragments
    - Pisces (fish)
        - Actinopterygii (bony fishes)
            - Palaeonisciformes
                - *Turseodus* spp.
                - *Cionichthys* sp.
            - Semionotidae
                - *Semionotus* sp.
        - Sarcopterygii (lobe finned fish)
            - Coelacanthini
            - cf. *Pariostegus* sp.
    - Reptilia
        - Archosauria
            - Crurotarsi
                - Phytosauria (crocodile-like archosaurs)
                    - intederminate sp.
                - Suchia (crocodiles and relatives)
                    - Aetosauridae (armored herbivorous archosaurs)
                        - *Aetosaurus* cf. *arcuatus*
                    - three undetermined species belonging to three groups of Suchia

10 m above the skeletons (Fig. 3-3). According to them, the fibrous radial caliche seen in some nodules may be due to the replacement of original aragonite by calcite implying an arid environment with seasonal wet periods.

Age

Olsen (1977), Olsen et al. (1982), and Olsen et al. (1989) argued that the presence of the fish *Turseodus* in the Triangle Brick Quarry (Table 4-1) indicated correlation with the Lockatong Formation of the Newark basins and the "upper member" of the Cow Branch Formation of the Dan River basin, and was hence late Carnian in age. The Triangle Brick assemblage would therefore be younger than the Cumnock Formation of the adjacent Sanford sub-basin of the Deep River basin. However, Huber et al. (1993) pointed out that *Turseodus* ranges throughout the entire Chinle group of Carnian and Norian age and was therefore of very limited time-stratigraphic value. Huber et al. (1993) also suggested that the presence of *Stegomus* in the Triangle Brick assemblage indicated correlation with the lower to middle Passaic Formation of the Newark basin and was therefore of early to ?middle Norian in age. Thus, it would be in the Neshanician land vertebrate faunachron of Huber et al. (1993). Most recently Lucas et al. (1997) show that *Stegomus* is a junior synonym of *Aetosaurus*, the latter well known from Norian age continental strata in the Germanic basin and Greenland and from marine strata in the middle Norian columbianus zone of the Italian Alps. This strongly supports a Norian age for the Triangle Brick assemblage. A Norian age is also consistent with a preliminary assessment of the new skeletal material. If indeed the Triangle Brick assemblage is Norian in age as the new interpretations suggest, it is indeed significantly younger than the Cumnock Formation of late Carnian age (Fig. 3-2).

Note: The following references apply only to the above contribution and have been drawn from pages 38 and 39 of the orginal guidebook.

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