



## **Mutagenesis in land plants during the end-Triassic mass extinction**

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During the last 600 million years of Earth history, four out of five major extinction events were synchronous with volcanism in large igneous provinces. Despite improved temporal frameworks for these events, the mechanisms causing extinctions remain unclear. Volcanic emissions of greenhouse gases, SO<sub>2</sub> and halocarbons are generally considered as major factors in these biotic crises, resulting in global warming, acid rain and ozone-layer depletion. The occurrence of increased abundances of malformed land plant spores and pollen during the end-Permian and end-Devonian events have mainly been attributed to increased UV-B radiation due to ozone layer depletion. Here, we report exceptionally abundant malformed fern spores in Triassic–Jurassic boundary successions in Denmark, Sweden, and Germany. The high occurrences of abnormal fern spores during and after the mass extinction interval indicate severe environmental stress and genetic disturbance in the parent plants. This coincides with increased levels of mercury – the most genotoxic element on Earth – in both marine and terrestrial Triassic–Jurassic boundary successions, and offers compelling evidence that emissions of toxic volcanogenic substances contributed to the end-Triassic biotic crisis.