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A COMPARISON OF THE VERTEBRATE ASSEMBLAGES FROM THE NEWARK AND HARTFORD BASINS (EARLY MESOZOIC, NEWARK SUPERGROUP) OF EASTERN NORTH AMERICA

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Introduction

The sediments of the Hartford and Newark Basins (Figure 3.1) occupy a crucial position in the study of the early Mesozoic Newark Supergroup (Olsen, 1978; Olsen, in press 1). Historically, they were the first strata of the Newark in which faunal remains were found; by 1845, abundant reptile footprints (Hitchcock, 1858) and fossil fish (Redfield, 1845) had been recovered from both areas. Since that time a long series of distinguished workers including E. D. Cope, O. C. Marsh, E. Hitchcock, C. W. Gilmore, F. von Huene, J. T. Gregory, R. S. Lull, D. Baird, B. Schaeffer, and of course, E. H. Colbert, have made major contributions to the study of vertebrates from these beds. Considering the new kinds of stratigraphic data now being obtained from the Newark and Hartford basins (such as radiometric dating, paleomagnetic stratigraphy, palynostratigraphy, and physical microstratigraphy), it is appropriate to review the classically studied and newly uncovered vertebrates from these two basins and to place them in their stratigraphic context, thus following the tradition of Colbert (1946), Colbert and Gregory (1957), and Colbert (1965).

Outline of the Stratigraphy of the Newark and Hartford Basins

It is now agreed that the Newark and Hartford basins, along with other Newark Supergroup deposits, formed in conjunction with the initial phases of drift between North America and Africa (Manspeizer, Puffer, and Cousminer, 1978; Van Houten, 1977). Both basins preserve in excess of 4,000 m of largely detrital fill dominated by red clastics (Figure 3.2). Gray and black siltstone and sandstone beds are common (at least locally) and these, along with tholiitic basalt flows, provide the key to the internal physical stratigraphy of the basin section (Olsen, in press 2 and 3). Newark Basin strata are divided into nine formations (Figure 3.2), of which the lowest two, the Stockton and Lockatong formations, have no lithologic counterparts in the Hartford Basin. The remaining seven formations compare well with the seven formations of the Hartford Basin (Figure 3.2). The sequences of both basins are tantalizingly similar; they consist of a middle series of three multiple basalt flows and two major interbedded sedimentary formations sandwiched between two thick, primarily red, sedimentary units. This rough comparability has suggested to many authors that each of the respective formations can be directly correlated (Russel, 1892; Schuchert and Dunbar, 1941; Sanders, 1963). Until recently there were no data available to test what Jepsen (1948, p. 16), called "this undemonstrated but appealing assumption. . . ." Within the last ten years, however, palynological and geophysical evidence has helped to clarify much of the broader

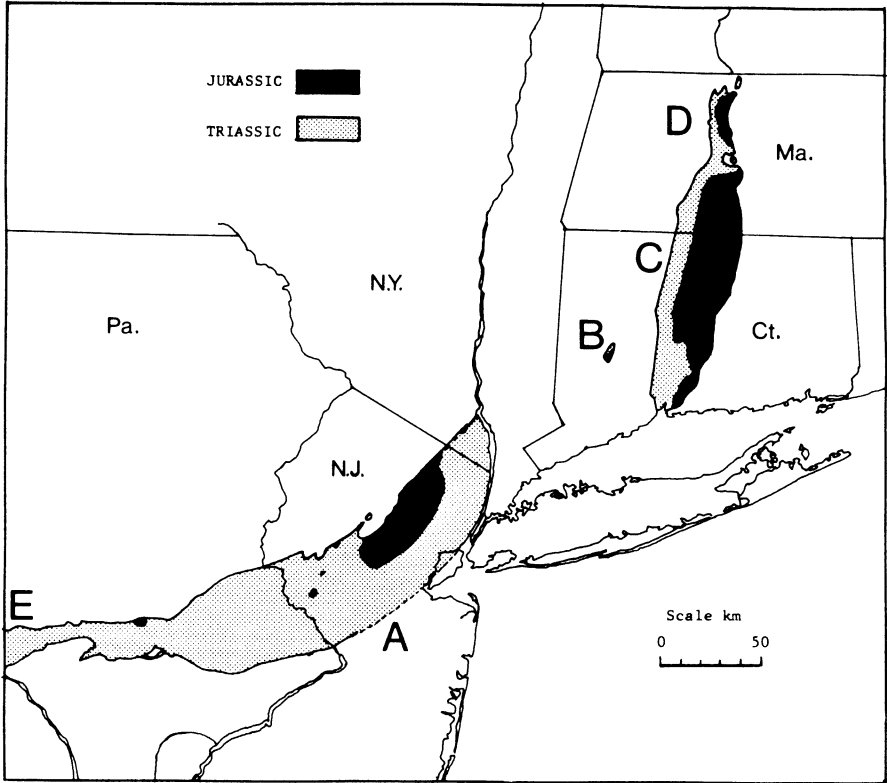


Figure 3.1. Position of the Hartford and Newark basins of the Newark Supergroup: A, Newark Basin; B, Pomperaug Basin; C, Hartford Basin; D, Deerfield Basin; E, northern terminus of Gettysburg Basin.

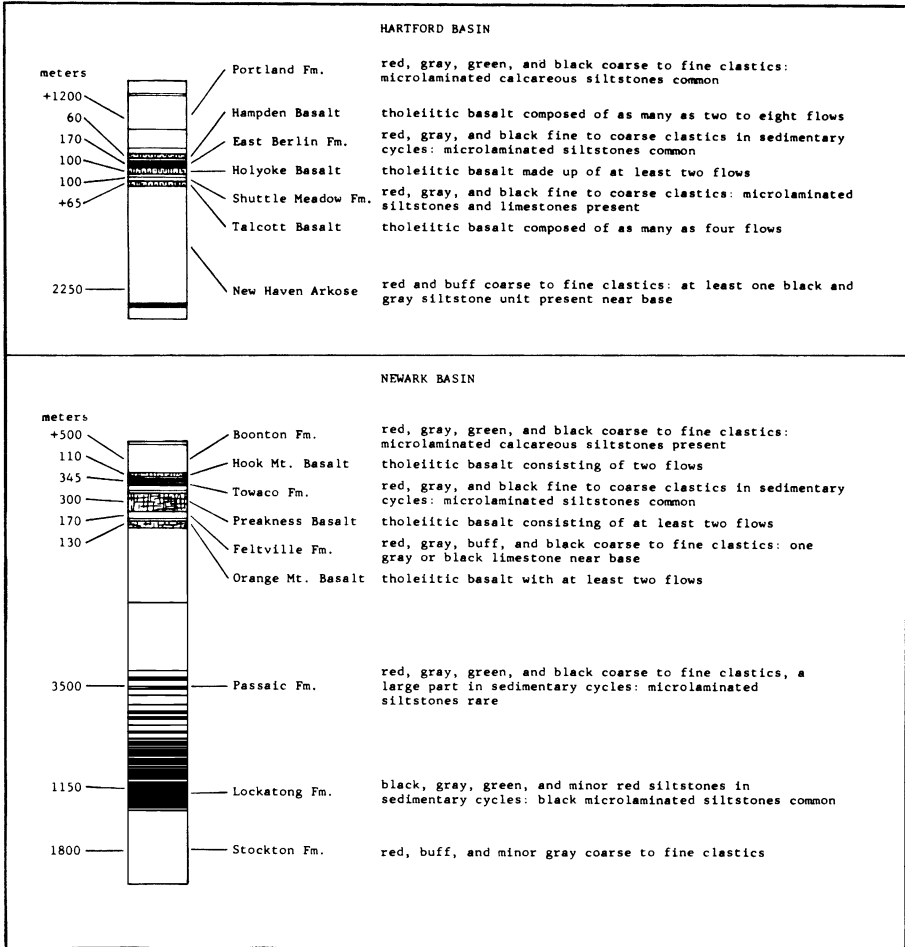


Figure 3.2. Lithologic divisions of the Newark and Hartford basins. Hartford basin thicknesses from Hubert, et al. (1978), and Cornet (1977a). Newark Basin divisions and thicknesses from Olsen (in press 1 and 2). Note that the thicknesses of pre-Orange Mountain Basalt formations are derived from the central Newark Basin while the post-Passaic formation thicknesses are derived from the largest area in which they are preserved, the Watchung Syncline. In the latter area the pre-Orange Mountain Basalt formations are thinner.

picture. As discussed below, the biostratigraphic data roughly confirm the correlation of the larger divisions of the homotaxial sequences, although the details deny any simple one-to-one correlation of basalt flows or sedimentary formations.

The Vertebrate Assemblages: Stockton and Lockatong Formations

The oldest vertebrate fossil from the Newark and Hartford Basins is the lower jaw of a very large amphibian (*Calamops paludosus*) found at the base of the Stockton Formation (Sinclair, 1917). This specimen has been recently prepared and now appears to represent a large capitosaur (W. Seldon, personal communication; Olsen, Baird, Seldon, and Salvia, in preparation). Its stratum lies about 1,700 m below the base of the late Carnian Lockatong Formation, but cannot be readily correlated with any other horizon of the Newark Supergroup because of a lack of relevant biostratigraphic data. The age of *Calamops* is therefore indeterminate, although probably Late Triassic.

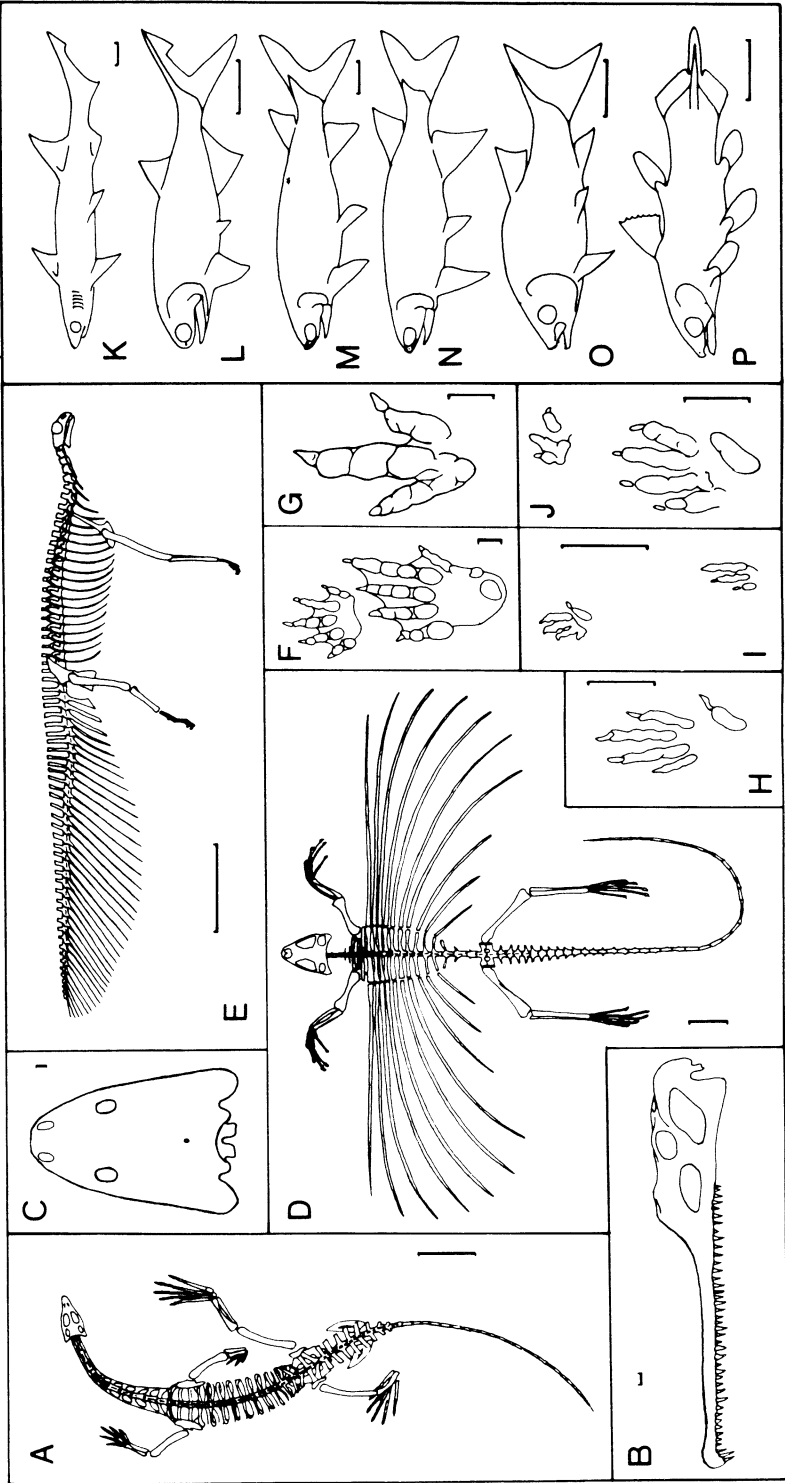
The uppermost 100 m of Stockton Formation and lower 500 m of the Lockatong Formation of the Newark Basin have produced a rich and abundant vertebrate assemblage, of which the most characteristic members are fishes (Figure 3.3). The most numerous taxa are the coelacanth *Diplurus newarki*, several species of the palaeoniscoid *Turseodus*, and holosteans of the "*Semionotus brauni* group" (Olsen, McCune, and Thomson, in press). Much less common are the subholosteans *Cionichthys* sp. and *Synorichthys* sp., and the hybodont shark *Carinacanthus jepseni*. These fishes have been found in basins to the south and have proved useful for correlation (Olsen, McCune, and Thomson, in press).

A surprisingly abundant suite of small reptiles is found with the fishes (Figure 3.3). Perhaps the most striking of these is the gliding lizard *Icarosaurus sieferi* which Colbert (1966, 1970) described from a partially articulated skeleton from the northern Newark Basin. Since the original description a number of very fragmentary specimens have been found, although none of these adds anything to Colbert's original descriptions.

Tanytrachelos (Olsen, 1979) is a small eosuchian found in surprisingly large numbers at a growing list of Lockatong localities (Olsen, in press 3). Originally described from the upper member of the Cow Branch Formation of the Dan River Group in North Carolina and Virginia, it possesses a suite of characters which show that its nearest relative is the long-necked *Tanystropheus* from the Old World Middle Tri-

Figure 3.3. The upper Stockton and lower Lockatong vertebrate assemblage: A, *Tanytrachelos* cf. *T. ahynis*, reconstruction; B, *Rutiodon carolinensis*, reconstruction; C, *Eupelor* (*Metoposaurus*) *durus*, reconstruction; D, *Icarosaurus sieferi*, reconstruction; E, "deep-tailed swimmer," tentative reconstruction; F, *Apatopus lineatus*, composite, right manus and pes; G, *Grallator* sp., left pes; H, *Gwynnedichnium minore*, right pes; I, *Rhynchosauroides brunswicki*, right manus and pes; J, *Chirotherium* cf. *evermani*, right manus and pes; K, *Carinacanthus jepseni*, reconstruction; L, *Turseodus* sp., reconstruction; M, *Synorichthys* sp., reconstruction; N, *Cionichthys* sp., reconstruction; O, semionotid of "*Semionotus brauni* group," reconstruction; P, *Diplurus newarki*, reconstruction. Scale 2 cm.

A, original; B, from Colbert, 1965; C, based on *Metoposaurus diagnosticus* from Colbert and Imbrie, 1956; D, modified from Colbert, 1970; E, original; F, from Baird, 1957; G, from Olsen, et al., in prep.; H, original, traced from Bock, 1952; I, from Olsen and Galton, 1977; J, from Olsen, et al., in prep.; K, original, based on PU 13739; L, modified from Schaeffer, 1952b and 1967; M, modified from Schaeffer, 1967; N, modified from Schaeffer, 1967; O, original; P, modified from Schaeffer, 1952a.



assic. There are two possible senior synonyms of *Tanytrachelos*: *Rhabdopelix* (Cope, 1870) and *Gwynnedosaurus* (Bock, 1945). Both of these taxa are from the same locality in the Locketong and consist of disarticulated associations of bones, some individual elements of which cannot be distinguished from *Tanytrachelos*. Huene (1948) felt that *Gwynnedosaurus* was allied with *Macrocnemus* and *Tanystropheus*, a judgment in line with the tanystropheid relationships of *Tanytrachelos*. On the other hand, other elements of *Gwynnedosaurus* and *Rhabdopelix* are very different than *Tanytrachelos* and suggest the specimens represent several mixed taxa; the older two names should, thus, be regarded as *nomina dubia*.

Another small and very peculiar reptile common at several Locketong localities has come to be known as the "deep-tailed swimmer" (Colbert and Olsen, in preparation; Olsen, in press 3). This reptile's most distinctive character is a deep, ventrally directed tail fin supported by extraordinarily long hemal spines (Figure 3.3). In addition, its front limbs are longer than its hind, and its lower jaw is beak-like and edentulous anteriorly. At this point the "deep-tailed swimmer" cannot be assigned to any reptilian order, although a newly discovered small reptile from the Norian of Italy (R. Zambelli and R. Wild, personal communication) bears some interesting similarities to it.

Lysorocephalus gwynnedensis is the name given to a small skull from the Locketong of Pennsylvania described as a lysorophid amphibian by Huene and Bock (1954). Although the addition of a lysorophid to the Locketong assemblage would be intriguing, the overall structure of the skull is very suggestive of a fish skull, particularly *Turseodus* (Baird, personal communication). This taxon is therefore omitted from the list in Table 3.1.

Skeletal remains of larger tetrapods from the upper Stockton and lower Locketong include the metoposaur amphibian *Eupelor* (*Metoposaurus*) *durus* (Cope, 1866, 1871; Colbert and Imbrie, 1956; Olsen, Baird, Seldon, and Salvia, in preparation) and varied phytosaur material (Figure 3.3). Most of the latter is referable to *Rutiodon* and the rest is indeterminate (Cope, 1871; Huene, 1913; Colbert, 1943, 1965; Olsen, Baird, Seldon, and Salvia, in preparation).

A number of Locketong reptile taxa, named in the older literature, are based on isolated teeth (see Huene, 1921); most of these teeth are surely phytosaurian but are generically indeterminate. A tooth taxon worth mentioning at this point, however, is "*Thecodontosaurus*" *gibbidens*, which seems to represent an ornithischian dinosaur. Since Huene's (1921) review, the locality for this form has been repeatedly cited as "Locketong Formation, Phoenixville, York County, Pennsylvania." The correct locality for this important form is New Oxford Formation, near Emigsville, York County, Pennsylvania (Frazer and Cope, 1886). This locality is in the Gettysburg Basin, not the Newark; Phoenixville is in Chester County, not York County. All tooth taxa from the Locketong are omitted from Table 3.1.

In addition to these skeletal remains, a suite of footprints has recently been found in upper Stockton beds of New York State (Figure 3.3); these beds appear to be the lateral equivalents of the lower Locketong (Olsen, in press 3). The forms found so far include the ubiquitous lepidosaurian track *Rhynchosaurooides* spp., the thecodont footprint *Chirotherium* cf. *C. eyermani*, the phytosaur track *Apatopus lineatus*, and a variety of small dinosaurian footprints mostly assignable to the theropod track genus *Grallator* (Olsen, Baird, Seldon, and Salvia, in preparation). Added to this list is the peculiar thecodont-like track *Gwyneddichnium* (Bock, 1952) from the

TABLE 3.1
Vertebrates from the Hartford Basin. Comparable data for the Newark Basin are listed in Olsen (in press 2).

Taxon	Formation	Reference
FISHES		
" <i>Semionotus micropterus</i> group"	Shuttle Meadow and probably East Berlin formations	Olsen, McCune and Thomson, in press
<i>Ptycholepis marshi</i>	Shuttle Meadow Formation	Schaeffer, Dunkle, and McDonald, 1977
<i>Redfieldius</i> spp.	Shuttle Meadow through lower Portland formations	Schaeffer and McDonald, 1978
<i>Diplurus</i> cf. <i>D. longicaudatus</i>	Shuttle Meadow and East Berlin formations	Schaeffer, 1948
" <i>Semionotus elegans</i> group"	lower Portland Formation	Olsen, McCune, and Thomson, in press
<i>Acentrophorus chicopensis</i>	middle through upper Portland Formation	Olsen, McCune, and Thomson, in press
REPTILES		
<i>Hypsognathus fenneri</i>	?upper New Haven Arkose	YPM
sphenodontid rhynchocephalian	upper New Haven Arkose	PU 18835
<i>Stegomus arcuatus</i>	lower New Haven Arkose	Marsh, 1896
phytosaur (<i>Belodon validus</i>)	upper New Haven Arkose	Lull, 1953
archosaur tooth	Shuttle Meadow Formation	Galton, 1976
<i>Stegomosuchus longipes</i>	middle Portland Formation	Lull, 1953
<i>Anchisaurus polyzelus</i>	middle and upper Portland Formation	Galton, 1967
<i>Ammosaurus major</i>	upper Portland Formation	Galton, 1967
<i>Podokesaurus holyokensis</i>	middle Portland Formation	Lull, 1953
<i>Batrachopus</i> spp.*	Shuttle Meadow, East Berlin, and Portland formations	UM Lull, 1953
<i>Anomoepus</i> spp.*	Shuttle Meadow, East Berlin, and Portland formations	Lull, 1953
<i>Grallator</i> spp.*	Shuttle Meadow, East Berlin, and Portland formations	Lull, 1953
<i>Anchisauripus</i> spp.*	Shuttle Meadow, East Berlin, and Portland formations	Lull, 1953
<i>Eubrontes giganteus</i> *	Shuttle Meadow, East Berlin, and Portland formations	Lull, 1953

*Indicates a footprint taxon.

lower Lockatong. The majority of other footprint taxa described by Bock (1952) are either completely indeterminate or have prior synonyms (Baird, 1957; Baird, personal communication).

The age of the upper Stockton and lower Lockatong appears to be late Carnian, on the basis of palynomorph assemblages recovered and studied by Cornet (1977a,b). According to Cornet (1977a), the boundary between the Lockatong and Passaic formations appears to coincide with the late Carnian-Norian boundary as palynologically recognized for the central part of the Newark Basin. Since the lower New Haven Arkose of the Hartford Basin has produced palynomorph assemblages of early Norian age (Cornet, 1977a), the entire Stockton-Lokatong sequence and its faunal assemblage predates the entire Hartford Basin column. In addition, most vertebrate assemblages from the Passaic Formation and the New Haven Arkose differ greatly from the Stockton-Lokatong assemblage. This difference cannot be taken literally, however, since the Lockatong is so clearly biased towards small aquatic organisms (compare Figures 3.3 and 3.4).

New Haven Arkose and Passaic Formation

Skeletal assemblages from the New Haven Arkose of the Hartford Basin and the Passaic Formation of the Newark Basin (Figure 3.2) are very similar, both taxonomically and in mode of occurrence. The lower Passaic Formation has produced two partial skeletons of aetosaurian thecodonts both referable to *Stegomus arcuatus* (Figure 3.4) (Jepsen, 1948; Baird, personal communication), a form originally described from the New Haven Arkose (Marsh, 1896; Lull, 1953). The more recently discovered New Jersey specimen (PU 21750) has a skull with a long tapering snout more like that of *Aetosaurus* from the German Stubensandstein than *Stagonolepis* from the Elgin beds of Scotland. Interestingly, scutes identical to those of *Stegomus* and distinct from both *Aetosaurus* and *Stagonolepis* have recently turned up in the same Yale collection of bones from the Stubensandstein from which Gregory (1953) identified a scute of another aetosaur, *Tyothorax*. The recently discovered specimen of *Stegomus* from New Jersey comes from beds yielding a Norian palynoflora (near member F, Cornet, 1977a), and the stratigraphic position of both the specimens described by Jepsen (1948) and the New Haven Arkose specimen described by Marsh (1896) are commensurate with this age.

The middle Passaic Formation has produced fragmentary remains of phytosaurs. These include the type material of *Clepsysaurus pennsylvanicus* (Lea, 1852, Colbert and Chaffee, 1941) and a partial maxilla from a different locality. Both of these specimens are Rhaetian based on palynomorph assemblages from stratigraphically close beds (i.e., the Perkasio Member and its lateral equivalents) (Cornet, 1977a). In the Hartford Basin a phytosaur scapula described as *Belodon validus* by Marsh (1893) was found in the upper New Haven Arkose about 1,500 m above and 40 km to the north of the horizon producing the above mentioned early Norian palynomorph assemblage (Figure 3.2). All these phytosaur remains are generically indeterminate (Colbert, 1965).

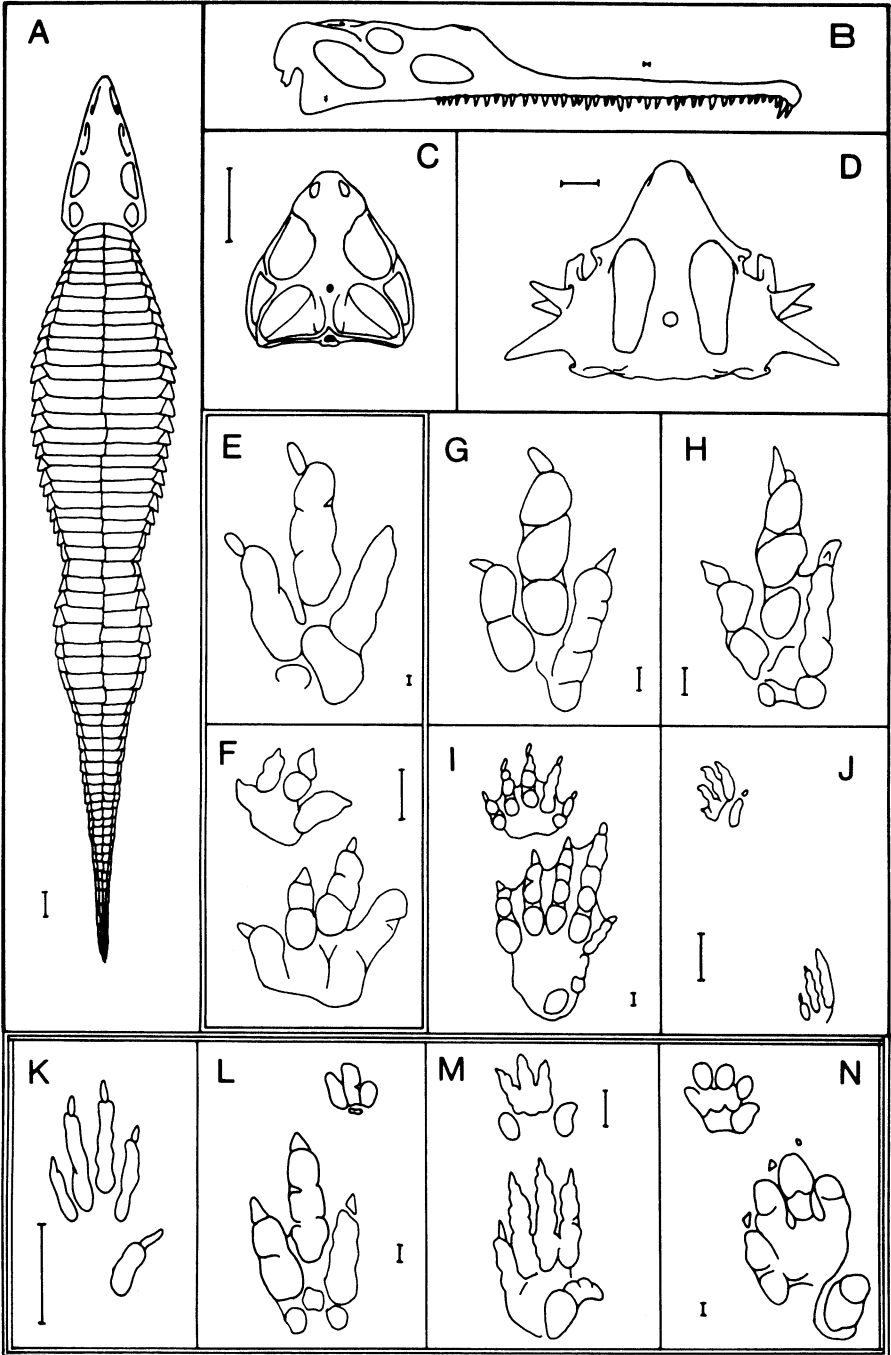
From sandstones of the upper Passaic Formation and the upper New Haven Arkose come skeletons of the procolophonid *Hypsognathus feneri*. The structure of the skull shows that *Hypsognathus* was far more specialized than any other known procolophonid. The type specimen was described by Gilmore (1928) and this was followed by Colbert's (1946) detailed study based on additional, more complete

material. One more skull and a skeleton have more recently been collected (Baird, personal communication, and Colbert, personal communication). All of this material was found in the northern Newark Basin, in an interval about 800 m above an early Rhaetian palynomorph-bearing unit (Cornet, 1977a). In 1967 an excellent skull and skeleton of *Hypsognathus* was found in a block in a stone wall in Meriden, Connecticut (Ostrom, 1967, 1969). A combination of information on the heavy mineral suite present in the matrix (Griggs, 1973) and on the coarseness of the sandstone strongly suggest that the upper division of the New Haven Arkose (Krynine, 1950) was the source of the block. This rough lithologic determination corresponds with the stratigraphic range of the New Jersey material.

Two other skeletal forms from the New Haven Arkose-Passaic Formation tetrapod assemblage require note. One is from the middle Passaic Formation (probably Norian) and consists of a partial skull and postcranial skeleton, named *Sphodrosaurus pennsylvanicus* by Colbert (1960). Colbert assigned *Sphodrosaurus* to the procolophonids primarily on the basis of very primitive "reptilian" features. The occiput of *Sphodrosaurus* lies far anterior to the rear of the skull, and this, in combination with the sculptured surface of the visible skull bones (Colbert, 1960), indicates that *Sphodrosaurus* is only distantly related to *Hypsognathus*, if it is a procolophonid at all. The other form is from the upper division of the New Haven Arkose of Meriden, Connecticut (Case, 1972) and is a nearly complete skull (PU 18835) of an undescribed small sphenodontid rhynchocephalian surprisingly similar to *Sphenodon* (Baird, personal communication) (Figure 3.4). This is the first definite osteological record of a sphenodontid in the North American Triassic, although Baird (1957) identified their presence on the basis of the presence of the footprint taxon *Rhynchosauroides* from the Passaic Formation.

In addition to tetrapods, the lower Passaic Formation has produced some very fragmentary fish, including cf. *Diplurus* sp., *Synorichthys* sp., and *Semionotus* sp. These remains are too rare and too poorly preserved to be very useful in correlation.

While skeletal remains have so far been rare in the Passaic, reptile footprints are abundant throughout the formation. These tracks are very important in providing a link with the footprints from the younger parts of the Newark and Hartford basins. The Passaic footprints can be divided into two broad assemblages on the basis of stratigraphic position (Figure 3.4). The lower assemblage occurs in the portion of the Passaic dated palynologically as Norian (Cornet, 1977a), and is dominated by *Rhynchosauroides*, several species of *Chirotherium*, small species of *Grallator*, and a very unusual form which has been called "*Anchisauripus*" *milfordensis* and "*Grallator*" *sulcatus* (Baird, 1957). The latter two ichnospecies clearly belong in their own genus (Baird, personal communication). This taxon (Figure 3.4) is characterized by a *Grallator*-like pes in which, for the size of the track, digit III is unusually short. The metatarsal-phalangeal pads of both digits II and IV are deeply impressed, which results in a tulip-shaped outline of the pes impression. The most distinctive feature, however, is a small three-toed manus impression present in nearly every trackway. This form is known from scores of specimens, from several horizons, and from three Newark Supergroup Basins: the Fundy Basin, Newark Basin, and Gettysburg Basin. Despite its apparent abundance, it corresponds to no known group of reptiles, although its *Gestalt* is dinosaurian. Other footprint taxa present in this lower Passaic assemblage are the phytosaur track *Apatopus lineatus* and the thecodont-like *Gwynnedichnium* (Olsen, in press, 2).



It is important to note that all the footprint taxa found in the Stockton-Lockatong footprint assemblage are also found in the lower Passaic assemblage.

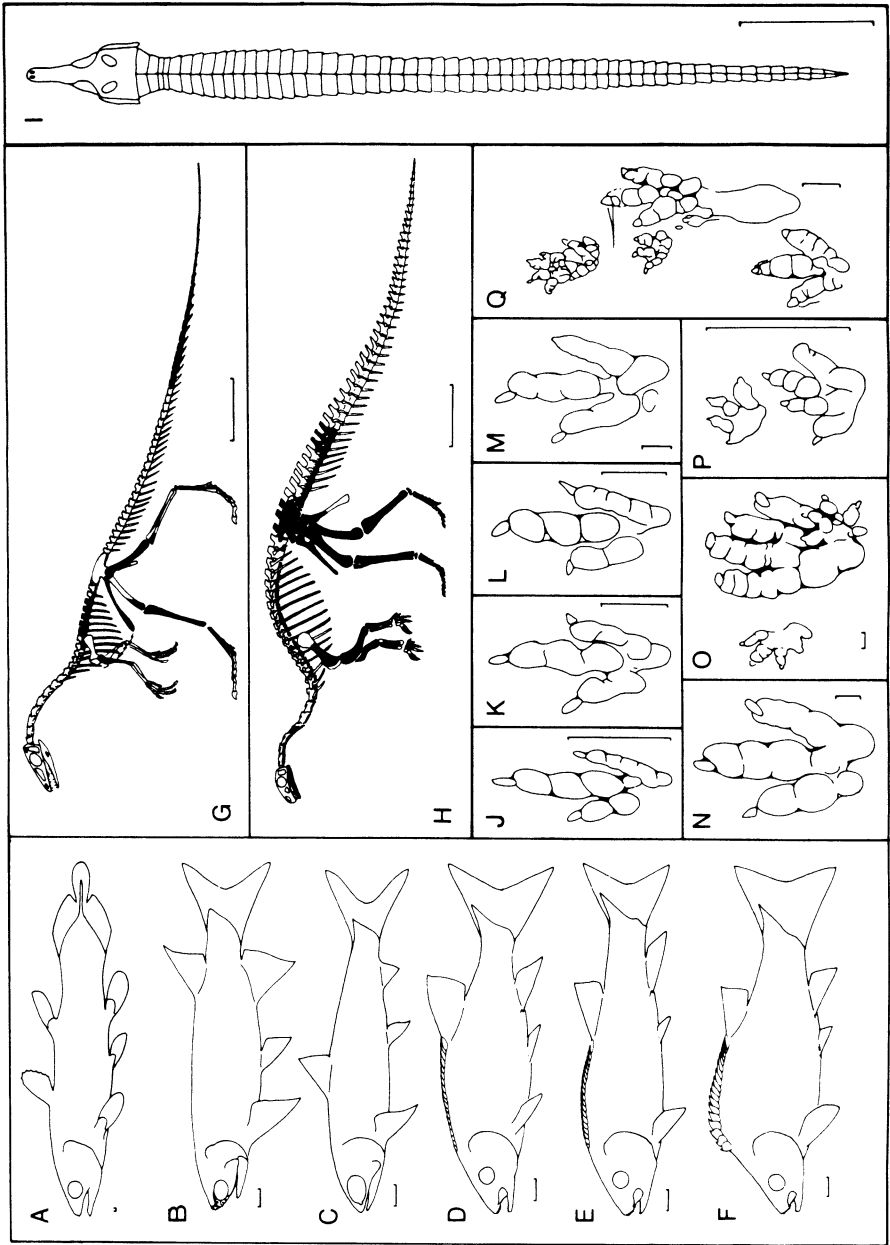
The upper Passaic assemblage of footprints is known from the upper 100 m of the formation. In marked contrast to the lower assemblage, small and large grallatorid footprints are dominant; these include forms traditionally known as *Anchisauripus sillimani* and *Anchisauripus minusculus*. Also common are the earliest Newark occurrences of the probable crocodyliomorph track *Batrachopus*. Present in small numbers are *Apatopus lineatus* and *Rhynchosauroides*; conspicuous by their absence are species of *Chirotherium*. On the basis of the relative position of these beds with respect to the overlying Orange Mountain Basalt (Figure 3.2), the upper Passaic assemblage appears to correlate with late Rhaetian or earliest Jurassic palynomorph-bearing sequences in the southern Newark Basin (Cornet, 1977a). The transitional assemblage between these lower and upper Passaic assemblages would be expected to occur throughout the more than 1,000 m of Passaic Formation of Rhaetian age. The few footprints found in these beds are not very good. They do indicate the presence of more large grallatorids than the lower Passaic assemblage, yet *Chirotherium* is still present. Unfortunately, no New Haven Arkose footprints have found their way into museum repositories, although some have been found (Lull, 1953). Footprints are common, however, in the Hartford Basin sedimentary rocks above the New Haven Arkose (Figure 3.2) and this assemblage has its counterpart in the post-Passaic formations of the Newark Basin. The Passaic Formation footprints thus provide a transitional assemblage between the thecodont-lepidosaur dominated Carnian and Norian Newark Basin beds and the dinosaur-crocodyliomorph dominated assemblages of the Jurassic formations of both the Newark and Hartford basins.

Jurassic Formations of the Newark and Hartford Basins

The Feltville Formation (Figure 3.2) rests on the Orange Mountain Basalt which, in turn, rests on the Passaic Formation and is the oldest Newark Basin formation which appears to be Early Jurassic on the basis of palynomorph correlation (Cornet, 1977a). The Orange Mountain Basalt has yielded radiometric ages of 193–136 Ma,

Figure 3.4. The Passaic Formation and New Haven Arkose vertebrate assemblage: A, *Stegomus arcuatus*, reconstruction of skull and dorsal armor; B, a phytosaur skull, reconstruction; C, new sphenodontid rhynchocephalian, reconstruction—temporal arches largely hypothetical; D, *Hypsognathus fenneri*, reconstruction; E, *Anchisauripus minusculus*, right pes; F, *Batrachopus deweyi*, right manus and pes; G, *Anchisauripus* sp., right pes; H, *Grallator* sp., right pes; I, *Apatopus lineatus*, composite, right manus and pes; J, *Rhynchosauroides brunswicki*, right manus and pes; K, *Gwynnedichnium minore*, right pes; L, new genus formerly called *Anchisauripus milfordensis* and *Grallator sulcatus*, right manus and pes; M, *Chirotherium lulli*, composite, right manus and pes; N, *Chirotherium parvum*, composite, right manus and pes. Scale 1 cm. Note that E and F (surrounded by double line) are known only from the upper Passaic assemblage; K, L, M, and N (surrounded by triple line) are restricted to the lower assemblage of the Passaic; and G, H, I, and J occur through the Passaic.

A, original, based on Jepsen (1948), Marsh (1896), Walker (1961), and PU 21750; B, based on *Rutiodon carolinensis* from Colbert (1965); C, original based on PU 18835; D, original based on YPM specimen; E, original, based on AC 16/1; F, from Lull (1953); G, original, based on AC 9/14; H, from Baird (1957); I, from Baird (1957); J, from Olsen and Galton (1977); K, original, traced from Bock (1952); L, original, based on CM specimen; M, from Baird (1954); N, from Baird (1957).



which also suggest an Early Jurassic age (Sutter and Smith, 1979). The Feltville Formation footprint assemblage (Figure 3.5), like that of the upper Passaic assemblage, is dominated by large as well as small grallatorids, including *Grallator* sp., *Anchisauripus sillimani*, *Anchisauripus minusculus*, and *Eubrontes* sp. As in the upper Passaic assemblage, *Batrachopus* sp. is present. The oldest Newark Basin occurrence of the probable ornithopod footprint *Anomoepus* spp. is in the Feltville, and it is the presence of this genus which distinguishes the Feltville from the upper Passaic assemblage.

The Feltville-type assemblage is also characteristic of the overlying Towaco and Boonton Formations in the Newark Basin and all post-New Haven Arkose sedimentary formations of the Hartford Basin (Figure 3.2). In the Newark Basin, the Towaco Formation has produced the bulk of the Jurassic footprints, while in the Hartford basin this role is taken by the Portland Formation. As far as this analysis goes, these assemblages are indistinguishable. The Portland has, however, very rare examples of the giant ?crocodiliomorph track *Otozoum* (Figure 3.5), and I believe its absence from the Newark Basin could be due to inadequate sampling.

The footprint taxa characteristic of the Feltville Formation have what has been traditionally called a "Connecticut Valley" aspect (Lull, 1953; Baird, 1957). The contrast between this "Connecticut Valley"-type footprint assemblage and the lower Passaic assemblage is, I believe, the most fundamental division of Newark Supergroup assemblages; they share only small *Grallator* species. This contrast was pointed out by Lull (1953), Colbert (1946, 1965), Colbert and Baird (1958), Colbert and Gregory (1957), and Olsen and Galton (1977). It is important to note that, like the Feltville Formation, all Newark and Hartford Basin formations which preserve a "Connecticut Valley"-type of footprint assemblage have also yielded palynomorph assemblages of Early Jurassic age (Hettangian through Toarcian, Cornet, 1977a); also, the interbedded basalt flows have produced Early Jurassic dates (Armstrong and Besancon, 1970; Sutter and Smith, 1980). This is true of the Newark Supergroup as a whole (Olsen, McCune, and Thomson, in press; Cornet, 1977a).

The relative homogeneity of the "Connecticut Valley"-type assemblage through all the post-Passaic and post-New Haven Arkose Formations is not reflected in the

Figure 3.5 Jurassic vertebrate assemblage of Newark and Hartford basins: A, *Diplurus longicaudatus*, reconstruction; B, *Redfieldius* spp., reconstruction; C, *Ptycholepis marshi*, reconstruction; D, member of "*Semionotus elegans* group," reconstruction; E, member of "*Semionotus micropterus* group," reconstruction; F, member of "*Semionotus tenuiceps* group," reconstruction; G, *Podokesaurus holyokensis*, reconstruction—only black portions actually preserved; H, *Ammosaurus major*, reconstruction—only black portions preserved; I, *Stegomosuchus longipes*, reconstruction; J, *Grallator cursorius*, right pes; K, *Anchisauripus hitchcocki*, right pes; L, *Anchisauripus* sp.; M, *Anchisauripus minusculus*, right pes; N, *Eubrontes* cf. *E. giganteus*, right pes; O, *Otozoum moodii*, left pes and left and right manus; P, *Batrachopus deweyi*, right manus and pes; Q, *Anomoepus crassus*, right manus (impressed three times) and right pes (impressed twice—once with tarsus). Scale of A-F, 8 cm; scale of G-I, 10 cm; and scale of J-Q, 5 cm.

A-C from Olsen, McCune, and Thomson (in press); D, original based on YPM 6567; E, original, based on YPM 0000; F, original, based on YPM 8162; G, original, data from Lull (1953) and reconstructed partly on the basis of *Coelophysis*; H, based on data in Galton (1976); I, original, based on Walker (1968) and Lull (1953); J, original, based on AC 4/1; K, from Lull (1953); L, original, based on AC 9/14; M, original, based on AC 16/1; N, original, based on AC 45/1; O, original, based on AC 15/14; P, from Lull (1953); Q, original, based on RUGM 50:4:1.

many fish assemblages. The vertical changes in fish assemblage composition allow for their use in correlation within the Newark Supergroup (Olsen, McCune, and Thomson, in press). The most abundant fishes through the Newark and Hartford basin Jurassic are members of the genus *Semionotus*. It is crucial to note that the old concept of *Semionotus* as a Triassic "index fossil" must be abandoned because it is due to long standing taxonomic artifacts; specimens of *Semionotus* spp. are, in fact, common through the Jurassic and Early Cretaceous (Olsen, in preparation). Even though at the generic level *Semionotus* is useless in biostratigraphy, at lower taxonomic levels, such as species and species-groups, it may prove valuable for correlation (Olsen, McCune and Thomson, in press).

Fishes from the Feltville Formation (Figure 3.5) differ completely from those present in the underlying Lockatong (Figure 3.3). Semionotid fishes of the "*Semionotus tenuiceps* group" are overwhelmingly abundant. The only other genus so far found is the subholostean *Ptycholepis*. The Towaco Formation has produced only semionotids and these seem allied to those of the Feltville (Olsen, McCune and Thomson, in press). Semionotids of the Shuttle Meadow Formation of the Hartford Basin, on the other hand, are very different from those of the Feltville and Towaco. Semionotids of the "*Semionotus micropterus* group" and the subholostean *Redfieldius* are the dominant taxa of the Shuttle Meadow; smaller numbers of the coelacanth *Diplurus* cf. *D. longicaudatus* and *Ptycholepis marshi* are also present. The lesser-known East Berlin Formation assemblage seems essentially the same as the Shuttle Meadow. Interestingly, an assemblage like that of the Feltville and Towaco occurs in the Deerfield Basin, to the north of the Hartford Basin, and an assemblage like those of the Shuttle Meadow and East Berlin formations occurs in the Culpeper Basin 500 km to the south of the Hartford Basin. Therefore, simple endemism in individual basins can be ruled out as an explanation for the differences in the fish assemblages. My colleagues and I argue that the simplest hypothesis is that the Feltville and Towaco formations are older than the Shuttle Meadow and East Berlin formations, as depicted in figure 3.6 (Olsen, McCune, and Thomson, in press; Cornet, 1977a).

In contrast to the older Jurassic formations, the upper Boonton Formation of the Newark Basin and lower Portland Formation of the Hartford Basin (Figure 3.2) have essentially the same fish assemblages. Semionotids of the "*Semionotus elegans* group" and *Redfieldius gracilis* are the most common taxa in both assemblages. *Diplurus longicaudatus* and *Ptycholepis* sp. are known from the Boonton Formation but not from the lower Portland, probably because of the very small sample size of the Portland assemblage. Palynomorph assemblages from these beds in both basins show them to be Sinemurian (Cornet, 1977a).

The middle and upper Portland Formation contain a fish assemblage dominated by a form which Newberry (1888) called *Acentrophorus chicopensis*, as well as some *Semionotus* species. Unfortunately, the fish are very poorly preserved (although abundant) and *A. chicopensis* must be regarded as an indeterminate holostean. The beds producing this assemblage appear to be Toarcian in age (Cornet, 1977a), and thus this is the youngest Newark Supergroup fish assemblage.

Apart from footprints and one tooth (Galton, 1971), the only Jurassic tetrapod remains in the two basins have been found in the Portland (Lull, 1953). *Podokesaurus holyokensis* is a small, lightly built theropod found in a glacial boulder at Mt. Holyoke College in Massachusetts. Its probable provenance is the Portland Forma-

tion (Lull, 1953), although this, along with its true systematic position, will never be known with certainty, since it was destroyed in a fire. Colbert (1964) synonymized *Podokesaurus* and *Coelophysis*. This was the most economical approach when the two genera were thought to be the same age (i.e., Triassic). If, however, *Podokesaurus* is from the Portland Formation, it is probably about 15 million years younger than *Coelophysis*. The characters cited by Colbert (1964) and Colbert and Baird (1958) as shared between *Coelophysis* and *Podokesaurus* are also shared with other small theropods such as the upper Stormberg *Syntarsus* (Raath, 1969). To avoid the possible artifact of overextending the stratigraphic range of *Coelophysis* it is appropriate to conserve *Podokesaurus* as a separate genus and to regard it as an indeterminate small theropod. This same argument applies to a sandstone natural cast of the impression of parts of a hind limb and pelvis of a small theropod, also from the Portland Formation (Colbert and Baird, 1958). I would prefer to regard this specimen as *incertae sedis* among the theropods rather than to refer it either to *Coelophysis* (Colbert and Baird, 1958) or to *Podokesaurus*.

A very important Portland reptile is *Stegomosuchus longipes*, formerly thought to be a psuedosuchian (Lull, 1953) and now thought to be a crocodile very similar to *Protosuchus* (Walker, 1968) (Figure 3.5). Also present in the Portland are the prosauropod dinosaurs *Ammosaurus* and *Anchisaurus* (Huene, 1906; Lull, 1953; Galton, 1976). The prosauropods and *Stegomosuchus* are from portions of the Portland which are Toarcian in age or younger (Cornet, 1977a). As Galton (1971) pointed out, this skeletal assemblage has its affinities with that of the Navajo Sandstone of the Glen Canyon Group of the southwestern United States. The lower beds of the Glen Canyon Group (Moenave Formation), like the lower beds of the Portland Formation, have produced palynomorph assemblages of Sinemurian or Pliensbachian age (Cornet, 1977a; Olsen and Galton, 1977; Baird, this volume). It can thus be concluded, on the basis of fish and palynomorph correlation that at least the upper Boonton Formation and lower Portland Formation correlate, and that beds equivalent to the upper (?Pliensbachian-Toarcian and younger) beds of the Portland Formation have not been preserved in the Newark Basin (Figure 3.6).

Summary

In a broad way, the major homotaxial lithologic divisions of the Newark and Hartford basins correlate (Figure 3.6). The New Haven Arkose and the Passaic Formation correlate; the basalt flow formations and interbedded sedimentary formations are roughly contemporaneous; and parts of the Boonton and Portland formations correlate. However, the sequences in the two basins differ in many details. Strata equivalent in time to the Stockton and Lockatong are entirely absent in the Hartford Basin; both the Feltsville and Towaco formations appear to be older than the Shuttle Meadow and East Berlin formations; and the entire upper two-thirds of the Portland Formation is younger than the youngest beds of the Boonton Formation (Figure 3.6). These correlations are, of course preliminary; their main purpose is to organize the biostratigraphic data in the simplest manner. The conclusions are limited not only by the incompleteness of the paleontological data, but also by realities of biological temporal and spacial heterogeneity, realities necessarily deemphasized in the assumptions of biostratigraphic procedure. Only with the accumulation of additional biostratigraphic and presumably independent geophysical data will these correlations be tested and then improved.

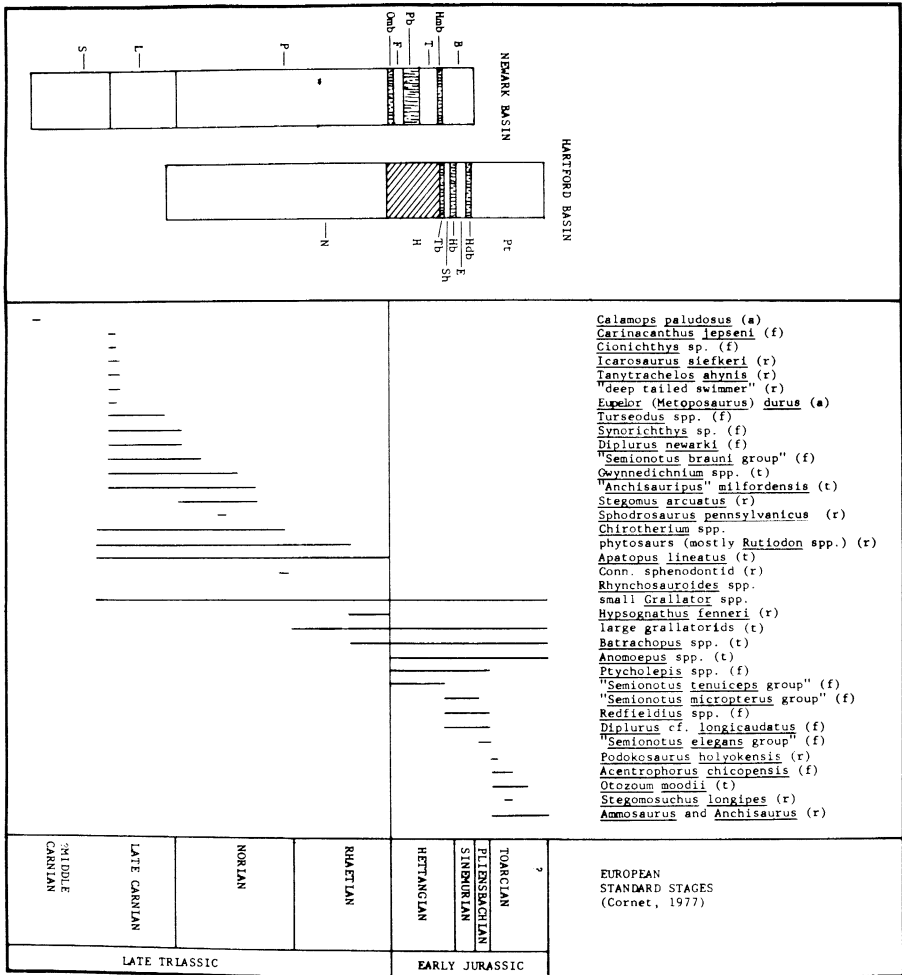


Figure 3.6. Correlation of the formations of the Newark and Hartford Basins. Abbreviations of lithologic divisions as follows: B, Boonton Formation; E, East Berlin Formation; F, Feltville Formation; H, inferred hiatus; Hb, Holyoke Basalt; Hdb, Hampden Basalt; Hmb, Hook Mountain Basalt; L, Lockatong Formation; N, New Haven Arkose; Omb, Orange Mountain Basalt; P, Passaic Formation; Pb, Preakness Basalt; Pt, Portland Formation; S, Stockton Formation; Sh, Shuttle Meadow Formation; and T, Towaco Formation.

All thicknesses of columns proportional to those in Figure 2 except for the New Haven Arkose which is drawn disproportionately thick.

Letters next to taxa denote the nature of the fossil as follows: a, amphibian skeletal remains; b, fish skeletal remains; r, reptile skeletal remains; t, reptile track taxon. Data for taxon distributions in Olsen (in press 2) and Table 3.1.

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Abbreviations for Specimen Repositories

- AC—Pratt Museum, Amherst College, Amherst, Massachusetts
- AMNH—American Museum of Natural History, New York, New York
- CM—Carnegie Museum of Natural History, Pittsburgh, Pennsylvania
- PU—Vertebrate Paleontology collection, Guyot Hall, Princeton University Museum of Natural History, Princeton, New Jersey
- UM—University of Massachusetts, Geology Department, Amherst, Massachusetts
- WU—Geology Department Museum, Wesleyan University, Middletown, Connecticut
- YPM—Peabody Museum, Yale University, New Haven, Connecticut