PALEO-ENVIRONMENTAL EFFECTS OF THE MID-PLEISTOCENE TRANSITION IN THE TROPICAL ATLANTIC AND EQUATORIAL AFRICA

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In this co-operative project between the departments MCG and MBT, supported by ALW, the tropical environmental changes at the start of the Late Pleistocene ice ages were investigated using lipid biomarkers and their stable carbon isotope compositions. At that time, the Mid-Pleistocene Transition (MPT) lasting from about 920 to 650 thousand years before present (kyr BP), the mean global ice mass increased and the 100-kyr cycle of the Late Pleistocene became established. The utilized lipid biomarkers are specific biochemicals derived from known organisms, such as haptophyte algae. If preserved in the sediments, they can provide insights in the past environmental conditions. The investigations were done on sediments from the Angola Basin in the tropical South Atlantic Ocean. The Angola Basin is characterised by strong seasonal changes in the atmospheric circulation. From June to August, strong southern Hemisphere trade winds blow over the Angola Basin transporting large amounts of atmospheric dust from dry areas in southern Africa. Wind-driven surface water mixing causes elevated surface water productivity by oceanic upwelling, i.e. supply of nutrients to the photic zone from below a shallow nutricline. From December to February, a strong monsoon with high precipitation in southern Africa leads to maximum Congo River discharge.

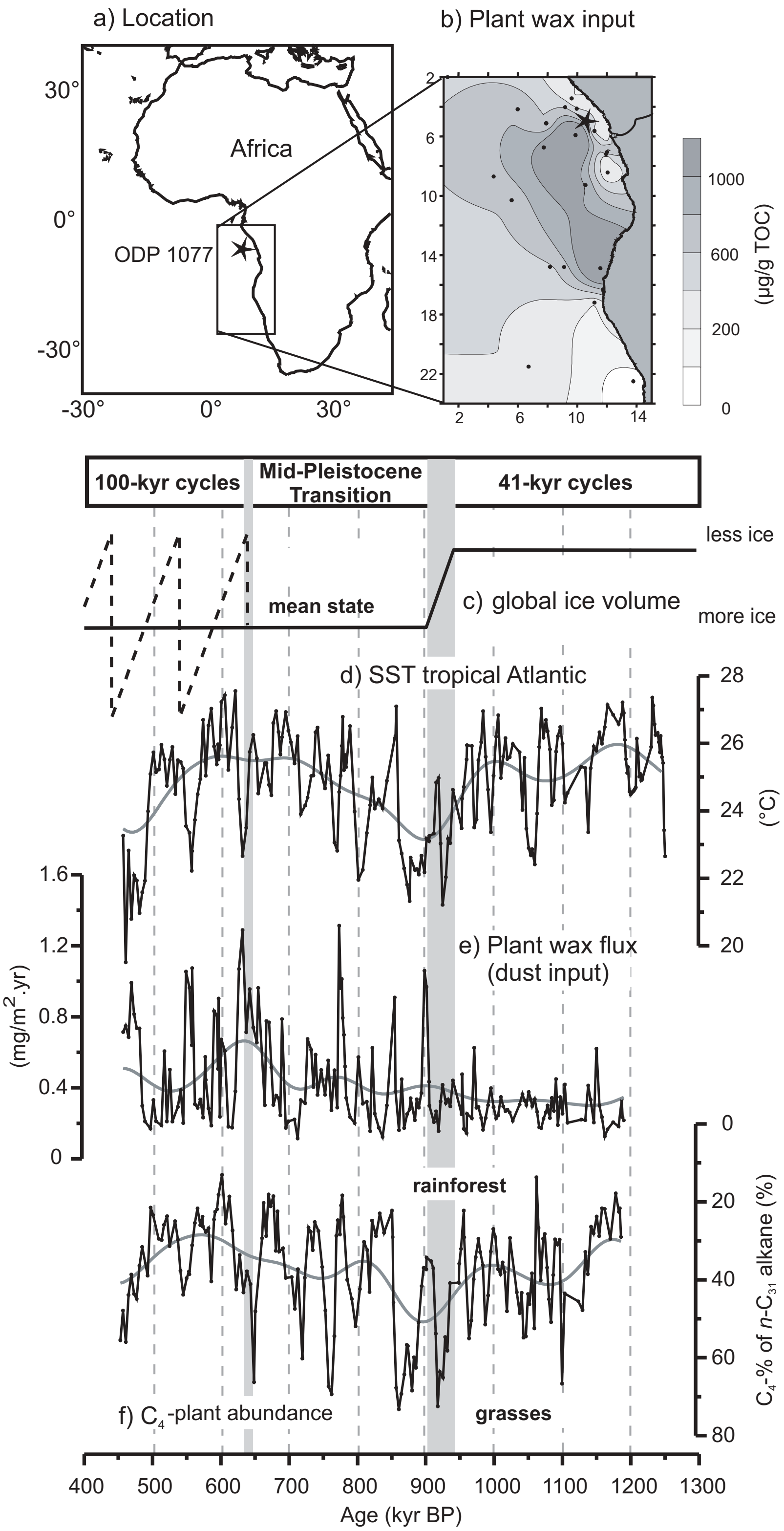
For an accurate understanding of the lipid biomarker variations and their significance, modem atmospheric-dust samples and surface-sediment samples were analysed. The lipid parameters were mapped in detail and linked to specific environmental conditions. The main lipids in the dust samples are derived from the epicuticular wax coating of terrestrial higher plants. Their stable carbon isotopic compositions appeared to primarily reflect the contemporary type of vegetation on the adjacent continent; the molecular parameters in the surface sediments reflect the main production, transport and preservation processes in the Angola Basin.

These findings were applied to the mid-Pleistocene time series derived from the Ocean Drilling Program (ODP) sediment core 1077 (lower Congo deep-sea fan). Surprisingly, the growth of the global ice mass led to a long-term warming of the tropical Atlantic Ocean during the MPT. This warming must be caused by the temporary but severe reduction of North Atlantic Deep-Water formation, the carrier of surface-water heat from the tropics to the high latitudes. The tropical sea-surface temperature (SST) variations followed the changing frequency behaviour of the high-latitude ice volume, i.e. the onset of the 100-kyr cycle. They responded, however, significantly earlier on the orbital insolation changes. This linkage indicates an early response of the tropics, which receive the largest part of the global insolation, on the changing surface thermal gradient of the South Atlantic.

After the growth of the global ice volume, the compression and energising of the atmospheric circulation cells stimulated the aeolian dust transport, significantly increasing the accumulation of plant wax lipids in the Angola Basin. The Mid-Pleistocene vegetation changes detected by the stable carbon isotopic compositions of the plant waxes, appeared strongly correlated with the tropical SST. Consequently, the low-Iatitude SST directly controls the African aridity via the tropical precipitation-evaporation balance and thus determines the large-scale vegetation type in southern Africa. The low SST at the beginning of the MPT thus led to an aridification of subtropical and tropical Africa, while the long-term warming caused the re-expansion of rainforest afterwards.

The environmental changes also had important effects on the marine ecosystem in the Angola Basin. The monsoonal forcing of river-induced productivity was dominant before the growth of the ice volume in the MPT, while afterwards the wind-driven upwelling of nutrient-rich deeper waters became more important for marine production. The strength of the upwelling depended mainly on the wind strength, which increased with growing global ice volume. Subsequently, the low-Iatitude forcing of marine productivity was suppressed.

This project thus provides new insights in the climate linkages between the high-Iatitudes and the tropics, and the effects of the marine environmental changes on the sensitive terrestrial and marine ecosystem.



a) Location of ODP Site 1077 in the Congo deep-sea fan. b) Plant-wax input into the Angola Basin, reflected by the concentrations of the C_{25} to C_{35} odd-numbered *n*-alkanes in surface sediments. c) Schematic evolution of the global ice volume during the Mid-Pleistocene Transition (MPT). d) Sea-surface temperatures during the MPT at Site 1077, determined with the alkenone-unsaturation method. e) Plant-wax input during the MPT, given by accumulation rates of the C_{25} to C_{35} odd-numbered *n*-alkanes. f) C_3- (rain forest) to C_4-plant (grasses) vegetation changes in subtropical and tropical Africa, derived from the ?^{13}C-values of the *n*-C_{31} alkane. The vertical grey bars mark the beginning en end of the MPT.