

Origin and paleo-environment of the first modern mammals in China during the Paleocene-Eocene Thermal Maximum 'Paleo-environment'- BL/36/C54

(Geographic) study area : China / Shandong, Henan, Hunan, Xinjiang, Anhui provinces

Data used: Chinese geological maps, Reference comparative collections of the RBINS and IBCAS

Field campaigns: Shandong and Henan (07-27.09.2009); Hunan and Xinjiang (14-26.05.2009); Anhui (07-21.03.2010; 03-19.05.2010)

Context and objectives

True primates appeared suddenly on all three northern continents at the beginning of the Eocene Epoch, about 55.5 million years before present. They make their first appearance exactly during the Paleocene-Eocene Thermal Maximum (PETM), a 100.000 years-lasting abrupt global warming event that represents the warmest period of the last 65 million years. *Teilhardina*, the oldest primate, is now known on all three continents in association with the Carbon Isotope Excursion (CIE) that marks the PETM. Relative positions within the CIE indicates that Chinese *Teilhardina asiatica* is the oldest, Belgian *T. belgica* is younger, and North American *T. brandti* and *T. americana* are the youngest. Analysis of morphological characteristics in scanning electronic microscopy of all four species supports an Asian origin and a westward Asia-to-Europe-to-North America dispersal for *Teilhardina*.

High-resolution isotope stratigraphy indicates that this happened in an interval of about 25.000 years (Smith et al, 2006, PNAS). The fossil record indicates that primates are not the only modern mammal group that appears during the PETM. This is also the case for the first rodents, modern ungulates (artiodactyls, perissodactyls), and modern carnivores. The PETM climate changes obviously also affected the contemporaneous floras. These floral changes and the interaction of floral and faunal changes are still almost completely unknown. Only recently, the first transitional flora was published, and floral changes were suggested to be comparable to those in postglacial periods and those predicted for an anthropogenic global change.

What are the ancestors of the modern mammal orders? How did the PETM affect paleofloras? Is the global PETM event the driving mechanism for the dispersal of modern cosmopolitan mammals and for the progressive extinction of endemic archaic mammals on all the continents?

Identification of Late Paleocene and Early Eocene Chinese mammal faunas and their environment and characterisation of the remarkable paleoclimate during the PETM are keys in the understanding of the appearance and success of the first modern mammals 55 million years ago.

Methodology

Exploratory missions, excavations and multidisciplinary analyses are done in several Chinese localities from the Late Paleocene and Early Eocene (60 to 50 million years ago). This includes the famous early Eocene Wutu coal mine (Shandong province), and the Paleocene-Eocene transition Lingcha Formation (Hunan province) that has yielded the oldest primate *Teilhardina asiatica*. Diversity analysis of mammal faunas mainly based on dental remains and comparison with Europe (especially the Belgian Earliest Eocene Dormaal fauna, the reference-level for Europe), North America and India allow to analyse the paleobiogeography of mammal groups, and to distinguish the endemic groups of each continent from the groups that made intercontinental migrations around the PETM.

This is combined with the identification of the associated floras based on palynology and macrofossils (seeds, leafs and wood anatomy) to characterise both the paleo-environment of the mammals, and the paleo-climate that evolved very quickly around the PETM. Isotopic analyses of the carbon (δC^{13}) of the organic matter from the sediment in the different sections allow high resolution dating of the fossils, by a geochemical technique developed by a Belgium team including FUNDP and RBINS.

Results

Exploration missions: among the localities visited until now by a team of RBINS-IBCAS during four international expeditions between 2008 and 2010 some sites have been considered important for collecting:

- Macrofossils (vertebrates and plant remains) and paleopalynological samples at Wutu coalmine in the Changle County of Shandong Province.
- Geological samples for Carbon isotopic analysis from Lingcha Formation at Hengyang in Paleocene-Eocene transition of Hunan Province.
- Palynological samples from Late Cretaceous through Early Eocene Qiuba, Gaoyugou and Dazhang Formations in the Tantou area of Henan Province.
- Vertebrates from the late Paleocene of Anhui province.

Studies:

- Anatomy of a partial skeleton discovered in Wutu coal mine of Shandong province indicates a primitive tapiroid with a mosaic of primitive and derived characters. This particular combination of characters seems to result from an endemism of some modern mammals in Eastern China at the end of the early Eocene.
- Fossil seeds discovered in Wutu coal mine indicate the presence of a Rosaceae. It belongs to the genus *Prunus* and represents the oldest Asian record of this worldwide dispersed fruit.
- Borehole core samples from a drill of about 500 m in the neighbour of Wutu coal mine have been cut into two subsamples that were shared between Chinese and Belgian specialists. Preliminary isotopic analyses done by FUNDP indicate a low level of $\delta^{13}C$ between 325 and 435 m deep indicating a special climatic event that could correspond to the Early Eocene Climatic Optimum. Pollen analyses of these especially interesting sampling levels are under process by IBCAS. Reconstruction of the environment based on this borehole indicates a temperate climate in Eastern China whereas most of Western Europe was subtropical at that time.
- Preliminary results from recently discovered late Paleocene vertebrates from Anhui province complete the knowledge on some poorly known key mammal groups such as ancestors of rodents and rabbits.

Products and services

- Redaction of three papers for peer reviewed journals about the three studies that yielded important results are in process:
 - . Li Y., Smith T., Liu C-J., Yang J., Li C-S. Endocarps of *Prunus* (Rosaceae: Prunoideae) from the Early Eocene of Wutu, Shandong Province, China confirming extant diversity centers in Eastern Asia. *Review of Palaeobotany and Palynology* (nearly submitted).
 - . A new Tapiroid-like mammal group from the early Eocene of China for *Journal of Vertebrate Paleontology*.
 - . Paleo-environmental and paleo-climatic reconstruction of the early Eocene of Eastern China based on the evolution of a lake deposits for *Proceedings of the National Academy of Science*.
- Abstracts and talks have been presented at two congresses:
 - SMITH, T., WEI, M.-R., LI, C.-S., 2008. Cranium and associated postcranial elements of the primitive tapiroid *Chowliia* from the Early Eocene of Wutu Coal Mine (Shandong Province, China): Phylogenetic affinities. *Journal of Vertebrate Paleontology*, 28 (supplement to Number 3): 145A.
 - MISSIAEN & SMITH, T., 2009. An updated mammal biochronology and biogeography for the Paleocene and early Eocene of Asia. *In*: international symposium on terrestrial Paleogene biota and stratigraphy of Eastern Asia, Beijing, China, abstract book p. 40-41.
- WebPages related to the project are under construction on RBINS website (3 million visitors in 2009) with a link on the IBCAS website.

Execution

Period: April 2008 - March 2010 (extended up to March 2011)

Research Team/network:

Belgium :

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Discipline

Paleontology

Paleo-environmental reconstruction

Climate change study

Perspective / Recommendation for future

The project has been funded for the Belgian side for a period of 2 years. The funding of the Chinese side started later but for a period of 3 years. For this reason, the execution period for the Belgian side has been extended for one year and the project is still ongoing. The execution of the project has thus been somewhat delayed the first year but the results are very encouraging. Access to borehole cores in mines and discovery of exceptionally thick Paleocene-Eocene geological sections in some Chinese localities authorise for the first time a real climatic and environmental reconstruction. Important results obtained during this project and efficient Chinese-Belgian collaboration between the two institutions in complementary domains allow us to propose a new bilateral cooperation project for the future with the extension of the PETM time period to the early Paleogene in order to characterise the analogies to the present global changing.