Discovery and chronological division of the *Hipparion* fauna in Laogaochuan Village, Fugu County, Shaanxi

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Over two hundred species of the *Hipparion* fauna belonging to the Baode Stage have been found in more than a hundred localities in China. All of these fossils had been thought to come from the same horizon by most scientists till the end of the 1950s[1]. Since 1960, the *Hipparion* fauna has been discovered from different horizons and different ecologic groups, and extensive studies of taxonomy and evolution of some mammals have been made. Scientists have recognized the multi-level distribution of the faunas of the Baode Stage[2—4].

In 1985 the authors found some isolated mammalian teeth fossils in the Laogaochuan Village, Fugu County, Shaanxi Province. Since 1986 a large-scale fossil collection has been done for years. The most significant thing is that we have collected a large number of well-preserved fossils from three different fossil-bearing beds in the same section. All the specimens were collected around Wangdaifu ridge of Laogaochuan Village about 60 km northwest of the Fugu County town. The Neogene sediments containing three fossil-bearing beds are 52 m in thickness. It is located in unconformity on the top of the Jurassic strata and in disconformity under the loess. According to lithological characters, the Neogene deposits in the Laogaochuan area can be divided into three members. The lower member, 23.5 m in thickness, is yellowish-gray and yellowish-red sandy clay containing white-gray Ca-rich layers. Abundant fossils have been collected from the bottom of this member at Lamagou gully. The middle member, 16.5 m thick, is reddish-brown sandy clay with clear layered concretions. The upper part of the middle member in the Miaoliang section yields relatively abundant fossils. The upper member, 12 m in thickness, is brownish-red, or reddish-brown clay containing a lot of unlayered calcareous concretions free of fossils. According to the type of the fossils and paleomagnetic dating, the lower and middle members have a late Late Miocene age and the upper one, a Pliocene age.

1 Mammalian fauna and their features

There are three fossil-bearing layers in the Laogaochuan area. The lower layer is situated near the bottom of the lower member of the Neogene, and the middle and upper layers are located respectively in the middle and upper parts of the middle member of the Neogene. According to preliminary identification, the lower layer contains more than 20 genera and species in some 5 orders of mammalian fossils. They are mainly *Dinocrocuta gigantea, Ictitherium wongi, Platybelodon* sp., *Hipparion chiai, H. forstenae, Chilotherium habereri. Acerorhinus hezhengensis, Sinotherium largrelli, Palaeotragus* cf. *decipiens, Samotherium* sp., *Gazella gaudryi, Miotragocerus* sp., cf. *Pleisiaddex minor.* As all of these fossils were collected from the Lamagou gully, we assign them to the Lamagou fauna.

Fossils are rare in the middle fossil layer, but plentiful in the upper one. The chief species from the middle and upper layers are *Adcrocuta eximia variabilis,* Gomphotheriidae, *Hipparion* sp., Chilotherini, *Honanotherium* sp., *Chleuastochoerus stehlini, Eostytoceras blanvillei, Muntiacus* cf. *lacustris, Cervavitus novorossiae, C. demissus, Procapreolus latifrons.* The fossils from the middle and upper layers were all collected from the Miaoling ridge. Since the two layers are very close to each other and have similar features, we collectively call them the Miaoliang fauna. The Lamagou fauna is a mammalian assemblage with *Chilotherium* and *Acerorhinus* as the dominant elements. There are also numerous *Dinocrocuta, Hipparion, Palaeotragus, Samotherium* and *Gazella.* Apart from a small number of typical forest dwellers such as deer and brachiodont gazella, most animals of this fauna are grassland or sparse woods grassland dwellers. Compared with the Lamagou fauna, the Miaoliang fauna shows great change. Different kinds of muntjaic, the typical forest-inhabited mammals, became the principal part of this fauna in both species and number. The hypsodont *Samotherium* and *Palaeotragus* were replaced by the brachiodont *Honanotherium*, and there are also many forest-dwelling animals like *Chleuastochoerus stehlini.* On the contrary, some typical grassland inhabitants, such as high-crowned gazella, disappeared in large number. The change in feature of the above two faunas reflects different environments in which they lived respectively. In the light of mammalian assemblage, the Lamagou fauna lived in sparse woods and grassland, while the Miaoling fauna, in typical forest.

It is worthy to be noted that the Middle Miocene and early Late Miocene *Platybelodon* has been found in the Lamagou fauna, which is absent in the Miaoliang fauna. Instead, *Eostyloceras,* a typical member of the terminal Late Miocene is dominant in the Miaoling fauna. This is another piece of important evidence to distinguish the two faunas in terms of age.

The Baode area of Shanxi Province is one of the areas yielding abundant *Hipparion* faunas in China. Among the fossil localities of the Baode area, Loc. 31 and 32 yield the

most similar fauna to the Lamagou fauna, shearing the genera and species: *Ictitherium*, *Honanotherium*, *Hipparion*, *Sinotherium*, *Chilotherium*, *Palaeotragus*, *Samotherium*, *Plesiddaix*, *Trogoreas*, etc. Their common features are: i) both regions have plenty of Bovinae mammals with high-crowned teeth; ii) *Samotherium* and *Paleaotragus* are the main species of Giraffidae; iii) no or very few Cervidae mammals have been found; iv) Rhino, especially *Chilotherium* is the dominant dwellers. All of those common characters reflect the fact that the faunas in Lamagou and Loc. 30 and 31 of Baode lived in the same palaeoecologic environment and in the same age, and they all belong to faunas of grassland or sparse wood-grass land. On the other hand, the Miaoling fauna are closely related to those of Longjiagou, Gansu Province and Loc. 49, etc. of Baode area. The common features of the three areas are: i) they all contain abundant fossils of Cervidae mammals such as *Eostyloceras blanvillei*, *Muntiacus* cf. *lacustris*, *Cervavitus novorossiae*, *C. demissus* and *Procapreolus latifrons*; ii) *Acerorhinus* is the dominant element of Rhinocerotidae and no real *Chilotherium* has been found; iii) all three areas are rich in fossils of low-crowned teeth mammals such as *Honanotherium*, *Gazella gaudryi* and *Chleuastochoerus stehlini*.

For a long time the *Hipparion* fauna from most localities in China have been considered to be from the equivalent horizon of different ecological enviroments such as forest (southern Shanxi and Henan), grassland (Qingyang, Gansu Province) and mixed type (northern Shaanxi and Shanxi). In fact the actual situation is far different. Since correlation of faunas between different localities is still difficult, it is uncertain whether there are contemporaneous faunas of different ecological environments in different areas. In the Laogaochuan district of Fugu County, the *Hipparion* fauna of different ecological environments is actually of different ages.

2 Age of fossil-bearing layers

According to paleomagnetic dating, the Neogene deposits of Wangdaifuliang near the Laogaochuan Village has recorded the Gilbert polarity chron, Epoch 5, Epoch 6 and Epoch 7 in the palaeomagnetic column. Comparing the three fossil-bearing layers, we have found that the lower fossil-bearing layer (the layer containing the Lamagou fauna) corresponds to the middle stage of Epoch 7, about 7.4 Ma B.P.; while the middle and upper ones (the layers yielding the Miaoling fauna) respectively correspond to the later stage of Epoch 6 and Epoch 5, 6.1 Ma B.P. and 5.3 Ma B.P. respectively. Compared with the age (or zone) of the European Tertiary land mammal, the Lamagou fauna corresponds to MN12 and the Miaoliang fauna to MN13[5—6] (fig. 1).

The *Hipparion* fauna we generally refer to is a mammalian assemblage belonging to the Turolian. In China, this stage has been named the Baode Stage. As mentioned above, all of these faunas are not possibly from the same horizon. But the term Baode Stage has been used for a long time and it is familiar to paleontologic and

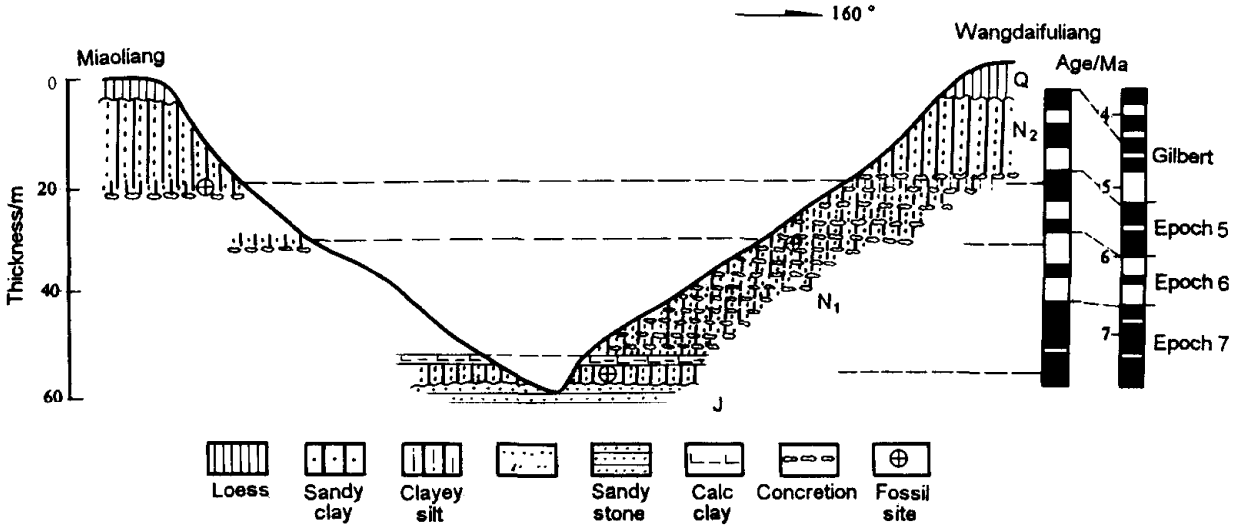

Fig. 1. Neogene section and paleomagnetic dating of Laogaochuan, Fugu, Shaanxi.

stratigraphic workers. Therefore, it might be better to continue to use this term. Now that more reliable materials and data have been collected, we propose two substages under the Baode Stage, the Lamagou Substage and the Miaoliang Substage. The former is represented by the Lamagou fauna, with a paleomagnetic age of 7—8 Ma B.P.; and the latter is represented by the Miaoling fauna having an age of about 5.2—7 Ma B. P.

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