KEYWORDS: ***Petroglyph – Eastern Tianshan – Direct dating – Replication experiment – China***

SCIENTIFIC RESEARCH AT THE HONGSHANKOU PETROGLYPH SITE COMPLEX IN THE EASTERN TIANSHAN RANGE, NORTHWEST CHINA

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Abstract. As the first phase of the 'Eastern Tianshan Range Project', a series of surveys conducted in 2020 and 2021 at the Hongshankou rock art site complex, Xinjiang, China, has systematically recorded and studied 135 rock art panels with 436 petroglyphs. Forty-two microerosion age estimates ranging from the 12th century BCE to the 7th century CE have been secured by profitably utilising the universal calibration coefficient curve for quartz. Furthermore, a replication experiment of rock art production has also been completed at the site complex.

1. Introduction

The Tianshan Range, which covers an area in the heartland of the Eurasian continent of 2500 km in length from east to west (more specifically, from the Xingxingxia Valley, Xinjiang, China, to the Qizilqum Desert, Uzbekistan) and 300 km wide on average from north to south, lies within the territories of China, Kazakhstan, Kyrgyzstan and Uzbekistan (Fig. 1). The main body of the mountain system was formed during the late Palaeozoic and Mesozoic (Zhang and Wu 1985: 13), and a massive intrusive event occurred between 480 Ma and 240 Ma ago (Mabi et al. 2014). However, its present geomorphological features result from crustal movement since the late Cenozoic (Li et al. 2006: 905).

Geographically, the entire mountain system is divided into three sections: the western, central and eastern. The area of the eastern Tianshan Mountains, consisting of Barkol Mountain, Moqinura Mountain, Karlic Mountain, Barkol Steppe, Yiwu Valley and the Hami Basin, represents a geographic unit that used to have particular significance in a cultural sense. On the one hand, it was the first land of what Europeans called Serindia or the Xiyu (which means the 'Western Regions' in Chinese) mentioned in ancient Chinese historical records, where the Han people[1] set foot

1 Han is the main ethnic group in China, representing 91% of the country's population (the remaining 9% is made up of 55 minority ethnic groups). Its appellation originated from the Han Dynasties (the 2nd century BCE – the 3rd century CE). The Han people describe themselves as the descendants of the legendary sovereigns in the remote ages, i.e. Huang Di and Yan Di (the Yellow Emperor and the Fire Emperor, who are believed to have been two tribal chiefs of 5000–6000 years ago living in the middle

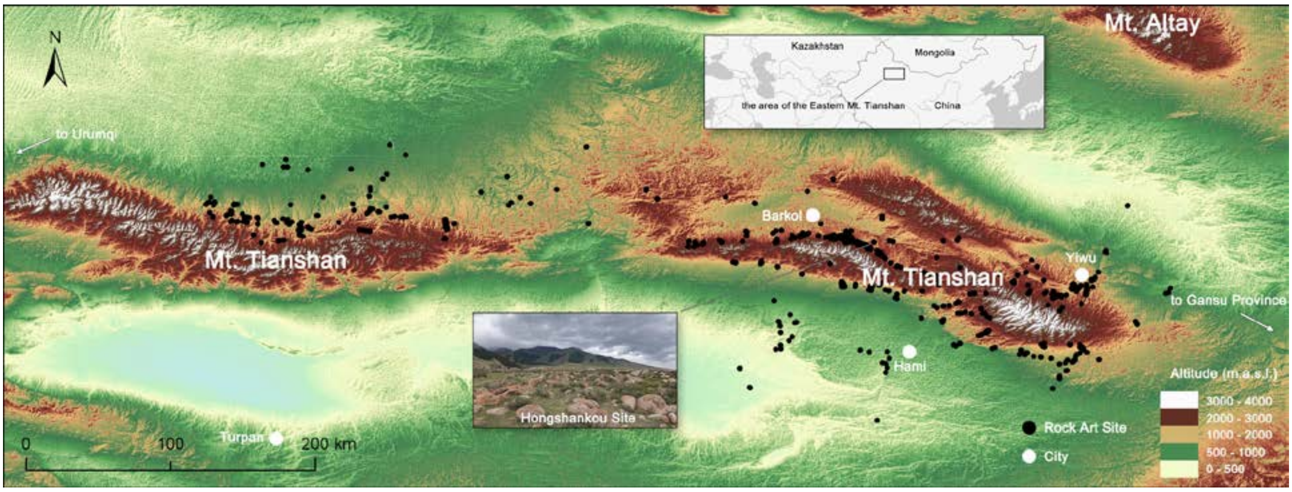

Figure 1. *Rock art sites in the eastern Tianshan Range, Xinjiang, northwest China.*

after a long trudge across the famous Hexi Corridor. On the other hand, in the past three thousand years, almost every nomadic group from central Asia or southern Siberia (e.g. the Xiongnus, Yuezhis, Wusuns, Rourans, Tölös, Türks, Tanguts, Khitans, Jurchens) had to control this area first to cut the connection between the Zhongyuan ('Central Plains' in Chinese, referring to the basins and plains around the middle and lower reaches of the Yellow River which is traditionally regarded as the cradle of the ancient Chinese civilisation) and the Xiyu. For millennia, the dynamic interactions have built strong and unique geo-cultural connections among the eastern Tianshan and the adjacent areas, such as the Yili Valley, the Altay Mountains, the Taklimakan Desert, the Mongolian Plateau and the Central Plains. Therefore, this area is, without doubt, one of the keys to understanding the formation of the 'Silk Roads' and the interplay of cultures along them in the past.

Although its particular significance is almost self-evident, the eastern Tianshan Range was not paid enough academic attention until the very last decade of the 20th century. The early archaeological missions in Xinjiang conducted by both Chinese and Europeans mainly focused on Buddhist remains, military fortresses, beacon towers and city ruins in oases, recorded in M. A. Stein, S. Hedin, P. Pelliot and W. Huang's travel notes. The interest in nomadic sites has become a noticeable trend only in the most recent decades. Thanks to China's Third National Survey of Cultural Heritage (the 3rd NSCH in brief, 2007–2011), a tremendous number of seasonal settlements, cemeteries and rock art sites related to ancient nomadic life have been found in the area. According to the authors' rough statistics, 110 rock art site complexes along the slopes of the eastern Tianshan Mountains consisting of more than 11000 panels with possibly over a million petroglyph motifs have been reported. Some of the sites are enormous; for example, 2480 rocks bearing petroglyphs have been observed at the Shirenzigou Site on the north slope, while the Wulatai Site on the other side of the mountain is believed to comprise no less than 3000 decorated rocks (archaeologists of Northwest University provided this information). Since the beginning of this century, researchers from Xinjiang Institute of Archaeology and Northwest University have conducted a series of archaeological surveys and excavations at several settlements and cemeteries. They have also preliminarily recorded hundreds of rock art panels along both sides of the mountains. Nevertheless, compared with the astonishingly vast quantity of rock art, the current academic efforts are still paltry. The lack of scientific study of this rock art has become an impediment that hinders the progress of regional archaeological research.

Being aware of the above, in 2019, the authors of this paper determined to start a regional scientific program focusing on rock art called 'The Eastern Tianshan Range Project' (the ETRP in brief). The project is defined as a long-term (lasting for 5–10 years), non-government-funded activity. Its basic goal is to determine when and by whom those petroglyphs were made, through various experimental and analytical means. Methodologically, it also aims to address a long-existing problem in the field of rock art dating, i.e. in most cases, the age estimates of sites are secured by analysing samples collected from only a few motifs. However, a site complex may comprise hundreds or even thousands of rock art panels, and sometimes hundreds of motifs exist on one panel. The described usual way of sampling can only provide very limited results in defining the complex as a whole. Therefore, the crucial point of rock art dating is to render the results statistically significant, which demands a relatively large quantity of data collected from the site. In reality, only very few places can meet the required conditions. For instance, microerosion analysis requires abundant uncontaminated granular crystals of quartz or feldspar on rock surfaces; hence it is most readily applicable at granite sites. Fortunately, the innumerable granite boulders along the slopes of the eastern Tianshan Mountains delivered by millions of years of glacial movement and flash floods allow researchers to make such attempts. Therefore, since 2020, fieldwork has been conducted at specific sites in Barkol and Yiwu as the project's first steps. This paper aims to report the progress made during the past two years at the Hongshankou site complex near Barkol.

2. Fieldwork at Hongshankou Rock Art Site Complex (2020–2021)

This archaeological site complex is located at Hongshan Farm, about 25 km southeast of Barkol County, Xinjiang Autonomous Region. Since being discovered in the first few years of this century, 255 tombs, 66 dwellings, three large architectural complexes and 496 rocks with petroglyphs lying on the broad alluvial fan about 1 km outside the Hongshan Valley ('Hongshankou' means 'entrance of the Red Mountain Valley' in Chinese) have been reported (Fig. 2). After a preliminary survey and recording in 2008, archaeologists from Northwest University suggested that Hongshankou might be the largest known site complex of the seasonal settlement of ancient nomads in the eastern Tianshan Mountains area (Research Centre of Silk Roads Archaeology of Northwest University 2014: 29).

2.1 Direct dating

In 2020, the site was selected as the first workplace of the ETRP, and since then, 119 rocks bearing 436 petroglyphs have been studied (about 1/5 of the reported quantity, which actually has become smaller since 2015 because of the construction of an 8 km long asphalt road which connects the valley and the G335 National Highway leading to the town). Intensive application of microerosion analysis and replication experiments have been conducted. According to the authors' observation, over 40% of the petroglyphs were made on granite, the rest on gabbro and diorite. Most of the rock art panels are severely weathered; hence the superimpositions among motifs are unclear. The dominant technical form of rock art production at Hongshankou is the sgraffito, made by removing the varnish layer to reveal a differently coloured surface beneath. According to taphonomic logic, sgraffiti have a very limited life span, and in most cases, they remain visible for no more than three millennia (Bednarik 1994, 1995). The studied motifs are mainly zoomorphic, including 376 'caprids' (perhaps *Capra sibirica* and *Ovis ammon*), 3 'cervids', 16 'equids', 1 'bovid', 16 'canids' and 1 'camelid', while very few are anthropomorphous (10), 'symbolic' (8), object-like (1) and unidentified (4). Ovicaprine-like motifs are the most common (86.2%). Moreover, three styles have been observed, linear, silhouetted and outlined (see Fig. 3), consisting of 313, 99 and 24 motifs, respectively, and of which linear is the major style (71.8%). The information of some typical sites as examples is listed in Table 1 and Figure 4, and the rest will be provided in a future, more detailed monograph.

During the field microscopy, the researchers used a monocular microscope with a 100× fixed power lens system for observation, a 15× optical magnifier and a 40× digital lens for photography. Dozens of micro-wanes have been located and analysed (Fig. 5). The researchers have also visited the Museum of Barkol and examined the only two existing stone tablets with clear dates discovered in the vicinity, the Ren Shang Bei and Pei Cen Bei inscriptions[2] for securing local calibration

reaches of the Yellow River). However, the growth of the Han group from Neolithic river tribes to over a billion of the population was, in fact, a continuous process of absorbing neighbouring ancient peoples like the Hu, Di, Yi and Qiang; hence in this sense, the Han is probably not an ethnic group based on genetic ties, but more likely a cultural group built upon the consensus of Confucianism-based social order and the Chinese language.

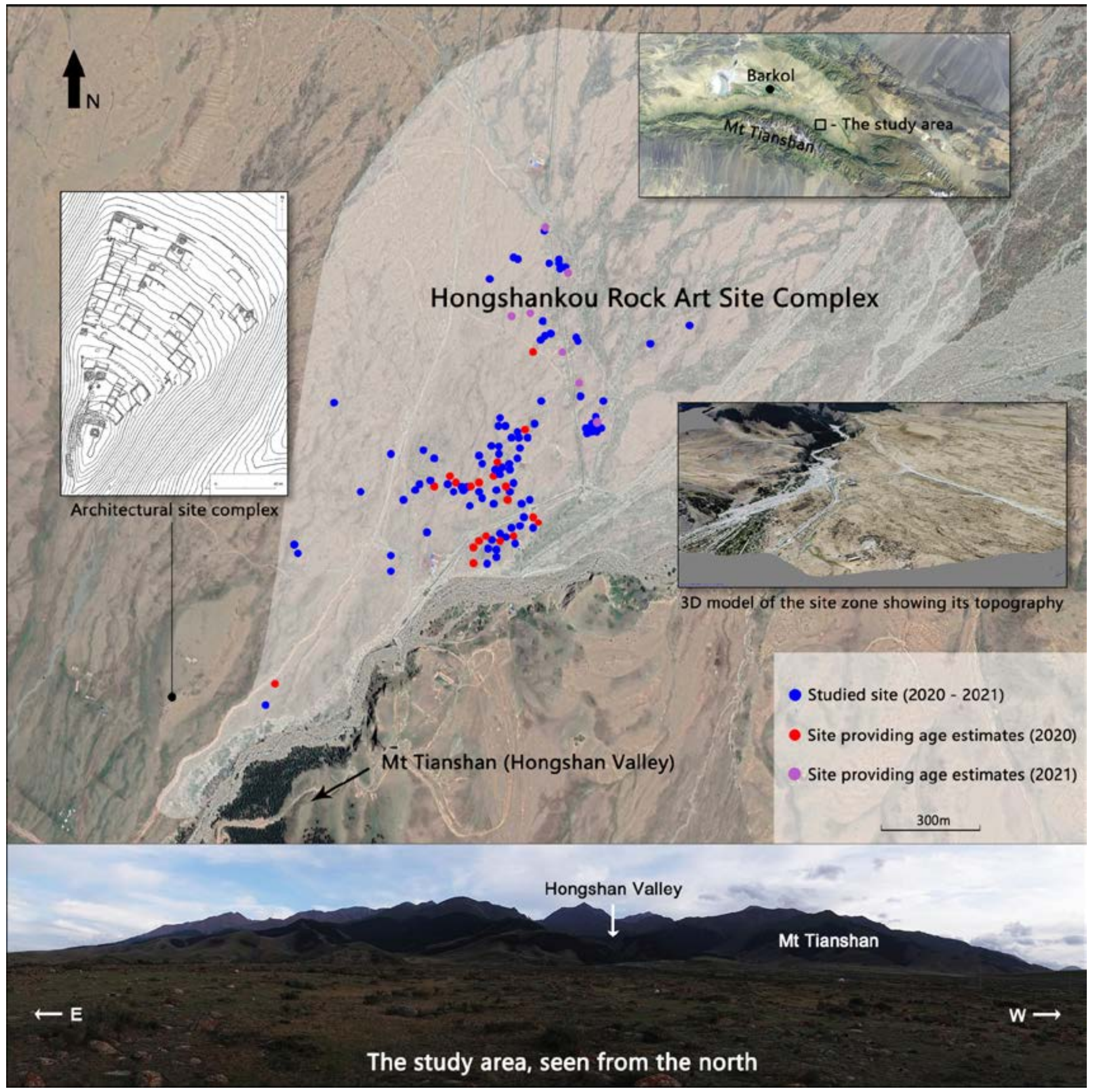

***Figure 2.** The Hongshankou Rock Art Site Complex study area, Barkol, Xinjiang, northwest China.*

2 These two inscriptions were both made for recording victories by the troops of the Eastern Han Dynasty during the conflicts with nomadic tribes in the 1st and 2nd centuries CE. The former was carved in 93 CE, describing General Ren Shang's triumph of defeating the main force of Northern Xiongnu and capturing their king, Yuchujian Chanyu, while the latter was set up in 137 CE, recording the decapitation of King Huyan of Northern Xiong

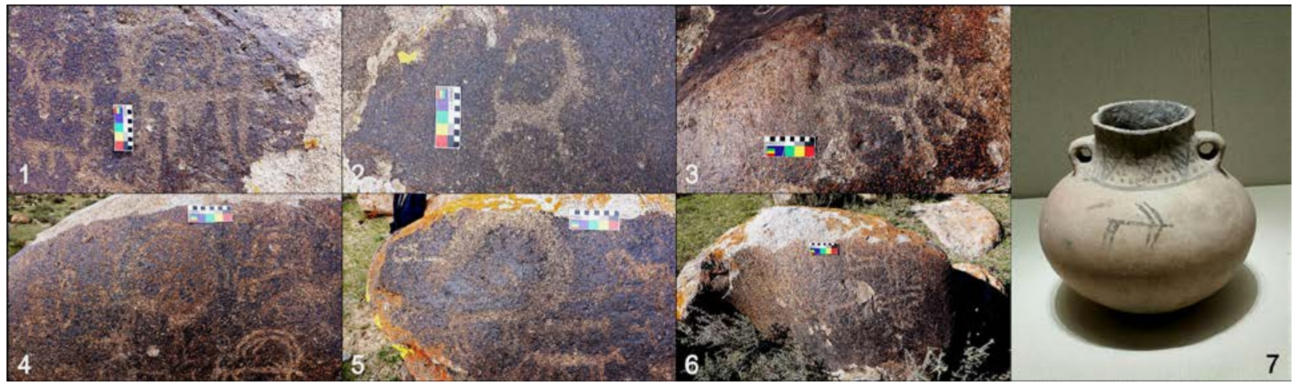

***Figure 3.** Typical motifs at the Hongshankou site (1) some linear sheep-like motifs; (2) a silhouetted sheep-like motif; (3) an outlined deer-like motif; (4) a motif combined with a 'sheep' and a 'wheel'; (5) a re-created bighorn sheep-like motif; (6) a cross-like symbol; (7) painted pottery excavated from Yanblaq cemetery, Hami, now conserved in the Museum of Xinjiang Uyghur Autonomous Region.*

Site	Size (m)	Rock art panel			Micro-wane		
		Panel	Orientation/ inclination	Motif & technique & style	Wane	Location (quartz)	Length & widths (μm)
HSK57	1.5×1.3 ×1.4	Panel 1	SE131°/29°	10 sheep-like; percussion; 7 linear, 2 silhouetted, 1 outlined	Wane 1	At one of the 'front legs' of a silhouetted sheep-like motif on the top left corner of the panel	130; 8/10/11/11/10/ 11/12/11/11/10
		Panel 2	SW180°/65°	4 sheep-like, 1 anthropomorph (archer-like), 2 wolf-like, 1 wheel-like, 2 unidentified; percussion; 5 linear, 5 silhouetted	Wane 1	At the 'tail' of a linear sheep-like motif on the right part of the panel	150; 5/5/5/6/8/ 7/6/5/5
					Wane 2	At the 'belly' of the same motif	120; 13/12/12/11/12/10/ 10/11/10/10/10
HSK98	4.2×1.9 ×1.8	Panel 1	SW234°/67°	7 sheep-like; percussion; 3 outlined, 4 linear	Wane 1	At the 'head' of an outlined sheep-like motif on the right part of the panel	50; 8/8/9/9/10 /10/9/8/7
		Panel 2	NW311°/19°	2 sheep-like; percussion; silhouetted			
		Panel 3	NE46°/41°	7 sheep-like, 1 dog-like; percussion; 4 linear, 3 silhouetted, 1 outlined	Panels 3 and 4 used to be one; a fracture event split the original panel. The event occurred on the north side and caused a mass of 2×0.8×1 m to exfoliate. Many micro-wanes of 2–3 μm wide can be observed on the surface of the fracture, indicating that the event happened within the past 1000 years, and its age also represents the *terminus ante quem* of some motifs on the bottom of Panel 3, which were broken by the fracture.		
		Panel 4	NE59°/90°	2 sheep-like; percussion; 1 outlined, 1 linear	Wane 1	At the 'tail' of an outlined sheep-like motif on the upper part of the panel	60; 10/10/11/12/ 12/13/14/13
HSK 101	0.8×0.8 ×0.4	Panel 1	NW278°/46°	2 sheep-like, 1 anthropomorph (archer-like); percussion; linear	Wane 1	At the 'horn' of a linear sheep-like motif on the lower part of the panel	70; 12/12/13/14/ 15/15/15/13
HSK 108	1.5×1 ×1.15	Panel 1	SW248°/53°	20 sheep-like, 1 anthropomorph (archer-like); percussion; 13 linear, 2 outlined, 2 silhouetted	Wane 1	At the 'belly' of a linear sheep-like motif at the centre of the panel	50; 11/12/13/ 13/14/13
					Wane 2	Same as the Wane 1	120; 12/12/13/14/15/15 /15/15/13/13/12
					Wane 3	At the 'head' of a silhouetted sheep-like motif on the upper part of the panel	90; 11/12/12/13/13/ 12/13/12/10/11
					Wane 4	At the 'horn' of a linear sheep-like motif on the right part of the panel	70; 11/13/13/15 /14/13/12

***Table 1.** Some sites of Hongshankou.*

nu by General Pei Cen. The two stelae are conserved at the Barkol museum.

***Figure 4.** Some sites of Hongshankou (the yellow tape measure is 1 m long).*

***Figure 5.** Field microscopy of rock art (HSK 108).*

curves. Unfortunately, those tablets are unsuitable for the lack of crystalline quartz, meaning the Universal Calibration Curve (UCC) was the only solution available to the analysts. The annual precipitation of Barkol County ranges from 230 mm (at Barkol Lake; see Cao 2015) to 300 mm (at Songshutang Valley; see Guo 2010). The location of the Hongshankou Site has the approximate altitude and landform of Songshutang, matching the value of 4.2 μm/ka in the UCC. After calibration, forty-two age estimates from the 12th century BCE to the 7th century CE have been secured (see Table 2), in which HSK 101 provided the earliest date of E3250+320/-390 years BP ('BP' refers to 'before 2021'). The latest is of E1380+520/-190 years BP ('BP' refers to 'before 2020') and came from HSK 57 (Fig. 6). Figure 7 shows that the major part (76.2%) of the age values concentrates in the range of 2000–2999 years BP, and the value distribution of different styles is entirely random.

Site	Motif	Style	Micro-wane	Wane length & widths (µm)	Age estimate
HSK 2	'sheep'	linear	China-Hongshan-kou2-EQ-16/7/2020	100; 6/8/10/10/9/12/10/10	E2230+630/-800
HSK 12	'sheep'	silhouett-ed	China-Hongshan-kou12a-EQ-16/7/2020	140; 12/11/10/10/10/10/10/11/10	E2490+370/-110
	'sheep'	silhouett-ed	China-Hongshan-kou12b-EQ-16/7/2020	80; 12/11/10/9/8/8/8	E2250+610/-350
	'horse-man'	silhouett-ed	China-Hongshan-kou12c-EQ-16/7/2020	190; 6/6/6/8/8/9/10/10/8/10/11/10	E2020+600/-590
HSK 16	'sheep'	linear	China-Hongshan-kou16-EQ-18/7/2020	170; 12/12/10/10/10/10/10/9/ 9/10/10/9/9/8	E2350+510/-450
HSK 17	'sheep'	silhouett-ed	China-Hongshan-kou17-EQ-18/7/2020	70; 6/8/9/10/10/10/10/10	E2170+210/-740
HSK 21	'sheep'	linear	China-Hongshan-kou21-EQ-18/7/2020	100; 9/12/12/12/10/10/9/10/11	E2510+350/-370
HSK 27	'deer'	outlined	China-Hongshan-kou27-EQ-18/7/2020	110; 5/6/8/6/6/5/5	E1400+500/-210
HSK 28	'sheep'	linear	China-Hongshan-kou28-EQ-18/7/2020	130; 15/13/13/10/10/10/11/11/12	E2780+790/-400
HSK 29	'sheep'	silhouett-ed	China-Hongshan-kou29a-EQ-18/7/2020	100; 13/13/12/12/10/10/11/12	E2770+330/-390
	'sheep'	linear	China-Hongshan-kou29b-EQ-18/7/2020	60; 7/11/12/9/9/8	E2220+640/-550
HSK 30	'sheep'	linear	China-Hongshan-kou30-EQ-19/7/2020	130; 13/13/12/12/10/10/11/10/10/9	E2620±480
HSK 35	'horse-man'	linear	China-Hongshan-kou35-EQ-19/7/2020	150; 10/10/11/11/10/10/10/9/9/8	E2330+290/-430
HSK 38	'sheep'	linear	China-Hongshan-kou38-EQ-19/7/2020	90; 7/8/8/8/9/9/9/10/9	E2040+340/-370
HSK 40	'sheep'	silhouett-ed	China-Hongshan-kou40a-EQ-19/7/2020	90; 13/13/11/12/11/10/10/10/9/9	E2570+530/-430
	'horse'	linear	China-Hongshan-kou40b-EQ-19/7/2020	100; 7/7/8/6/6/5/6	E1530+370/-340
	'horse'	linear	China-Hongshan-kou40c-EQ-19/7/2020	100; 10/10/9/9/8/6/6/5	E1880+500/-690
HSK 46	'sheep'	silhouett-ed	China-Hongshan-kou46a-EQ-20/7/2020	160; 10/10/11/13/15/14/11/10 /10/11/10	E2700+870/-320
	'sheep'	silhouett-ed	China-Hongshan-kou46b-EQ-20/7/2020	100; 6/7/7/9/7/7/6	E1670+470/-240
HSK 49	'sheep'	silhouett-ed	China-Hongshan-kou49a-EQ-20/7/2020	70; 12/11/11/10/10/10/8/8	E2380±480
	'sheep'	linear	China-Hongshan-kou49b-EQ-20/7/2020	100; 12/13/12/12/10/10/10/10/10	E2620+480/-240
HSK 50	'sheep'	linear	China-Hongshan-kou50-EQ-20/7/2020	130; 14/13/12/10/10/9/10/10/9/9	E2520+810/-380
HSK 57	'sheep'	silhouett-ed	China-Hongshan-kou57a-EQ-20/7/2020	130; 8/10/11/11/10/11/12/11/11/10	E2500+360/-600
	'sheep'	linear	China-Hongshan-kou57b-EQ-20/7/2020	150; 5/5/5/6/8/7/6/5/5	E1380+520/-190
	'sheep'	linear	China-Hongshan-kou57c-EQ-20/7/2020	120; 13/12/12/11/12/10/10/11 /10/10/10	E2620+480/-240
HSK 61	'sheep'	silhouett-ed	China-Hongshan-kou61-EQ-20/7/2020	160; 10/10/11/12/13/11/11/10 /11/10/10/9/10	E2530+570/-390
HSK 68	'sheep'	linear	China-Hongshan-kou68a-EQ-20/7/2020	100; 10/10/11/10/12/10/9/9/9/9	E2360+500/-220
	'horse'	silhouett-ed	China-Hongshan-kou68b-EQ-20/7/2020	70; 5/5/6/8/10/10/8	E1800+580/-610
HSK 71	'horse-man'	silhouett-ed	China-Hongshan-kou71-EQ-20/7/2020	150; 8/10/10/9/8/9/11/12/12/10	E2360+500/-460
HSK 76	'sheep'	outline	China-Hongshan-kou76-EQ-21/7/2020	140; 10/11/13/11/10/9/10/9/8/8	E2360+740/-460
HSK 78	'horse-man'	silhouett-ed	China-Hongshan-kou78-EQ-21/7/2020	100; 10/8/7/7/10/10/9/10/11/10	E2190+430/-520
HSK 84	'sheep'	linear	China-Hongshan-kou84-EQ-11/7/2021	60; 10/10/9/8/8/10/10/8	E2170+210/-270
HSK 89	'sheep'	linear	China-Hongshan-kou89-EQ-11/7/2021	70; 10/11/11/12/10/10/9/8	E2410+450/-510
HSK 90	'sheep'	silhouett-ed	China-Hongshan-kou90-EQ-11/7/2021	120; 10/10/10/12/13/13/13/12	E2770+330/-390
HSK 93	'sheep'	linear	China-Hongshan-kou93-EQ-12/7/2021	200; 10/11/12/10/10/10/11/12 /13/13/12/12/11/10	E2670+430/-290
HSK 98	'sheep'	outline	China-Hongshan-kou98a-EQ-12/7/2021	50; 8/8/9/9/10/10/9/8/7	E2060+320/-390
	'sheep'	outline	China-Hongshan-kou98b-EQ-12/7/2021	60; 10/10/11/12/12/13/14/13	E2830+500/-450
HSK 101	'sheep'	linear	China-Hongshan-kou101-EQ-12/7/2021	70; 12/12/13/14/15/15/15/13	E3250+320/-390
HSK 108	'sheep'	silhouett-ed	China-Hongshan-kou108a-EQ-13/7/2021	50; 11/12/13/13/14/13	E3020+310/-400
	'sheep'	silhouett-ed	China-Hongshan-kou108b-EQ-13/7/2021	120; 12/12/13/14/15/15/15/15 /13/13/12	E3230+340/-370
	'sheep'	silhouett-ed	China-Hongshan-kou108c-EQ-13/7/2021	90; 11/12/12/13/13/12/13/12/10/11	E2830+270/-450
	'sheep'	linear	China-Hongshan-kou108d-EQ-13/7/2021	70; 11/13/13/15/14/13/12	E3100+470/-480

Table 2. *The microerosion dating results from Hongshankou of the surveys in 2020 and 2021.*

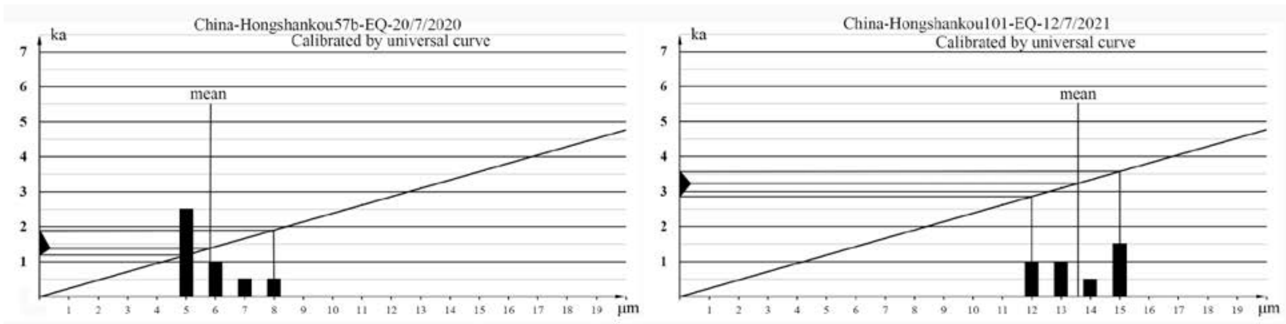

Figure 6. *Microerosion age estimates from HSK 57 and 101.*

2.2 Replication experiment

To examine the effectiveness of tools made of different materials on the varnish cover, the authors have selected a granite boulder of 0.5 × 0.5 × 0.35 m at Hongshankou site for an experiment. The rock's south side was covered by a 30 × 30 cm area of dark-brown varnish, and the plan was to make four linear caprid motifs of 7 × 7 cm, which is the most common motif type at the site.

The tools prepared were a chisel of aluminium-bronze (200 mm long with a 16.5 mm long point), a chisel of high-carbon steel (244 mm long with a 60 mm long point), a percussion/engraving stone (mur-e) of granite (85 × 40 mm) and two hammerstones (weighing 1 and 2 kg respectively).

The experimental process (Fig. 8) comprised the

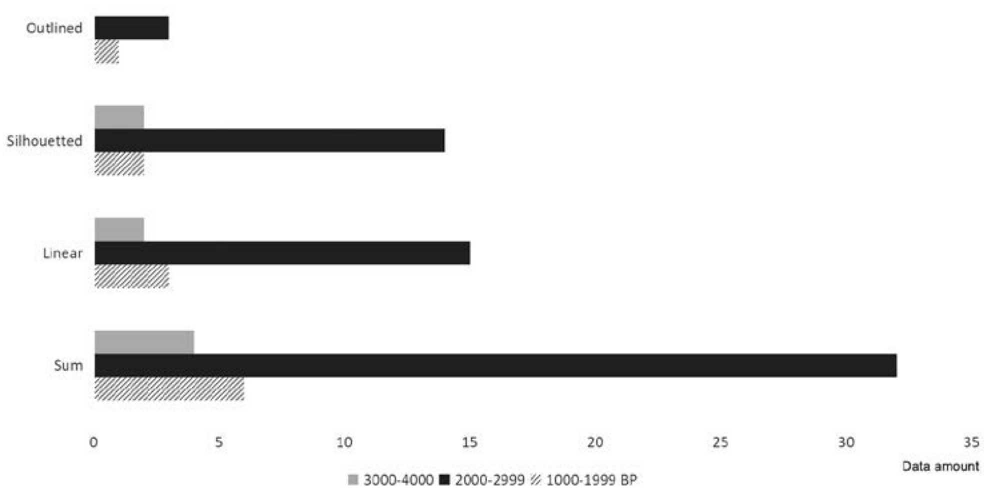

***Figure 7.** Value distribution of the age estimates of the motifs.*

following:

(1) Indirect/direct percussion with the bronze tool: the operator conducted indirect percussion on the varnish cover with one hand holding the chisel and the other holding a hammerstone of 1 kg. The chisel point became blunt after only 10 impacts. The hammerstone shattered after one minute, so the operator conducted direct percussion with the chisel at a frequency of 3 impacts per second. The entire process took 7 minutes.

(2) Indirect/direct percussion with the steel tool: the operator conducted indirect percussion on the varnish cover with one hand holding the chisel and the other holding a hammerstone of 2 kg; after 1 minute switched to direct percussion at a frequency of 3 impacts per second. The entire process took 7 minutes.

(3) Scratching with the stone tool: the operator conducted scratching with the mur-e on the varnish cover at a frequency of 1 cut per second. The entire process took 7 minutes.

(4) Direct percussion with the stone tool: the operator conducted direct percussion with the mur-e on the varnish cover at 3 impacts per second. The entire process took 7 minutes.

The tools were re-measured once the above process had been completed and found to be distinctly worn: the steel chisel, bronze chisel and stone tool were 264, 200 and 85 mm long in the beginning but 262.5, 197 and 78 mm long after use.

The experiment shows that:

(a) Different tools have different capacities for damaging the varnish layer. Generally, they follow this order from the strongest to the weakest: direct percussion with the high-carbon steel chisel > direct percussion with the granite tool > scratching with the granite tool > direct percussion with the aluminium-bronze chisel.

(b) The varnish cover is tough, even harder than high-carbon steel. The point of the steel chisel became blunt after the first fifty impacts. Although aluminium bronze is harder than other kinds of bronze alloy, it is still much softer than the varnish, wore fast yet hardly caused damage to the varnish. Considering the unacceptable efficiency-cost ratio, bronze tools may never have been used for rock art production in this area.

(c) Indirect percussion with hammerstone and steel chisel is very difficult to handle, strenuous and poorly efficient. Scratching with the stone tool leaves only slight markings on varnish; pounding with it works more effectively, but the wear is much faster.

Therefore, based on the above knowledge, the petroglyphs of Hongshankou were most likely made by direct percussion with steel or stone tools. Moreover, it is to be pointed out that the experiment's primary purpose was to test the efficiency of different tools on the varnish cover, which has been confirmed to be extremely tough during the process. Many people (both scholars and the locals) believe that a substantial part of the rock art motifs in the eastern Tianshan Mountains was made with bronze tools, yet this presupposition has been disproved in the experiment. In addition, each experimental period was set to last 7 minutes because the operator was exhausted after the first 7 minutes of almost 1500 continuous blows on the rock, so '1500 impacts in 7 minutes' has been assumed as an average limit of the rock art makers' endurance, then a break would be needed to recover strength. The authors are aware that 7 minutes is not long enough to create a petroglyph of standard depth, but they suffice to test the capacity of tools.

3. Discussion

This project is the first scientific attempt to assess the Hongshankou rock art site complex. The authors have studied 119 rocks bearing 436 petroglyphs which may represent 1/5 of the known sites. Forty-two age estimates have been secured by effectively utilising microerosion analysis. Meanwhile, the replication experiment provided knowledge important to the understanding of the rock art's production.

According to the dating results, the earliest age estimate of E3250+320/-390 years BP came from HSK 101, while HSK 57 contributed the latest one of E1380+520/-190 years BP, indicating that the tradition of rock art creation at Hongshankou might have commenced in

***Figure 8.** Replication experiment at Hongshankou: (1) conducting the experiment; (2) the motifs made by different tools: a. by steel chisel, b. by bronze chisel, c. by stone tool scratching, d. by stone tool percussion; (3) the tools used: a granite stone tool, a high-carbon steel chisel and an aluminium-bronze chisel; (4) the wear of the bronze chisel after use.*

the 12th century BCE (the Late Shang Dynasty) and become discontinued after the 7th century CE (the Early Tang Dynasty). Moreover, the statistics show that a major part of the petroglyphs was made between the 7th and the 1st century BCE (from the Eastern Zhou to the Western Han Dynasty, or from the Late Bronze to the Early Iron Age), when Yuezhi, Xiongnu and Han people ruled this area successively. The authors have also noticed that some non-negligible iconographic similarities exist between the rock art motifs of Hongshankou and the painted patterns on some of the potteries (Fig. 3) excavated from the well-known Yanblaq cemetery, Hami, and Baiqir cemetery, Yiwu. Radiocarbon samples of the former date back to 1300–565 BCE (Zhang et al. 1989) and the latter is believed to have been created between 950–550 BCE (Ma 2020). Perhaps such synchronicity is not only a coincidence.

A cultural Darwinism-like interpretive approach assuming an evolutionary sequence from simplicity to complexity has been widely accepted and adopted in China's rock art research, especially in most recent years. Many archaeologists, art historians, ethnologists and folklorists believe that rock art in different styles found in the historically nomadic regions of China (Xinjiang, Tibet, Inner Mongolia, Gansu, Ningxia) was probably made diachronically. Linear styles were followed by outlines and, in turn, by the silhouette styles (Yu 2015; Geli 2017; Jing et al. 2020; Yu and Wang 2020; Yu and Xi 2020; Ding and Yu 2021; Li et al. 2020; Qiao et al. 2021). However, according to the statistics, there has been no supporting evidence for that presupposition so far in this study (see Fig. 6 and Table 2).

Another prevalent interpretation of rock art production in Mt Tianshan claims that the silhouette motifs on the varnish cover were made with bronze tools, for some 'tiny impact marks' can be observed. However, in this study, the utilisation of bronze tools has been disproved by the replication experiment, while scratching with stone tools and indirect percussion are regarded as almost ineffective. Only direct percussion with steel/iron/stone tools is believed to be effective; nevertheless, it is still exhausting to significantly impact the varnish even by this technique.

Accordingly, some new questions appear, such as why did rock art creation apparently cease after the 7th century CE? What motivated people to keep making rock art for over 1000 years since it was such hard work? On what did the preference of styles depend? Was it an individual pursuit, or did it have the community's consensus? All these questions need further studies to answer.

As a first phase of the ETRP, following the standards of IFRAO in the mentioned area, the scientific attempts in the first two years (2020–21) at Hongshankou have yielded preliminary results. The intensive utilisation of microerosion analysis has been proven feasible at the site, and a series of age estimates with statistical significance has been secured. This is the first time a series of dates, derived from any method from a single rock art site complex, is numerically large enough to permit credible statistical pronouncements. Besides, experimental means have also played an indispensable role during the research. All of the progress will enrich understanding of those mountains' past roles in human history, while, on the other hand, the potential of the cross-check with archaeological finds heralds for direct dating of rock art a promising future of ultimately benefitting from the related discipline. With the developing connection between rock art science and archaeology, the importance of a multi-disciplinary knowledge system in rock art study will be gradually recognised, and probably to a large extent, this scientific field will be reshaped by such awareness.

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