

## Mammalian and Fish Biostratigraphy, Geochronology, and Paleoenvironment of Qaidam Basin in Northern Tibetan Plateau

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Qaidam basin is the largest terrestrial basin on the Tibetan Plateau and has the most continuous sedimentary records in the Cenozoic of China. Although constituting some of the first known fossil vertebrates from the Tibetan Plateau and discovered on early scientific expeditions in the 1930s by Birger Bohlin, mammalian fossils from Qaidam basin have not played a significant role in the basin stratigraphy. Our explorations in the Qaidam basin during the past several years have resulted in the first stratigraphically well documented collection of fossil vertebrates. In addition to being the most informative organisms for terrestrial biostratigraphy in the Cenozoic, the new fossil vertebrates offer a unique window into the ancient biotas that chronicle the Late Cenozoic uplift of the plateau and associated environmental changes.

Here we establish for the first time a faunal sequence of Late Oligocene to Early Pliocene age (Wang et al., in press). Four mammalian faunas are recognized: Olongbuluk Mammal Fauna (Middle Miocene), Tuosu Mammal Fauna (early Late Miocene), Shengou Mammal Fauna (early Late Miocene), and Huaitoutala Mammal Fauna (Early Pliocene).

The Olongbuluk Mammal Fauna (OMF) consists of taxa from the upper part of Lower Youshashan Formation in the Huaitoutala-Olongbuluk Mountain section and the Naogebayin Mountain section. It is characterized by *Hispanotherium*

(Deng and Wang, 2004a), *Lagomeryx tsaidamensis*, *Stephanocemas*, and possibly *Dicroceros*. With the exception of *Acerorhinus tsaidamensis*, which also occurs in the overlying Tuosu Mammal Fauna, the OMF is represented by typical Middle Miocene forms and has little else in common with the Late Miocene Tuosu and Shengou faunas.

The Tuosu Mammal Fauna (TMF) is restricted to the lower part of the Upper Youshashan Formation. Members of this fauna are mainly from the Tuosu Nor section, the middle part of the Olongbuluk section, and possibly part of the Barunyawula section. It is characterized by *Ictitherium*, *Adcrocuta eximia*, *Chalicotherium brevisrostris* (Wang and Wang, 2001), *Hipparion teilhardi* (Deng and Wang, 2004b), *Sivatherinae* indet., *Dicroceros* (TVPP V13086), *Euprox* sp. (small), *Olongbulukia tsaidamensis*, *Qurliknorina* sp., *Tossunnoria*, *Tsaiidamotherium*, *Protoryx* sp., *Tetralophodon*, and *Struthio*. The TMF is easily distinguished from the underlying Olongbuluk Mammal Fauna by its lack of Middle Miocene elements such as *Hispanotherium*, *Lagomeryx*, and *Stephanocemas*. Compared to the overlying Shengou Mammal Fauna, the TMF is typified by a dominance of several bovids endemic to the Qaidam basin, such as *Olongbulukia*, *Qurliknorina*, *Tossunnoria*, and possibly *Tsaiidamotherium*. In addition, *Chalicotherium* also appears to be restricted to the TMF.

The Shengou Mammal Fauna (SMF) is in the Upper Youshashan Formation, and is mainly from the lower part of the Shengou section and the upper part of the Naogebayin section. It

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*matritense* (Deng and Wang, 2004a), *Acerorhinus tsaidamensis*

is typified by large mammals such as *Ictitherium*, *Adcrocuta eximia*, *Plesiogulo*, *Promephitis parvus*, *Acerorhinus tsaidamensis* (Deng and Wang, 2004a), *Dicerorhinus ringstromi* (Deng and Wang, 2004a), *Hipparion* cf. *H. chiai* (Deng and Wang, 2004b), *Hipparion weihoense* (Deng and Wang, 2004b), *Hipparion teilhardi* (Deng and Wang, 2004b), *Euprox* sp. (large), *Gazella*, and *Amebelodon*. Small mammals include: *Soricidae* indet., *Talpidae* indet., *Sinotamias* sp., *Sciurotamias* cf. *S. pusillus*, *Pliopetaurista* sp., *Eomyidae* indet., *Lophocricetus* cf. *L. xianensis*, *Protalactaga* sp., *Sylodipus?* sp., *Myocricetodon lantianensis*, *Cricetidae* indet., *Sinocricetus* sp., *Huerzelerimys* sp. nov., *Pararhizomys* sp., *Ochotona* sp., and

*Ochotonoma* sp. nov..

The SMF is distinguished from the Tuosu Mammal Fauna by the dominant presence of dicrocerine deers, which often are large in size, and by a notable absence of a variety of endemic bovids, such as *Olonbulukia*, *Qurliknorina*, etc. Based on its large and small mammals, the SMF is undoubtedly Late Miocene in age (Baodean of East Asian Land Mammal Age).

The Huaitoutala mammal fauna is consisted of a single locality, CD9822, in the Huaitoutala section. It is currently characterized by five small mammals: *Orientalomys/Chardinomys* sp., *Mimomys* sp., *Micromys* sp., *Pseu*

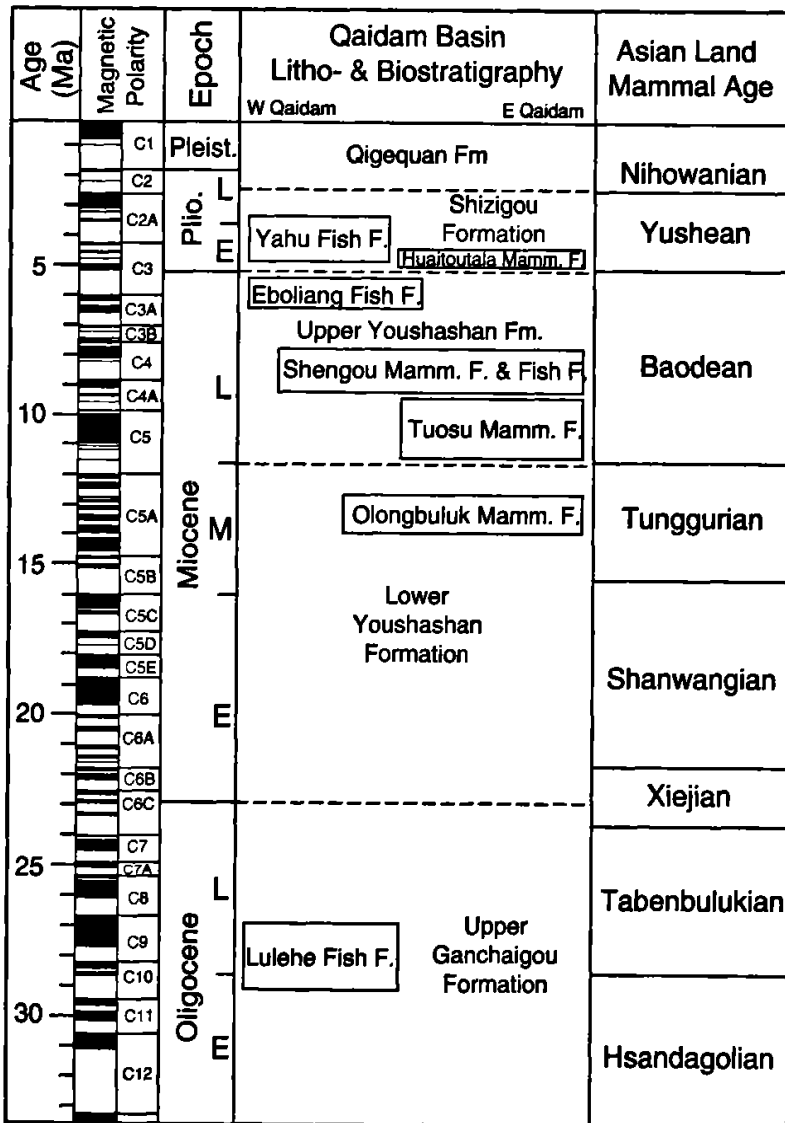


Figure 1. Vertebrate faunal sequences of Qaidam basin. Divisions of Asian Land Mammal ages are based on Qiu and Qiu (1995).

*domeriones* sp., and an unidentified shrew (Soricidae indet.), as well as ostrich egg shells. All of the genera are known in the Late Miocene or Pliocene faunas of Eurasia, except *Chardinomys*, which is endemic to northern China. The joint appearance of *Chardinomys* and *Miomys*, both of which first occur in the Early Pliocene of China, indicates a Pliocene age in the Yushan Land Mammal age.

All four mammal faunas can be directly or indirectly tied to a paleomagnetic section in the Olongbuluk-Huaitoutala area, permitting robust calibration of the chronology of these faunas (Fang et al., in press) (Fig. 1). The following three mammal faunas can be directly tied to the Olongbuluk-Huaitoutala magnetic section and are correlated to various magnetic chrons: Olongbuluk Fauna in magnetochrons 5Ar to 5ACn (12.42–14.09 Ma), Tuosu Fauna in magnetochrons C4Ar to C5r (~9.10–12.00 Ma), Huaitoutala Mammal in magnetochron C3n.3n (4.80–4.90 Ma).

At least four fish faunas are also recognized: Lulehe Fish Fauna (late Early to early Late Oligocene), Shengou Fish Fauna (early Late Miocene), Eboliang Fish Fauna (late Late Miocene or Early Pliocene), and Yahu Fish Fauna (Early Pliocene). The fish faunas represent the only records of their respective time in the Tibetan Plateau and thus by themselves cannot be used for age determination. However, these fish faunas are either integrated into paleomagnetic sections or directly tied to mammal faunas of known ages, permitting independent assessment of their chronology (Fig. 1).

The Lulehe Fish Fauna is currently composed of only two fishes in the Upper Ganchaigou Formation. Locality CD0301 produced several unbranched fin rays with serrations on posterior edge, which possibly belong to the family Cyprinidae. Locality CD0407, on the other hand, contains pharyngeal bones with teeth, fin rays with serrations, and pelvic bones, which are tentatively placed in the subfamily Barbinae.

The Eboliang Fish Fauna is currently under study, and its detailed composition is not yet clear. The Eboliang fishes are not pachyostotic as in the Yahu Fish Fauna (see below), indicating a far less saline environment.

The Yahu Fish Fauna consists of a single undescribed species, whose pharyngeal teeth share similarities to some extant schizothoracine cyprinids. The 22 known localities (CD0504–07, 0640–53, 0663–67) span approximately 220 m of strata, and they probably represent the last surviving pachyostotic fishes in a hypersaline environment.

Zoogeographically, Qaidam mammal faunas show increasing endemism through time, presumably related to topog-

raphic barriers formed by the growth and uplift of the Tibetan Plateau and to climatic changes triggered by the same tectonic process. Fishes that were trapped in internally drained basins developed pachyostotic morphologies in response to hypersaline environments, which are associated with the increasing aridity of the Tibetan Plateau since Early Pliocene.

Preliminary analysis of carbon isotopes on the dental enamel of mammalian herbivores from the Late Miocene faunas in Qaidam basin suggests a pure C<sub>3</sub> diet.

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#### REFERENCES CITED

- Deng, T., Wang, X., 2004a. New Material of the Neogene Rhinocerotids from the Qaidam Basin in Qinghai, China. *Vertebrata Palasiatica*, 42(3): 216–229
- Deng, T., Wang, X., 2004b. Late Miocene *Hipparion* (Equidae, Mammalia) of Eastern Qaidam Basin in Qinghai, China. *Vertebrata Palasiatica*, 42(4): 316–333
- Fang, X., Zhang, W., Meng, Q., et al.. High Resolution Magnetostratigraphy of the Neogene Huaitoutala Section in the Eastern Qaidam Basin on the NE Tibetan Plateau, Qinghai Province, China and Its Implication on Tectonic Uplift of the NE Tibetan Plateau. *Earth and Planetary Science Letters* (in Press)
- Qiu, Z. X., Qiu, Z. D., 1995. Chronological Sequence and Subdivision of Chinese Neogene Mammalian Faunas. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 116: 41–70
- Wang, X., Wang, B. Y., 2001. New Material of a *Chalicotherium* from Tsaidam Basin in Northern Qinghai-Tibetan Plateau, China. *Paläontologische Zeitschrift*, 75(2): 219–226
- Wang, X., Qiu, Z., Li, Q., et al.. Vertebrate Paleontology, Biostratigraphy, Geochronology, and Paleoenvironment of Qaidam Basin in Northern Tibetan Plateau. *Palaeogeography, Palaeoclimatology, Palaeoecology* (in Press)