DENG Tao, 2013. Paleo-altimetry of the Tibetan Plateau as indicated by mammalian fossils. *Acta Geologica Sinica* (English Edition), 87 (supp.): 857-858.

Paleo-altimetry of the Tibetan Plateau as indicated by mammalian fossils

DENG Tao

Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, 142 Xizhimenwai Road, Beijing 100044

The Tibetan Plateau is the youngest and highest plateau on the earth, and its elevation reaches one-third of the height of the troposphere, with profound dynamic and thermal effects on atmospheric circulation and climate. The uplift of the Tibetan Plateau was an important factor of global climate change during the late Cenozoic and strongly influenced the development of the Asian monsoon system. However, there have been heated debates about the history and process of Tibetan Plateau uplift, especially the paleo-altimetry in different geological ages.

The Lunpola Basin in northern Tibet has well-developed Cenozoic strata and an average elevation of about 4700 mm above sea level (asl). The total thickness of Cenozoic deposits in the Lunpola Basin is over 4000 m, and consists of the Niubao Formation in the lower part and the Dingqing Formation in the upper part. Estimations of the paleo-elevation of the Lunpola Basin have been very different. During the deposition of the Dingqing Formation, the lowest estimate has been reported to be about 1000 m, but the highest published estimate is 4500 m. Recently, a humerus fragment of the Early Miocene rhino *Plesiaceratherium* was found in the Dingqing Formation, which was significant for age determination and the paleo-altimetry estimation. *Plesiaceratherium* has been inferred to live in subtropical and warm temperate forests, preferring a warm and humid climate. The correlations and adjustments based on modern alpine vegetation vertical zones in the Himalayas and the Early Miocene global climatic conditions indicate that the highest elevation in the Lunpola Basin at the time of the deposition of the Dingqing Formation could not have exceeded 3170 m asl. Thus, considering the ecological requirements of rhinos through a paleo-temperature adjustment for the Early Miocene, the most reasonable paleo-elevation for *Plesiaceratherium* is close to 3000 m asl.

The material of the three-toed horse *Hipparion xizangense* from Bulong, Biru in northern Tibet includes limb bones, especially distal elements, with an age of early Late Miocene at about 10 Ma. The metapodial proportions of *H. xizangense* are nearly identical to those of *H. primigenium* from Europe, indicating their common locomotive function, which means that *H. xizangense* was a woodland-forest horse and lived in a habitat with a lower elevation. Combining with the rodent *Brachyrhizomys naquensis* and the palm pollens in the same horizon, the forest where *H. xizangense* lived in should be lower than an elevation of about 2500 m asl.

Hipparion forstenae from the Gyirong Basin in southern Tibet is represented by skulls and mandibles, but lacking limb bones, with an age of late Late Miocene at 7.0 Ma. *H. forstenae* was widely distributed in Gansu and Shanxi provinces in eastern China with a lower elevation, so this species would have lived in similar environments in Gyirong. The presence of significant amounts of C_4 grasses in the diets of *H. forstenae* and other herbivores from Gyirong indicates that the climate in the area was much warmer and the elevation was much lower in that time than today. The carbon isotope data from the high Himalayas, after accounting for late Cenozoic global cooling and paleoatmospheric CO_2 levels, indicate that this part of southern Tibet was less than 2900~3400 m asl in the latest Miocene.

A well-preserved skeleton of the Pliocene *Hipparion zandaense* was found from the Zanda Basin in southwestern Tibet, with an age of 4.6 Ma. Morphological features indicate that *H. zandaense* was a cursorial horse that lived in alpine steppe habitats. Because this open landscape would be situated above the timberline on the steep southern margin of the Tibetan Plateau, the elevation of the Zanda Basin at 4.6 Ma ago was estimated to be ~4000 m asl using an adjustment to the paleo-temperature in that time as well as comparison with modern vegetation vertical zones. Thus, we conclude that the southwestern Tibet Plateau achieved the present-day elevation in the mid-Pliocene.

* Corresponding author. E-mail:

The earliest woolly rhino *Coelodonta thibetana* was also discovered from the Pliocene deposits of the Zanda Basin at 3.7 Ma. Ice Age megafauna have long been known to be associated with global cooling during the Pleistocene and their adaptations to cold environments, such as large body size, long hair and snow-sweeping structures, are best exemplified by the woolly mammoths and woolly rhinos. The new Tibetan fossils suggest that some megaherbivores first evolved in Tibet before the beginning of the Ice Age. The cold winters in high Tibet served as a habituation ground for the megaherbivores, which became pre-adapted for the Ice Age, successfully expanding to the Eurasian mammoth steppe. This high elevation estimate is consistent with a cold (indistinguishable from modern) climate with lengthy subfreezing temperatures during the winters, coinciding with the evidence based on the *H. zandaense* skeleton.

Key wards: Tibetan Plateau, Neogene, mammalian fossil, elevation, paleo-altimetry