Late Cenozoic climate and habitat change in northwestern China from the carbon isotopic record of herbivore tooth enamel

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The Linxia Basin is located on the triple junction of the northeastern Tibetan Plateau, West Qingshui Mountain, and the Loess Plateau, and is delineated by high angle deep thrusts. The northern margin of the basin is 70-150 km south of Lanzhou, the capital of Gansu Province. The basin is filled with 700-2000 m of thick Tertiary deposits that are dominated by lacustrine mudstones and red clays punctuated by fluvial conglomerates or sandstones, and 30-200 m of Quaternary loess. The Linxia Basin is part of the regions with the richest Late Cenozoic mammal fossils in China as well as the whole Eurasia. The Late Oligocene Indricotherium fauna, the Middle Miocene Piatybelodon fauna, the Late Miocene Hipparion fauna, and the Early Pleistocene Equus fauna are the most representative in the Linxia Basin. Mammals are very sensitive to climatic and environmental changes. The strong uplift of the Tibetan Plateau during the Late Cenozoic greatly affected climate and environment, which would be reflected from the evolution of mammalian faunas. The Linxia Basin is located in the transitional zone between the Tibetan and Loess Plateaus. During the important period of the uplift of the Tibetan Plateau in the Late Cenozoic, the Linxia Basin has the mammal fossil assemblages, which can exactly determine geological ages, and the thick deposits, which can accurately reflect climatic variations. As a result, the Linxia Basin is the best site to study the uplift process of the Tibetan Plateau and its influence to climate and environment. For the study to the Tibetan Plateau, the Linxia Basin can correspond to or be better than the classical Siwaliks on the southern margin of the Tibetan Plateau.

The δ13C values of tooth enamel from 116 individual teeth, representing 18 different herbivore species and an age range from 28 Ma to 2.6 Ma, fall between −14.4 and −12.4‰, and indicate a diet dominated by C3 plants for all herbivores. The δ13C differences among species indicate a mixed habitat in the basin that probably included woodland-grassland mixture. C3 grasslands and forests throughout much of the Paleogene and Neogene. However, the Quaternary tooth enamel and soil δ13C values indicate that C4 grasses have become an important component of local ecosystems in the area since at least the Middle Pleistocene. This is in striking contrast to what was observed in Pakistan, Nepal, Africa and Americas where C4 plants expanded rapidly at about 5.8 Ma as indicated by a positive δ13C shift in mammalian tooth enamel and paleosols. The lack of evidence for C4 plants in the Linxia Basin prior to 2.6 Ma suggests that East Asian summer monsoon was probably not strong enough to affect this part of China throughout much of the Neogene. This implies that the Himalayan and the Tibetan Plateau may not have reached the present-day elevation, and extend to induce a strong monsoon circulation before 2.5 Ma and regional climatic conditions played an important role in controlling the expansion of C4 plants.

The average δ13C and δ18O values of tooth enamel of horses (a) and rhinos (b) from the Linxia Basin.