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The stratigraphy of mass extinction

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The discovery of the end-Cretaceous bolide impact and the recognition of mass extinctions through taxonomic compendia triggered keen interest in the stratigraphic pattern of species extinctions. A principal question has been whether patterns of fossil occurrence indicate gradual, stepwise, pulsed, or instantaneous extinction. Based on principles of sequence stratigraphy, marine ecology, and evolution, numerical models of fossil occurrences in stratigraphic sections indicate that the last occurrence of fossils does not generally indicate the time of extinction but is instead controlled by stratigraphic architecture. These models have been confirmed in multiple field studies from different sedimentary basins of different ages. These models identify several distinct processes controlling the last occurrence of fossils. Anything that lowers the probability of collection of a species, such as peak abundance or environmental tolerance, causes the last occurrence to be shifted backward in time relative to the time of extinction. Sequence-bounding subaerial unconformities generally also force the last occurrence backward in time, except in the case of reworking, which may place fossil remains in rocks younger than the time of extinction. Unconformities also cause last occurrences of multiple species to be clustered as a result of the hiatus. Surfaces of abrupt facies change, such as flooding surfaces and surfaces of forced regression, also cause last occurrences to be clustered, with such clustering reflecting the environmental preferences of species. Stratigraphic condensation can also cause clustering of last occurrences. All of these surfaces - subaerial unconformities, flooding surfaces, surfaces of forced regression, and condensed horizons - have highly predictable positions with depositional sequences. Thus, it is the normal expectation that last occurrences should be clustered in the fossil record, that these clusters should occur in stratigraphically predictable positions, and that these clusters arise even when extinction rates are constant through time. Many interpretations of the tempo of extinction based on stratigraphic patterns of last occurrences need to be reinterpreted in light of the sequence stratigraphic record. In particular, double-pulsed extinctions are a common result of prolonged elevated extinction, with clusters of last occurrences produced by subaerial unconformities, flooding surfaces surfaces of forced regression, and condensed horizons.