

Dinosaur abundance was not declining in a "3 m gap" at the top of the Hell Creek Formation, Montana and North Dakota: Comment and Reply

COMMENT

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The study of dinosaur abundance in the Hell Creek Formation by Sheehan et al. (2000) raises three points that require comment. Additionally, some of their history of the "3 m gap" requires emendation. As the authors correctly state, in the late 1970s and early 1980s various workers observed that dinosaur remains seemed to be absent or rare in the upper 3 m of the Hell Creek Formation in northeastern Montana. As Sheehan et al. note, this was subsequently seen as a geographically wider phenomenon. It must be emphasized that this was first noted before the 1980 publication of the seminal Alvarez et al. (1980) paper on asteroid impact as a cause of Cretaceous-Tertiary extinctions, and thus was, at least at first, not used in argumentation about the asteroid impact extinction theory. In addition, it was not as the authors state that in the early 1990s "after dinosaur fossils and footprints were found in the gap, [that] it came to be viewed as an interval of rare fossils." Rather, earlier, during the mid-1980s, University of California—Berkeley crews explored this "gap" and found that the uppermost Hell Creek and lowermost Tullock Formations were quite rare in fossil vertebrates, not just dinosaurs (Bryant, 1989). I cannot speak for other authors, but since this work over ten years ago I have not, as the authors state, used this gap as an argument for gradualist extinction. What I said in the book (Archibald, 1996, p. 47) that they cite is "does this mean that one can argue that the gap represents a true disparity in time between dinosaur extinction and asteroid impact? I think the answer is no. . . ." I went on to cite possible reasons for such a gap, none of which suggested it had anything to do with various theories of dinosaur extinction.

Although the results of these authors are intriguing, they must be placed in the context of older and newer work. They too lightly dismiss others' work when they note that in previous studies there was a ". . . lack of rigorous documentation of low dinosaur abundance in the [3 m] interval. . . ." In her 1989 monograph Bryant discusses the work of University of California—Berkeley crews in which few vertebrate fossils were found in the upper Hell Creek and lower Tullock Formations in McCone and Garfield Counties. She specifically noted the highest being 1.9 m below the formational and Cretaceous-Tertiary boundaries. One of the areas the authors include in their analysis, Marmarth, North Dakota, has been the subject of an ongoing project by Pearson since 1986. To date, over 10000 specimens have been recovered (Pearson, 1999). He found that different levels within the Hell Creek Formation near Marmarth show varying levels of fossil abundance. One of these is the last few meters at the top of the Hell Creek Formation, which has a lower abundance. Thus, we have two studies that suggest that there is an interval of lower fossil abundance near the top of the Hell Creek and one that suggests there is no such interval. More importantly, the first two studies examined all vertebrates, while Sheehan et al. limited themselves to less than 20% of the vertebrate taxa—the non-avian dinosaurs. We have not reached a definitive answer to this problem. The Sheehan et al. (2000) study simply does not address the broader issue of whether there is a lower abundance of fossil vertebrates within the uppermost few meters of the Hell Creek Formation.

The authors discuss the issue of reworking of fossils into higher stratigraphic levels, arguing that this is not a problem in their study areas. This is

a concern, however, especially in sedimentary facies that are part of fluvial systems, such as the Hell Creek Formation. Thus, their highest dinosaurian remains near the top of the Hell Creek Formation could have been reworked from lower in the section. As they note, "in spite of a concentrated effort, no dinosaur fossils were found by our crews above the Hell Creek Formation." What they do not make clear is that overlying Paleocene strata in their study areas, with possibly one exception (e.g., Hunter et al., 1997), are vastly less rich in vertebrate fossils than comparably aged sites to the west in McCone and Garfield Counties. Thus, the lack of dinosaurs from overlying Paleocene strata tells us nothing in their sections. By comparison, in Paleocene sites in McCone County, dinosaur bones and teeth, and Lancian (late Maastriichtian) mammals are very common and are almost certainly reworked, as Lofgren showed in his monographic treatment at McGuire Creek (Lofgren, 1995). Thus, when one has a more completely fossiliferous section across the Cretaceous-Tertiary boundary in the upper Great Plains, the problem of reworking becomes quite obvious. As I have not worked in the authors' study areas, I cannot offer an opinion as to whether reworking is a problem with their study. What we know of more fossiliferous sections, however, strongly indicates that reworking must not be so lightly dismissed.

Finally, I cannot agree with Sheehan et al. (2000) that the issue of "a 3 m gap at the top of the Hell Creek Formation. . . is pivotal to understanding the pattern of dinosaur extinction." As I noted, I have not even thought it much of an issue for some 10 years. A far more important question is the pattern and amount of extinction of all vertebrates, not just dinosaurs. As is now well documented by specimens housed in museums, as compared to the field survey of these authors, the level of extinction for vertebrates in the one area for which we know it (northeastern Montana) is about 50% for some 107 species (about 10% higher than comparable intervals before and after). Furthermore, 75% of the disappearances are concentrated in just 5 of 12 monophyletic taxa—sharks, lizards, ornithischians, non-avian saurischians, and marsupials (Archibald, 1996). Such differential patterns and levels are not "consistent with an abrupt extinction event that coincided with a bolide impact" (Sheehan et al., 2000, p. 525), but instead argue for a more complex set of events as causal factors for extinction at the Cretaceous-Tertiary boundary. Thus, the vertebrate rather than just the dinosaur record does argue that the impact was at most a coup de grace.

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