

WERE PERMIAN-TRIASSIC EXTINCTIONS SUDDEN AND CAUSED BY IMPACT? C.R. Chapman. Southwest Research Inst., #400, 1050 Walnut St., Boulder CO 80302 USA. E-mail: cchapman@boulder.swri.edu.

The K-T mass extinction was very sudden (e.g., >70% of Cretaceous forams went extinct simultaneously, within the precision of the marine fossil record [1]). The Chicxulub impact clearly caused the K-T boundary. But geologic records are less complete for other large, earlier mass extinctions and the chances are poor that causal craters remain. For the biggest one, the P-T, equivocal evidence for impact has been debated and many alternative causes have been advanced [cf. 2]. Here I evaluate a recent claim [3] that there was a gradual component to extinction of vertebrates before the P-T. I then discuss why impacts by near-Earth objects (NEOs) should be regarded (a) as the "null hypothesis" or mostly likely cause of mass extinctions, barring disproof, rather than (b) as just one of many possible causes or even the explanation of last resort, which remains a common perspective among paleontologists.

Ward *et al.* [3] argue for some P-T gradualism and also "that at least some species originated" before the boundary. Neither conclusion is supported by their data. They define a zero-level plausibly marking the sudden event. They claim that vertical distributions of 126 fossil skulls from 21 taxa collected in the Karoo Basin negate a wholly sudden mass extinction. Their case for gradualism rests on just 9 skulls in 3 taxa, distributed over 60m below zero. About 5 other taxa plausibly went extinct at zero, ~3 others passed through, and ~8 taxa originated above zero-level (the extinction opened ecological niches, plausibly fostering speciation).

The uppermost skull of the 3 critical taxa was ~10m below zero. The case for gradualism depends on a statistically conclusive tendency for these skulls to be absent as the zero-level is approached. Yet in 10 random trials distributing 9 items between 0 and -60, 3 show an even stronger avoidance of the zero-level than do the actual data. Plainly, there is no robust case for a gradual extinction. (One of the 3 taxa is actually useless, despite being claimed as having the highest confidence, 0.875, of all. Based on just 2 skulls from the same depth [~-52m], it provides no evidence about extinction. The other 2 taxa have claimed confidences of just 0.5.) Ward *et al.* violated their adopted methodology [4] in many ways. Even had correct methods been used, there would still be less than 1-sigma confidence that there was a gradual component to P-T extinctions. Statistics of 9 fossils are hardly worthy of a 5-page report in *Science* and wide coverage by the news media.

Indeed, such statistics of fossils from a non-marine, terrestrial environment may reflect evolving Karoo ecology and simple migrations of species around Pangaea, rather than extinction. Astronomical evidence is that impact of one or more NEOs larger than the K-T boundary extinctions is statistically likely in the past 0.5 Gyr; the Earth can hardly have avoided the inevitable, horrific resulting consequences [5]. Thus, absent countervailing evidence or some other equally sudden, energetic modifier of the ecology (no terrestrial alternative is so sudden or energetic), presumption must favor the inevitable NEO impacts to explain mass extinctions.

References: [1] Paul C.R.C. 2005. *Palaeogeography*, in press. [2] Erwin D.H. et al. 2002. *USGS Spec. Paper 356*, 363-383. [3] Ward P.D. et al. 2005. *Science* 307:709-714. [4] Wang S.C. & Marshall C.R. 2004. *Paleobiology* 30:5-18. [5] Chapman C.R. 2002. *USGS Spec. Paper 356*, 7-19.