

GUIDELINES FOR INTERPRETING THE STRATIGRAPHIC RECORD OF EXTINCTIONS: DISTINGUISHING PATTERN FROM ARTIFACT

HOLLAND, Steven M., Department of Geology, University of Georgia, Athens, GA 30602-2501, U.S.A.

Extinction episodes, such as mass extinctions, biomere boundaries, and coordinated stasis turnover events, are typically studied by examining the record of last occurrences (LAD) of taxa in single outcrops, despite the fact that biases introduced by sampling, taphonomy, facies control, and depositional sequences can be more intense at the outcrop scale than in coarser-scale compilations. These processes can not only suppress the intensity of extinction pulses, but are also capable of generating artifactual LAD pulses that can be easily mistaken for true extinction events.

Numerical simulations were used to formulate a set of guidelines for distinguishing extinction-driven and artifact-driven pulses of last occurrences. The basic model has been previously published (Holland, 1995), but includes Gaussian facies control of taxa with respect to water depth, cyclically varying water depths within a series of parasequences and depositional sequences, and stochastic origination and extinction. A set of sequences varying in duration and water depth were simulated but were typical of cratonic and upper coastal plain sequences in that they consisted of a non-depositional lowstand (LST), a relatively brief transgressive systems tract (TST), and a relatively long highstand systems tract (HST). Extinction risk over time was modeled in four ways: (1) time-homogeneous, (2) time-homogeneous with a pulse of higher risk, (3) time-homogeneous with an interval of higher risk, and (4) episodic extinction risk.

The time-homogeneous model did not produce pulses of elevated extinction, yet consistently generated artifactual LAD pulses amid a low background level of last occurrences. Sequence boundaries were preceded by a pulse of last occurrences dominated by taxa that went extinct during the LST. TST flooding surfaces were preceded by pulses of last occurrences dominated by shallow water stenotopes that became extinct prior to the reoccurrence of shallow water facies in the subsequent HST.

Although they also generated the same artifactual LAD pulses, the other three models also generated LAD pulses that coincided with true extinction pulses. These pulses could be recognized as true extinction events whenever they occurred within the HST and the TST, but not when they occurred in the LST, at sequence boundaries, or at TST flooding surfaces. These true extinction pulses also caused the artifactual pulses at earlier sequence boundaries and TST flooding surfaces to be more intense than normal, but this increased strength would be difficult to recognize in actual field studies. In some cases, these precursor LAD pulses preceded the actual extinction by several million years. Among all the models, the episodic extinction model was unique in that it lacked the steady background numbers of LAD found in all the time-homogenous extinction runs.

In general, any LAD pulse that corresponds with a sequence boundary or a TST flooding surface should be viewed as a potential artifact. For example, clusters of last occurrences reported at the Permo-Triassic boundary in the Alps occur at TST flooding surfaces and may well be artifacts, not true extinction pulses. LAD pulses occurring within the HST and within the TST (but not at flooding surfaces) are likely to be biologically real. A lack of steady background LAD may indicate that episodic models of extinction are more appropriate than time-homogenous models.

Holland, S.M. 1995. The stratigraphic distribution of fossils. *Paleobiology*, 21:92-109.