THE RISE OF ETHIOPIAN FORESTS

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An active rift system divides northeast Africa and has caused large-scale changes in regional topography, affecting patterns in climate and ecosystem structure. Although formation of the Ethiopian highlands is coupled to such rifting processes, its cause(s) and developmental timeline are subject to debate. The strong influence of topographic changes on (sub)tropical African ecosystems is suspected by paleontologists with respect to regional Ethiopian species shifts in the early Miocene, and indicates rifting processes might be recorded through ecologic change. In this study, we attempt to disentangle coeval landscape changes in topography, plant-type abundance and (hydro)climate via a multi-proxy approach.

Lacustrine mudstones (n = 96) deposited between 35 to 17 million years ago (Ma) were sampled from todays' Ethiopian highlands. We analysed the solvent-extractable organic matter of these sediments, including microbial lipids (GDGTs) and the stable carbon and hydrogen isotopic composition of plant-wax *n*-alkanes ($\delta^{13}C_{wax}$ and δD_{wax}). Furthermore, we analyzed today's isotopic signals in surface water (δD_{water}) and flora to delimit the current isotopic gradients against topography.

The results of our study show a complex isotopic pattern in various areas of Ethiopia during the Oligocene, turning into clearer trends throughout the Miocene. Oligocene samples show remarkable organic matter preservation (TOC values, 2 to 10%), and extreme isotopic variability of up to 6‰ for $\delta^{13}C_{wax}$ and 70‰ for δD_{wax}. Both $\delta^{13}C_{wax}$ and δD_{wax} values become progressively more negative from the late Oligocene to the mid-Miocene, indicating continuous evolution associated, for instance, with topographic uplift or climate. GDGT-derived temperature reconstructions show increasing temperatures from the late Oligocene to early Miocene, which could be related to global late Oligocene warming. Subsequently, global temperatures remain stable, but Ethiopian climate seems to cool. Low $\delta^{13}C_{wax}$ values (-32 to -35‰) and associated terpenoid data offer evidence of woodlands dominated by angiospermous species, which apparently grew denser over time. In contrast, most African environments feature reduced tree cover and instead form grasslands during the Miocene. We show possible scenarios between climate and topographic change to determine the environmental feedback. For instance, our δD data from modern river waters shows an average isotopic lapse rate against altitude of 1.4‰ per 100 m, which we use when reconstructing paleo-altitude.

In this study we unravel the complicated relationships between climate change and tectonic activity in the Ethiopian highlands. Using multiple, complementary proxies from terrestrial and marine sites, we can test how individual, though interrelated, factors are reflected through molecular isotopic information to reconstruct the formation of Ethiopian forests.