KEYWORDS: ***Cupule – Age estimate – Microerosion analysis – Northeast China***

THE 2018 EXPEDITION TO ANSHAN CUPULE SITES, NORTHEAST CHINA

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Abstract. A survey conducted in August 2018 in Anshan City, China, has systematically recorded and studied three site complexes including eight rock art panels with over 300 petroglyphs mainly consisting of cupules. Five microerosion age estimates have been secured from some of them, ranging from the 2nd century BCE to the 7th century CE, by profitably utilising the universal calibration coefficient for quartz.

1. Introduction

The city of Anshan is located near the north-eastern coastline of mainland China (Fig. 1). Its dominant landscape consisting of hills and alluvial plains was forged by crust movements during the geological time. Extensive intrusive strata of the Cretaceous period were exposed during the formation of fold and fracture structures caused by the Himalayan Movement (a local term referring to the tectonic events of the late Alpide orogeny in China); therefore, granite and adamellite are the most common types of rock. Fourteen petroglyph sites have been discovered on the slopes and ridges of Mt Dongshan to the east of the city during the Third National Survey of Cultural Heritage of China from 2007 to 2011. Local investigators have made a preliminary record, but as far as the authors are aware, no scientific work of rock art has been launched. The mountain, covering an area of 4.6 × 2.6 km, about 100–210 m above the surrounding land (160–270 m a. s. l.), is a laccolith of intrusive igneous rock formed during the Yanshanian phase (also a local term referring to the tectonic events of the early Alpide orogeny in China).

The earliest known evidence of human activities in Pleistocene around Anshan City was found at Xiaogushan Cave (30000 years bp). From the 4th to the 2nd millennium BCE, a hybrid-type of semi-agricultural semi-nomadic society appeared, for instance, the Xigou and Xianrendong Cultures. Some local researchers have made an analogy between the cupules and the tiny pit marks occurring on some potteries at Niuheliang

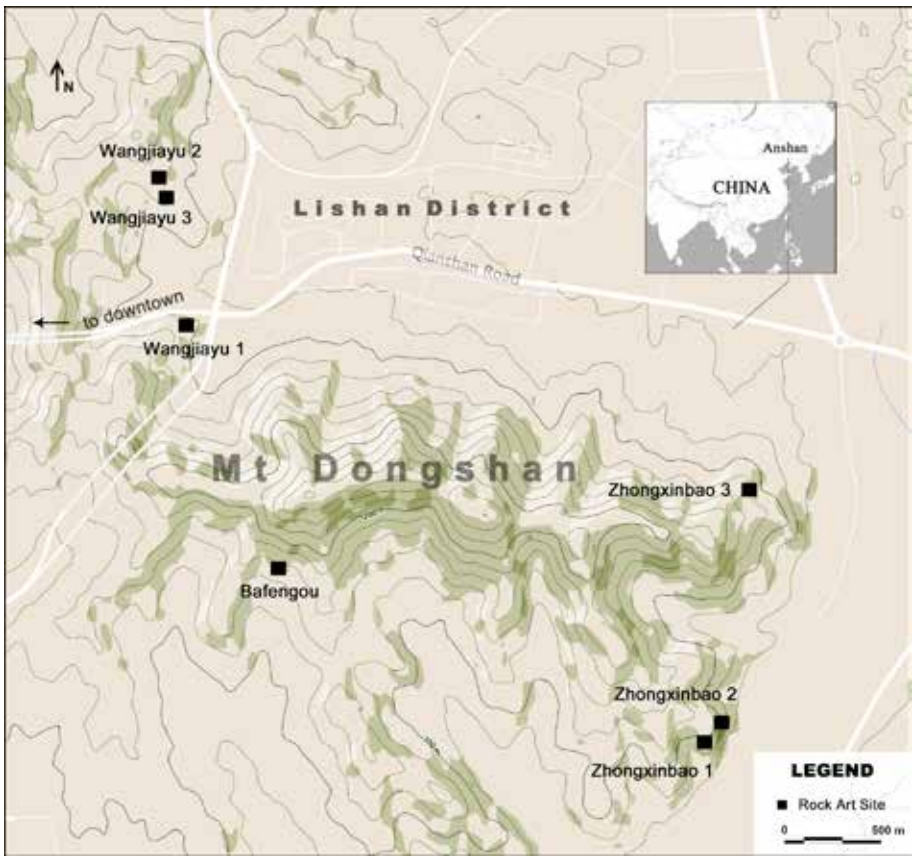

Figure 1. *The study area in Anshan City, Liaoning Province, northeast China.*

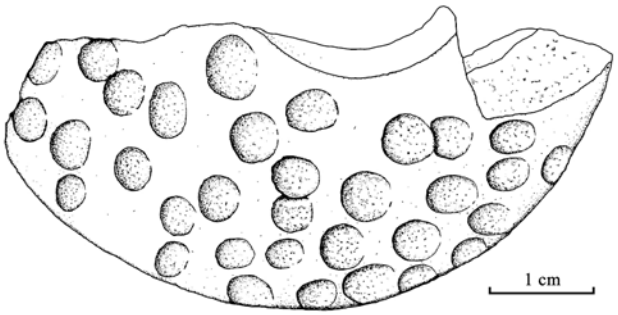

Figure 2. *Pit marks on a pottery fragment of the Niuheliang culture (sample N2Z7: 110 collected at Tomb 1, Location 2, Niuheliang Site, Lingyuan City, Liaoning Province, northeast China; see Liaoning Institute of Archaeology and Cultural Heritage 2012: 71).*

Neolithic Site about 400 km to the east of the city (Fig. 2), then assumed that a cultural connection exists (Yang et al. 2017). They suggest that a tradition of rock art production has lasted for thousands of years from the Holocene (Zhang and Wang 2010; Li and Gu 2012). However, up to the present, none of such hypotheses has been successfully proved.

According to recent local reports, some of the sites have been vandalised by urban expansion in the last decade (Li et al. 2019). In 2018, the authors of this paper conducted a systematic survey of three main site complexes of Anshan petroglyphs, including the sites of Bafen'gou, Wangjiayu and Zhongxinbao. Over 300 motifs (mainly cupules) on eight panels have been measured, recorded, statistically analysed and microscopically examined, then five age estimates by microerosion analysis have been secured (Fig. 3).

2. The sites

2.1 Bafen'gou

The first site that the authors visited was in Bafen'gou Valley (meaning 'valley of eight tombs' in Chinese). A granite boulder of 1.97 (length) × 1.24 (width) × 1.12 (height) m was found in an orchard of pear trees on the south slope of the mountain from where one can overlook the entire valley. The rock art panel is on the top surface, which is severely weathered, and multiple exfoliation scars can be seen. Eighty-four cupules occur on the panel, most of them are arranged randomly, while some in rose-like circles and several are connected with grooves. The average size of the cupules is 49.4 (diameter) × 12.9 (depth) mm, in which the largest is 95 × 41 mm, while the smallest is 29.7 × 3.9 mm.

The vertical surface on the west side of the rock is

Figure 3. *The studied sites: 1 – Banfen'gou; 2 – Wanjiayu 1; 3 – Wangjiayu 2; 4 – Wangjiayu 3; 5 – Zhongxinbao 2; 6 – Zhongxinbao 3.*

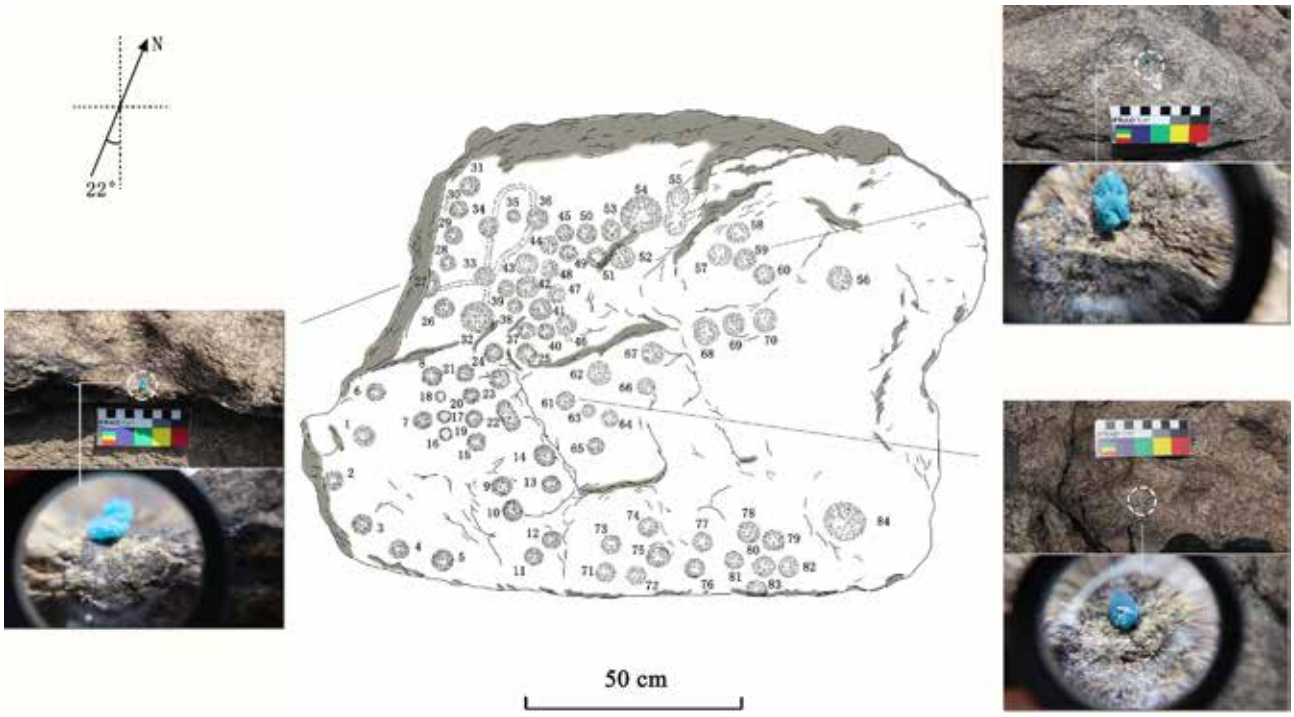

Figure 4. *The panel of Bafen'gou site; the measured micro-wanes in cupule 27, 59 and 61 are marked by blue plasticine.*

a quasi-flat plane, caused by a massive fracture event. The fracture has split a cupule into two and left a half-cupule at the broken edge (cupule 27, the other half is missing, see Fig. 3). The fracture event postdates the production event of the cupule. The researchers have successfully located an ideal micro-wane at 90° of 130 μm length on clear crystalline quartz on the fracture plane, a bit below the broken bottom of the cupule, yielding the following widths: 8, 10, 10, 10, 11, 12, 8, 9, 10 = 88/9 = 9.78 μm. This data can be beneficial in understanding the age of the fracture event, and the *terminus ante quem* of the cupule as well. Most of the rock art panels examined in the survey were severely weathered and covered by mineral deposit, lacking in identifiable evidence of superimposition relationship; therefore, to build a credible time sequence among rock art motifs only based on ordinary observation with naked eyes seems not feasible. At the same time, the case of cupule 27 has shown another way to partially achieve this goal under such circumstances, by utilising direct dating on relevant natural taphonomic events to 'indirectly' estimate the age of rock art.

Another two suitable micro-fractures were then found: the first one could be observed on a quartz nodule at the lower edge of the rim of cupule 59 and was 160 μm long, yielding the following widths: 10, 12, 8, 10, 10, 10, 12, 12, 10, 8, 8 = 110/11 = 10 μm; the other one of 210 μm long was on crystalline quartz adhering to the wall of cupule 61, yielded these widths: 10, 10, 12, 15, 15, 18, 18, 20, 20, 18, 15, 12, 15, 8 = 206/14 = 14.71 μm (Fig. 4).

2.2 Wangjiayu

This is a site complex consisting of three rock art panels which are distributed along the margins of Wangjiayu Valley (meaning 'valley belonging to the Wang family' in Chinese).

Wangjiayu 1 is a granite outcrop of 4.6 × 2 × 1.1 m, located at the very edge of the north slope of the mountain. Ninety-six cupules occur in double rows or rose-like circles on the top surface. The average size of the cupules is 49.5 (diameter) × 13.4 (depth) mm, in which the largest is 117.6 × 46.8 mm, while the smallest is 26.3 × 7 mm. The largest cupule 34 sits in the centre of a set of a rose-like circle arranged by small cupules, filled with soil and plants, and some rotating traces can be witnessed on its wall, which look similar to traces on the walls of the 'potholes' and 'drip pits' of Fangcheng cupule sites (Jin and Chao 2019).

The panel has experienced thousands of years of severe exfoliation and other types of weathering, the grains of quartz are extremely shattered and poorly idiomorphic, a state causing great difficulties in a dating attempt. The two scientists have found only one suitable fracture at 90° on a fine and clear crystalline quartz below the rim of cupule 12 after thorough microscopic examination of all the ninety-six cupules. The micro-wane is 110 μm long, yielding the widths of: 10, 10, 15, 15, 18, 18, 20, 18, 18, 15, 10, 10 = 177/12 = 14.75 μm (Fig. 5).

Wangjiayu 2 and 3 were discovered on the ridge of a small branch of Mt Dongshan, about 600 m north from Wangjiayu 1. The fifty cupules of Wangjiayu 2 occur on a granite outcrop of 3 × 2.75 × 1.5 m, most of which are arranged in incomplete rose-like circles or rows, very few are arranged randomly. The average size of the cupules is 49.4 (diameter) × 13.1 (depth) mm, in which the largest is 76.8 × 14.4 mm, while the smallest is 33.6 × 9.7 mm. The major part of the panel is covered by black accretion, which makes the observation on

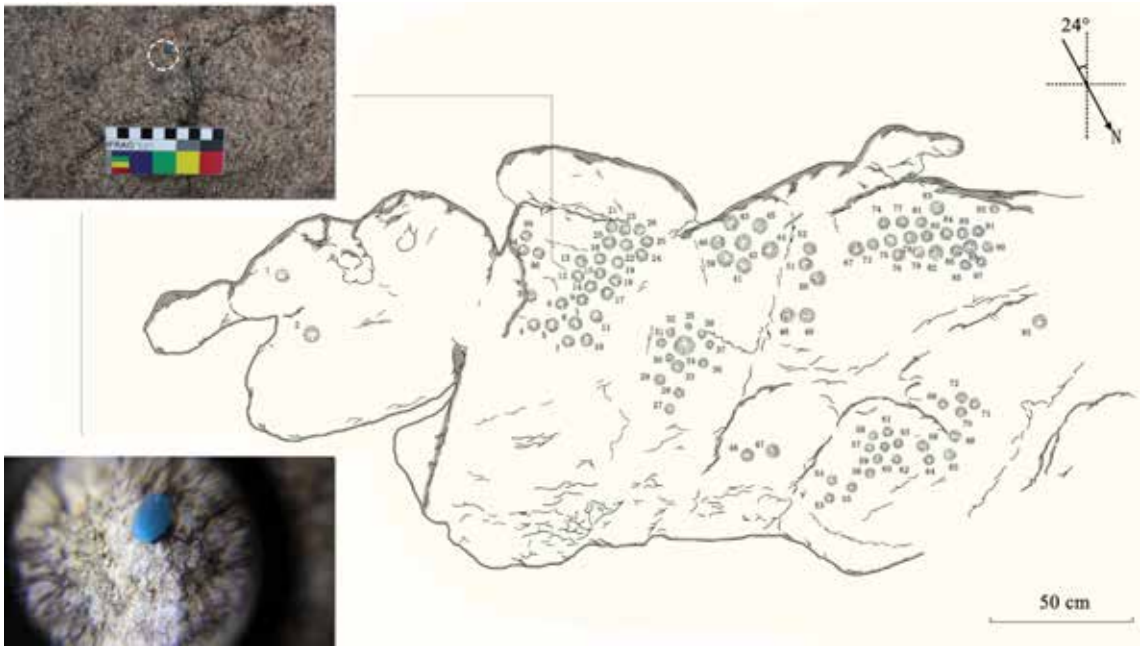

Figure 5. *The panel of Wangjiayu 1; the measured micro-wane in cupule 12 is marked by blue plasticine.*

their micro-topography very difficult. The researchers have found only one measurable fracture at 90° below the rim of cupule 4. The micro-wane is 100 μm long, providing these widths: 12, 13, 15, 18, 18, 20, 20, 21, 22, 20, 18, 15, 15 = 227/13 = 17.46 μm (Fig. 6).

About forty metres south from this site, a small granite outcrop of 1.7 × 1.06 × 0.42 m appears in the bush close to a hiking track. Ten cupules are distributed in a rose-like circle or randomly on it. Their average size is 50.6 × 10.5 mm, in which the largest is 75.4 × 14.1 mm, while the smallest is 40.2 × 8.6 mm. All the cupules are covered by black accretion; hence the microerosion analysis is not applicable.

2.3 Zhongxinbao

This site complex has three sites along the east side of the mountain, and its name '*Zhongxinbao*', which means 'fort of loyalty', comes from a nearby village.

Zhongxinbao 1 is situated on a granite cliff about 30 m high. The rock art panel is 15 m long, 10 m wide, and is covered mainly by sands delivered downhill by runoff water. Fifty-two cupules occur randomly or in rose-like circles on the exposed part of the severely granular-exfoliated panel, and their average size is 39.2 × 9.5 mm, in which the largest is 70.6 × 19.2 mm, while the smallest is 24.8 × 5.9 mm. No suitable micro-wane could be observed; however, it is noteworthy that the rims of some cupules rise upwards slightly with quite wavy micro-topographic features which closely approximate what the cupule 25 of Wushigou 1 in Fangcheng looks like in a microscope (see Jin and Chao 2019). It possibly represents an early stage of the KEM (kinetic energy metamorphosis) phenomenon (Bednarik,

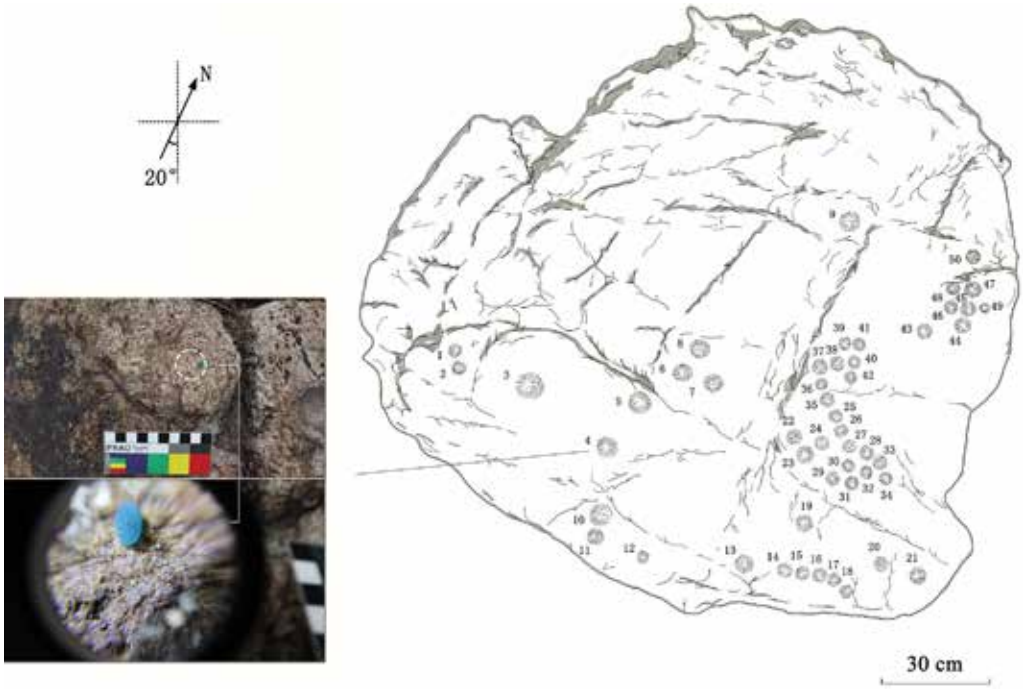

Figure 6. *The panel of Wangjiayu 2; the measured micro-wane in cupule 4 is marked by blue plasticine.*

Figure 7. *Left: the early phase of KEM can be witnessed in some cupules of Zhongxinbao 1; one of them is marked by a white arrow. Right: the micro-topographic view of the wavy rim of a cupule at Zhongxinbao 3.*

2015); and if it does, it would be the second time that KEM has been observed on granite (Fig. 7).

Zhongxinbao 2 is a 3 × 2 m granite outcrop located about 50 m north along the cliff. Eleven rock art motifs made with the 'sgrafitti' technique can be seen on the panel: ten dots and one grid-like motif. All the motifs are extremely shallow (depth ≤ 1 mm), as they were made by only removing the thin reddish weathering layer.

Zhongxinbao 3 is a sandstone outcrop lying on the top of a mountain ridge about 1 km north. Sixteen cupules occur randomly or in rose-like circles on a severely weathered panel of 0.6 × 0.5 m. The average size of the cupules is 38.7 × 12.6 mm, in which the largest is 70.1 × 19.8 mm; the smallest is 22.5 × 8.1 mm. Very clear micro-topographic features caused by KEM can be observed in many of them.

3. Interpretation of the data

The microerosion analysis, as a direct and effective method for dating petroglyphs, has been utilised at many sites in China. Analysts usually need to collect calibration data from dated inscriptions in order to secure valid age estimates of micro-wanes. For instance, in the studies in central China, researchers have used the *Deyunshan Calibration Curve* (Bednarik 2015; Tang et al. 2017; Tang et al. 2018; Jin and Chao 2019). In 2015, the *Universal Calibration Curve* was proposed (see Beaumont and Bednarik 2015; updated in Bednarik 2019) which theoretically allows the method to be used without specific samples for calibration like before. Since then, some age estimates calibrated by the UCC have been secured (Tang et al. 2020; Jin and Chao 2020).

In this expedition, the two researchers have checked a large number of inscriptions bearing clear dates. Unfortunately, no suitable coefficient for calibration has been successfully secured in the study area. Most of the inscriptions are covered by paint (in red, white or gold; it is a local custom to re-paint the inscriptions every several decades in order to maintain their visual contrast to natural rock surfaces, because some of them are regarded as masterpieces of Chinese calligraphic art), which makes microerosion analysis impossible. Hence, it is a better solution under such circumstance to use the UCC (for more information about the basic principles and recent development of microerosion analysis, see Bednarik 1992, 1993 and 2019).

The average annual precipitation of Anshan is c. 700 mm, and according to the UCC, this value refers to 8.6 μm/ka. By applying this coefficient, five age esti-

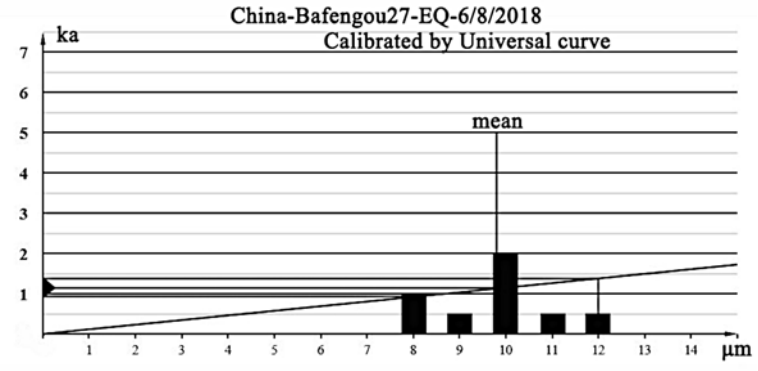

Figure 8. *Microerosion age estimate from the massive fracture under cupule 27, Bafen'gou site.*

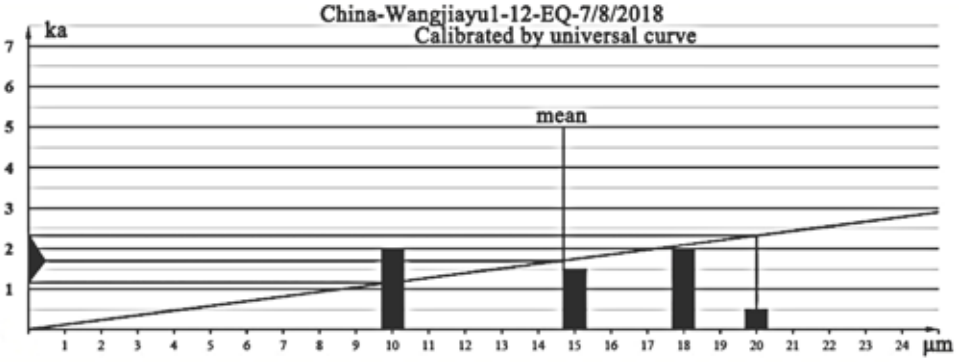

Figure 9. *Microerosion age estimate from cupule 12, Wangjiayu 1.*

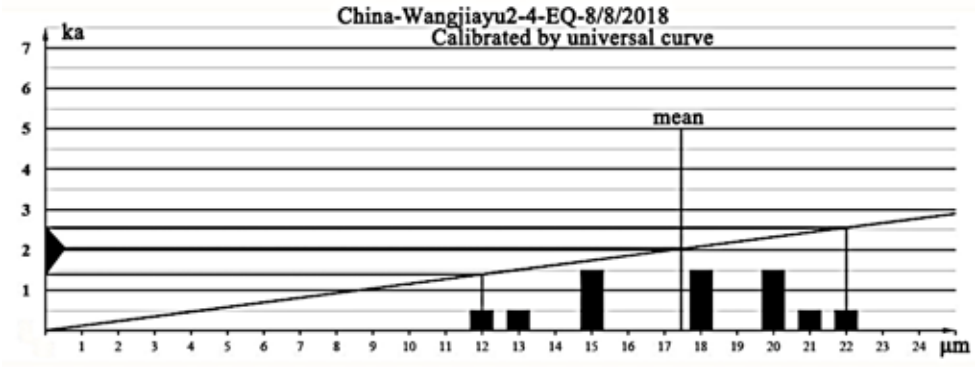

Figure 10. Microerosion age estimate from cupule 4, Wangjiayu 2.

Site	Motif	Micro-wane	Age estimate
Bafen'gou	Cupule 27	China-Bafengou27-EQ-6/8/2018	E1140+260/-210
	Cupule 59	China-Bafengou59-EQ-6/8/2018	E1160+240/-230
	Cupule 61	China-Bafengou61-EQ-6/8/2018	E1710+620/-780
Wangjiayu 1	Cupule 12	China-Wangjiayu1-12-EQ-7/8/2018	E1720+610/-560
Wangjiayu 2	Cupule 4	China-Wangjiayu2-4-EQ-8/8/2018	E2030+530/-630

Table 1. The microerosion dating results from Anshan of the survey in 2018.

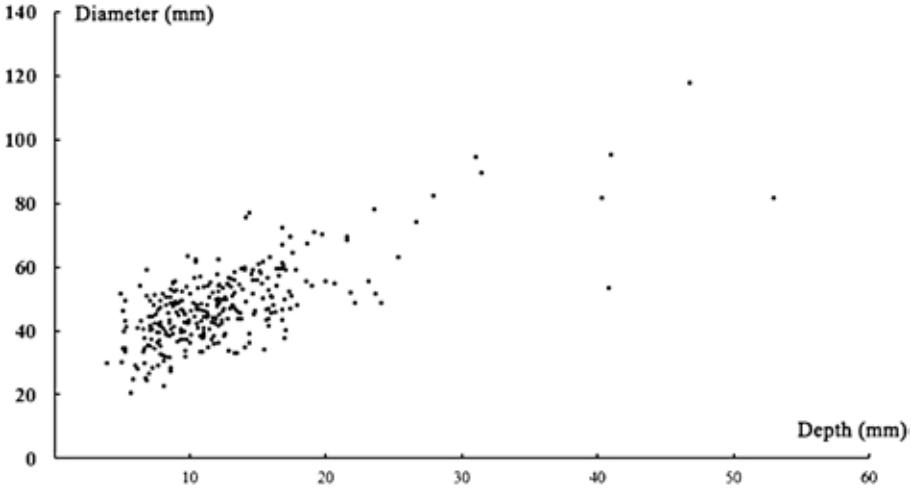

Figure 11. Scatter diagram of the size values of the cupules.

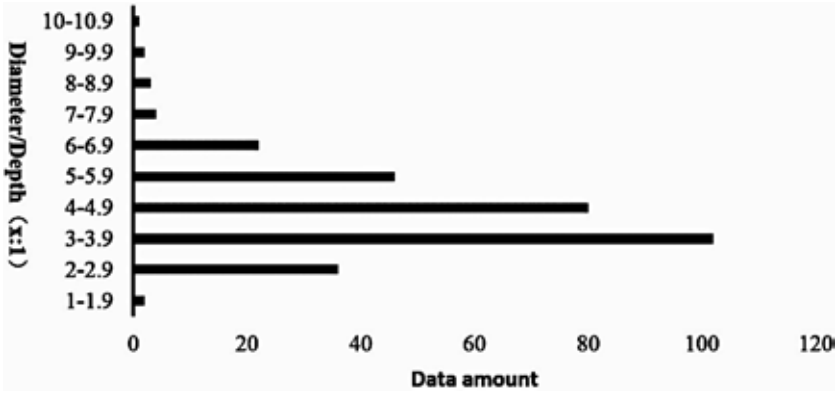

Figure 12. Value distribution of the ratios of diameters to depths of the cupules.

mates have been secured. The massive fracture that split the cupule 27 of Bafen'gou site yielded an estimate of E1140+260/-210 years bp (throughout this paper, 'bp' refers to 'before 2018 CE', not to the radiocarbon reference point), indicating that the production of cupule 27 was no later than this time (Fig. 8). Cupule 59 and 61 yielded two estimates of E1160+240/-230 years bp and E1710+620/-780 years bp. Cupule 12 of Wangjiayu 1 provided an estimate of E1720+610/-560 years bp (Fig. 9); while cupule 4 of Wangjiayu 2 produced the largest value of E2030+530/-630 years bp (Fig. 10) (Table 1).

4. Conclusion

In this expedition, 317 cupules have been recorded and studied. For the majority of these cupules, their values of diameters range between 25–60 mm, and those of the depths are between 5–25 mm (the average value of their sizes is 46.2 × 11.6 mm). The ratios of values of their diameters to their depths are mainly distributed in the interval of 3:1–5.9:1 (the average ratio is 4.4:1) (Figs 11 and 12). Comparing all these values with the micro-topographic features observed through a microscope, it is reasonable to assume that most of the cupules in Anshan were manufactured by stone tools. Only very few of them which occur with steep walls were possibly the results of metal tool utilisation. Rose-like circle and parallel rows are the dominant patterns of arrangement of the motifs, which might be connected to some specific uses.

The existing studies (mentioned at the beginning of this paper) have given various interpretations to Anshan petroglyphs, such as works of some legendary leaders in the remote past (2nd–3rd millennium BCE) like *Zhuan*

Xu and *Yu* (the former was allegedly the grandson and the successor of Yellow Emperor, and the latter is regarded as the father of the founder of the first dynasty [Xia] in Chinese history. However, the existence of these mythic sovereigns is still unverified), symbols of fertility worship, constellations and ancient maps, but none of these views can be proved by concrete evidence. Well-organised fieldwork supported by basic science seems more reliable than just imagination. In that sense, the present work is not only the first program to apply a direct dating method to Anshan petroglyphs, but also an initial attempt of scientific research on the rock art sites in this part of northeast China. The researchers have secured five age estimates by applying microerosion analysis, ranging from the 2nd century BCE (Western Han Dynasty) to the 7th century CE (Tang Dynasty). Although the use of UCC has made the results more tentative, they can still be considered as valid and acceptable, and their scientific potential of being re-calibrated by further research remains fully.

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