



Refined Permian–Triassic timeline reveals early collapse and delayed recovery of the south polar terrestrial ecosystem

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The collapse of late Permian Gondwanan floras, and extinction of glossopterids, heralded the end of one of the most enduring and extensive biomes in Earth's history. The Sydney Basin, Australia, hosts a near-continuous, age-constrained succession of high southern palaeolatitude (~65–75°S) terrestrial conditions spanning the end-Permian extinction (EPE) interval. Sedimentological, stable carbon isotopic, palynological and macrofloral data were collected from two cored coal-exploration wells and correlated. Six spore-pollen biostratigraphic zones were identified within the uppermost Permian to Lower Triassic succession, corresponding to discrete vegetation stages developed before, during and after the EPE interval. Collapse of the glossopterid biome marked the onset of the terrestrial EPE and significantly predated the marine mass extinctions and conodont-defined Permian–Triassic Boundary. The EPE was characterized by collapse of the dominant Permian taxa; the immediate aftermath witnessed high abundances of opportunistic fungi, algae and ferns. This transition is coeval with the onset of a gradual global decrease in $\delta^{13}\text{C}_{\text{org}}$ and the primary extrusive phase of Siberian Traps Large Igneous Province magmatism. Primary gymnosperm groups of the Gondwanan Mesozoic all appeared in the region soon after the collapse, but remained rare throughout the immediate post-EPE succession. Faltering recovery was due to a succession of rapid and severe climatic stressors until at least the late Early Triassic. Concurrent with the Smithian–Spathian boundary (~249 Ma), indices of increased weathering, thick redbeds, and abundant pleuromeian lycophytes likely signify marked climate warming and intensification of the Gondwanan monsoon climate system.