KEYWORDS: ***Cupule – Age – Microerosion – Central China***

THE 2018 EXPEDITION TO FANGCHENG CUPULE SITES IN CENTRAL CHINA

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Abstract. A survey conducted in May 2018 in Fangcheng County, China, has systematically recorded and studied five site complexes including 21 rock art panels with over 250 petroglyphs, mainly consisting of cupules, and has secured nine microerosion age estimates ranging from late Neolithic to early Post-Ancient Era, by profitably utilising the Deyunshan calibration coefficient for quartz provided by the 2014 expedition.

1. Introduction

The Nanyang Basin, which is located in the centre of the land of China, was formed by the collision of the Yangtze Platform and the Central China Orogen during the Palaeozoic and Mesozoic eras, and its quite hilly landscape was forged by the plate movements in those periods. Fangcheng County, a sub-administrative division of Henan Province, lies in the margin of the basin, with the Mt Funiu in the north-west and the Mt Tongbai in the south-east. Hundreds of petroglyph sites (mainly cupules) have been witnessed and reported by locals within this area since 2010, but no systematic survey has been conducted so far. In 2014, a multinational research group launched a microerosion dating project across China, including numerous sites in Ningxia, Jiangsu and Henan. In the area of Fangcheng, those researchers have visited the sites of Wufuling, Zhaodian, Huihuimo and Xiaomazhuang, and have secured several age estimates. Besides, three calibration curves were provided by the inscriptions of Guanyinshan, Deyunshan and Laomogou (Tang et al. 2017).

The 2014 expedition was the first scientific study of Fangcheng petroglyphs; however, there are still hundreds of sites remaining unrecorded. In view of this, after a detailed discussion with members of the 2014 expedition, taking the IFRAO standards as reference, the authors of this paper have worked out a systematic recording and research plan on Fangcheng petroglyphs, by applying measuring, photographing, drawing, microscopic observation, microerosion dating, 3D reconstruction and replicative experiments. As the first step of this program, the authors have conducted a survey on five site complexes of Fangshan, Zhangzhuang, Laoguanshigou, Yilipo and Wushigou in May 2018, during which 21 rock art panels with over 250 petroglyphs, mainly consisting of cupules, have been investigated and recorded; moreover, nine age estimates were secured (Fig. 1).

2. The sites

2.1 Fangshan

The Fangshan Hill, a laccolith of intrusive igneous rock formed during the Yanshanian (a local term referring to the tectonic events of the early Alpide orogeny in China) phase, is about 110–130 m above the surrounding land (275 m a.s.l.), and 20 km east from Fangcheng County. It was called originally Zi-

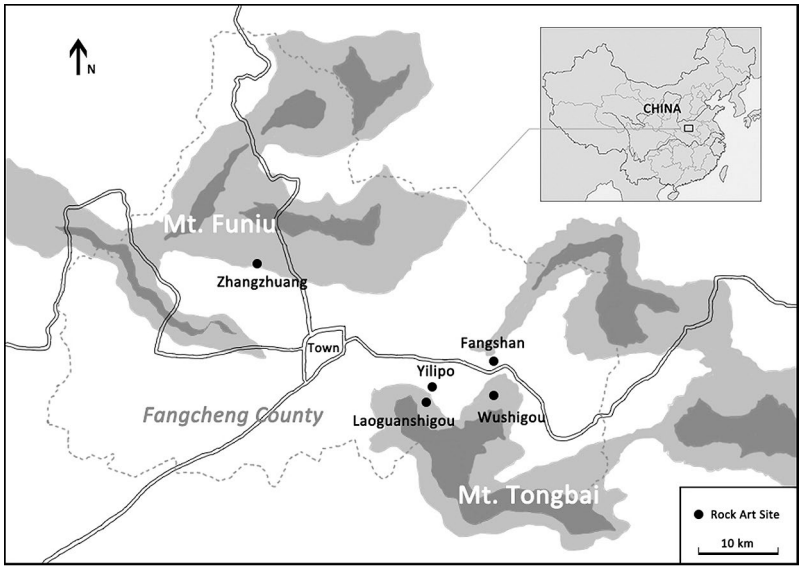

Figure 1. *The study area in Fangcheng County, Henan Province.*

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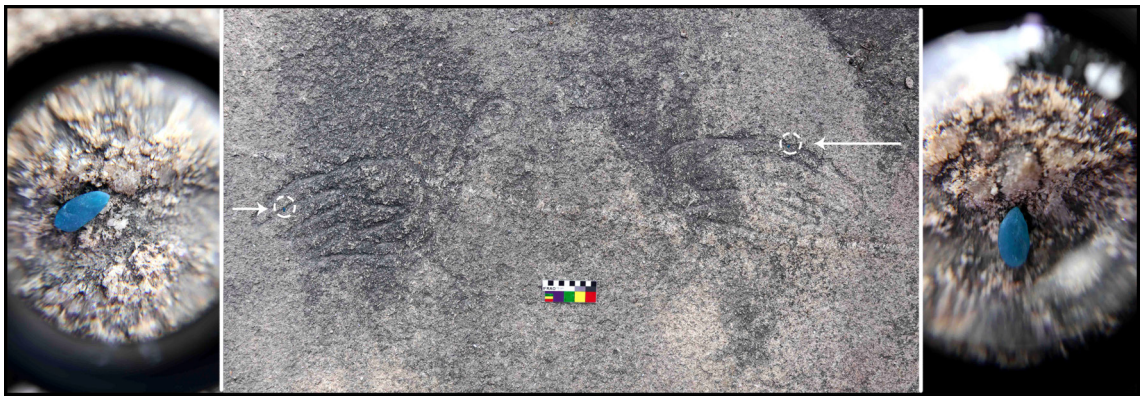

Figure 2. *Zoomorphic motifs of Fangshan 2, the measured micro-wanes are marked by blue plasticine.*

fangshan (Zifang's Hill), a name given by local people to commemorate Zhang Zifang, a famous strategist of the early Western Han dynasty (202 BC–8 AD). There are four petroglyph sites found in an area between its south side and the north side of Wugang village, and have been studied by the authors.

Fangshan 1 is in a granite shelter on the south-west side of the hill, halfway up to its top. The shelter, located in a small gully with steep gradients (24°), used to be a huge boulder of 5 m height and 7 m width, its current entrance of 2.18 m high and 4.75 m wide is a result of exfoliation caused by millions of years of water movement. The rock bearing the petroglyphs which is about 1.8 m long, 1.6 m wide and 0.3 m thick, was a part of the exfoliated rock mass, and has been re-shaped into a quite smooth appearance by runoff water. Thirty-five cupules and two grooves occur randomly or are arranged in a double row on the top surface of the rock, the average size of the cupules being 60.7 (diameter) × 16.4 (depth) mm. The largest is 102.1 × 31.2 mm and the smallest is 29.9 × 6.6 mm. Impact marks of 1–2 mm can be seen in several cupules. The rock does contain quartz grains, but it is not suitable for microerosion analysis as the panel has not been exposed to rainfall.

A gentle slope lies between the hillside and Wugang village, where numerous granite outcrops can be seen. Fangshan 2, 3 and 4 are distributed in this area.

Fangshan 2 is on a giant outcrop about 30 m to the north-west of Wugang village. The outcrop is 10 × 20 m, of which the top is severely weathered. The petroglyphs, two axisymmetric waterfowl-like zoomorphic motifs in naturalistic style, occur on a flat panel of 4 × 5 m on its east side, inclined at 12° from horizontal. Motif 1 on the left is 525 × 375 mm, the average width and depth of its grooves are 9.8 and 4.5 mm; motif 2 on the right is 430 × 375 mm, the average width and depth of its grooves are 6.9 and 5.4 mm. Two microerosion determinations were obtained from these two petroglyph motifs. The first derives from a single quartz grain in the groove of the wing of the left motif. A micro-wane of 300 μm length yielded the following wane widths: 22, 25, 30, 40, 20=137/5=27.4 μm. The second derives from a single quartz nodule in the groove of the wing of the right motif. The micro-wane measures again 300 μm and yielded the following wane widths: 35, 30, 30, 30=125/4=31.25μm (Fig. 2).

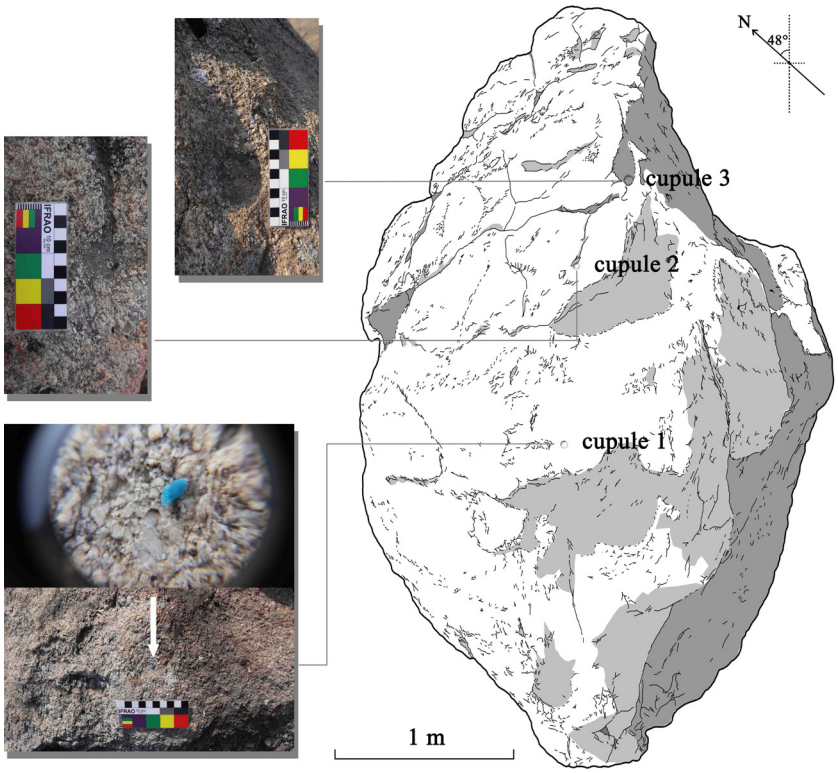

Figure 3. *Cupules of Fangshan 4, the measured micro-wane is marked by blue plasticine.*

Fangshan 3 is a granite boulder about 200 m to the north-west of Fangshan 2, 50 m south-east from the tree line at the hillside. The rock measures 2.9 (L) × 1.3 (W) × 2.4 (H) m, with severely weathered surface. It is rather remarkable that its vertical northern surface is full of lattice cracks which might be the result of a long-term freeze-thaw action. Four cupules

Figure 4. *Cupule 25 of Wushigou 1; note the hardened rim.*

occur randomly on the top of the rock, filled with dust or bird droppings, or with some lichen adhering to their surface. The average size of the cupules is 69.8 (diameter) × 19.1 (depth) mm, in which cupule 4 is the largest, of 88.1 × 56.3 × 21.3 (oval-shaped) mm. There are numerous inclusions of crystalline quartz in the rock, but the majority of them are of granular appearance and the fracture angles are outside the required range, thus the microerosion analysis is not applicable.

Fangshan 4 is a monzonitic granite boulder with a pinkish appearance because of the abundance of orthoclase feldspar, about 400 m to the north-east of Fangshan 3, 50 m south-east from the tree line at the hillside. The rock is 4.8 (L) × 1.8 (W) × 2.1 (H) m, with the surface severely weathered. Its vertical northern surface is full of lattice cracks, and a 10 cm wide crack occurs on its south-east side which is so deep that almost cuts through the whole rock. Three cupules with average size of 53.6 (diameter) × 11 (depth) mm were found on the top surface inclined at 10° from horizontal, in which the cupule 1 is the shallowest, with a depth of 5.1 mm. At the edge of its bottom, a major body of crystalline quartz was found, of which two edges at 90° were measured: micro-wane 1 is 320 μm long and yielded the following wane widths: 20, 30, 20, 20, 20, 20, 20=150/7=21.43 μm; micro-wane 2 is 400 μm long and provided these wane widths: 20, 25, 20, 25, 20, 20=130/6=21.67μm. A huge quartz nodule sits at the centre of the cupule 2, but the fracture angles are outside the required range. The surface of cupule 3 contains quartz, but is of granular appearance and lacks distinctive crystal texture (Fig. 3).

2.2 Wushigou

About 2.8 km to the south of Fangshan Hill, at the opposite side of Zhaodian Valley, lies the Yanziding (wild geese' top) Hill, a laccolith of intrusive igneous formed during the Yanshanian phase which is about 100 m above the surrounding land (265 m a.s.l.). The runoff water from the slope eroded a steep gully at the hillside called Wushigou (gully of stone shelter). Five petroglyph sites were found along the northern ridge of the hill.

Wushigou 1 is in a granite shelter on the edge of a cliff. The shelter used to be a huge boulder, 5 m high and 6 m wide; its current entrance of 2.85 m height and 3.1 m width is a result of erosion caused by millions of years of water movement. The rock bearing petroglyphs which is about 2.93 m long, 1.72 m wide and 0.3 m thick, was a part of the exfoliated rock mass and has been re-shaped into a quite smooth appearance by runoff water. Some accretion of carbonate and silica can be seen along the direction of water flow. Sixty-two cupules and one groove occur randomly or be arranged in parallel rows on the top surface of the rock, most of them with unclear edges. They are severely corroded, thus only six cupules can be measured, of which the average size is 75.2 (diameter) × 20.1 (depth) mm. It is noteworthy that the rim of the cupule 25 is steeply risen upwards with quite wavy micro-topographic features (Fig. 4), this phenomenon might be a result of 'kinetic energy metamorphosis' (Bednarik 2015). If it is it would be the first time KEM has been observed on granite. The rock does contain quartz grains, but it is not suitable for microerosion analysis as the panel has not been exposed to the rain. Along the dripline of the shelter, several drip pits occur on the bedrock, with some dead algae adhering below their rims.

Wushigou 2 is a granite boulder about 180 m to the east of Wushigou 1. The rock is 1.76 (L) × 1.47 (W) × 1.15 (H) m. Twenty-six cupules and two grooves were found on the slightly granular-exfoliated top panel, and their average size is 76.7 (diameter) × 22.5 (depth) mm, in which the largest is 136.2 × 49.8 mm; the smallest is 45.1 × 15.4 mm. Cupules 1–7 and cupule 26 occur randomly, while cupules 9–22 are arranged in double rows. Cupule 23 is semi-surrounded by cupules 24, 25 and a curved groove connecting them.

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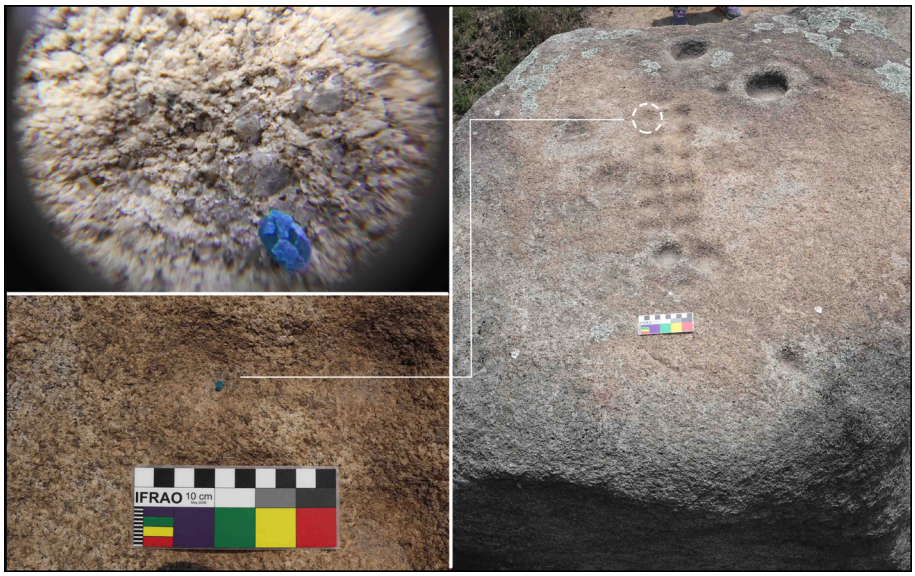

Figure 5. *Cupules of Wushigou 2; the measured micro-wane is marked by blue plasticine.*

These four motifs together might form a meaningful complex. The researchers found a crystalline quartz grain with a perfect fracture-edge of 90° at the centre of the cupule 9. The micro-wane is 300 μm long and yielded the following wane widths: 22, 20, 20, 15, 20, 20, 22, 20, 20, 20, 15, 12, 20, 10=256/14=18.29 μm (Fig. 5).

About 170 m to the north-east of Wushigou 2 is the location of Wushigou 3, 4 and 5. These three sites, which are suggested to have been a ritual complex, lie on a large granite outcrop of 15 × 10 m, and were examined by the researchers of the 2014 expedition (mentioned as Shipenggou site, in Tang et al. 2017). The top of the outcrop is severely eroded by water movement; as a result, an extremely shattered and rugged appearance is left.

Wushigou 3 is a 'phallus'-shaped cylindrical rock column, 0.87 m high, bearing an unusually large cupule on the top, the diameter of which is 270 mm and the depth is 74.9 mm. The cupule is experiencing granular exfoliation, and extensive crystalline quartz grains can be seen on its wall; however, no age data were successfully collected as the wall was so steep that the microscope could not be steadily placed.

Wushigou 4 used to be an integrated rock exposure on the north side of the outcrop, and was eroded lately into four separated panels. Twenty-four cupules are arranged in single row, in double rows or randomly on three of the four panels. Their average size is 53.9 (diameter) × 14.3 (depth) mm, in which the largest is 92.7 × 23.6 mm, and the smallest is 36.3 × 12.8 mm. One microerosion determination was obtained from a 90° edge of a fractured crystalline quartz in the cupule 6 on panel 1. Its micro-wane is 400 μm long and yielded the following wane widths: 25, 22, 20, 18, 15, 13, 10, 15, 20, 15, 15, 13, 18, 20, 18=257/15=17.13 μm (Fig. 6).

At a higher position on the south side of the outcrop, is located the Wushigou 5. The exposure of 5.5 × 2.4 m was eroded into several panels, on two of them occur 25 cupules in double rows or are randomly arranged. Their average size is 53.5 (diameter) × 16.7 (depth) mm, in which the largest is 88.3 × 13.4 mm, and the smallest is 12.9 × 13.1 mm (Fig. 7). In 2014, members of the dating expedition secured a microerosion age estimate from a cupule on the panel 1, but this time the authors of this paper failed to re-locate the same quartz grain.

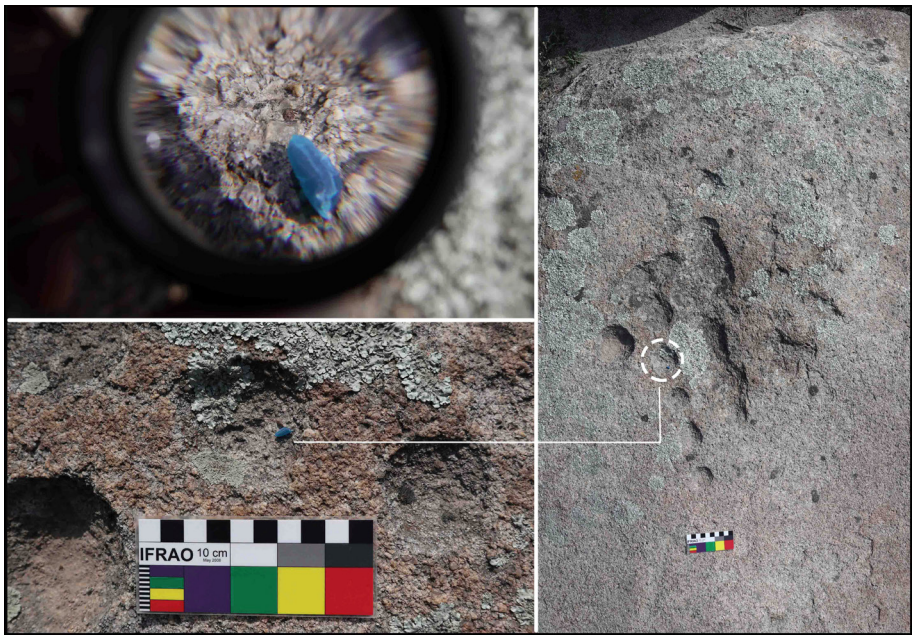

Figure 6. *Cupules of Wushigou 4-1; the measured micro-wane is marked by blue plasticine.*

2.3 Zhangzhuang

A series of gentle hills lie about 2 km to the south of Mt Funiu, and 20 km north-west from the Fangcheng County, where the Zhangzhuang site is located. Twenty-five cupules and two grooves were found on an upper Proterozoic mica-quartzose schist rock exposure of 20 × 10 m, about 50 m to the west of the Zhangzhuang village. The exposure is actually a bedding plane. The strata were bent into an anticline during the 'Himalayan Movement' (a local term referring

to the tectonic events of the late Alpide orogeny in China), then the hinge broke and has been gradually weathered and exfoliated into its current appearance. The cupules occur randomly or are arranged in rows, most of them have a quite smooth surface, and no clear tool marks can be found. However, some parallel scratching traces can be observed by microscope; it seems that the cupules had been ground or polished after their production.

Figure 7. *3D reconstruction of the panel 1 of Wushigou 5.*

The average size of the cupules is 49.7 (diameter) × 15.5 (depth) mm, in which the largest is 83.8 × 24.8 mm, and the smallest is 20.3 × 8.5 mm. Cupule 6 was made on a quartz vein, two crystalline quartz grains were found on its bottom. The first grain at the western margin of the bottom provided two measurable wanes, in which the micro-wane 1 is 210 μm long and yielded the following wane width: 10, 10, 9, 10, 8, 10, 10=67/7=9.57 μm; the micro-wane 2 is 300 μm long and yielded these wane widths: 15, 12, 12, 10, 15, 12, 20, 12=108/8=13.5μm. The other grain on the east offered one measurable wane of 250 μm length yielding the following wane widths: 15, 20, 12, 10, 12, 10=79/6=13.17μm (Fig. 8).

2.4 Laoguanshigou and Yilipo

About 15 km east from Fangcheng County, along the north side of Mt Tongbai, lies a gully called Laoguanshigou (referring to 'rocky gully frequently deluged' in Chinese), with steep banks full of granite outcrops. Three sites are distributed along the slope on its north bank.

Laoguanshigou 1 is a granite boulder on the slope, where two panels bearing cupules were found. One is on the top, the other is on the east side of the boulder. Four cupules occur singly on the top panel, their surfaces are very rough, experiencing extensive granular exfoliation, no tool traces can be identified. The eastern panel inclines at 10° outward, forming a semi-shelter structure, of which the upper part, especially the area along the dripline, is covered by silica accretions, while a great amount of lichen and algae adheres to its lower surface. A dozen abnormal cupules can be observed, with one side extremely shallow, even at the same level of the surrounding rock surface. These cupules are all severely exfoliated, and no traces of anthropogenic impact can be found. Generally speaking, no evidence of human intervention can be confirmed at this site.

Laoguanshigou 2 is a rock exposure on the top of the bank, very close to the lime pool of a quarry. This site was highly recommended by the local guide for its unusually deep 'cupules'. The panel is covered by a thick lamina of carbonate accretions, on which several huge cone-shaped or semi-spindle-shaped cupules filled with dirt and plants were found. Their walls are very steep, of which the upper parts are almost vertical. No tool marks can be seen, however, there are extensive parallel spiral traces on their walls. Based on these observations, these 'cupules' are much more likely potholes (Bednarik 2008) rather than anthropogenic marks (Fig. 9).

Laoguanshigou 3 is a granite outcrop at the bottom of the gully. The panel is heavily weathered and exfoliated, on which 11 cupules are arranged either aligned or randomly. The average size of the cupules is 48.1 (diameter) × 11.7 (depth) mm, in which the largest is 74.3 × 20.5 mm, and the smallest is 13.8 × 10.4 mm.

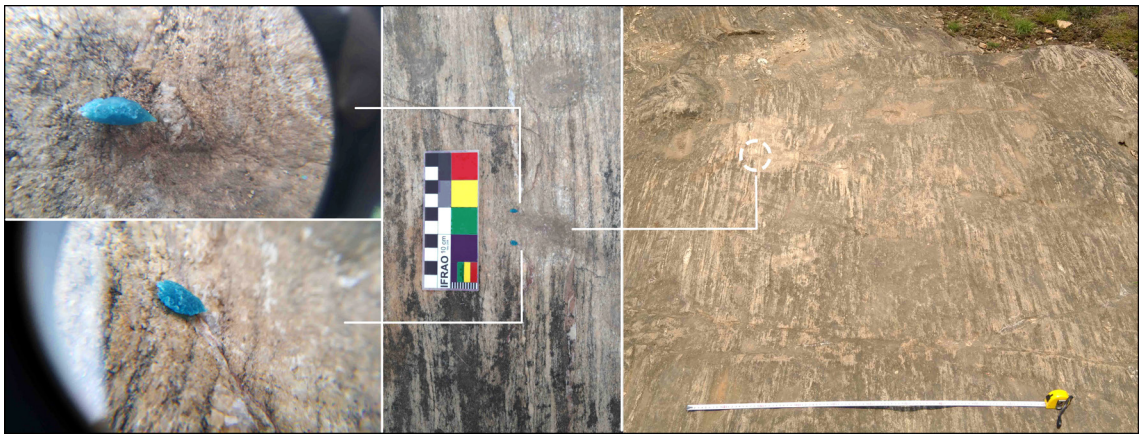

Figure 8. *Cupules of Zhangzhuang, the measured micro-wanes are marked by blue plasticine.*

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Their surfaces are quite smooth, and the fractured quartz crystals are all too tiny to be measured, with unclear appearance.

Yilipo is a small village about 2 km to the north of Laoguanshigou, where two rock art panels were found on a granite bedrock right behind a villager's house. Panel 1 contains a huge cupule and a dozen smaller ones arranged in double rows, but unfortunately, the former has been filled with cement by locals and the latter are covered by lichen. The circumstance of panel 2 is even worse, for the rock surface is highly weathered and covered by mosses. All of the above made any measuring and microscopic analysis impossible. In view of this, the two researchers decided to leave the panels untouched to keep their scientific potential for further studies.

Figure 9. *One of the unusually deep 'cupules' of Laoguanshigou 2 (left), comparing it with a drip pit at Wushigou 1 (right); note the blackish accretions in both pits which might represent the position of water surface.*

3. Interpretation of the data

One of the most valuable legacies of the 2014 rock art dating expedition is the Deyunshan calibration microerosion coefficient which can greatly facilitate the following studies of petroglyphs in central China. By applying this coefficient of 6.6 μm/ka (Fig. 10), nine age estimates of quartz have been secured in the present study: the zoomorphic motif 1 of Fangshan 2 yielded an estimate of E4150 + 1910 / - 1120 years bp (throughout this paper, 'bp' refers to 'before 2018 CE', not to the radiocarbon reference point), while the zoomorphic motif 2 yielded an estimate of E4730 + 570 / - 180 years bp (Fig. 11); cupule 1 of Fangshan 4 provided two different but quite close dates, one of E3250 + 1300 / - 220 years bp and the other of E3280 + 510 / - 250 years bp; cupule 6 of Zhangzhuang site provided three different age estimates, E1450 + 70 / - 240 years bp (Fig. 12), E2050 + 980 / - 530 years bp and E1990 + 1040 / - 470 years bp (the former two are obtained from one crystal); cupule 9 of Wushigou 2 yielded an age estimate of E2770 + 560 / - 1250 years bp;

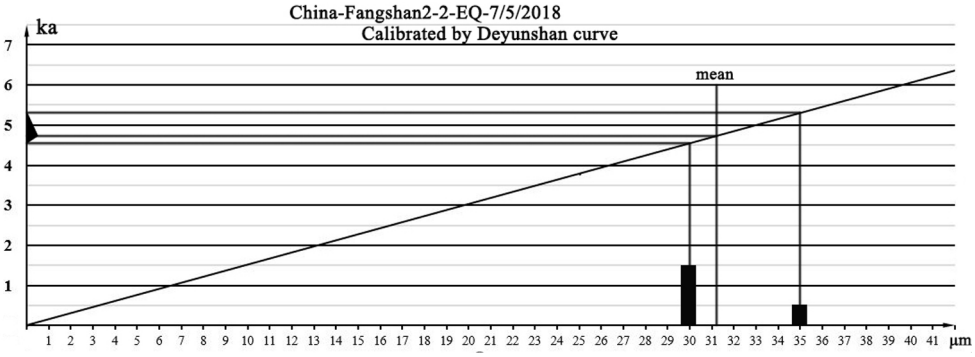

Figure 11. *Microerosion age estimate of the zoomorph 2 at Fangshan 2.*

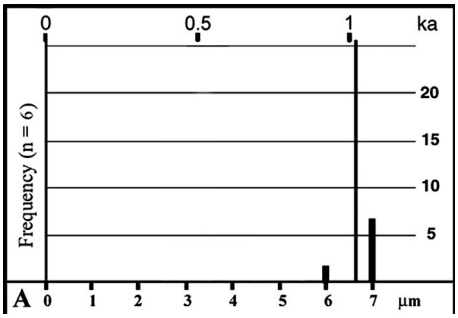

Figure 10. *The Deyunshan microerosion calibration curve for quartz, used as the standard for Henan Province (Tang et al. 2017).*

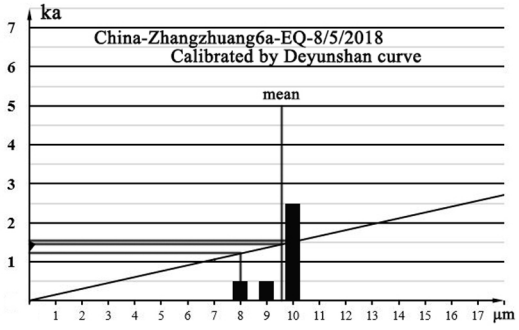

Figure 12. *Microerosion age estimate yielded by one of the three micro-wanes in the cupule 6 of Zhangzhuang.*

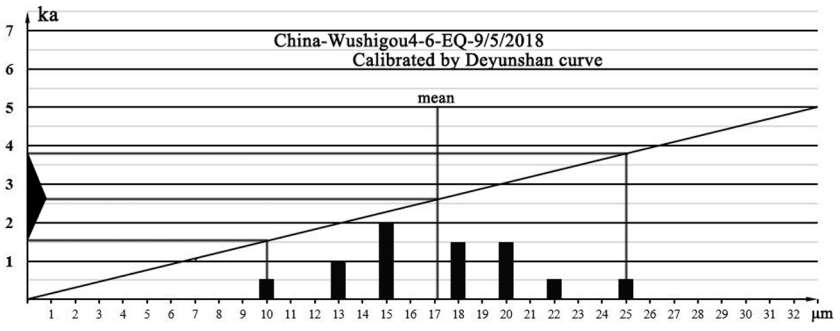

Figure 13. *Microerosion age estimate of the cupule 6 of Wushigou 4.*

Site	Motif	Micro-wane	Age estimate
Fangshan 2	Zoomorph 1	China-Fangshan2-1-EQ-7/5/2018	E4150+1910/-1120
	Zoomorph 2	China-Fangshan2-2-EQ-7/5/2018	E4730+570/-180
Fangshan 4	Cupule 1	China-Fangshan4-1a-EQ-7/5/2018	E3250+1300/-220
	Cupule 1	China-Fangshan4-1b-EQ-7/5/2018	E3280+510/-250
Zhang-zhuang	Cupule 6	China-Zhangzhuang 6a-EQ-8/5/2018	E1450+70/-240
	Cupule 6	China-Zhangzhuang 6b-EQ-8/5/2018	E2050+980/-530
	Cupule 6	China-Zhangzhuang 6c-EQ-8/5/2018	E1990+1040/-470
Wushigou 2	Cupule 9	China-Wushigou2-9-EQ-9/5/2018	E2770+560/-1250
Wushigou 4	Cupule 6	China-Wushigou4-6-EQ-9/5/2018	E2600+1190/-1080

Table 1. *The microerosion dating results from Fangcheng of the survey in May 2018.*

and cupule 6 of Wushigou 4 yielded an age estimate of E2600 + 1190 / - 1080 years bp (Fig. 13).

4. Discussion

In this expedition, two researchers have studied five site complexes including 21 rock art panels with over 250 motifs, and have secured nine age estimates (see Table 1). However, there are still hundreds of sites that need to be investigated in this region. At the end of the 2014 report, the experts point out that 'for a wide-ranging understanding of rock art traditions in this great country, thousands of such data would be required'. In this sense, the 2018 expedition is a follow-up work of the 2014 effort, but considering the extensive amount of cupule sites in central China, this might be the beginning of another long march. According to the results of microerosion dating of 2018, the ages of the examined petroglyph sites range from late Neolithic to early post-ancient era, in which Fangshan 2 is the oldest, of the Longshan Period (3000 BCE – 1900 BCE), while the latest is Zhangzhuang site where some rock art was created in the Western Han Dynasty (202 BCE – 8 CE), and was probably retouched in the last few decades of the period of the Northern and Southern Dynasties (420 – 589 CE). Moreover, the two age estimates that the authors secured at Wushigou are very close to the data obtained at the same site (E2650 ± 380) in 2014, which could to help demonstrating the repeatability of microerosion analysis.

The equipment used by the authors for microscopic observation was a base-free monocular optical microscope with fixed magnification of 100×, which sometimes produced more deviations in measuring than binocular stereomicroscopes, but still could be regarded as a comparatively ideal choice because of its excellent portability and flexibility and its unique advantage of the possibility of being put into, not just over, cupules to observe closely their 'floors' and 'walls' (ordinary microscopes usually are not capable of such operation). This is especially suitable for a small team consisting of only two researchers, lacking further logistical support.

Benefiting from the progress of photogrammetry and digital processing, the technology of 3D reconstruction has become much simpler and convenient, can be done even with one digital camera, thus it will surely play a key role in field recording and documentation of rock art in further studies.

In addition, unfortunately, the application for replicative experiment was not approved by local authority for the issues of 'safety', while it is rather interesting that, as far as the authors know, none of conservation measures has been carried out to the petroglyph sites till now. It seems that the true intrinsic value of rock art will possibly not be realised in a short time, as this underdeveloped region is still suffering from poverty and bureaucracy. Accordingly, what is of the greatest concern to the authors is the prospect that vandalism and natural deterioration will affect this cultural heritage over the next few decades.

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