Deadline for Nominations: 15 September 1977

AAAS–Newcomb Cleveland Prize: Contest Year Is Nearly Over

The deadline for nominations of papers for the AAAS–Newcomb Cleveland Prize is fast approaching. Readers are invited to nominate papers published in the Reports section of *Science* from 3 September 1976 to 26 August 1977. The prize of $5000 and a bronze medal is now given annually to the author of an outstanding paper that is a first-time publication of the author's own research.

Nominations must be typed and the following information provided: the title of the paper, issue in which it was published, author's name, and a brief statement of justification for nomination. Nominations should be submitted to AAAS–Newcomb Cleveland Prize, AAAS, 1515 Massachusetts Avenue, NW, Washington, D.C. 20005. Final selection will rest with a panel of distinguished scientists appointed by the Board of Directors.

The award will be presented at a session of the annual meeting at which the winner will be invited to present a scientific paper reviewing the field related to the prizewinning research. The review paper will subsequently be published in *Science*. In cases of multiple authorship, the prize will be divided equally between or among the authors; the senior author will be invited to speak at the annual meeting.

Reports

The Oldest Macroborers: Lower Cambrian of Labrador

Abstract. *We have discovered numerous borings of* Trypanites *penetrating skeletons and synsedimentary cemented limestones in archaeocyathid reefs of the Forteau formation in southern Labrador. These are, to date, the oldest known macroborings. The discovery of these structures extends the record of large endolithic organisms 100 million years from the Lower Ordovician to the Lower Cambrian. This immediately postdates the appearance of metazoans with hard parts and confirms that endoliths have played a role in reef formation since the early Cambrian.*

The Forteau formation is a sequence of shales, limestones, and minor sandstones about 120 m thick that outcrops, mainly in shoreline section, in southern Labrador and in western Newfoundland (Fig. 1) (*1*). These Cambrian sediments are the upper part of a sandstone (Bradore formation) to shale to limestone (Forteau formation) sequence that unconformably overlies Precambrian granites and granite gneisses of Grenville age. The middle part of the Forteau formation contains a series of archaeocyathid reefs, specifically a lower patch-reef complex and an upper reef-mound/oolite-shoal complex (*2*).

The lower, 20-m-thick patch-reef complex is best developed in Labrador and grades eastward into black, potassium-rich shales. The complex consists of individual patch reefs or groups of patch reefs and associated calcarenites separated by subtidal, calcarenite-shale rhythmites. Reefs (Fig. 2A), which may attain a stratigraphic thickness of 20 m, are made up of numerous overlapping small mounds. Each mound is a jumble of sticklike and vaselike archaeocyathids along with coelobitic algae and foraminifers (?) set in a matrix of red lime mudstone which was deposited as internal sediment. The tops of shelter cavities are commonly roofed with synsedimentary cement.

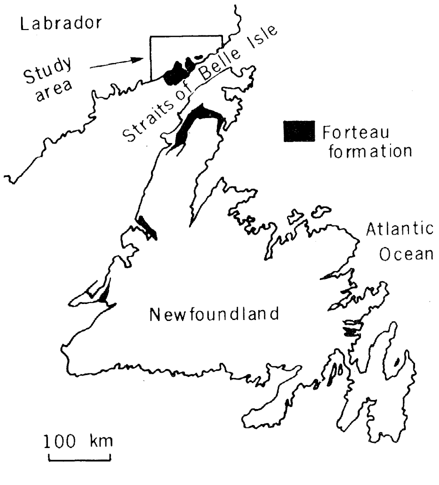

Fig. 1. Map of Newfoundland and southern Labrador, showing the distribution of Forteau formation outcrop, and the study area on the north shore of the Straits of Belle Isle.

The upper, 15-m-thick archaeocyathid-mound/oolite-shoal complex, a series of irregularly distributed mounds, surrounded by, or intercalated with, oolitic lime grainstones, can be traced some 75 km eastward from Labrador across the Great Northern Peninsula of Newfoundland. Each mound comprises upright robust to delicate archaeocyathids, in a matrix of skeletal lime grainstone to calcareous siltstone.

On the basis of trilobites the Forteau formation is assigned a late Lower Cambrian age, mainly in the *Bonnia-Olenellus* zone (*3*). This is confirmed by the archaeocyathid fauna, particularly the forms *Archaeocyathus* and *Cambrocyathus* which are characteristic of the uppermost Lower Cambrian Lena or Elanka stage as defined on the Siberian Platform (*4*).

The shape of the individual mounds that make up the archaeocyathid reefs is not wholly constructive, but also appears to be partly a function of erosion. In cross section skeletal lime sands are seen to directly overlie truncated archaeocyathid skeletons and argillaceous lime mud, clearly indicating that the mound surface was hard and subsequently eroded before deposition of the overlying skeletal sand. Where outcrop permits, the overlying lime sands can be stripped away, or erosion has removed overlying mounds to reveal a mound surface composed of many upright and toppled archaeocyathids, each one planed off and surrounded by lime mudstone. Scattered across the mound surface are numerous small black dots, as if ink had been splattered on the rock (Fig. 2B). These dots are the apertures of sediment-filled borings. The small, circular, sediment-filled tubes (borings) penetrate archaeocyathid skeletons alone and archaeocyathid skeletons and the lime mud between (Fig. 3A), and can be commonly seen passing through from one to the other. The boring organisms appear to have been a quantitatively minor, although integral, reef community component. In thin section the borings are seen to cut synsedimentary cement as well, and are filled with dolomite, terrigenous silt, clay, and trilobite debris, as well as lime mud.

The borings are circular to subcircular in transverse section, show little variation in shape from aperture to base, are straight, and are most commonly oriented normal to the surface (Fig. 3B), although some obliquely oriented examples are found. The length of the tubes is variable and ranges from 1.3 to 2.5 cm, with a mean length of 1.9 cm. Borings do not interconnect or branch, and are never U-shaped.

On the basis of shape, the borings belong to the morphogenus *Trypanites* Magdefrau 1932, which, as defined, consists of simple, unbranched, pouch-shaped borings, with a single opening to the surface (*5*). A detailed description and a discussion of the extensive synonymies is found in Bromley and in Pemberton *et al.* (*5*).

Because *Trypanites* is a morphogenus, it is possible that several groups of organisms are responsible for the borings. On the basis of size, shape, and geologic age the most likely organisms are polychaete worms, cirripeds, or sipunculids. However, Pemberton *et al.* (*5*) have recently shown that for *Trypanites* borings from the Silurian of Ontario, the borers were most likely sipunculids; this probably applies to other early Paleozoic *Trypanites* borings as well. In younger occurrences *Trypanites* is found associated with both cold temperate (?) and warm tropical waters (*6*). The association with archaeocyathids, ooid shoals, and stromatolites, all found in the stratigraphic section in Labrador, suggests that the organisms responsible for *Trypanites* in the Cambrian of Labrador lived in tropical to subtropical shallow marine waters.

Although evidence of boring by metazoans is common, especially in the upper Paleozoic, such evidence is rare in the lower Paleozoic, and to our knowledge, aside from an occurrence of a possible sponge boring in a Lower Cambrian *Hyolithes* (*7*), such borings are unknown from sedimentary rocks of Cambrian age (*8*).

The described occurrences of middle and lower Paleozoic *Trypanites* borings are few: in a disconformity surface at the top of an Upper Devonian biostrome in Iowa (*9*); in hard grounds ranging in age from Upper Devonian to Lower Ordovician of the Russian Platform (*10*); in carbonates at the top of a section of Upper Devonian back-reef sediments in the Snipe Lake Reef complex, Alberta, Canada (*11*); in dolomites at the Silurian-De-

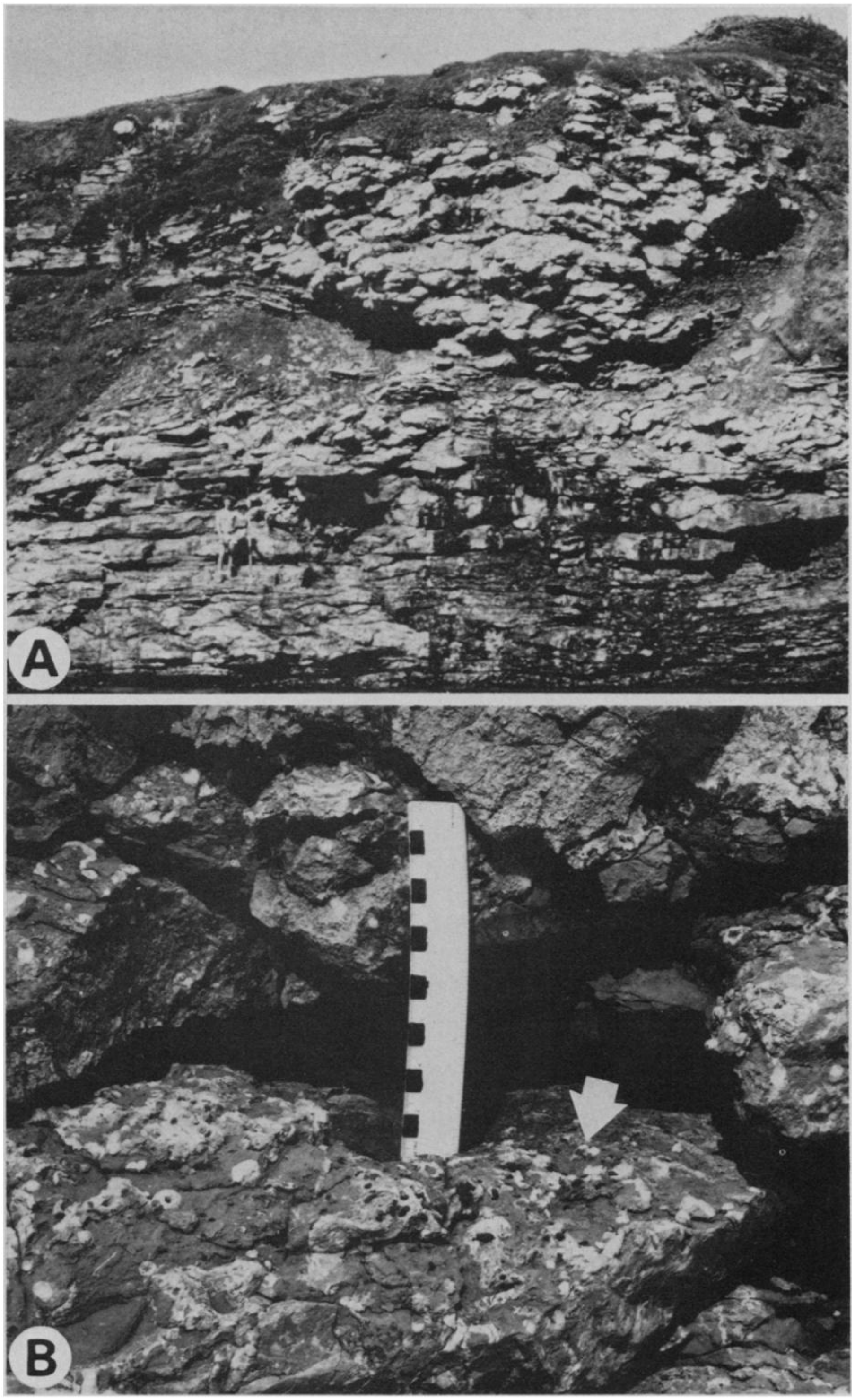

Fig. 2. (A) An archaeocyathid reef in cross section along the northern shore of the Straits of Belle Isle, Labrador. The reef is the large, poorly bedded, elliptical structure near the center; the man is 2 m tall. (B) A partially eroded reef illustrating the top of an archaeocyathid mound (at arrow) within the reef; the white patches are archaeocyathids, and the black dots scattered over the top of the mound are apertures of sediment-filled borings.

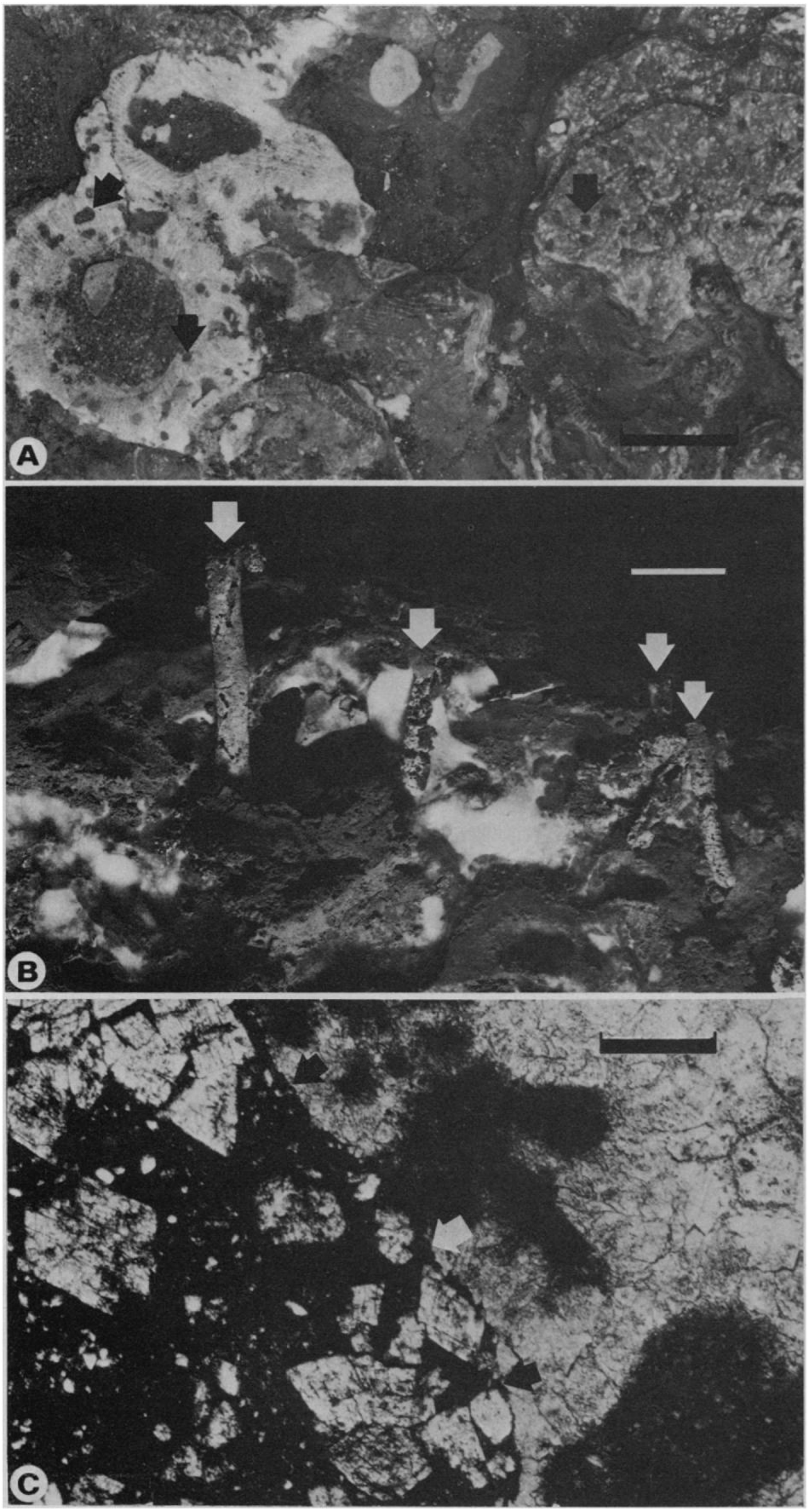

Fig. 3. Macroborings. (A) The surface of an archaeocyathid mound; arrows indicate apertures of *Trypanites* borings which penetrate archaeocyathids (left) and sediment matrix (right); scale bar, 2 cm. (B) Sediment-filled macroborings of *Trypanites* (indicated by arrows) etched from a vertical section slab through an archaeocyathid mound. The borings can be seen to penetrate both archaeocyathid skeletons and *Renalcis*–sediment matrix. Scale bar, 1 cm. (C) Thin-section photomicrograph, in plane light, showing the contact between the sediment and dolomite-rhomb–filled macroboring at left, and calcite cement and *Renalcis* at right. The arrows indicate the contact. Note that the boring cuts both *Renalcis* and cement crystals, indicating that cementation was very early, and preceded boring. Scale bar, 200 μm.

vonian boundary disconformity in southern Ontario, Canada (*12*); in biocalcarenite at the top of the Laurel formation in the Middle Silurian of Indiana (*13*); in carbonates of the Champlainian Bromide formation and Viola limestone of Oklahoma (*14*); in limestone overlain by conglomerate in the Middle Ordovician of Minnesota (*15*); and in the Lower Ordovician of the Baltic region, where the borings are found in hard grounds in bituminous shale and in concretions of dark bituminous limestone (*16*).

On the basis of the above, the *Trypanites* borings in the archaeocyathid reefs of southern Labrador and western Newfoundland appear to be the oldest known such structures. This occurrence extends the known range of *Trypanites* and of all macroborers from the Lower Ordovician to the Lower Cambrian.

The discovery of macroborings in the Lower Cambrian has several important geologic implications. The fabric and structure of modern coral reefs, the most complex of all sedimentary deposits, are not only the product of rapid accretion resulting from the biological fixation of carbonate, but are also the product of biological destruction primarily by a host of endolithic organisms (*17*). Recent studies have also shown that boring by endolithic organisms coupled with early subsea cementation is one of the most important diagenetic processes that reefs undergo in their development (*18*). The discovery of macroendoliths in the earliest metazoan reefs indicates that boring organisms have played a role in the formation of reefs throughout the Phanerozoic. Clearly the complex pattern of biological accretion, internal sedimentation, early cementation, and biological destruction did not develop gradually through the Cambro-Ordovician, but was present at the very beginning of metazoan reef development.

With the extension of the occurrence of *Trypanites* to the Lower Cambrian a preliminary trend is now emerging in the evolution and diversification of marine endoliths during the lower Paleozoic. From the Lower Cambrian to the Middle Ordovician the only known macroboring is the morphogenus *Trypanites*, yet during the Upper Ordovician and Lower Silurian there is a radiation of macroendolithic forms (*19*). We suggest that the reason for this delayed radiation may have been absence of a suitable ecologic niche. Although reefs composed of large skeletal metazoans are present in the Lower Cambrian, with the extinction of archaeocyathids at the end of the early to Middle Cambrian there were no large skeletal metazoans to take their place, and hence no skeletal reefs until the Middle Ordovician with the appearance of bryozoa. The only available niche for macroborers from Middle Cambrian to Middle Ordovician, was hard grounds. With the reestablishment of reefs in the Middle Ordovician, and increase in the number and diversity of available hard substrates, macroboring organisms began to radiate and diversify. Therefore, the diversification of macroborings appears to parallel the development and expansion of the reef habitat in the early Paleozoic.

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20. We thank the Department of Engineering, and in particular W. Campbell, of Memorial University, for making field facilities in Labrador available, and J. Whorwood, McMaster University, and W. Marsh, Memorial University, for photographic assistance. This research was funded by National Research Council of Canada grant A-9159 to N.P.J.

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Triassic-Jurassic Tetrapod Extinctions: Are They Real?

Abstract. *Terrestrial vertebrate fossils show that part of the Newark supergroup of the eastern United States, all of the Glen Canyon group of the southwestern United States, and the Upper Stormberg group of southern Africa are Early Jurassic. This new correlation demonstrates that the supposed widespread tetrapod extinction at the Triassic-Jurassic boundary is an artifact of spurious correlation.*

Recent work on the timing of extinctions of higher-level taxa (*1*) is limited by the reliability with which the ranges of those taxa are placed in the geologic time scale. One such mass extinction involving terrestrial vertebrates purportedly occurred at the Triassic-Jurassic boundary (*1*). It has been recently pointed out (2) that this "extinction" might be the result of a poor Early Jurassic record. A reappraisal of correlations of early Mesozoic deposits of the world shows that a distinct Early Jurassic terrestrial vertebrate record does exist and that it is transitional between the familiar Late Triassic and Late Jurassic faunas.

The divisions of the early Mesozoic of Europe were originally based on major lithologic changes and hiatuses in the rock succession, so that the boundaries of the major rock units are, by definition, the time-stratigraphic boundaries of the early Mesozoic. The correlation of these time-stratigraphic units from their type areas is limited by whatever time-equivalent data are available (*3*). Vertebrate fossils provide one commonly used means of correlating continental early Mesozoic deposits of the world with the type Triassic and Early Jurassic of Europe. Unfortunately, many faunal data from the type areas are not useful for correlation. The marine and estuarine fish faunas of the German Triassic have more in common with Liassic (Early Jurassic) faunas of northern Europe than either has in common with nonmarine faunas of other early Mesozoic areas (*4*).

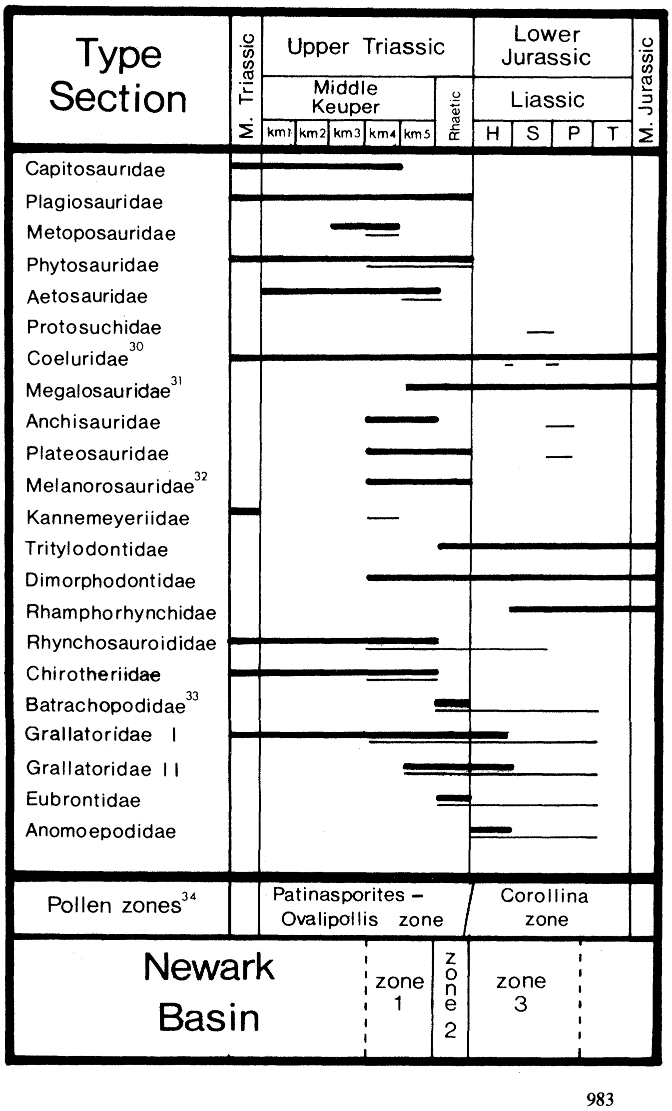

Fig. 1. Ranges of correlative vertebrates, and broad palynomorph zones (*34*) of the type areas of the Upper Triassic and Lower Jurassic (Liassic) and the Newark Basin of the Newark supergroup. Heavy horizontal lines represent the ranges of taxa in the European type areas, while light horizontal lines show the ranges for the Newark Basin. The ranges of the Protosuchidae, Coeluridae, Anchisauridae, and Plateosauridae are based on correlation of zone 3 with the Portland formation of the Hartford Basin. Abbreviations of the stages of the Lower (Early) Jurassic: *H*, Hettangian; *S*, Sinemurian; *P*, Pleinsbachian; *T*, Toarcian. Standard divisions of the German Middle Keuper are km 1 to 5. Note that the Lower Keuper and Upper Keuper have been omitted from the figure because they are, more or less, equivalent to parts of the Middle Triassic and Rhaetic, respectively.