Climatic Variations in China during the Quaternary

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Abstract: Climatic variations in China during the Quaternary have long been a question of debate. Considerable data now available support Professor Li Siguang's (J.S. Lee) suggestion that there were four glacial periods. In his later years the views of Professor Li have received support from more recent information demonstrating that a further glacial period and periglacial phenomena preceded the Boyang Period.

During the Quaternary 3,500,000 years ago there were a number of climatic fluctuations in China, having an amplitude of over 10°C and a cycle of $10^4$ to $10^5$ years. Each fluctuation lasted from the onset of one glacial period to that of the next, encompassing a glacial period and an interglacial. Tab 1 provides a comparison between the glacial periods in China during the Quaternary and those in other regions of the world.

Temperature Changes in China during the Quaternary

Basic data used in reconstructing the climate of China during the Quaternary include surviving evidence of glacial activity, periglacial phenomena, weathering crusts and fossil soils of various types, Quaternary flora and fauna and their evolution, evidence of transgression and regression along the coastal plains, shifts of lake shores in arid and semi-arid regions, etc. Each individual item is capable of reflecting climatic change or tectonic movement. Viewed as a whole, these data contribute towards a better explanation of the laws governing climatic change. An understanding of climatic changes during the Quaternary can, therefore, only be acquired through analysis of a vast number of geological phenomena.

The authors have constructed a graph showing temperature variations in China during the last 10,000,000 years, based on glacial relics and periglacial phenomena dating from the Quaternary, information derived from spores and pollen samples collected from cores drilled in the North China Plain*, palaeomagnetic data relating to the Quaternary obtained from the Yuanmou formation and from along the Qing hai — Tibet highway, weathering crusts and fossil soils. The results are explained briefly below:

Climate in the Pliocene: the result of a sudden fall in world temperature

The brownish-red, purplish-red and grey clay layers at depths of 512 to 556 m in the eastern part of the North China Plain were formed in the Pliocene approximately 3,500,000 years ago. Among the spores and pollen obtained were large quantities of deciduous and broadleaf tree seeds of the temperate zone such as *Quercus*, *Ulmus*, *Juglans*, and sub-tropical tree seeds such as *Carya*, *Hamamelis*, *Coryiopsis*, *Myrica*, *Magnolia*, *Haruissania*, *Liquidambar*, *Myrtaceae*, *Nelis*, *Sapindus*, *Lauraceae*, *Rhus*, *Symilocas* and *Ilex*. This mixture of deciduous broad-leaf forest containing evergreen broadleaf trees and coniferous forest reflects the divisions of mountain vegetation belts. Climate in the low-lying regions was northern sub-tropical, similar to that in present-day Zhejiang, Jiangxi and central Hunan south of the Yangtze River, with mean annual temperatures 50—70°C higher than that of North China today. Pliocene spores and pollen from cores drilled near Shenyang contained seeds of sub-tropical plants such as *Tilla*, *Acer*, *Juglans* and *Alnus*, with scattered *Liquidambar*, *Symilocas*, *Tsuga chinensis* and *Pillocarpus***, similar to those of North China.

* Yang Zi geng and Ren Zhen ji, op cit.
** Gu Shang yong, op cit.
Towards the end of the Pliocene the climate was dry and cool, as evidenced by Upper Pliocene spores and pollen in the N and NW areas of China. Apart from some tropical and sub-tropical plants, the spores and pollen of the Weihe Basin were mainly of the families Chenopodiaceae, Compositae and Artemisia, and Ephedrätze, which amounted to 60% of the total*. The spores and pollen found in the Tianzhu formation, Sunyi County, Beijing, were mainly those of grasses, belonging to the families Cruciferae, Artemisia, Liliaceae, Polygonaceae and Chenopodium album, with a small number of Pteridium aquilinum spores and aquatic plants. The cool, dry climate of the Pliocene indicated the imminent onset of the Great Ice Age in the Quaternary.

In China’s N and NW regions during the Pliocene, red soil was quite well developed, its northern latitudinal limit reaching to 42° N. The present northern latitudinal limit of red soil is 25° N, a difference of 17°. Assuming a difference of 0.65°C for one degree of mean annual temperature in central latitudes, the mean annual temperature in North China during the period of red soil development during the Pliocene would have been 11.5°C higher than today. The red soil was the principle horizon at the time of the evolution of the Hipparchion and other grassland animals found between northern China and southern Tibet. At that time the landscape was one of grassland with a few trees. Special attention is drawn to the thick layer of limestone gravel deposited around the Tanggula Mountains about 5,000,000 years ago, indicating the existence of a cold climate in the Pliocene.

The climate of the Pliocene, therefore, represented the latter stage of the world-wide decrease in temperature which began during the late Mesozoic. The fact that temperatures were then 5° to 10°C warmer indicates that the mild climate at that time differed little from that of the interglacial period in the Quaternary, the climate prevailing at that time in that part of China which lies in central latitudes showed no obvious signs of being affected by the country’s latitudinal zonation.

The Early Glacial Period of the Quaternary (ca. 3,500,000–3,000,000 years ago)

A number of sites have been located where moraine development occurred during this period. They are the Hongya of Yangyuan, Hebei, the basin in the Kunlun Mountains pass along the Qinghai-Tibet highway, Dukou in Sichuan and Yuanmou in Yunnan. At these locations moraine or fluvioglacial deposits developed to varying degrees below the lacustrine sediments. Above the red moraine in Dukou was the bottom horizon of the Xigeda formation (lake facies). Palynological investigation revealed some 30 to 52.9% of Abies. This mixed coniferous-broadleaf forest indicated the division of the mountain vegetation into vertical belts, as well as the wet and cold climate of the early Pleistocene. In the late Pliocene, the change from the mixed evergreen coniferous-broadleaf forest in Sanying coal formation in Western Yunnan to the mixed coniferous-broadleaf forest in the Xigeda formation indicated the climate became colder.

In the early Pleistocene, dark coniferous boreal forest and pratum flourished in the eastern part of the North China Plain. Picea and Abies pollen accounted for 46.7% of the total. The mean annual temperature was 8°C lower than at present. In the Weihe Basin there was hardly any vegetation except for a few coniferous and broadleaf tree species, some grass and Botrychium spores. The Ice Age had set in. From the Pliocene to the early glacial period of the Quaternary, the temperature fell by 18°C.

The Early Interglacial Period (3,000,000–2,100,000 years ago)

The climate in Yuanmou, Yunnan, was southern subtropical. The vegetation included evergreen broadleaf and monsoon forest varieties such as Cedrus, Cathaya, Cryptomeria, Caryya, Liquidambar, Myrica, Castanopsis, Santalum, Exocarpus, Cyathia, Dicksonia, Cibotium and Dacrydium. Mean annual temperature was at least 30–40°C higher than at present, with a mean monthly minimum of over 10°C. The eastern part of the North China Plain was characterised first by broadleaf, mostly Quercus, then by coniferous-broadleaf forest and grassland. The mean annual temperature was 40–50°C higher than at present. In the Weihe Basin climate was northern sub-tropical to temperate.

Mean annual temperature was 20–30°C higher than today. The presence of the Ammonia tepida in the sea indicates that water temperatures then were 25–30°C. In the area of the Kunlun Mountains pass in the Qinghai-Tibet Plateau, bush-grassland dominated by Sabina flourished. Deciduous-broadleaf forest developed, consisting of Betula and Corylus genera. The mean annual temperature oscillated between 20–8°C, 10°C higher than in the Sizishan periglacial period.

The Sizishan Periglacial Period (2,100,000–1,500,000 years ago)

In the middle and upper layers of early Pleistocene lake facies in the Jiangtang, Nihewan and Sanmen various types of freeze-thaw fold were found — a periglacial phenomenon occurring near the upper limit of permafrost. Their existence testified to the development of permafrost in these locations. The distribution of occurrence — from N

* Sun Xiu yu et al., op cit.