Acid trauma at the Cretaceous-Tertiary (K/T) boundary in eastern Montana: Comment and Reply

COMMENT

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In his recent article hypothesizing about the occurrence of acid rain at the Cretaceous-Tertiary (K/T) boundary in eastern Montana, Retallack (1996) stated that "acidic trauma may explain the transition in Montana from … herbivorous to insectivorous vertebrates." There is no such transition recorded in the vertebrate record across the K-T boundary. The authors Retallack cited (Sheehan and Fastovsky, 1992) did not make this claim and did not discuss the vertebrates that appeared after this transition. Of the 107 vertebrate species now well-documented in the Hell Creek Formation, a minimum of 52 (or 49%) survived. Of the 55 species that disappeared (either becoming extinct or migrating with environmental change), 29 were carnivorous or insectivorous, 14 were omnivorous, 11 were herbivorous, and one was a filter feeder. Of the 52 species and relatives that survived, 45 were carnivorous or insectivorous, six were omnivorous, and one was a filter feeder (tabulated from Archibald, 1996). Mammals show the greatest evolutionary change among vertebrates through the K-T transition. Of the 18 species known to appear in the interval just after the K-T boundary in Montana, eight were herbivorous, nine were omnivorous, and one was carnivorous or insectivorous (Lofgren, 1995). Thus, if we can say anything, it is that more herbivores became extinct than omnivores, and the least extinction occurred among carnivores and insectivores. However, new species of herbivores and omnivores appeared, resulting in no net transition to insectivores.

It is clear from modern case studies that aquatic vertebrates suffer most from acid rain (Cox, 1993). As pointed out by both supporters (D'Hondt et al., 1994) and doubters (Weil, 1994a, 1994b) of the acid rain scenario, aquatic vertebrates show among the highest survivorship—exactly opposite acid rain predictions. Retallack's suggestion that "calcareous smectitic soils" may have buffered the aquatic systems does not accord with what is known of modern lakes that remain acidic even though they are underlain by limestone (Pollman and Canfield, 1991). Further, Retallack was assuming that the calcareous component of the rocks that we see in the field is the same as that of the original soils. It is more likely that these calcareous components are of diagenetic origin, deposited from ground waters long after the soil formed and was buried. Even more troubling is that we don't know the lateral extent of the paleosol types and compositions that Retallack discusses, as they are from a single stratigraphic section in eastern Montana.

What we know of the reaction to acid rain of extant vertebrates coupled with the K-T vertebrate record provides no support to the kind of acid rain scenario proposed by Retallack (1996).

REPLY

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My position on differential extinction across the K-T boundary was merely to agree with previously published views (Sheehan and Hansen, 1986; Sheehan and Fastovsky, 1992) that insectivores were least affected among land animals. I am pleased that Archibald agrees with this, and apologize for the misleading terseness of my paper (Retallack, 1996). Large carnivores and herbivores were very hard hit. The dominant latest Cretaceous, duckbill and ceratopsian dinosaur herbivores had specialized dental batteries with no parallel among Late Cretaceous or early Paleocene mammals that Archibald interprets as herbivores. Herbivore extinction is an expectation of a life crisis that involved acidification that would brown leaves. Another expectation is the transition observed in K-T vegetation from evergreen dicots to deciduous dicots and conifers (Retallack, 1996). Yet another indication of acid trauma is the heavy extinction of freshwater molluscs across the K-T boundary in the northern Great Plains states (documented by Hartman, 1996). Aquatic vertebrates were less affected, as Archibald emphasizes, but this does not mean there was no acid. The bioassay implied by decimation of aquatic molluscs, but not aquatic vertebrates, is that ground-water pH depression was between 5.5 and 4. My proposal for atmospheric scrubbing and soil buffering was to explain this modest acidification compared with the dire predictions of some impact scenarios and from observed leaching of the boundary bed.

Much of the carbonate and smectite in latest Cretaceous paleosols of Montana can be shown to have originated in soils, because of petrographic observations of diffuse micritic nodules replacing clay skins and grains and filling etch pits in grains (McSweeney and Fastovsky, 1990, Fig. 6). There also are minor detrital grains and burial cements in sandstones (Retallack et al., 1987; Retallack, 1994). Other evidence for pedogenic origin of most of the carbonate and smectite is the remarkably uniform composition and appearance of the clayey paleosols in the Hell Creek Formation from Buffalo, South Dakota, to Marmarth, North Dakota, to Jordan, Montana—some 400 km. Archibald's implication that my Bug Creek and Hell Creek sections are atypical is at variance with my observations and those of others (Fastovsky and McSweeney, 1987; McSweeney and Fastovsky, 1987).

Archibald's comment takes what I consider the simplistic view that acidification is either present or not, when there are widely differing degrees of acidification, which I calculated. Weathering is a process of acidification and every buffer has a finite capacity. Although Florida has much carbonate bedrock, acidic seepage lakes occur in areas dominated by base-poor soils (Ultisols, Spodosols: Pollman and Canfield, 1991), very different from the base-rich latest Cretaceous paleosols of the Hell Creek Formation. Given my agreement with Archibald on selective extinction of acid-prone organisms of latest Cretaceous ecosystems, the question is not whether there was acidification at the K-T boundary, but how much.

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