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Air density of the Permian atmosphere: constraints from raindrop impact craters

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Unlike the composition of earth's ancient atmosphere, the corresponding air density is almost unknown, but can be estimated from the size of fossil raindrop impacts (Som et al. 2012). Their dimension is among other factors, controlled by air density, whereas large impacts form in a less dense atmosphere and vice versa. In this study we measured fossil raindrop impact craters preserved in Lower Permian terrestrial sandstones from the Flechting High, northern Germany. The substrate and raindrop size dependence on resulting raindrop impact was investigated through experiments with water droplets of measured volume falling with their terminal velocity on a disintegrated sandstone substrate. The experimental relation between raindrop momentum and imprint dimension can be used to estimate the palaeo-air density (Som et al. 2012). These estimates strongly depend on the unknown drop size distribution of the rain event that produced the measured fossil imprints. The maximum bound of the air density is $\sim$3.5 kg/m3, calculated assuming that the maximum measured imprint area of 67$\pm$1.5 mm2 was formed by the theoretically largest naturally occurring raindrop with a diameter of 6.8 mm. More probably estimates of maximum raindrop diameters for a rainfall rate of 100 mm/hr are between >3.2 and >4.3 mm (Willis and Tattelmann 1989; Ochou et al. 2007), yielding air density estimates for the Early Permian of $\sim$0.5 and $\sim$1.2 kg/m3, comparable to the present-day value of 1.2 kg/m3.

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