

The Interaction of Impact and Volcanism at the end of Earth's Cretaceous Period

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Earth's biosphere has suffered several mass extinctions which fundamentally reshaped terrestrial ecosystems. The Cretaceous Paleogene boundary (KPB) extinction eliminated non-avian dinosaurs and ushered in the Age of Mammals, eventually including humans. Endogenous and exogenous causes have been hypothesized for the KPB, represented by Deccan Traps volcanism and the Chicxulub bolide impact, respectively. The other two most severe extinction events (end-Permian and end-Triassic) are clearly associated with massive flood volcanism but not impacts.

High-precision ⁴⁰Ar/³⁹Ar geochronology establishes that the KPB was coincident with the Chicxulub impact [Renne et al., 2013]. Modern ⁴⁰Ar/³⁹Ar [Renne et al., 2015] and U/Pb [Schoene et al, 2015] geochronology has also established that both of these events occurred during the ~700 ka temporal span of the Deccan eruptions exposed in the iconic Western Ghats (WG) of India. It is increasingly clear that the Deccan magma system underwent profound changes at the inception of the Wai Subgroup, which may contain >70% of the erupted Deccan volume. These changes, including increased lava volumes and mean magma production rate, and decreased crustal contamination of erupted magmas, collectively imply a state shift in the Deccan magma system. The temporal coincidence, to within <50 ka, of the state shift with such a statistically rare event as the Chicxulub impact is highly improbable unless they were genetically related. Accordingly, the Deccan state shift may have been triggered by the far-field seismic effects of the Chicxulub impact [Richards et al., 2015], including a transient crustal permeability increase and rapid induced volatile exsolution.

Other extinctions coeval with flood volcanism but without clear evidence for impact suggest that the former may be sufficient to destabilize the biosphere. However, if these magma systems tend towards a critical internal pressure state, other triggers such as unusually large earthquakes may induce accelerated eruption with significant environmental consequences. Further high-precision geochronology is needed to resolve changes in tempo in such systems.

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