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# MICROEROSION DATING OF XIANJU PETROGLYPHS, ZHEJIANG PROVINCE, CHINA

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**Abstract.** A survey conducted in November 2014 in Xianju County, China, has profitably utilised the soundly dated rock inscription Wufubei for microerosion calibration. A small team has managed to secure a calibration curve and eleven age estimates from petroglyphs of Xiaofangyan and Songlongshan sites, which are two of the nine petroglyph sites known in Xianju. It is the first time Xianju petroglyphs have been subjected to attempts of direct dating.

## 1. The empirical field data

Xianju petroglyphs are located in Taizhou City of Zhejiang Province. Nine petroglyph sites have been discovered in this area since 2002, which are Songlongshan, Zhongyangkeng, Xiaofangyan, Xitang, Dongping, Yuling, Yangnongdian, Duishangang and Shimengyang (Fig. 1). This group of sites comprises more than 220 iconic and aniconic motifs, of which the 'snake' motif and the 'rake' motif are the most common. The petroglyphs are characterised by fluency of their lines and simplicity of style. Two clusters of petroglyphs were examined in the present project: Xiaofangyan and Songlongshan. Most of the rock surfaces in these two sites contain crystalline quartz that offers opportunities for microerosion analysis (Bednarik 1992, 1993, 1997, 2007; Tang 2012; Tang and Gao 2004; Tang and Mei 2008; Tang et al. 2014) where crystals have been fractured by rock art production. In addition, the team has investigated the Wufubei inscription to secure microerosion calibration, and some associated components, including a *guifu* pedestal, a stone 'man' and stone 'lion' near the inscription that are thought to be of similar age.

Xiaofangyan site is located to the north-east of Zhuxi town, its petroglyphs distributed across a huge exposure of granite bedrock. The gently sloping top of this rock features most of the motifs, with few on the

almost vertical lower parts (Zhang 2009: 75). Fractured crystalline quartz suitable for microerosion analysis occurs in some of these petroglyphs. Various motifs were pounded on the rock surface, such as 'sickle' motifs, rectangular frame motifs and 'snake' motifs, featuring a number of superimpositions.

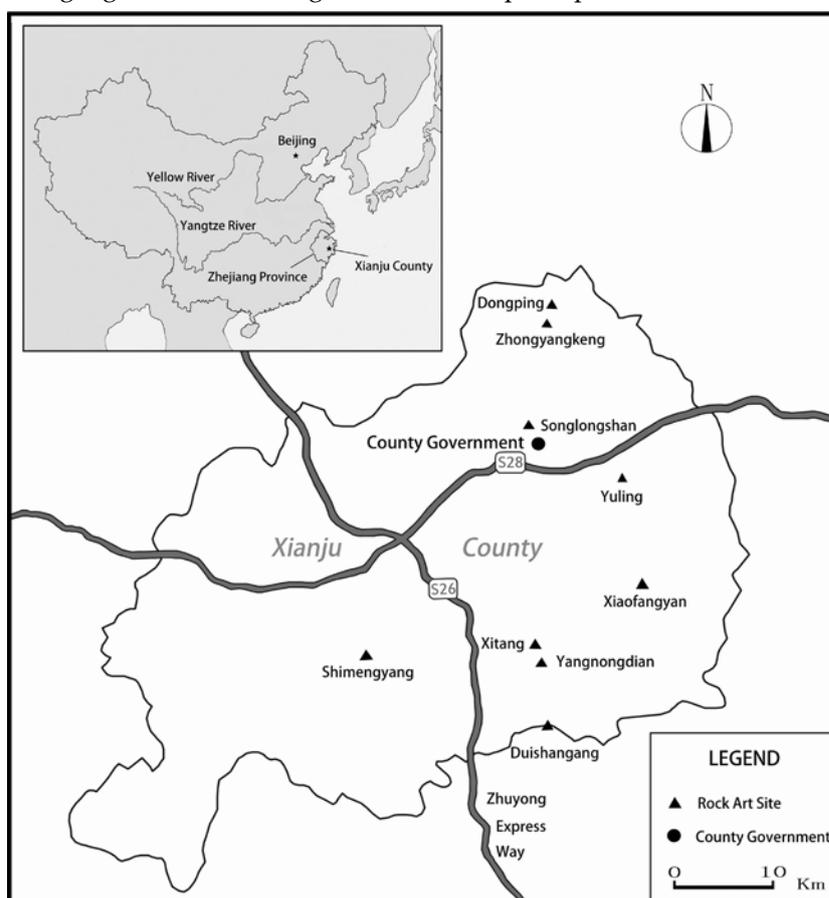


Figure 1. The study area in Xianju County, Zhejiang Province.



**Figure 2.** Part of the Wufubei inscription, showing the character used for analysis. Potential micro-wanes are marked by red plasticine.

The second investigated site, Songlongshan site, is about 500 m from the Jinjiakeng mountain, to the north of Zhaojiayang village, Fuying Subdistrict. There is a 10 m wide stream at the foot of the mountain (Hua 2013: 97). Petroglyphs have been discovered on the rock benches near the stream, and they include grid motifs, rectangular frame motifs, 'rake' motifs and 'sickle' motifs.

As the microerosion calibration of this area, the team has selected the Wufubei inscription, which is a granite inscription with a *guifu* pedestal facing south-west, located in front of Wufu's tomb in Shirentan, to the north-east of Houliwu village, Guanlu town. It is 2.7 m high, 1.3 m wide and slightly inclining forward. The inscription, created in 1203 CE, records the story of

Wufu's life and the reason why the courtiers requested a posthumous monument for him. Furthermore, a stone 'lion' and a stone 'man' of the same period have been found in the bush near the inscription. The former stands in front of the inscription, while the latter lies on the left. Micro-wane widths of them have been successfully measured and collected by the team.

### 1.1. Wufubei

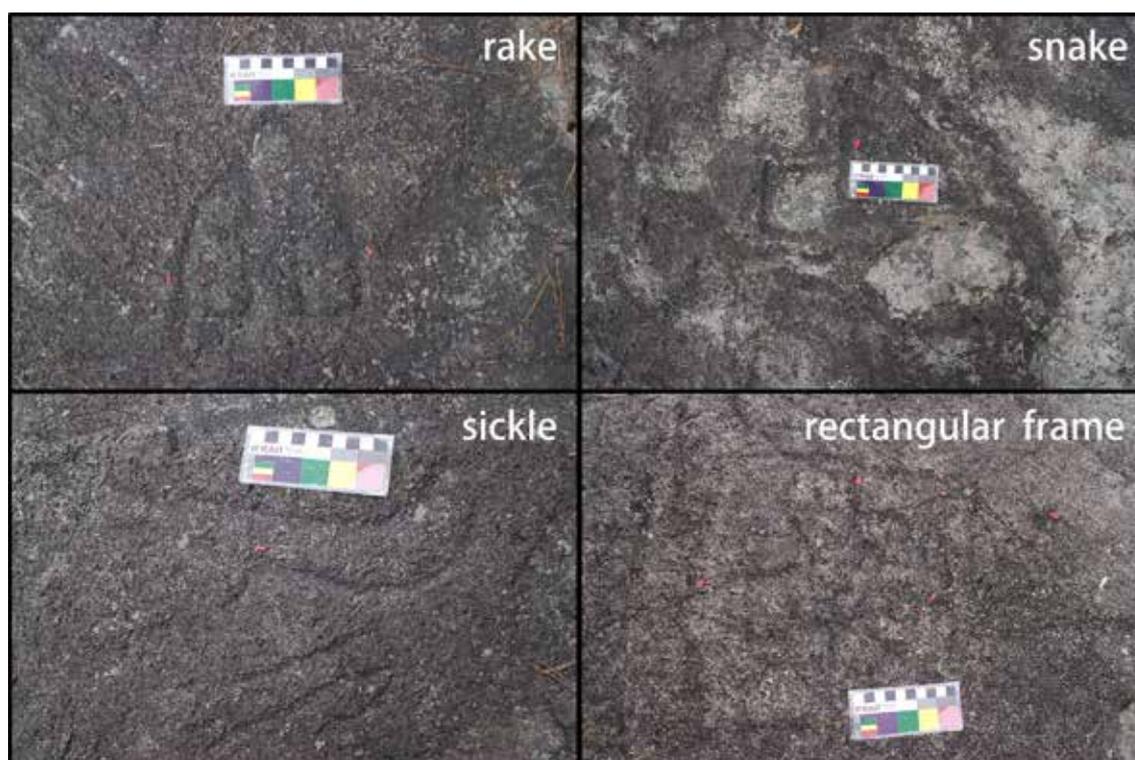
The inscription, *guifu* pedestal, stone 'lion' and stone 'man' are all made of granite. Examining the inscription, the team has found a micro-wane of quartz in the first character of the seventh row from the left, the length of which is 71  $\mu\text{m}$  and the measured widths are: 7, 7, 7=21/3=7  $\mu\text{m}$ . The team has also found a micro-wane of quartz on the *guifu* pedestal, the widths of which are: 7, 7, 10=24/3=8  $\mu\text{m}$ , and two micro-wanes of quartz on the stone 'lion': the one on the lion's head is about 71  $\mu\text{m}$  long and yielded: 7, 7, 7=21/3=7  $\mu\text{m}$ , and the other one, which is much shorter and below the brow ridge is 25  $\mu\text{m}$  long and yielded: 5, 7, 7=19/3=6.33  $\mu\text{m}$ . In addition, on the chest of the lying stone 'man', one micro-wane has been found, which is 29  $\mu\text{m}$  long and yielded wane-widths of: 6, 7, 7=20/3=6.66  $\mu\text{m}$ .

### 1.2. Xiaofangyan site

The petroglyphs occur on the surface of a large granite bedrock exposure which contains extensive components of crystalline quartz that offer possibilities for microerosion analysis. Most of the petroglyphs are 'snake' motifs or 'sickle' motifs and composed of simple lines. They might have been engraved by using metal



**Figure 3.** 'Snake' motif, Xiaofangyan. The measured micro-wane is marked by red plasticine above the IFRAO Standard Scale.



**Figure 4.** The four most common motif types at the Xianju petroglyph sites. Red plasticine marks locations where promising sites for microerosion were examined.

tools as the grooves are very deep. In this site, six micro-wanes of quartz have been observed and measured. The first one that we have found was in a 'snake' motif (Fig. 3), is 667  $\mu\text{m}$  long and yielded: 10, 13, 17=40/3=13.33  $\mu\text{m}$ . The second group of data was offered by a 40  $\mu\text{m}$  long micro-wane in one of the 'sickle' motifs by the right side of the first micro-wane, yielding: 10, 15, 15, 20=60/4=15  $\mu\text{m}$ . The third micro-wane was found in another 'sickle' motif to the left of the 'snake' motif and is 30  $\mu\text{m}$  long and yielded: 10, 10, 15=35/3=11.66  $\mu\text{m}$ . Moreover, a 29  $\mu\text{m}$  long micro-wane was found in a 'sickle' motif (Fig. 4) on the lower sloping surface of the rock, which yielded: 14, 14, 14=42/3=14  $\mu\text{m}$ .

### 1.3. Songlongshan site

The petroglyphs are engraved on the upper surfaces of a group of granite rocks forming benches, mainly consisting of 'rake' motifs (or building-shape motif), 'sickle' motifs and 'millstone' motifs. The first petroglyph that the team has found was a rectangular frame motif on the second floor of the rock benches, which comprises two micro-wanes of quartz, each about 500  $\mu\text{m}$  long, yielding: 15, 10, 10, 10=45/4=11.25  $\mu\text{m}$ . The team has also observed and measured two micro-wanes of quartz in another rectangular frame motif on the first floor of rock benches. The one in the left groove of the frame is 20  $\mu\text{m}$  long and yielded: 13, 10, 9=32/3=10.66  $\mu\text{m}$ , while the other one is 40  $\mu\text{m}$  long, yielding: 10, 10, 15=35/3=11.66  $\mu\text{m}$ . In addition, on a much higher floor, we have found a 750  $\mu\text{m}$  long micro-wane which yielded: 6, 12, 12, 12=42/4=10.5  $\mu\text{m}$ .

Numerous motifs were found on almost every floor

of the site. A 'rake' motif on the highest floor contains a 55  $\mu\text{m}$  long micro-wane, yielding the following wane-widths: 10, 10, 14, 14=48/4=12  $\mu\text{m}$ . One of the 'sickle' motifs (Fig. 5), which can be found in almost every petroglyph site of Xianju, offered the following micro-wane data: 14, 10, 7=31/3=10.33  $\mu\text{m}$ .

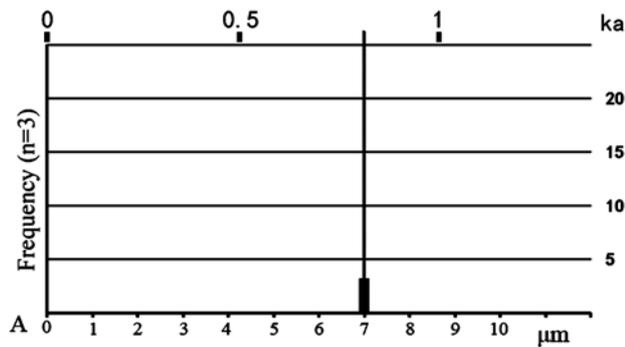
## 2. Interpretation of the data

### 2.1. The calibration curve

The average width of the micro-wanes from quartz on the Wufubei rock inscription and associated items is 7  $\mu\text{m}$ , which corresponds to a microerosion coefficient of 8.6  $\mu\text{m}/\text{ka}$ . The team has chosen the calibration curve for quartz on the Wufubei rock inscription as the basis for all age estimates from Xiaofangyan and Songlongshan (Fig. 6). The *guifu* pedestal of Wufubei



**Figure 5.** 'Sickle' motif, Songlongshan. The measured micro-wane is marked by red plasticine.

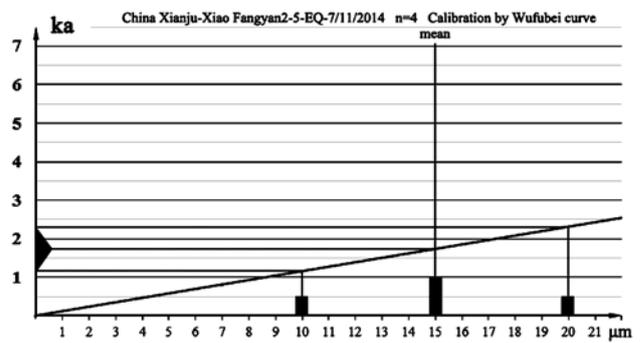


**Figure 6.** The microerosion calibration curve for quartz from the Wufubei inscription, used as the standard for Xianju County.

has provided an age estimate of  $E930 + 230 / - 120$  years BP (throughout this paper, 'BP' refers to 'before 2014 CE', not to the radiocarbon reference point). The stone 'lion's' head yielded a date of E810 years BP, while the micro-wane below the brow ridge provided a date of  $E740 + 70 / - 160$  years BP. The age estimate of the stone 'man' was  $E770 + 40 / - 70$  years BP. These results overlap just barely in their tolerance margins.

#### 2.2. The dating attempts of Xianju petroglyphs

The four petroglyphs analysed at Xiaofangyan site were numbered from 1 to 4. The 'snake' motif, Xiaofangyan 1, yielded a date of  $E1550 + 430 / - 390$  years BP. Two 'sickle' motifs, Xiaofangyan 2 (Fig. 7) and Xiaofangyan 3, were made in different periods, in which the Xiaofangyan 2, the older one, yielded a date of  $E1740 + 590 / - 580$  years BP, while the age estimate



**Figure 7.** Microerosion age estimate of Xiaofangyan 2.

of Xiaofangyan 3 was  $E1360 + 380 / - 200$  years BP. Xiaofangyan 4 provided a date of E1630 years BP.

Two micro-wanes found in the first rectangular frame motif of Songlongshan site both yielded a same date of  $E1310 + 430 / - 150$  years BP. However, the second rectangular frame motif provided two different dates, one of  $E1240 + 270 / - 190$  years BP (Fig. 8) and the other of  $E1360 + 380 / - 200$  years BP. The third rectangular frame motif yielded  $E1220 + 180 / - 520$  years BP (Fig. 9).

In addition, one 'rake' motif in Songlongshan site yielded a date of  $E1400 + 230 / - 240$  years BP, and a 'sickle' motif provided a date of  $E1200 + 430 / - 390$  years BP.

### 3. Conclusion

This is the first program to apply a direct dating method to Xianju petroglyph sites. By comparing eleven sets of micro-wane data from Xiaofangyan and Songlongshan with the calibration curve of Wufubei,

Site	Motif	Micro-wane	Age estimate
Wufubei 2	Guifu pedestal	China Xianju-Wufubei2-1-P2-EQ-7/11/2014: 7, 7, 10=24/3=8 µm	$E930+230/-120$
Wufubei 3	Head of stone 'lion'	China Xianju-Wufubei3-1-P2-EQ-7/11/2014: 71×7, 7, 7=21/3=7 µm	E810
	Brow ridge of 'lion'	China Xianju-Wufubei3-2-P2-EQ-7/11/2014: 25×5, 7, =19/3=6.33 µm	$E740+70/-160$
Wufubei 4	Breast of stone 'man'	China Xianju-Wufubei4-1-P3-EQ-7/11/2014: 29×6, 7, =20/3=6.66 µm	$E770+40/-70$
Xiaofangyan	Xiaofangyan 1	China Xianju-Xiaofangyan1-5-EQ-7/11/2014: 667×10, 13, 17=40/3=13.33 µm	$E1550+430/-390$
	Xiaofangyan 2	China Xianju-Xiaofangyan2-5-EQ-7/11/2014: 40×10, 15, 15, 20=60/4=15 µm	$E1740+590/-580$
	Xiaofangyan 3	China Xianju-Xiaofangyan3-4-EQ-7/11/2014: 30×10, 10, 15=35/3=11.66 µm	$E1360+380/-200$
	Xiaofangyan 4	China Xianju-Xiaofangyan4-4-EQ-7/11/2014: 29×14, 14, 14=42/3=14 µm	E1630
Songlongshan	Rectangular frame 1	China Xianju Songlongshan1-1-P5-EQ-7/11/2014: 500×15, 10, 10, 10=45/4=11.25 µm	$E1310+430/-150$
	Rectangular frame 1	China Xianju Songlongshan1-2-P4-EQ-7/11/2014: 500×15, 10, 10, 10=45/4=11.25 µm	$E1310+430/-150$
	Rectangular frame 2	China Xianju Songlongshan2-1-P4-EQ-7/11/2014: 20×13, 10, 9=32/3=10.66 µm	$E1240+270/-190$
	Rectangular frame 2	China Xianju Songlongshan2-2-P4-EQ-7/11/2014: 40×10, 10, 15=35/3=11.66 µm	$E1360+380/-200$
	Rectangular frame 3	China Xianju Songlongshan3-1-P4-EQ-7/11/2014: 750×6, 12, 12, 12=42/4=10.5 µm	$E1220+180/-520$
	'Rake' 1	China Xianju Songlongshan4-1-P4-EQ-7/11/2014: 55×10, 10, 14, 14=48/4=12 µm	$E1400+230/-240$
	'Sickle'	China Xianju Songlongshan5-1-P4-EQ-7/11/2014: 14, 10, 7=31/3=10.33 µm	$E1200+430/-390$

**Table 1.** The microerosion dating results from Xianju of the survey in November 2014.

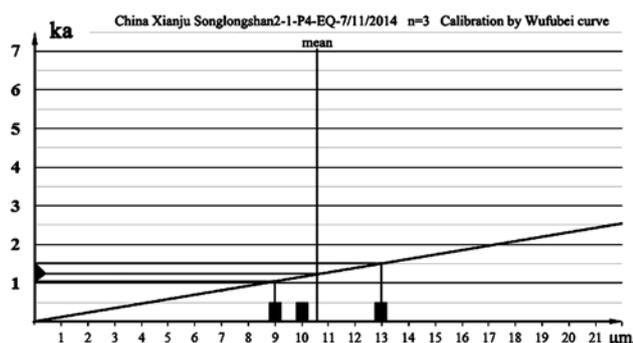


Figure 8. Microerosion age estimate of Songlongshan 2-1.

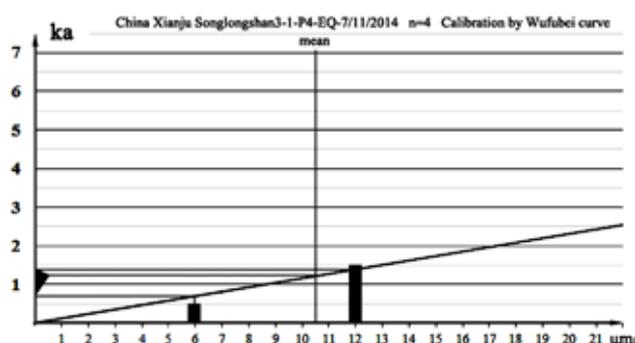


Figure 9. Microerosion age estimate of Songlongshan 3-1.

several microerosion age estimates have been secured. Accordingly we can say that the analysed petroglyphs at Xiaofangyan site were made from about 1740 to 1360 BP (274–654 CE), yet those at Songlongshan site were made much later, from about 1400 to 1200 BP (614–814 CE). According to the historical chronology of China, the creation of the petroglyphs at Xiaofangyan site lasted through a long period from the Wei to the early years of Tang Dynasty, while the successive creation of petroglyphs at Songlongshan site occurred during the Tang Dynasty.

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