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Impacts, volcanism, sea-level and climate fluctuations : a multi-causal scenario for the Cretaceous-Tertiary mass extinctions

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Mass extinctions events occur in Earth history when environmental stresses exceed tolerance limits for organisms and consequently lead to their extinction. The magnitude of the extinction depends on the kind of stress, various environmental factors and the tempo at which stress is imposed; the latter determines whether a mass extinction is gradual or sudden. A multiproxies study is therefore of great interest for a better understanding of the causes which led to a mass-extinction. Paleontologic, climatic and ecologic data reviewed here thus provide strong evidence for a progressive, rather than sudden, mass extinction pattern that began during the last 500 k.y. of the Cretaceous and culminated at the K-T boundary. No single kill mechanism can be identified for this extinction pattern. Evidence for a likely multi-event killing mechanism includes a series of rapid and extreme climate fluctuations associated with sea-level changes, a period of major volcanic activity prior and across the K-T boundary and asteroid or comet impacts (comet showers). Thus, the mass extinction resulted from an addition of unfavorable conditions, which includes long-term perturbations (e.g. Deccan traps volcanism, cooling, sea-level fluctuations) and short-term event asteroid impacts, giving the final stroke to an already stressed biosphere. Our multistratigraphical studies of numerous latest Maastrichtian sections (e.g. Negev, Tunisia, Israel, South Atlantic, Walvis Ridge DSDP 525) point towards increased volcanic input linked to Deccan volcanism leading to greenhouse warming due increased atmospheric CO_2. Our re-

cent investigations on intertrapean sediments located in the Rajahmundry area, eastern India indicate that major part of the traps were erupted before the KT boundary. Subsequent weathering (mainly into smectite clay mineral) of large areas of basaltic rocks may explain therefore the global cooling occuring at and after the KTB, by CO2 uptake due to alteration. A multi-impact scenario is now most consistent with the impact ejecta evidence. The first impact is associated with major Deccan volcanism and likely contributed to the rapid global warming between 65.4-65.2 Ma, decrease in primary productivity and onset of terminal decline in planktic foraminiferal populations. The K/T boundary impact marks a major drop in primary productivity and the extinction of all tropical and subtropical species. The early Danian global cooling may have contributed to the delayed recovery in productivity and evolutionary diversity.