

Pattern and pace and origin of biotic change through the continental early Mesozoic as seen in Eastern North America and Morocco

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The early Mesozoic was characterized by extraordinary faunal and floral change in continental ecosystems. Not only did all extant groups of terrestrial vertebrates evolve, but the Early Mesozoic witnessed two of the largest mass-extinction events of the Phanerozoic, one at the end of the Permian and one at the Triassic-Jurassic boundary. The latter extinction remains enigmatic: considerable debate exists on its magnitude, duration, synchrony of land and sea extinctions, and origin.

The most recent and exhaustive literature compilations of global data show that, depending on the metric, the Triassic-Jurassic mass-extinction, continental or marine, is at least as large in magnitude as the more famous Cretaceous-Tertiary event, and by some measures, larger than the Permo-Triassic extinction. However such compilations have been criticized, with some justification, as requiring severe decimation of the temporal resolution of the data with the result that an interval of concentrated biotic turnover spanning 15 million years cannot be distinguished from a catastrophic mass-extinction taking 3 years.

Rift basins formed during the Late Permian through Early Jurassic in eastern North America and Morocco have properties that considerably illuminate these issues. Many of the rift basin sequences are characterized by very high accumulation rates and cyclical lake deposits paced by Milankovitch climate change, providing a high-resolution internal chronometer. They preserve a wealth of biotic data spanning equatorial to subtropical paleolatitudes and, at least for the Early Jurassic, a lateral transition in Morocco from continental to marine environments. The younger strata of these basins are interbedded with flood basalts of the giant Central Atlantic magmatic province (CAMP) that has been implicated in the cause of the mass extinction itself.

Based on correlation by paleomagnetic reversal stratigraphy and time calibration by Milankovitch cyclostratigraphy, only two intervals of concentrated biotic change are evident in these rift sequences. The older interval correlates to the marine Carnian-Norian boundary and is characterized by a significant floral and vertebrate transition. Unfortunately, in many outcrops this interval coincides with a tectonostratigraphic sequence boundary, making assessment of the rate of change difficult, although constrained within 2 m.y. The other interval of concentrated change is coincident with the Triassic-Jurassic boundary. Keeping in mind that this boundary has not been formally defined, lacks a GSSP, and there is no agreement of marine index species, the continental microfloral transition as seen in eastern North America is very similar to that seen in marine boundary sections. In eastern North America the biotic transition occurs below the oldest CAMP basalts. On the basis of Milankovitch cyclostratigraphy the faunal transition occurs in less than 30 ky and the floral change less than 10 ky. In at least two rift basin sections, a "fern spike" and modest Ir anomaly are synchronous with the biotic turnover. If the eastern North American pattern is general, the Triassic-Jurassic boundary occurs -20 ky below the extrusion of the oldest basalts, seemingly negating CAMP lava eruption as the extinction cause.

Nonetheless, the close proximity of the CAMP to the extinction level has sparked a justifiable search for CAMP basalts that might predate the boundary in Morocco, which has more extensive outcroppings of CAMP lavas and adjacent strata than elsewhere. Recently, Marzoli et al., (2004) and Knight et al. (2004) report such basalts in the Central High Atlas.

Based on palynology, which according to them does not appear to show the characteristic extinctions, paleomagnetic reversal stratigraphy, and basalt geochemical trends, the bulk of the Central High Atlas basalts predate the boundary.

There are significant problems with this contention, however. First, the extinction level was not successfully identified in any of the studied sections. Second, the paleomagnetic reversal stratigraphy is completely restricted to the basalt sequence and interbedded strata and thus lacks sufficient context to correlate uniquely with the eastern North American reference stratigraphy, and third the supposed vertical trends in basalt geochemistry may be as simply explained as a result of lateral trends. However, this Marzoli-Knight hypothesis of correlation is still a viable one and has the attractive attribute of being testable by carbon isotopic stratigraphy and additional paleomagnetic work.

One problem particular to the outcrops in Nova Scotia and Morocco is that the intervals of interest immediately below the CAMP basalts are quite thin, subject to metamorphism and surficial deformation, the latter due to gliding of the basalts on top the underlying incompetent mudstones and their consequent shearing. This problem renders many outcrops unsuitable for the high-resolution stratigraphy necessary for the analysis of rates of microfloral change. We would argue that the best approach to the problem would be the collection of one or more reference cores through the entire basalt sequence well into the underlying strata, which could be sampled at any level necessary.

Biotic change seen at the Carnian-Norian and Triassic-Jurassic boundary are seen at lower levels of resolution globally, and punctuate the Triassic development of a fully mature continental ecosystem. The Triassic-Jurassic boundary, however marks a massive change, apparently ending the reign of the high-diversity continental biotas that developed with regional variations and ushering in remarkably globally uniform assemblages dominated by dinosaurs. Biotic diversity evidently took tens of millions of years to recover, but dinosaurian dominance prevailed for 136 m.y. until the next of the biggest mass extinctions at the Cretaceous-Tertiary boundary.
