ated or that these forams have been reworked from Paleocene beds on the crater rim that were previously thought to postdate the crater.

Our ⁴⁰Ar⁻³⁹Ar age of 49.15 ± 0.18 Ma implies that the Kamensk structure is early Eocene, not Paleocene or KT boundary age. This isotopic age, recalculated using a reference age of 520.4 Ma for MMB-1, is 49.84 ± 0.18 Ma, which is identical (within experimental error) to the 50.5 ± 0.8 Ma age reported by Bottomley and York [10] for the 50-km-diameter Montagnais impact structure on the continental shelf off Nova Scotia. This close match in age for the two impact structures may only be fortuitous, but alternatively, it might indicate that both impact structures formed during nearly simultaneous impacts of large fragments of a single disrupted comet.

It is also of interest to try to place Kamensk on the standard paleontologic and magnetostratigraphic timescales. If one uses the Harland et al. [11] or DNAG timescales, an age of 49.84 Ma would fall in chron 21N, and fossil plankton zones P10, CPI2, and NPI4. Harland et al. [11] or DNAG timescales, an age of 49.84 Ma would also fall in chron 21N, and fossil plankton zones P10, CPI2, and NPI4. From stepwise alternating field demagnetization measurements of the single specimen of core, we believe that we have recovered the orientation of the specimen and tentatively conclude that the characteristic magnetization is reversed and consistent with an age assignment to chron 22R.

References:  

MASS EXTINCTIONS: PERSISTENT PROBLEMS AND NEW DIRECTIONS. D. Jablonski, Department of the Physical Sciences, University of Chicago, 5734 South Ellis Avenue, Chicago IL 60637, USA.

Few contest that mass extinctions have punctuated the history of life, or that those events were so pervasive environmentally, taxonomically, and geographically that physical forcing factors were probably involved. However, consensus remains elusive on the nature of those factors, and on how a given perturbation (impact, volcanism, sea-level change, oceanic anoxic event) could actually generate the observed intensity and selectivity of biotic losses. At least two basic problems underlie these long-standing disagreements: (1) difficulties in resolving the fine details of taxon ranges and abundances immediately prior to and after an extinction boundary and (2) the scarcity of simple, unitary cause-and-effect relations in complex biological systems.

Detailed Stratigraphic Patterns: Local outcrops and cores are the ultimate source of the data used to analyze mass extinctions, but the pitfalls to taking local data at face value are still little appreciated, resulting in massive overinterpretation of paleontological patterns. The accumulation of sediments and fossils is discontinuous and environmental change is the rule, so that temporal gaps and stepped extinctions are inevitable on some scale in any local sequence. Further, reworking and time-averaging mix fossils from successive intervals; radiocarbon dates on shells collected from surface sediments and forams in core tops indicate a time-averaging window of 10⁻¹⁰⁻¹⁴ yr in marine shelf and deep-sea sediments alike [1]. Statistical protocols are available to test for artificial extinction steps and to place confidence limits on stratigraphic ranges [2,3], but to date these have seen little use in the mass extinction literature: nearly all workers wants to take their data at face value and as virtually devoid of local overprint. Clearly, the answer to this problem is to test patterns against an appropriate null hypothesis.

Inferring Cause from Effect: One fundamental obstacle in linking extinction patterns and hypothesized forcing factors resides in the nature of complex systems: nonlinearities, thresholds, and elaborate feedbacks often rule out the reconstruction of simple cause-and-effect cascades. The same forcing factor might have radically different effects depending on the state of the system at the time of perturbation, and several alternative forcing mechanisms might produce the same biotic response. The survival of an evolutionary lineage during a mass extinction, for example, could be because it (1) lived in a habitat that was not stressed, (2) possessed a physiology or life habit that allowed it to survive in a stressed habitat, (3) was so widespread that its range includes a locality that provided a refuge, and so on. Urgently needed is not another catalog of potential reasons for survival or extinction, but the development of protocols for testing the alternatives. This is partly a matter of constructing large, robust databases amenable to statistical analysis, and coming to grips with the need to integrate local and synoptic databases. With sufficient tuning, the long list of potential KT killing mechanisms can indeed account for virtually any conceivable extinction pattern; therefore, while the mere fact of observed selectivity clearly is no argument against impacts, neither is it an argument in their favor. The time for consistency arguments is past: hypothesized extinction mechanisms need to generate unique predictions on the timing, selectivity (taxonomic, biogeographic, ecologic), or other biotic patterns to advance beyond the status of plausible alternatives.

Selectivity is still a neglected area of study for mass extinctions, and even negative results will be important here. Selectivity is played out, if at all, at lower taxonomic levels (families and genera), biogeographically, or ecologically, and the relevant parameters are largely absent from the synoptic databases [4]. Consider the problem of multiple causation for one general pattern: the apparently higher extinction intensities in the tropics. The question is whether the greater losses of shallow-water late Devonian corals relative to deep-water genera, or of symbiont-bearing KT corals and rudist bivalves relative to nonsymbiotic corals and non-rudist bivalves, occur because (1) tropical biotas in general are fragile, perhaps because their species are adapted to a narrow range of climatic and other conditions; (2) reef communities in particular are such a tightly woven network of biological interactions that the initial removal of the same proportion of species as were lost at high latitudes could be more disruptive; and that tropical biotas contain a large proportion of extinction-prone endemics, so that losses are high here owing to biogeographic structure; or (4) the favored habitat of reef communities, low-sedimentation, and low-nutrient shallow-water platforms or ramps, is itself easily disrupted [5,6]. Some support exists for
of extinction mechanisms and biological consequences, both for the
have a similar basis. The statistical dissection of alternative mecha-
suffered no greater losses than did extratropical faunas [8]; the
bivalves found that tropical settings outside the carbonate platforms
Second, a global analysis of end-Cretaceous extinction in marine
(3) and (4). First, among-province variation in mass extinction
intensities within latitudinal belts tends to be positively related to
the proportion of endemic genera in the preextinction biota [7].
Second, a global analysis of end-Cretaceous extinction in marine
bivalves that found that tropical settings outside the carbonate platforms
suffered no greater losses than did extratropical faunas [8]; the
reported latitudinal gradient in plankton extinction intensities may
have a similar basis. The statistical dissection of alternative mecha-
nisms offers considerable promise for improving our understanding of
extinction mechanisms and biological consequences, both for the
Big Five mass extinctions and for the smaller extinction maxima
that occur throughout the Phanerozoic.

The initial physical and biological conditions must play a role in
the biotic response to a perturbation. Perhaps, for example, impacts
or volcanism at times of low relative sea level yield greater taxonomic
losses than the same event at times of high sea level when the
thermal inertia and other ameliorating effects of shallow seas
are prominent. This frequent suggestion has yet to be modeled
rigorously, let alone tested empirically, but may help to explain
why some geologically detectable impacts evidently had negligible
biotic effects. The global biota or even individual taxa may vary in
relative extinction vulnerability through time. For example, it may
take time to accumulate a new crop of extinction-prone taxa after a
major extinction event has removed all but the hardiest lineages.
Conversely, lineages may evolve in directions that make them less
vulnerable to successive perturbations. Such biotic lags and long-
term shifts might explain waiting times between extinction events [9,
but see 10], and the differential responses of individual taxa to
successive extinctions [7].

The evolutionary impact of mass extinctions is another active area
of research. Many of the biotic replacements once thought to repre-
sent competitive victories over inferior lineages now appear to have
been mediated by major extinction events, even though most species
extinctions in the fossil record, probably >90%, occur outside the
five major extinction events [11]. Mass extinctions have such pro-
found biological consequences because they bite deep into standing
diversity and disrupt background selection regimes, not because they
account for most species terminations. Traits that favor survival
during mass extinctions need have little correlation with those that
enhance survival and diversification during background times, so
mass extinctions can have unpredictable and lasting evolutionary
effects [5,7]. Not only do mass extinctions remove taxa and adapta-
tions well-suited to the background regimes that represent the great
bulk of geologic time, they create ecological and evolutionary oppor-
tunities by removing incumbent, dominant taxa and enabling other
taxa to diversify in the aftermath of the extinction event. On the
other hand, mass extinctions do not completely reset the evolutionary
clock: many major evolutionary and ecological trends transcend
even the Big Five events (e.g., the modernization of marine communi-
ties, the rise of flowering plants, and of predatory neogastropods).
We need to understand survivors and rebounds as well as victims and
ecosystem collapse.

Paleont. Soc., Short Courses in Paleontology, 6, Univ. of Tennessee,
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GLOBAL BIOTIC EFFECTS OF THE KT BOUNDARY
EVENT: MASS EXTINCTION RESTRICTED TO LOW LATITUDES? G. Keller, Department of Geological and
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One of the most important recent developments in KT boundary
studies is the growing awareness that (1) the mass extinction associ-
ated with this event is not the result of a single catastrophe, (2) that
extinctions occurred over an extended time period and were selective
rather than random within organismal groups as well as between
different groups, and (3) that the biotic effects were most severe and
sometimes limited to tropical-subtropical regions while high-latitu-
due faunas and floras escaped virtually unscathed. The growing
global body of high-resolution faunal and floral data upon which
these observations are based now provides the empirical database
and the opportunity to test various KT catastrophe scenarios whether
volcanic or bolide-impact based. Moreover, specific details of these
scenarios can now be tested, including the dust cloud-darkness and
shutoff of photosynthesis, acid rain, nuclear winter, and global green-
house scenarios all presumably leading to global mass extinctions.
Unfortunately, there has been no serious test of these scenarios based
on empirical data, largely because (1) many catastrophists ignore
paleontologists' data and interpretations that widely disagree with
their theories, (2) many paleontologists ridicule catastrophists' theo-
ries for which they see no basis in the fossil record, and (3) experts
disagree among themselves depending on which side of this scien-
tific chasm their sympathies lie. Despite these seemingly insur-
mountable differences, there is hope for a growing interdisciplinary
discourse as both sides accumulate and synthesize more observa-
tional data. All scientists agree that a major environmental change
occurred across the KT boundary; they disagree on the cause, whether
impact or volcanism, and on the biotic effects of this environmental
change. Here I will address the latter. Ultimately it is the biotic data
that must determine how significant a bolide impact or massive
volcanism at KT boundary time was for life on Earth.

The planktic foraminiferal record has played a unique role in the
KT boundary controversy. Near the base of the food chain, these
single-celled marine plankton are both sensitive to environmental
changes and a critical food source for higher, more complex organ-
isms. Moreover, they have long been known to undergo a virtually
complete faunal turnover between the end of the Cretaceous and
early Tertiary with deep-sea studies documenting a sudden mass
extinction at the boundary [1–3]. This prior interpretation cannot be
supported by subsequent studies for three major reasons. First, this
conclusion was originally based on deep-sea sections that have been
subsequently shown to contain major hiatuses spanning from 60 k.y.
to 500 k.y. of the basal Tertiary [4,5]. In these sections extinctions
and originations, spanning as much as 0.5 m.y. across the KT transi-
tion, are artificially concentrated at one horizon giving the appear-
ance of a sudden catastrophic mass extinction. In contrast, shallow