

¹⁴C AMS DATING THE TRANSITION FROM THE PALEOLITHIC TO THE NEOLITHIC IN SOUTH CHINA

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ABSTRACT. To study the transition from the Paleolithic to the Neolithic period and its duration, samples of charcoal, bone, flowstone and shells excavated from Bailiandong and Miaoyan caves, Guangxi Zhuang autonomous region, South China were dated using the Peking University AMS facility and liquid scintillation counter. The remains excavated from these sites show typical characteristics of the transition from the Paleolithic to the Neolithic. Radiocarbon dating results show a rapid transition from *ca.* 20 to 10 ka BP.

INTRODUCTION

The appearance of polished stone tools, pottery and the domestication of plants and animals are taken as criteria for the Neolithic period by most Chinese archaeologists. Recently, many archaeologists have considered food production to be a more important factor. The study of the transition from the Paleolithic to the Neolithic is an important focus of archaeological research in China. The karst area of South China has abundant caves and cultural remains of these periods. Bailiandong (White Lotus Cave), being one of the most important sites, is located in the southern slope of Baimian Mountain (White Face) 12 km southwest of the city of Liuzhou (109°20'E, 24°15'N) and 2 km from the famous Liujiang Man site, a Late Pleistocene fossil human (*Homo sapiens sapiens*) site (Fig. 1). The cave was discovered in 1956 and extensively excavated at the beginning of the 1980s (Science Museum of Bailian Cave Site *et al.* 1987). Cultural remains from deposits 3 m thick span the Late Paleolithic to Early and Middle Neolithic periods (Zhou 1986). Yuan *et al.* (1990) discussed the radiocarbon dating of the Bailiandong site and the transition from the Paleolithic to the Neolithic in South China. However, because of the difficulty of obtaining sufficient amounts of carbon for beta-decay counting, several key layers were not dated; hence, the strata and cultural features of the site were not fully understood until accelerator mass spectrometry (AMS) was used recently to measure the ¹⁴C ages.

Another interesting site is the Miaoyan (Temple Cave), which is near Guilin city (110°23'E, 25°04'N) and *ca.* 140 km from Bailiandong (Fig. 1). Discovered in 1988, two skeletons of *Homo sapiens*, tens of chopping artifacts and more than 10 polished bone tools were unearthed. Several potsherds were also excavated from the lower deposits. Based on the characteristics of cultural remains, the age of the site was estimated to be >10 ka BP.

METHODS

Twelve samples from the Bailiandong and Miaoyan sites were dated at the Peking University AMS Facility (PKUAMS) (Chen *et al.* 1994; Guo *et al.* 1995). We pretreated samples of charcoal and burned bones using the standard procedure, *i.e.*, acid/alkali/acid (AAA) washing. Dry samples were converted to CO₂ by combustion with CuO. Inorganic materials, such as freshwater shells and flowstone, were washed with water using an ultrasonic cleanser, soaked in dilute HCl, then rewashed

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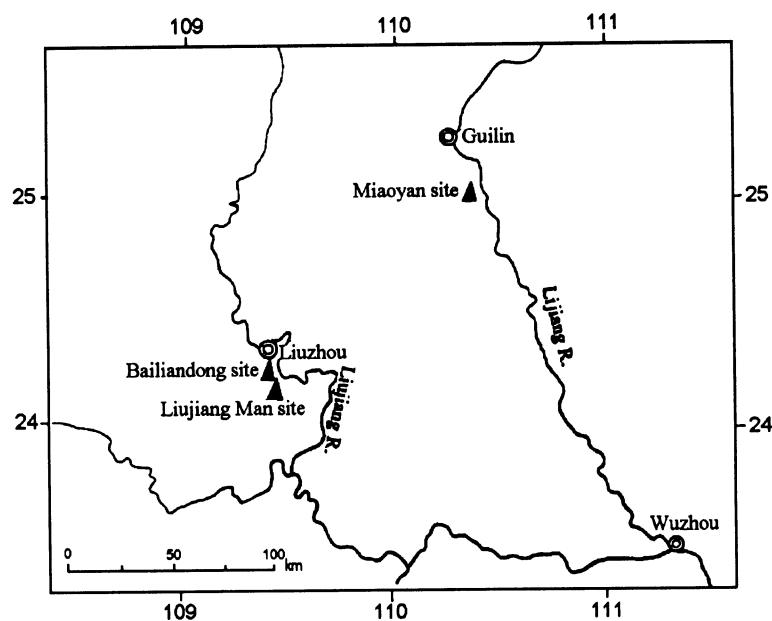


Fig. 1. Map of the Bailiandong and Miaoyan sites

with water to neutralize and convert them to CO_2 by reaction with phosphoric acid. The CO_2 was purified and catalytically reduced to graphite by H_2 on iron powder. The reaction time was usually *ca.* 2 h. We found no cross-contamination during sample preparation.

Standard samples were prepared using Chinese Sucrose Charcoal (Qiu *et al.* 1983); the ratio of its ^{14}C concentration to that of the International Modern Standard is 1.362 ± 0.003 . To check the validity of measurement, we included samples of known age in the measuring sequence. The results of new sample measurements were accepted only when the results of known-age samples were reproducible.

The target wheel in the ion source has 20 positions. The sample targets were measured sequentially, and every 3–4 unknown samples were followed by a standard sample. Each was measured for 500 sec, divided into 10 intervals. The average value was corrected against the blank and standard samples. The measurement usually continues for 6–8 revolutions, and the final results are calculated by weighted average.

Four samples were measured at the Department of Archaeology, Peking University, using a benzene liquid scintillation counting method. Sample pretreatment, benzene preparation and counting techniques are essentially the same as described previously (Fan *et al.* 1983).

RESULTS AND DISCUSSION

The cultural remains from Bailiandong are concentrated in two areas. The east deposit is at a higher level containing 8 layers; the west deposit contains 10 layers (Zhou 1986). The geological section of the east deposits of Bailiandong is outlined in Figure 2. The levels and their artifacts are as follows:

East 1 and 3: Many potsherds from Layer 1. 47 artifacts from Layer 3, which include 3 ground-stone tools: one knife, one hand axe, one holed pebble (weight stone) and two holed ornaments. The others include chopping tools, scrapers and flint points.

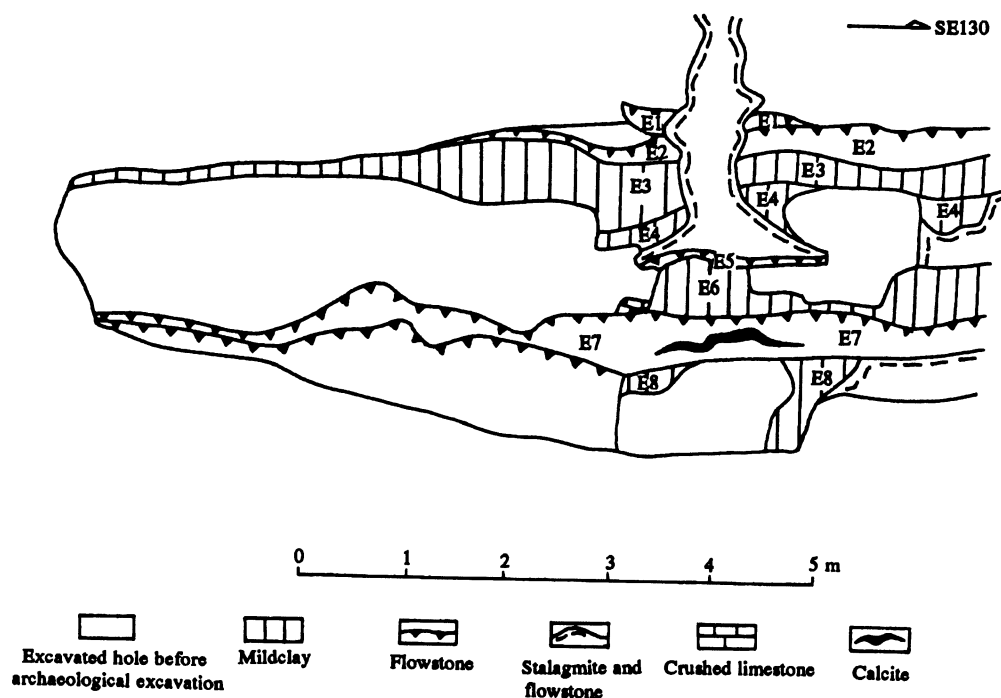


Fig. 2. Section of east deposits from the Bailiandong site, Liuzhou

East 4: 11 artifacts: 1 edge-ground knife, 1 polished antler awl, 1 shovel. The rest are chopping tools.

East 6: 25 artifacts: 1 holed pebble (weight stone), 1 grinding stone for hematite powder. The rest are pebble choppers and scrapers.

West 4: 64 artifacts: 1 edge-ground knife. The others are chopping tools, scrapers, points and flint points, graters and 1 flint arrow.

West 5 and 7: 81 artifacts: *e.g.*, chopping tools, scrapers, points and flint scrapers.

Tables 1 and 2 list the ages of the Bailiandong layers. The transition from the Paleolithic to the Neolithic in Bailiandong seems to have occurred from *ca.* 20–10 ka BP. Cultural characteristics of the period are roughly made pebble tools, holed pebbles (weight stone), edge-ground stone tools, antler and/or bone artifacts, tiny flint stone artifacts and early pottery. This period is the embryonic stage of early farming and animal domestication, reflecting the transition from a hunting/gathering economy to a food-producing economy.

The Bailiandong site was dated by ^{14}C counting and uranium-series dating (Yuan *et al.* 1990). The west deposits were dated at *ca.* 36–20 ka BP. However, no dates could be obtained for important Layers East 3–6 because of the difficulty in collecting sufficient material for conventional dating. The original measurements gave ages of 7 ka BP for East 1 and $11,340 \pm 150$ BP for a strip of pure calcite in East 7. Thus, all deposits from East 1–6 should be younger than 11,340 BP, which differs from an earlier statement by Yuan *et al.* (1990), that the deposits from 20,000–11,500 BP were probably missing from Bailiandong and the thread of cultural evolution was not clear. Our measurements show the age of East 7 to be $19,090 \pm 200$ BP (Table 1, BK94041), and on the basis of more detailed

TABLE 1. ¹⁴C Ages of the Bailiandong Site (East Area)

Stratum	Sample (Lab no.*)	Material	¹⁴ C age (yr BP)
East 1	BK82092†	Flowstone	6880 ± 125
East 2	BK94043	Flowstone	9250 ± 90
East 3	BA93016	Charcoal debris	10,840 ± 580
East 4	BA93017	Charcoal debris	13,170 ± 590
East 6	BA92003	Freshwater shells‡	14,240 ± 230
East 7	BK94041	Flowstone	19,090 ± 200
East 8	BA92013	Burned bone	19,670 ± 660

*BK=beta decay counting; BA=AMS measurement

†Yuan *et al.* (1990)

‡Freshwater shells are not an ideal ¹⁴C-dating material for and may offer an excessively old ¹⁴C age

TABLE 2. ¹⁴C Ages of the Bailiandong Site (West Area)

Stratum	Sample (Lab no.*)	Material	¹⁴ C age (yr BP)
West 1U†	BA94027	Charcoal debris	10,020 ± 290
West 2T	BK93033	Flowstone	12,420 ± 180
West 3	BA92017	Freshwater shells	17,930 ± 410
West 4T†	BK82097‡	Flowstone	19,350 ± 180
West 4T	BK92039	Flowstone	20,965 ± 150
West 4B†	BK82098§	Flowstone	25,920 ± 625
West 6	BKY82141§	Bone	28,000 ± 2000
West 10T	BK82101§	Flowstone	36,000 ± 2000

*BKY=U-series dating result

†U=upper part; T=top; B=bottom

‡Yuan *et al.* (1990)

stratigraphic research, we know the strip of calcite previously sampled was a secondary deposit from a younger period. The new dates in Table 1 also clearly show that the ages of east Layers 8–3 are between *ca.* 2.0–1.1 ka BP. These are the deposits thought to be missing by Yuan *et al.* (1990). The artifacts excavated from these layers have the cultural features of transition from the Paleolithic to the Neolithic.

Deposits from the Miaoyan site are *ca.* 2.5 m thick and divided into six layers. Table 3 shows the AMS dating results. The Miaoyan pottery was thick-walled, hand-built, undecorated and relatively low-fired. The clay was sanded and the largest quartz crystal is *ca.* 1 cm long. These are all primitive pottery features. The potsherds were unearthed from the middle of Layer 5. If the strata were not disturbed, the age of the pottery should not be younger than 14 ka BP (see Table 3). It is possible that the *Homo sapiens* in the area mastered primitive ceramic techniques during the transition from the Paleolithic to the Neolithic.

TABLE 3. ¹⁴C Ages at the Miaoyan Site

Stratum	Sample (lab no.)	Material	¹⁴ C age (yr BP)
2	BA92030-1	Walnut-rind charcoal	12,730 ± 370
3M*	BA92033-1	Walnut-rind charcoal	12,630 ± 450
4M	BA92034-1	Charcoal debris	13,710 ± 270
5L*	BA92036-1	Charcoal debris	18,140 ± 320
6L	BA92037-1	Charcoal debris	20,920 ± 430
6L	BA92037-3	Freshwater shells	21,555 ± 320

*M=middle level; L=lower level

CONCLUSION

Excavations from caves such as Bailiandong and Miaoyan in South China reveal a long prehistoric record dating from the Late Paleolithic to the Early and Middle Neolithic and enduring for *ca.* 30 ka. The ¹⁴C measurements show that the transition from the Paleolithic to the Neolithic occurred from *ca.* 20–10 ka BP in that area. During the transition, cultural features rapidly changed, characterized mainly by the appearance of holed pebbles, edge-ground and ground artifacts, pottery and the beginning of farming.

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REFERENCES

- Chen, C. E., Guo, Z. Y., Yan, S. Q., Li, R. X., Xiao, M., Li, K., Liu, H. T., Liu, K. X., Wang, J. J., Li, B. and Lu, X. Y. 1994 Accelerator mass spectrometry at Peking University: Experiments and progress. *Nuclear Instruments and Methods in Physics Research B*92: 47–50.
- Fan, C. Y., Tie-mei, C., Si-xun, Y. and Kai-mei, D. 1983 Radiocarbon activity variation in dated tree rings grown in Mackenzie Delta. In Stuiver, M. and Kra, R. S., eds., Proceedings of the 11th International ¹⁴C Conference. *Radiocarbon* 25(2): 205–212.
- Guo, Z. Y., Liu, K., Li, K., Wang, J., Li, B., Lu, X., Chen, C., Chen, T., Yuan, S. and Gao, S. 1995 Improvements and applications of AMS radiocarbon measurement at Peking University. *Radiocarbon*, this issue.
- Qiu, S. H., Cai, L. Z., Chen, T. M. and Yuan, S. X. 1983 Report on the Chinese Sucrose Charcoal Standard for ¹⁴C dating. *Kexue Tongbao (Journal of Science)* 28(5): 707–713.
- Science Museum of Bailian Cave Site *et al.* 1987 Archaeological finds in the Bailian Cave site of the Stone Age. *Southern Ethnology and Archaeology* 1: 143–160 (in Chinese).
- Yuan, S. X., Chen, T. M., Gao, S. J. and Ma, L. 1990 Dating of Dushizi, Yangchun and Bailiandong, Liuzhou sites: A discussion on the time of transition from the Paleolithic to the Neolithic culture in South China. In *Collected Papers on the 30th Anniversary of Archaeology Speciality, Peking University*. Department of Archaeology, Peking University, Peking, China Cultural Relic Publishing House: 40–47 (in Chinese).
- Zhou, G. X. 1986 On Bailiandong culture. *Memoirs of Beijing Natural History Museum* 40: 19–24 (in Chinese).
- _____ 1994 The supplement study on the Bailiandong cultures. In Zhou, G. X., ed., *Proceedings of International Symposium on China-Japan Relation of Paleoanthropoid and Prehistoric Culture*. Beijing, China International Radio Press (in Chinese).