

# Did Hydrological Change Drive the Expansion of C<sub>4</sub> Grasslands in India during the Late Miocene?

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The vegetation change from C<sub>3</sub> forests to C<sub>4</sub> grasslands in India, Pakistan, and Nepal during the late Miocene has been well-documented, with previous records indicating that carbon isotope changes in paleosols from Pakistan and marine sediments from the Bengal Fan correspond with a C<sub>4</sub> plant expansion. The uplift of the Tibetan plateau, monsoon variability, late Cenozoic cooling, and hydrological changes have all been suggested as potential causes of the C<sub>4</sub> grassland expansion, but the ultimate driver of this shift is still unknown. We further investigated the cause of the expansion of grasslands in India around 8 million years ago by testing if hydrological change had an effect on the vegetation shift. We analyzed leaf wax biomarkers in Bengal Fan deep-sea core sediments deposited between 20 Ma and 0.5 Ma from ODP sites 717 and 718, where terrestrial sediments from the Indian continent are deposited on the sea floor from the Ganges and Brahmaputra Rivers. The n-alkane concentrations, as well as carbon and hydrogen isotope ratios of the n-alkanes, in these samples were measured in order to again observe when the vegetation shift occurred and to determine changes in moisture/continental aridity. We found that an increase in carbon isotopic ratios occurred very abruptly, in between 6.35 and 5.5 Ma, with C<sup>13</sup>/C<sup>12</sup> increasing from ~-32 per mil to ~-26 per mil, indicating the change from a C<sub>3</sub> woodland to C<sub>4</sub> grassland-dominated vegetation. A concurrent increase in hydrogen isotopic ratios was also observed, with D/H increasing by ~30 per mil around 7 Ma, about 1 Ma before the shift in C<sup>13</sup>. These enriched hydrogen isotope values suggest that increased aridity likely drove the C<sub>4</sub> expansion.