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Trends in atmospheric carbon dioxide concentration at the Oligocene-Miocene transition reconstructed by using fossil plant material

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The Oligocene-Miocene transition represents a period in earth history marked by rapid cooling and glaciation of Antarctica, accompanied by a positive shift in 13C and 18O. According to modelling studies, formation of substantial Antarctic ice sheets requires pCO2atm to decrease below 500 ppm. Various proxies (such as Boron isotopes and 13C isotopes derived from marine organisms, stomatal density of terrestrial fossil plants) indicate a substantial general trend of decline in atmospheric CO2, from the Late Oligocene to the Early Miocene, from about 600 to 300 ppm, with values of about 450 to 300 ppm for the Oligocene-Miocene transition.

Here we use stomatal density values of fossil plants spanning a time interval from the Middle Oligocene to the Early Miocene. This proxy is based on the stomatal density response to atmospheric CO2. We applied, however, an approach that is based on a mechanistic model which couples photosynthesis and transpiration to diffusion, supplemented by an ecophysiological optimization model that provides an optimum use of water (transpiration). This optimization principle describes the adjustment of stomatal conductance in such a way that the maximum possible photosynthesis is accomplished at a minimum of water loss. This optimization phenomenon is confirmed for extant terrestrial plants. The model requires palaeoenvironmental conditions (such as atmospheric humidity, temperature, wind velocity and water availability) and anatomical data (such as depth, length and width of stomatal pore, thickness of assimilation tissue and leaf length).

Fossil plant material from several European sites is considered so far: The Weisselster basin in Saxony (Germany), the clay pit Unterfeld near Wiesloch-Frauenweiler (Germany), and Oberdorf in Styria (Austria). In order to obtain meaningful results, we investigate several species of different families: Eotrigonbalanus furcinervis (Fagaceae), Quercus rhenana (Fagaceae), Quercus praerhenana (Fagaceae), Laurophyllum pseudoprinceps (Lauraceae), Laurophyllum acutimontanum (Laurceae) and Platanus neptunii (Platanaceae).

In this contribution, we present first results of atmospheric carbon dioxide spanning a time interval from the Late Oligocene to the early Miocene, calculated from fossil Eotrigonobalanus furcinervis (Fagaceae) and the two Lauraceae species, Laurophyllum pseudoprinceps and Laurophyllum acutimontanum (Weisselster basin). The combined results indicate preliminary values for atmospheric carbon dioxide concentration of about 360 ppm in the Late Oligocene, 650 ppm at the Oligocene-Miocene transition and 340 ppm in the Early Miocene.