Substantial high CO_2-driven reduction in plant transpiration links loss of terrestrial and marine biodiversity: deep time evidence.

MARGRET STEINTHORSDOTTIR1, F. IAN WOODWARD2, FINN SURLYK3 AND JENNIFER C. MCELWAIN4

[1]Department of Geological Sciences, Stockholm University, and Bolin Centre for Climate Research, SE-106 91 Stockholm, Sweden

[2]Department of Animal and Plant Sciences, Sheffield University, Sheffield, S10 2TN, UK

[3]Geological Institute, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark

[4]School of Biology and Environmental Science, University College Dublin, Belfield, Dublin 4, Ireland

CO_2 is obtained and water vapor simultaneously transpired through plant stomata, driving the water uptake of roots. Stomata are key elements of the Earth's hydrological cycle, since a large part of the evapotranspiration from the surface to the atmosphere takes place via stomatal pores. Plants exercise stomatal control, by adjusting stomatal size and/or density in order to preserve water while maintaining carbon uptake for photosynthesis. A global decrease in stomatal density and/or size causes a decrease in transpiration and has the potential to increase global runoff. Here we show, from 91 fossil leaf cuticle specimens from the Triassic/Jurassic mass extinction boundary (ca. 201 Ma) of East Greenland, that both stomatal size and density decreased dramatically, coinciding with major environmental upheaval, steeply rising CO_2 concentrations and negative C-isotope excursions. These developmental and structural changes in stomata are estimated to have resulted in a 50-60% drop in stomatal and canopy transpiration as calibrated using a stomatal model, based on empirical measurements and adjusted for fossil plants. Field evidence additionally indicates a change to increased erosion and bad-land formation at the boundary. We hypothesize that plant physiological responses to high CO_2 concentrations at the Triassic/Jurassic boundary increased runoff at the regional and perhaps even global scale, resulting in increased flux of nutrients from land to oceans, leading to eutrophication, anoxia and ultimately loss of marine biodiversity. High-CO_2 driven changes in stomatal and canopy transpiration therefore provide a mechanistic link between coeval patterns of terrestrial ecological crisis and marine mass extinction at the Triassic-Jurassic boundary.