Atmospheric CO$_2$ and Climate Variability During Antarctic Deglaciation in the Early Miocene

A rise in atmospheric CO$_2$ is believed to be necessary for the termination of large-scale glaciations. Although the Antarctic Ice Sheet is estimated to have melted from 125% to 50% its modern size, there is thus far no evidence for an increase in atmospheric CO$_2$ associated with the Mi-1 glacial termination in the earliest Miocene. I will present evidence from a high-resolution terrestrial record of leaf physiological change in southern New Zealand for an abrupt increase in atmospheric CO$_2$ coincident with the termination of the Mi-1 glaciation. The quantitative $p$CO$_2$ estimates, made using a leaf gas exchange model, suggest that atmospheric CO$_2$ levels may have doubled during this period, from $500 \pm 100$ ppm to $1100 \pm 400$ ppm, and subsequently returned back to $425 \pm 50$ ppm. The fossil leaves and $\delta^{13}$C measurements used to reconstruct atmospheric CO$_2$ are from a drill core of annually laminated sediments that accumulated in a maar crater lake for a $\sim100,000$-yr period, spanning the Oligocene/Miocene boundary. The lake had a large and stable anoxic zone leading to remarkable preservation of organic material, including exquisitely preserved fossil leaves. The terrestrial ecosystem surrounding the lake also responded to large-scale hydrological changes during the 100,000-yr period, and I will present a rationale for using leaf wax dD values and $\delta^{13}$C values to distinguish the ecosystem’s hydrological response from its response to atmospheric CO$_2$ changes. Lastly, using varve-thickness measurements from the drill cores, I will examine evidence for ENSO forcing of the climate of southern New Zealand during the early Miocene.