Differences of Petroglyph Styles among Archaeological Sites with Spatial and Time-wise Distances

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Differences of styles of petroglyphs among several archaeological sites in the Central Asia are estimated based on the method of obtaining shape codes of petroglyphs, which was developed by the present authors. The samples for shape code analysis are confined to the petroglyphs of ibex (wild goat), which were abundantly carved in the Central Asia. It is shown that the style differences are correlated to the mutual distances among archaeological sites, but not to the differences of ages among them. This result supports the common opinion of archaeologists that petroglyph styles have not changed much since the Stone Age. This result is discussed from cultural aspects.
Key words: Petroglyph, Central Asia, Image Analysis, Skeleton, Style Difference

1. Introduction

In some regions in Central Asia and Russia a lot of petroglyphs of animals, humans and celestial bodeis are conserved, which were carved on rock surfaces from the Stone Age to several centuries A.D.. These petroglyphs are introduced in several references (Sher, 1980; Lasota-Moskalewska and Khujanazarov, 2000; Tashbayeva *et al.*, 2001). The present authors proposed a new quantitative method to characterize shapes of petroglyphs based on image analysis (Takaki *et al.*, 2006), and presented it at some conferences (Takaki *et al.*, 2009, 2010). The motivation of this work was an archaeologists' question why petroglyph styles did not change much for tens of thousands of years. For this question the present authors considered a necessity of a quantitaive method to cahracterize their styles. In this study figures of petroglyphs of ibexes (wild goats) were chosen because they are abundantly produced in Central Asia (see Fig. 1), and their image data are taken from Tashbayeva *et al.* (2001). A brief explanation of this method is given in the next section (the precise is given in Takaki *et al.*, 2006).

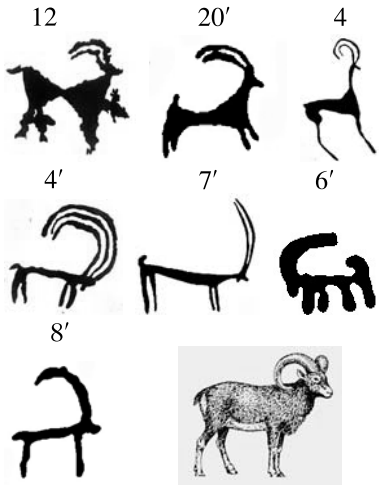

Fig. 1. Examples of ibex figures from seven archaeological sites (from Tashbayeva *et al.*, 2001) and a sketch of ibex (from Lasota-Moskalewska and Khujanazarov, 2000). Numbers correspond to those in Fig. 4.

2. Method of Analysis

From a digitized silhouette data of petroglyph a line figure called "skeleton" is obtained, which is a trajectory of centers of contact circles (see Fig. 2(a)), where a software 'Scion Image' is used in this process (at present a new version of this software "ImageJ" is available). Skeletons of ibexes are composed of parts easily recognized by naked eyes, that is, a nose (front tip of body), one or two horns, a neck, one or two fore-legs, a center of body, one or two rear-legs and a tail. They were given symbols, 'N, H, N, L, B, L, T', respectively, and these symbols are arranged in order from the nose through the tail as 'N-HH-N-LL-B-LL-T', where doubled symbols indicate the numbers of respective parts. Then, the difference in shapes is expressed as that of arrays of these symbols.

Since this array of symbols is not precise enough to distinguish various shapes, we observe fine structures of skeletons, as listed below:

- If a single line (a horn or a leg) comes out and branches into two, a symbol 'HH' or 'LL' is replaced by 'HB' or 'LB' ('B' means "branch").
- If two horns or legs are connected by lines after com-

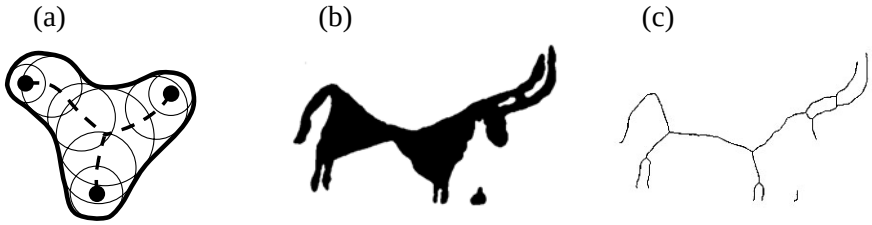

Fig. 2. Skeleton of silhouette figure. (a) Definition of the skeleton, (b) a silhouette figure of ibex from Tashbayeva *et al.* (2001), (c) skeleton of the ibex in (b).

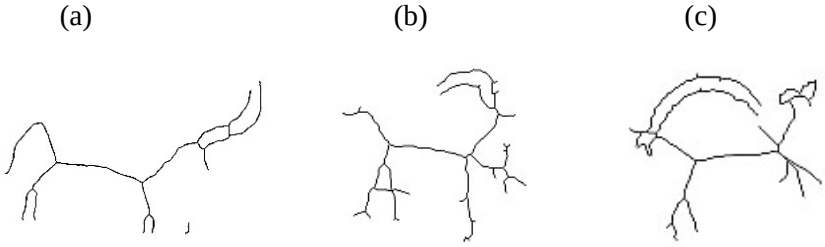

Fig. 3. Skeletons of figures of ibexes from Tashbayeva *et al.* (2001). Their shape codes are:

(a) N · · · · · · · HHC · · · · ·N · · · · · · · LB · · · · · ·B · · · · · · · LB · · · · · ·T · · · · · · ·
(b) N · · · · · · · HB · · · SSS N · · · · · · · LL · · · S S S B · · · · · · · L B C· · SSS T · · · · S· ·
(c) N · C· · S · · HH · · · SSS N · · · · · · · LB · · · S · · B · · · · · · · LB · · · S · ·T ·C C· S S ·

Table 1. List of seven archaeological sites with ages. "Middle point": the years at the middle points of the intervals shown in "Age", "Map": the numbers of the sites in Fig. 4.

Country	Location	Age	Middle point	Map
Kyrgyzstan	Saimaly Tash	neolithic-bronze	3,500 B.C.	12
	Jatyrak Tash	bronze-iron-A.D.	1,700 B.C.	20′
Uzbekistan	Sarmishsai	neolithic bronze	3,500 B.C.	4
	Saikhansai	bronze	2,500 B.C.	4′
Tadjikistan	Ak-jilga	bronze	2,500 B.C.	7′
	Lyangar	A.D.3-5c.	350 A.D.	6′
	Vybist Dara	A.D.1-6c.	300 A.D.	8′

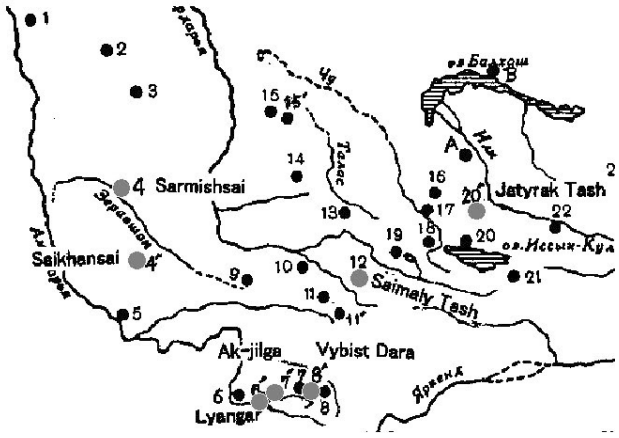

Fig. 4. Archaeological sites in Central Asia covering parts of Uzbekistan, Kazakhstan and Tadjikistan. Some sites are added to the map by Sher (1980). The larger dots with names are the sites treated in this work.

ing out of the body, an additional symbol 'C' (1 connection), 'CC' (2 or 3) or 'CCC' (more than 3) are added. Thus, existence of loops is expressed in this way.

- If several spines come out of a part of body, reflecting the roughness of body contour, symbols 'S' (1 spine), 'SS' (2 or 3) or 'SSS' (more than 3) are added. Ears or penis is looked upon as a spine.

For easy comparison among symbols of skeletons, each of seven parts of a body is given eight fields for writing symbols, so that one skeleton is expressed by a symbol array of 56 fields, which is called a *shape code*. Symbols for closed loops and spines are written at particular positions within eight fields of respective parts. As examples, the shape codes of the three ibexes are shown in Fig. 3. The degree of difference of two skeletons is defined by the number of fields with different symbols. Thus, the differences of the ibex pairs (a)–(b), (b)–(c) and (c)–(a) in Fig. 2 are 14, 12 and 12, respectively.

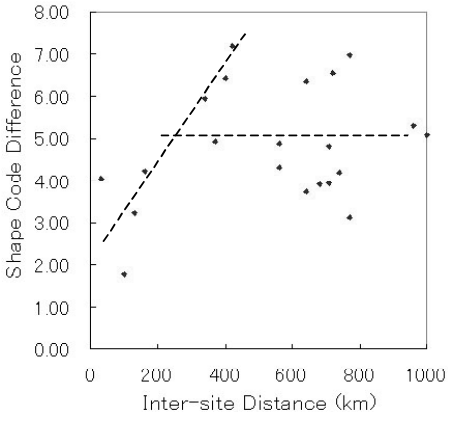

Fig. 5. Correlation of shape code differences with the spatial distances among archaeological sites. The correlation coefficient with distances less than 500 km is 0.83.

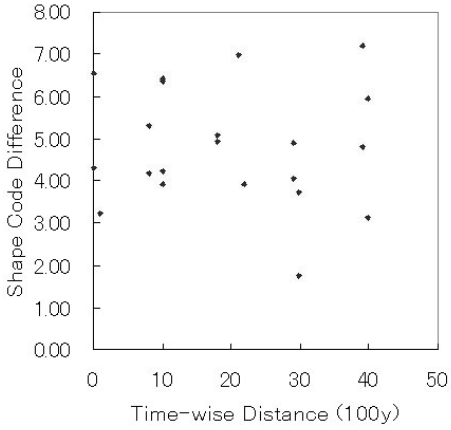

Fig. 6. Correlation of shape code differences with the time-wise distances among archaeological sites.

3. Results of Analysis

The seven archaeological sites are chosen, as listed in Table 1, from the monograph of Tashbayeva *et al*. (2001), which have many figures of ibexes. Locations of these sites are shown in Figure 4 with large dots and names of sites. Examples of ibex figures in these seven sites are shown in Fig. 1.

The difference of petroglyph styles between two archaeological sites was obtained by averaging differences of shape codes for all pairs of ibexes, each from respective sites. Of course, styles of other animals should be considered for comparison of archaeological sites. However, the ibex is chosen here because it is expressed as silhouette figure and has a variety of shapes. Comments on petroglyphs of other animals are given in the last section.

Mutual distances among these sites were obtained from linear distances on the map (Fig. 4). The ages of these sites are determined from the ages of petroglyphs, which are only roughly estimated, such as the neolithic, the bronze and the iron. In each of these seven sites petroglyphs belong mostly to the same age. The approximate intervals of ages for the Central Asia are as follows: neolihic age: 6000–4000 B.C., bronze age: 4000–1000 B.C. and iron age: 1000–0 B.C. The archeologist's estimations as "A.D." and "medieval age" are assumed to be 0–600 A.D. and 600–1200 A.D., respectively. The representative time points for ages are obtained from the middle points of intervals; for example, the middle point of the estimated age of "neolithic or bronze age (6000–1000 B.C.) is 3500 B.C.

Now, from the seven archaeological sites we have 21 pairs of sites. For each of these pairs the style difference based on shape codes, the spatial distances and the time-wise distance are obtained. Figures 5 and 6 show two kinds of correlations, the spatial distances vs. the style difference and the time-wise distances vs. the style difference, respectively.

In Fig. 5 the points are rather scattered, but a tendency is perceived that the style differences are correlated to the spatial distances within about 500 km. Beyond this distance the average difference has a value of about 5 and has no correlation is seen. However, the boundary between these two cases would be better estimated from the cross point of the two dashes lines in Fig. 5, i.e. at the distance of about 300 km.

Figure 6 shows no correlation between the style differences and the time-wise distances. The vertical scattering of data came from the dependence on spatial distances, and their central level did not increase with time.

4. Discussion

The present analysis of petroglyph styles based on their shape codes has revealed that the differences of petroglyph styles among archaeological sites increases with their mutual distances at least within the distances of about 300km. This result might suggest that a certain kind of interaction were made among people of regions within this distance, such as trades or cultural mixing. On the other hand, the lack of correlation between the style differences and the time-wise distances among archaeological sites supports the archaeologists' question, "Why did styles not change much with time?", i.e. this question is not merely from an impression of archaeologists. However, the present results do not give an answer of this question. The reason of constancy of styles should be investigated carefully also from cultural aspects.

It should be noted here that the above conclusions were derived by analyzing only the figures of ibexes, and should be confirmed by adding results from figures of other objects. Motifs of petroglyphs often carved in Central Asia are the ibex, the dog, the bull (including cow, ox, bison and aurochs) and the human. Among these motifs the ibex had a special roll, because it was looked upon as a sacred animal for its fertility. It was carved frequently and carefully, and was given a well-shaped form. Therefore, the ibex would be a good choice as a target in the first trial of research. The figures of dogs will be treated as the next step.

On the other hand, the bull and the human have difficulties, because their figures are complicated. Many of bulls are drawn not as silhouettes but have inner structures. Many figures of humans carry tools, such as spears (soldiers), or put on headgears (shamans). Therefore, their shape codes should be defined carefully. This is left for the future study.

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