# Diachronic Changes in the Indus Script Based on the Proposed Arrangement of the Indus Seal

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## 1 Introduction

### 1.1 Purpose of this study

Although various studies have been conducted on the Indus script, few have considered the possibility that the script has changed over time, and the seals on which the script was inscribed have not been studied stratigraphically. Thus, it has been common practice to analyze all scripts from all periods together, and not analyzing them separately by period. However, there is a great possibility that the shape, number, and usage of characters has changed over approximately 700 years, from 2600 to 1900 BC. There are many cases of other writing systems that have changed over the centuries. For example, the cuneiform used by the Mesopotamian civilization underwent significant changes in the form and number of characters, known as proto-cuneiform, over a period of 500 years due to the evolution of writing technology and the introduction of phonetic characters (Damerow, 2006). The possibility that the Indus script underwent similar changes as the cuneiform script should be considered.

According to Kenoyer and Meadow (2010), Kenoyer (2020), and Konasukawa (2020), seals inscribed with Indus scripts are distinctive and may be clearly

distinguished by period. It should be possible to examine the evolution of the script from period to period based on the periodication of the seals. If the formation process of the writing system and its transition can be clarified, a more accurate analysis of the writing system is possible. In addition, while research aiming at decipherment using artificial intelligence has been active in recent years[1], it is thought that the analysis of character strings by period will bring us one step closer to decipherment.

This study aims to clarify what characters were used and how they were used during each period based on the hypotheses of Kenoyer and Meadow (2010), Kenoyer (2020), and Konasukawa (2020) under the theme of 'chronological study of characters engraved on Indus seals.' This study does not directly aim to decipher the Indus script and does not deal with the meaning of the script or sentence structure. Comparisons with the scripts of other civilizations will be the subject of future research and will not be included in this study.

## 1.2 Previous studies

### 1.2.1 Linguistic or non-linguistic characters?

Although the characters inscribed on seals and amulets of the Indus civilization are generally regarded as linguistic characters, there has been much debate as to whether these 'characters' represent language in the first place. The following is a summary of some of the most representative examples of studies.

#### 1.2.1.1 Computer-based analysis

In the 1960s, Y. Knorozov, a Soviet researcher who contributed to the decipherment of the Mayan script, analyzed the Indus script by computer and concluded that it was a linguistic character because certain regularities were observed in it. He also analyzed the arrangement of the characters and concluded that the Indus script represented a Dravidian language, as it corresponded to the arrangement of Dravidian characters (Knorozov, 1965). At approximately the same time, a

[1] Parpola, Koskenniemi, Parpola and Aalto (1969), Rao (2009)

Finnish research team, including Parpola, conducted a similar study using computers and came to the same conclusion as Knorozov (Parpola et al., 1969). At the time, computer-based research was state-of-the-art and the results of that study attracted a great deal of attention.

#### 1.2.1.2 Criticisms of the Literal Theory

In 2004, Farmer et al. criticized the study by Knorozov et al., saying that the feature of 'regularity in sequence' is not limited to linguistic characters but found in both of linguistic or non-linguistic characters systems. So the Indus script cannot be dismissed as a linguistic character on this basis alone (Farmer et al., 2004). They also highlighted that it is impossible to identify a language from the sequence of characters alone, because the scripts of the 3rd millennium BCE are often abbreviated, and the same character is often used with various meanings. He also argued that the Indus script is non-linguistic because its character sequences are very short, with an average of 2–5 characters, and because limited characters dominate and too many characters appear only once. We know that during the Indus period there was interaction with the Mesopotamian civilization, and the people of the Indus civilization were aware of the existence of the writing system (Parpola, 1994). Farmer et al. conceded this point, however, he also noted that the Vedas of later India had long been passed down orally without being written. Farmer et al.'s argument still has some support today.

#### 1.2.1.3 Analysis using artificial intelligence

R. Rao (2009), a computer scientist at the University of Washington, has entered the debate of Linguistic versus non-linguistic characters in his work using artificial intelligence. He input four language samples (ancient Sumerian, Sanskrit, ancient Tamil, and modern English), four non-language samples (human genome, FORTRAN, bacterial protein sequences, and artificial language[2]), and a sample

[2] Natural languages follow basic grammar, however, there are exceptions. In contrast, programming languages such as FORTRAN and artificial languages such as Esperanto follow strict rules and have no exceptions. For this reason, Rao (2009) treats them as non-languages.

of strings of Indus characters into artificial intelligence to calculate and compare entropy values[3]. The results were then compared. The Indus string showed the same entropy value as the language sample. Rao concluded that the Indus script is very likely to represent a language.

#### 1.2.1.4 Summary

Thus, there are still various opinions regarding whether the Indus script is a linguistic character. However, it is clear from documents from the Akkadian period that the Indus civilization actively traded with Mesopotamian civilization, which had a well-established writing system. Although there are counterarguments such as Farmer et al. (2004) mentioned above, it is natural to think that the Indus civilization adopted the idea of writing from the Mesopotamian civilization through trade.

According to Parpola (2010), all seal scripts excavated from the central region of the Indus civilization have the same regularity, whereas Indus-style seal scripts found in areas far from the central region show different regularity. For example, character No. 311 frequently appears in the Indus script and is usually used alone at the end of a string. However, strings using this character in succession have been detected in the vicinity of Iraq and Iran. Such strings were not found outside of these regions. This suggests that the Indus script still represents a language and that the different regularity of the seals from regions far from the center is due to the use of the Indus script to write foreign words.

For these reasons, this study treats the Indus script as a language character.

### 1.2.2 Diachronic change of the Indus script

#### 1.2.2.1. Changes in sculptures and seal handles

J. Kenoyer and R. Meadow (2010) divided the Harappan period (2600 B.C. to 1900 B.C.) into three periods, 3A (2600 B.C. to 2450 B.C.), 3B (2450 B.C. to 2200 B.C.), and 3C (2200 B.C. to 1900 B.C.) and the seals excavated from the

[3] Entropy value is the amount of information and is a measure of irregularity.

stratigraphic levels of each period at the Harappa site were compared and examined. The results revealed that the engraving styles and types of seal handles changed with time, and the possibility of studying the diachronic change of seals was proposed.

Many of the Indus seals are engraved with animal motifs, and the motifs on the seals from Period 3A are relatively crudely engraved, giving an overall angular impression. As the period progresses, however, the motifs become more realistic, and in the seals of Period 3C, details such as muscles are represented (Kenoyer and Meadow, 2010).

Some Indus seals also have handles on the reverse side, the shape of which varies depending on the period. From Periods 3A to 3B, dome-shaped handles with a single slit in the center can be seen in many cases. However, from Periods 3B to 3C, a flat rectangular handle seems to have become the norm. Both handles have holes in their sides through which they are thought to have been carried or stored. In the latter half of Period 3C, the handles disappeared and perforations were seen on the sides of the seal body (Kenoyer and Meadow, 2010).

Based on the above, Kenoyer and Meadow concluded that Indus seals may be classified by period to some extent according to their characteristics.

#### 1.2.2.2 Changes in motifs and characters

Based on the stratigraphic excavation results from the Harappan site, Kenoyer (2020) further identified the characteristics of the animal motifs and lettering on the seals (Table 1), and highlighted the possibility of periodication. In Period 3A, the heads of the main animal motifs appear on the seal face to the right, and the lettering is messy and uneven (Kenoyer, 2020). In Period 3B, the heads of the animal motifs change to the left, however, the lettering remains messy (Kenoyer, 2020). In Period 3C, the heads of the animal motifs are still oriented to the left, as in Period 3B, however, the strings are well-organized, and the characters are of uniform size (Kenoyer, 2020).

**Table 1**: Chronological characteristics of seals inscribed with the Indus script.

| | |
|---|---|
| Period 3A (2600-2450 BCE) | -angular carving of animal predominantly facing right<br>-linear script placement (1 to 3 signs)<br>-curved script above animal motif |
| Period 3B (2450-2200 BCE) | -animal motif predominantly facing left<br>-linear but irregular script above animal motif |
| Period 3C (2200-1900 BCE) | -animal motif facing left<br>-bold, rigid, regular script |

**1.2.2.3 Addition of findings from the Farmaner site**

Konasukawa (2020) argued that since most of the Indus script is inscribed on Indus seals, it is essential to consider the chronological study of seals when discussing various aspects of the Indus script. Konasukawa added the stratigraphic excavation results of the Farmaner site to the results of the Harappan site and the results of Kenoyer's study. In addition, Konasukawa (2020) analyzed seals excavated from the Harappa site that were inscribed with right-facing motifs and clarified what kind of characters were inscribed on them. He highlighted that these characters were also inscribed on seals excavated from other sites and argued that these characters were shared by a wide range of Indus societies in the early Harappan period.

As described above, it is becoming evident that seals inscribed with Indus scripts are distinctive and distinguishable from period to period. Previous studies have dealt only with the period-specific characteristics of seals and have not touched on the differences between the periods. Since the Indus script is also inscribed on seals, it is possible to study the period-specific evolution of the script by referring to the periodication of the seals.

## 2 Materials and methods

### 2.1 Analysis target

5,240 seals are contained in the three volumes of the *Corpus of Indus Seals and Inscriptions* (Joshi and Parpola (eds.), 1987; Shah and Parpola, 1991; Parpola, 2010), and 17 seals are contained in excavations at Dholavira (Bisht, 2015). These 5,257 seals in total were further narrowed down to those that met Konasukawa's (2020) criteria of being inscribed with Indus script and being able to determine the orientation of the motif's head. The present writer excluded items that were ambiguous as to which period they were from. Incomplete items and items of foreign origin were also excluded because it is currently difficult to determine the period to which they belong. Thus, the number of seals analyzed was reduced to 1,137. The breakdown of the analyzed seals is presented in Table 2. The sites of Alladino, Balakot, Jhukar, Nausharo, Nindowari, Pirak, Chanhudaro, and other sites were grouped under 'Others' due to the small number of seals excavated.

**Table 2:** The seals broken down by number at various sites.

| Site | Number of seals | Site | Number of seals |
|---|---|---|---|
| Mohenjodaro | 833 | Lothal | 25 |
| Harappa | 196 | Dholavira | 7 |
| Kalibangan | 30 | Others | 35 |
| Banawali | 11 | | |

The geographic distribution of the sites dealt with in this study is shown in Figure 1. The Mohenjodaro site, located on the lower reaches of the Indus River in Sindh, southeastern Pakistan, is a representative site of the Indus civilization. It is believed to have functioned as the central city of the Indus civilization and is one of the largest ruins of Indus civilization. The Harappa site, located in the Ravi River Basin in the Punjab region of northeastern Pakistan, is a representative site of Indus civilization along with the Mohenjodaro site, and its design is like that of the Mohenjodaro site. The Kalibangan and Banawali sites are located in the Ghaggar River Basin in northern Rajasthan, India. Most of the sites in the Ghaggar River Basin date before the Harappan culture period, and the Kalibangan site

dates from 3000 BC (Osada, 2013). The Lothal site, located at the head of the Bay of Cambay in Gujarat, India, and the Dholavira site, located on the lower Indus River in Gujarat, India, are also representative of the Indus civilization.

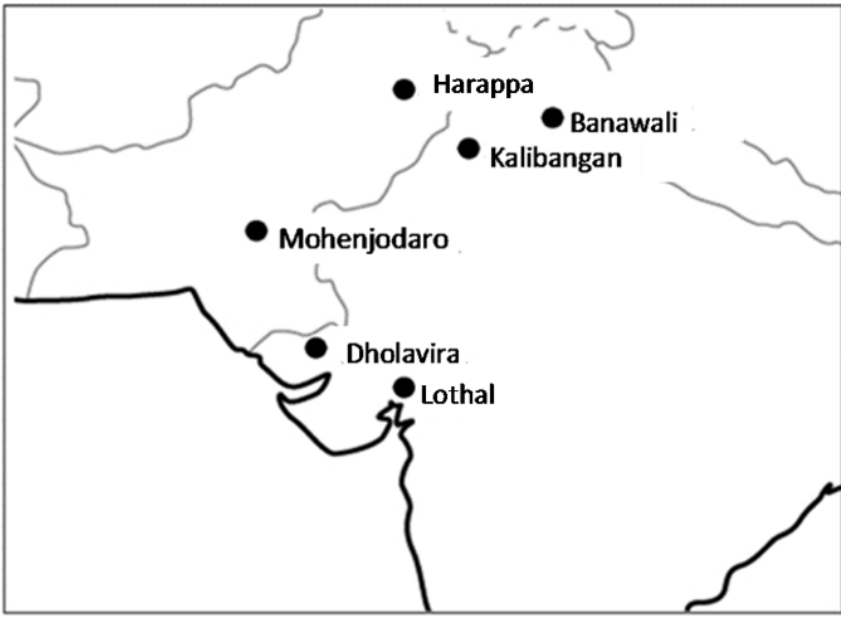


**Figure 1:** Geographic distribution of the sites mentioned in Table 2.

While stratigraphic excavations have been conducted at the Harappan site, proper stratigraphic excavations have not been conducted at other sites, and very few seals are clearly known to date to any period.

**2.2 Analysis Procedures**

Based on the chronological characteristics of the seals identified by Kenoyer and Meadow (2010) and Konasukawa (2020), the 1,137 seals analyzed were classified into the Early Period (Harappa Period 3A, 2600-2450 BC), Middle Period (Harappa Period 3B, 2450-2200 BC), and Late Period (Harappa Period 3C, 2200-

1900 BC), and the images were tagged using Nvivo[4] (Version 10), a qualitative research support software. Because of the ambiguity of the criteria for seals classified as Middle Period and Late Period, those that were difficult to determine were classified as Period Unknown and were not used in this study.

After classifying the seals by period and site, the characters inscribed on them were extracted, and based on the Indus script list and character numbers in *Deciphering the Indus Script* (Parpola, 1994), the character numbers used were listed, and the number of times each character was used was counted. The total number of characters used in a period was taken as the total number of characters, and the average number of characters inscribed on a seal was calculated by dividing the total number of characters by the number of seal. The number of characters inscribed on a single seal was also counted for each period and all sites. Based on these results, we analyzed the types of characters used in each period, the number of characters, the bias in their use, and the length of the character string.

## 3 Results

The results of the analysis using the methods described above were compared among sites in terms of the number of seals (Section 3.1), the relationship between the number of character and the total number of characters (Section 3.2), number of times each character was used at each site (Section 3.3), characters used throughout all the periods at each site (Section 3.4.), the most frequently used character at each site (Section 3.5), and the length of character strings (Section 3.6). The analysis was conducted in detail for each item. By clarifying the trends of these items by site, region, and period, it is possible to analyze which character was actively used at which sites and from which period, and how the number of character and length of character strings varied and changed from site to site. It is also possible to examine the characters frequently used at each site, during each period, and throughout civilization and all periods. Seals that are not clearly identified as being from the Middle or Late Period are considered as Period Unknown

[4] Nvivo is a software for data classification and analysis, which enables various data analyses using query and search functions.

and are excluded from the analysis in this study as described above, and therefore the number of characters and the total number of characters are not calculated.

### 3.1 Number of seals

Although the Indus civilization has more than 200 archaeological sites, the number of sites from which seals have been excavated is only a few dozen, according to *The Corpus of Indus Seals and Inscriptions* (Joshi and Parpola (eds.), 1987; Shah and Parpola, 1991; Parpola, 2010). The number of seals excavated from the sites covered in this study, organized by site and period, is listed in Table 3. The items for which the period is unknown are not treated in detail in this study because, as mentioned above, the reliability of the classification cannot be guaranteed.

**Table 3:** Breakdown of seals used in the analysis

| | Early Period | Middle Period and Late Period | | | Total |
|---|---|---|---|---|---|
| | | Middle Period | Late Period | Period unknown | |
| Mohenjodaro | 16 | 72 | 261 | 484 | 833 |
| Harappa | 3 | 16 | 64 | 113 | 196 |
| Kalibangan | 10 | 2 | 5 | 13 | 30 |
| Banawali | 11 | 0 | 0 | 0 | 11 |
| Lothal | 0 | 5 | 12 | 8 | 25 |
| Dholavira | 0 | 3 | 2 | 2 | 7 |
| Others | 2 | 5 | 7 | 9 | 23 |

Focusing on the Middle and Late Period, we can see that the number of seals at the Mohenjodaro site is remarkably large. The total number of seals from other sites is only approximately one-third of that of the Mohenjodaro site. Although the purpose of Indus seals has not yet been clarified, it is clear that their production and use are concentrated at the Mohenjodaro site.

The largest number of seals found at most sites were from the Late Period, with the exception of the Kalibangan and Banawali sites where more Early-Period seals were excavated.

### 3.2 Number of individual character types and total number of characters

As mentioned in Section 2.2., the present writer examined total number of characters inscribed on the seals of each site and period based on the list of characters by Parpola (1994), and counted number of times each individual character type was used. The results are shown in Table 4.

**Table 4:** Number of individual character types and total number of characters for each site

| | Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|---|
| | individual characters types | total number of characters | individual characters types | total number of characters | individual characters types | total number of characters |
| Mohenjodaro | 31 | 48 | 105 | 408 | 187 | 1248 |
| Harappa | 13 | 14 | 36 | 71 | 107 | 325 |
| Kalibangan | 26 | 37 | 14 | 15 | 20 | 21 |
| Banawali | 16 | 30 | 0 | 0 | 0 | 0 |
| Lothal | 0 | 0 | 25 | 29 | 32 | 50 |
| Dholavira | 0 | 0 | 12 | 14 | 10 | 12 |
| Others | 4 | 4 | 30 | 47 | 31 | 48 |

Overall, as the individual character types increase the total number of characters increase exponentially. In the early and middle periods, when individual character types are few, the total number of characters are also few, and little difference in number can be seen. This means that the same characters are not used frequently. However, when individual character types increased in the Late Period, the total number of characters increased significantly and the difference between the two was significant. In particular, at the Mohenjodaro site, the total number of characters were more than six times larger than the number of individual character types. This indicates that the same characters were used repeatedly.

The changes in the number of individual character types at each site by period were organized graphically, as shown in Figure 2.

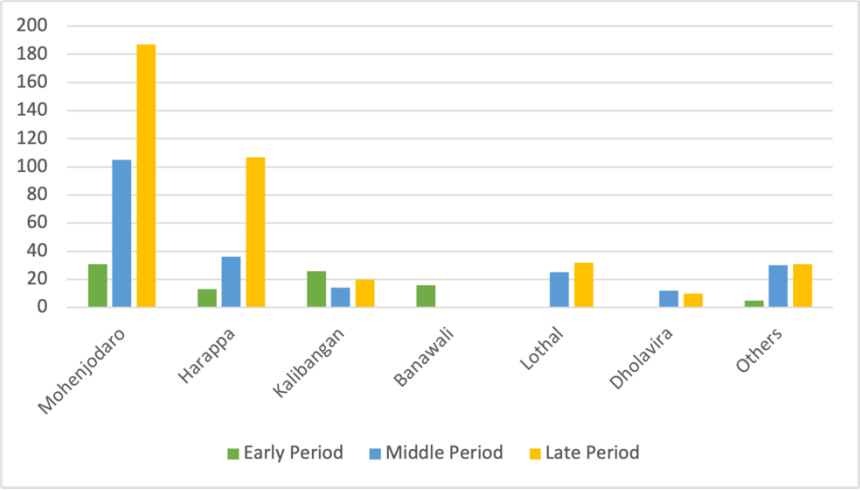


**Figure 2:** Change in the number of individual character types at each site

Individual character type increases with time, with the largest number of individual character types occurring in the Late Period. This indicates that the use of characters was most active in the later half of the Indus civilization. However, as mentioned in Section 3.1, the fact that seals were excavated at only a small portion of the sites indicates that the use of characters did not spread throughout the entire civilization, even though it flourished in the latter half of the period. This may have been influenced by the place where the Indus script was used, and further research is needed to determine the details.

### 3.3 Individual character types and number of times they are used at each site

Next, individual character types and the number of times they were used on the seals at each site were counted. The frequency of use is shown as a percentage, which is the number of times a character was used divided by the total number of characters in the seal during that period.

(1) Mohenjodaro Site

(i) Early Period（Appendix 1）

A total of 31 types of characters were identified on seals, classified as the Early Period seals excavated at the Mohenjodaro site. Most of the characters were used only in one instance each, but characters No. 91, 127, 270, 311, and 368 appeared more than once. Among them, No. 311 was found in seven instances, accounting for approximately 15% of the total number of characters.

(ii) Middle Period （Appendix 2）

A total of 105 types of characters were identified on the Middle Period seals excavated at the Mohenjodaro site. Compared with the Early Period, the number of characters used repeatedly increased. In particular, No. 127, 129, 311, and 376 were used frequently, and No. 127 and 311, which were used more frequently in the Early Period, were used significantly more frequently in the Middle Period than the other types of character.

(iii) Late Period （Appendix 3）

In the Late Period seals excavated at the Mohenjodaro site, 187 types of characters were identified. In this period, most character types were used repeatedly, and those used only once are rare. In the Late Period, characters No. 60, 72, 91, 127, 302, 311, and 376 were used more frequently. In particular, No. 127 and 311 were frequently used, similar to the Early and Middle Periods.

(2) Harappa Site

(i) Early Period（Appendix 4）

In the Early Period seals excavated at the Harappa site, 13 types of characters were identified. As at the Mohenjodaro site in the Early Period, most types of character were found to be used in only one instance, and only No. 311 was used twice.

(ii) Middle Period （Appendix 5）

A total of 36 types of characters were found in the Middle Period seals excavated at the Harappa site: No. 127, 150, 216, and 311 were used frequently, with No. 127 being used very frequently, approximately 13% more frequently than the other types of character.

(iii) Late Period （Appendix 6）
In the Late Period seals excavated at the Harappa site, 107 types of characters were identified. Unlike the Mohenjodaro site, many types of character were used only once. Symbols No. 72, 91, 127, and 311 were used repeatedly. In particular, No. 311, which was used most frequently during the entire period of the Mohenjodaro site, was used 34 times.

(3) Kalibangan Site
As mentioned in Section 3.1, many seals from the Early Period were excavated at the Kalibangan site, located in the Ghaggar River Basin. Therefore, the largest number of character types are from the Early Period.
(i) Early Period (Appendix 7)
A total of 26 types of characters were identified in the Early Period seals excavated from the Kalibangan site. Among these, characters No. 127, 311, and 376 were used relatively frequently, with No. 311 being used most frequently.

(ii) Middle Period (Appendix 8)
A total of 14 types of characters were found to be used in the Middle Period seals excavated from the Kalibangan site. Most types of character were used in only one instance.

(iii) Late Period (Appendix 9)
A total of 20 types of characters were identified on the Late Period seals excavated from the Kalibangan site. Most types of character were used only once, which is the same as in the Early and Middle Periods.

(4) Banawali Site
The Banawali site, located in the Ghaggar River Basin, as well as the Kalibangan site above, show that the number of seals and types of writing are both high in the Early Period.

(i) Early Period (Appendix 10)
In the Early Period seals excavated at the Banawali site, 16 types of characters were identified. Of these, the most frequently used were characters No. 91, 127, 311, and 376, with No. 127 being the most frequent.

(ii) Middle Period
Not applicable

(iii) Late Period
Not applicable

(5) Lothal Site
(i) Early Period
Not applicable

(ii) Middle Period（Appendix 11）
In the seals classified as Middle Period from the Lothal site, 25 different character types were used. Most types of character were used only once, but characters No. 91, 126, and 376 appeared more than once.

(iii) Late period (Appendix 12)
A total of 32 types of characters were identified on the Late Period seals excavated at the Lothal site. Unlike the Mohenjodaro and Harappa sites of the same period, most types of character were used only once. Among them, characters No. 4, 68, 91, 127, and 311 are used more than once.

(6) Dholavira Site
(i) Early Period
Not applicable

(ii) Middle Period（Appendix 13）
A total of 12 different characters were identified on seals, classified as Middle Period, that were excavated at the Dholaviraa site. Most of the characters were used only once, and only No. 1 and 127 were used twice.

(iii) Late Period（Appendix 14）
A total of 10 types of characters were identified on seals, classified as Late Period, that were excavated from the Dholavira site. As in the Middle Period, most of the characters were used only once, and characters No. 91 and 127 were used twice.

(7) Others (Appendix 15-17)
'Others' grouped the seals from various sites, because these number of seals were few. In total, there were five types of inscriptions on the seals classified as Early Period, 30 types as Middle Period, and 31 types as Late Period.

**3.4 Characters used throughout the entire period at each site**
In the table 5-9, the characters commonly used in all periods are organized by site, and a comparison of the frequency of each character used and its change is included. If the frequency of use increased by 25% or more, it is indicated as an increase (↗), if it decreased by 25% or more, it is indicated as a decrease (↘), and if it increased or decreased by less than 25%, it is indicated as no change (→).

(1) Mohenjodaro Site（Table 5）
A total of 20 characters was found at the Mohenjodaro site throughout the entire period. From the Early to Middle Period, most of the characters decreased in frequency. However, from the Middle to Late Period, half of the characters used

remained almost unchanged in frequency. In addition, characters No. 127 and 311 continued to be used at a relatively high frequency throughout the entire period.

**Table 5:** Changes in frequency of characters used throughout the entire period in Mohenjodaro

| | Early Period | | Middle Period | | Late Period | | Early Period | | Middle Period | | Late Period |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 | 2.08 | ↗ | 2.70 | → | 2.72 | 216 | 2.08 | ↘ | 0.49 | ↗ | 0.96 |
| 68 | 2.08 | ↘ | 0.25 | ↗ | 2.72 | 225 | 2.08 | ↘ | 1.47 | ↘ | 0.40 |
| 70 | 2.08 | → | 2.21 | → | 1.76 | 270 | 6.25 | ↘ | 0.74 | ↘ | 0.08 |
| 91 | 8.03 | ↘ | 2.70 | → | 2.88 | 272 | 2.08 | ↗ | 2.70 | ↘ | 0.88 |
| 97 | 2.08 | → | 2.45 | ↘ | 0.40 | 277 | 2.08 | ↘ | 0.25 | → | 0.24 |
| 127 | 8.03 | → | 7.11 | → | 6.73 | 278 | 2.08 | → | 2.21 | ↘ | 0.56 |
| 130 | 2.08 | ↘ | 0.74 | → | 0.88 | 302 | 2.08 | ↗ | 2.70 | → | 2.56 |
| 131 | 2.08 | ↘ | 0.25 | ↗ | 0.56 | 311 | 14.58 | ↘ | 10.05 | → | 9.29 |
| 162 | 2.08 | ↘ | 0.49 | ↗ | 1.04 | 354 | 2.08 | ↘ | 0.74 | ↗ | 2.32 |
| 192 | 2.08 | ↘ | 0.74 | → | 0.64 | 368 | 8.03 | ↘ | 2.21 | ↘ | 1.60 |

(2) Harappa Site（Table 6）

Five types of characters were used at the Harappan site throughout the entire period. And all of these characters are also used at the Mohenjodaro site. In addition, like the Mohenjodaro site, the most types of character decreased in frequency from the Early Period to the Middle Period, however, the most types of character did not change in frequency from the Middle Period to the Late Period. Among these, character No. 311 was used at a very high percentage in all periods, as is the case at the Mohenjodaro site.

**Table 6:** Changes in frequency of characters used throughout the entire period in Harappa

| | Early Period | | Middle Period | | Late Period |
|---|---|---|---|---|---|
| 91 | 7.14 | ↘ | 4.23 | → | 4.00 |
| 127 | 7.14 | ↗ | 12.68 | ↘ | 4.31 |
| 130 | 7.14 | ↘ | 1.41 | → | 1.54 |
| 278 | 7.14 | ↘ | 2.82 | ↘ | 1.23 |
| 311 | 14.29 | ↘ | 9.86 | → | 10.46 |

(3) Kalibangan Site（Table 7）

Only two types of character were used throughout the entire period at the Kalibangan site. Both characters were used at relatively high frequencies.

**Table 7:** Changes in frequency of characters used throughout the entire period in Kalibangan

| | Early Period | | Middle Period | | Late Period |
|---|---|---|---|---|---|
| 127 | 8.11 | → | 6.67 | → | 4.76 |
| 311 | 13.51 | ↘ | 6.67 | ↗ | 9.52 |

(4) Banawali Site

Only the seal from the Early Period were available.

(5) Lothal Site (Table 8, Middle and Late Period only)

At the Lothal site, only the seal from the Middle and Late Period were available. Nine types of characters were used throughout the Middle and Late Period at the Lothal site. Of the nine types, No. 72, 126, 312, and 376 do not appear at the Mohenjodaro site during the same periods. In addition, No. 91 is used with a high frequency in both the Middle and Late Periods.

**Table 8**: Changes in frequency of characters used throughout the entire period in Lothal.

| | Middle Period | | Late Period |
|---|---|---|---|
| 72 | 3.45 | ↘ | 2.00 |
| 91 | 10.34 | → | 8.00 |
| 126 | 6.90 | ↘ | 4.00 |
| 127 | 3.45 | ↗ | 6.00 |
| 130 | 3.45 | ↘ | 2.00 |
| 131 | 3.45 | → | 4.00 |
| 311 | 3.45 | ↗ | 6.00 |
| 312 | 3.45 | → | 4.00 |
| 376 | 6.90 | ↘ | 2.00 |

(6) Dholavira Site（Table 9）

At the Dholavira site, only the seal from the Middle and Late Period were available. Four types of characters were used throughout the entire period at the Dholavira site, of which No. 127 was used with high frequency in both the Middle and Late Periods.

**Table 9:** Changes in frequency of characters used throughout the entire period in Dholavira.

| | Middle Period | | Late Period |
|---|---|---|---|
| 91 | 7.14 | ↗ | 16.67 |
| 127 | 14.29 | → | 16.67 |
| 302 | 7.14 | → | 8.33 |
| 376 | 7.14 | → | 8.33 |

The above results show that the characters used throughout the entire period were almost the same at all sites. Symbol No. 91, 127, and 311 appeared at almost all sites in all periods.

### 3.5. Frequently used characters at each site

The table 10-15, contains the results of the most frequently used characters in each period, organized by archaeological site.

(1) Mohenjodaro Site（Table 10）

At the Mohenjodaro site, No. 311 had the highest frequency of use throughout all periods. No. 127 also had high frequency of use throughout all periods.

**Table 10:** Most frequently used characters in each period of Mohenjodaro

| Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|
| 311 | 14.58 | 311 | 10.05 | 311 | 9.29 |
| 91 | 8.33 | 127 | 7.11 | 127 | 6.73 |
| 127 | 8.33 | 376 | 5.39 | 376 | 3.85 |
| 368 | 8.33 | 129 | 3.43 | 91 | 2.88 |
| 270 | 6.25 | 91 | 2.70 | 60 | 2.72 |
| | | | | 302 | 2.56 |
| | | | | 72 | 2.48 |

(2) Harappa Site（Table 11）

At the Harappa site, character No. 311 was also used with a high frequency like at the Mohenjodaro site. However, unlike the Mohenjodaro site, No. 127 was used most frequently during the Middle Period.

**Table 11:** Most frequently used characters in each period of Harappa

| Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|
| 311 | 14.29 | 127 | 12.68 | 311 | 10.46 |
| | | 311 | 9.86 | 127 | 4.31 |
| | | 150 | 7.04 | 91 | 4.00 |
| | | 216 | 5.63 | 72 | 3.69 |

(3) Kalibangan Site（Table 12）

In the Early Period, characters No. 311 and 127 appeared with high frequency, as they did at the Mohenjodaro site.

**Table 12:** Most frequently used characters in each period of Kalibangan

| Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|
| 311 | 13.51 | 156 | 13.33 | 312 | 9.52 |
| 127 | 8.11 | | | | |
| 376 | 8.11 | | | | |

(4) Banawali Site （Table 13; Not applicable for Middle and Late Period)

The most frequently used characters from the Early Period found at the Banawali site were almost the same as those of the Kalibangan site, which is in the same Ghaggar region. The most frequently used character was No. 127, which accounted for approximately 17% of the total. In addition, No. 376, which was not used at the Mohenjodaro site in the same period, was used at a relatively high frequency.

**Table 13:** Most frequently used characters in each period of Banawali

| Early Period | |
|---|---|
| 127 | 16.67 |
| 91 | 13.33 |
| 311 | 10.00 |
| 376 | 10.00 |

(5) Lothal Site (Table 14; Not applicable for Early Period)

At the Lothal Site, character No. 91 was frequently used in both the Middle and Late periods. No. 127 and 311, which were frequently used at the Mohenjodaro and Harappa sites, were found in only one case each at the Lothar site from the Middle Period.

**Table 14:** Most frequently used characters in each period of Lothal

| Middle Period | | Late Period | |
|---|---|---|---|
| 91 | 10.34 | 68 | 8.00 |
| 126 | 6.90 | 91 | 8.00 |
| 376 | 6.90 | 4 | 6.00 |
| | | 127 | 6.00 |
| | | 311 | 6.00 |

(6) Dholavira Site (Table 15; Not applicable for the Early Period)
At the Dholavira site, No. 127 was used more frequently during both the Middle and Late periods.

**Table 15:** Most frequently used characters in each period of Dholavira

| Middle Period | | Late Period | |
|---|---|---|---|
| 1 | 14.29 | 91 | 16.67 |
| 127 | 14.29 | 127 | 16.67 |

Looking at the characters frequently used at each site and period, it is evident that the three types of characters discussed in Section 3.4, namely, No. 91, 127, and 311, were used with high frequency at many sites.

### 3.6. Length of string

In table 16-22, frequency distribution table of string length on the seals at each site at different periods is provided. The frequency distribution table is based on a scale of 1 to 15 (characters), with a scale width of two. The relative frequencies were calculated to two decimal places by dividing the frequencies by the total.

(1) Mohenjodaro Site（Table 16[5]）
The table 15 shows that in the Early Period, seals with 1–3 characters were more common, whereas in the Middle and Late Periods, seals with 4-9 characters became more common. This indicates that the length of the strings got gradually longer from the Early to Late periods in the Mohenjodaro site. However, even in the Middle and Late periods, seals with long strings of more than 10 characters did not become mainstream, and seals with 1-6 characters were still being created in large numbers.

[5] The relative frequency of 13-15 characters from the Mohenjodaro site, 3C period is 0.004, which is indicated as 0 for the convenience of two decimal places.

**Table 16:** Frequency distribution of string lengths on seals excavated at Mohenjodaro site

| Number of characters | Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 10 | 0.63 | 8 | 0.11 | 83 | 0.32 |
| 4-6 | 6 | 0.38 | 41 | 0.57 | 123 | 0.47 |
| 7-9 | 0 | 0.00 | 20 | 0.28 | 47 | 0.18 |
| 10-12 | 0 | 0.00 | 3 | 0.04 | 7 | 0.03 |
| 13-15 | 0 | 0.00 | 0 | 0.00 | 1 | 0.00 |
| Total | 16 | | 72 | | 261 | |

(2) Harappa Site（Table 17）

The Harappan site showed the same trend as the Mohenjodaro site. Although the variation in the number of characters increased from the Early to the Late Period, there were many 4-6 character seals throughout all periods. In particular, a comparison of the relative frequencies of the Late Period with those of the Mohenjodaro site showed that they were almost the same.

**Table 17:** Frequency distribution of string lengths on seals excavated at Harappa site.

| Number of characters | Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 1 | 0.33 | 4 | 0.27 | 18 | 0.28 |
| 4-6 | 2 | 0.67 | 10 | 0.67 | 28 | 0.43 |
| 7-9 | 0 | 0.00 | 1 | 0.07 | 15 | 0.23 |
| 10-12 | 0 | 0.00 | 0 | 0.00 | 3 | 0.05 |
| 13-15 | 0 | 0.00 | 0 | 0.00 | 1 | 0.02 |
| Total | 3 | | 15 | | 65 | |

(3) Kalibangan Site（Table 18）

As mentioned in Section 3.1, many of the seals excavated from the Kalibangan site were from the Early Period. In the Early period, many seals with 1–3

characters were excavated, however, seals with 7–9 characters were also excavated, indicating that there were more variations in the number of characters than in the Early Period at other sites. One seal with 13 characters from the Middle Period was excavated, however, it was judged appropriate to treat it as an outlier.

**Table 18:** Frequency distribution of string lengths on seals excavated at Kalibangan site.

| Number of characters | Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 5 | 0.50 | 1 | 0.50 | 2 | 0.40 |
| 4-6 | 3 | 0.30 | 0 | 0.00 | 2 | 0.40 |
| 7-9 | 2 | 0.20 | 0 | 0.00 | 1 | 0.20 |
| 10-12 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 13-15 | 0 | 0.00 | 1 | 0.50 | 0 | 0.00 |
| Total | 10 | | 2 | | 5 | |

(4) Banawali Site（Table 19）

At the Banawali site, only the seal from the Early Period were available. From the Early Period, as with the other sites, many seals with 1–3 characters were excavated; one seal with 7–9 characters were included, however, it was judged appropriate to treat it as an outliner.

**Table 19:** Frequency distribution of string lengths on seals excavated at Banawali site.

| Number of characters | Early Period | |
|---|---|---|
| | Number of seals | Relative frequency |
| 1-3 | 9 | 0.82 |
| 4-6 | 1 | 0.09 |
| 7-9 | 1 | 0.09 |
| 10-12 | 0 | 0.00 |
| 13-15 | 0 | 0.00 |
| Total | 11 | |

(5) Lothal Site（Table 20）

At the Lothal site, only the seal from the Middle and Late Period were available. From the Middle Period, seals with 4-6 characters were common, and seals with 1-3 characters were not excavated. The trend at the Middle site did not differ from that of other sites. From the Late Period, seals with 4-6 characters were produced in large numbers, as in other sites.

**Table 20:** Frequency distribution of string lengths on seals excavated at Lothal site.

| Number of characters | Middle Period | | Late Period | |
|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 0 | 0.00 | 6 | 0.50 |
| 4-6 | 4 | 0.80 | 5 | 0.42 |
| 7-9 | 1 | 0.20 | 1 | 0.08 |
| 10-12 | 0 | 0.00 | 0 | 0.00 |
| 13-15 | 0 | 0.00 | 0 | 0.00 |
| Total | 5 | | 12 | |

(6) Dholavira Site（Table 21）

At the Dholavira site, only the seal from the Middle and Late Period were available. Although it is difficult to determine trends at the Dholavira site because of the small number of excavated seals, both the Middle and Late Period sites show similar trends as the other sites.

**Table 21**: Frequency distribution of string lengths on seals excavated at Dholavira site.

| Number of characters | Middle Period | | Late Period | |
|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 1 | 0.33 | 0 | 0.00 |
| 4-6 | 2 | 0.67 | 1 | 0.50 |
| 7-9 | 0 | 0.00 | 1 | 0.50 |
| 10-12 | 0 | 0.00 | 0 | 0.00 |
| 13-15 | 0 | 0.00 | 0 | 0.00 |
| Total | 3 | | 2 | |

(7) Others（Table 22）

At other sites, two seals with 1–3 characters from the Early Period were excavated and seals with 4-6 characters were the most common in the Middle to Late Period, which is almost the same as the trend at other sites.

**Table 22:** Frequency distribution of string lengths on seals excavated at others.

| Number of characters | Early Period | | Middle Period | | Late Period | |
|---|---|---|---|---|---|---|
| | Number of seals | Relative frequency | Number of seals | Relative frequency | Number of seals | Relative frequency |
| 1-3 | 2 | 1 | 1 | 0.13 | 2 | 0.2 |
| 4-6 | 0 | 0 | 4 | 0.50 | 7 | 0.7 |
| 7-9 | 0 | 0 | 3 | 0.38 | 1 | 0.1 |
| 10-12 | 0 | 0 | 0 | 0.00 | 0 | 0 |
| 13-15 | 0 | 0 | 0 | 0.00 | 0 | 0 |
| Total | 2 | | 8 | | 10 | |

The above results show that short-character string seals did not disappear from the Early to Late Period, and they still existed in the Late Period. From this, it can be assumed that as the period progressed, seals did not simply become longer, but they became capable of producing longer character strings.

## 4. Conclusion

In Section 3.1, we observed the distribution of the number of seal by period and site, and found that seals from the Late Period were the most abundant at all sites except the Ghaggar River Basin. Since the seals are inscribed with characters, it can be inferred that the use of characters was most active in the Late Period at most sites of the Indus Civilization.

In Section 3.2, we compared the number of individual character types to the total number of characters and analyzed how the number of characters changed from period to period and site to site. It was found that the total number of characters increased exponentially as the number of characters increased. It was also found that the number of characters increased gradually in the latter half of the period at most sites. The increase in the number of characters indicates that the

Indus writing system became more complex, and it can be inferred that the Indus civilization became a society that required a larger number of characters from the Early to Late periods.

In Section 3.3, we summarized the types of characters used at each site during each period and the number of times they were used. The Indus Civilization sites have not yet been fully excavated, and it is thought that there are still many textual materials that have not yet been discovered. However, even considering this, the types of characters used differ from period to period. Although the total number of characters used at the Mohenjodaro site in the latter half of the period is very large (1,248), there are many characters that appeared only in the Early and Middle Periods. This suggests that the Indus script may have changed from period to period.

In Section 3.4, we analyzed the characters used throughout the entire period at each site and found that almost the same character types were used throughout the entire periods at all sites. Among them, Character No. 91, 127, and 311 appeared at almost all sites from the entire period. The fact that these three characters have been used continuously since the Early Period indicates that they had important implications for the Indus civilization, although the specific meanings of these characters are not known.

In Section 3.5, we analyzed the most frequently used characters at each site and found that characters 91, 127, and 311 mentioned in Section 3.4 were used frequently at many sites. A high frequency of use indicates that these characters had an important meaning in that period and region which reinforces our hypothesis.

In Section 3.6, we analyzed the length of character strings by site and period. It was found that the number of seals with long character strings increased in the latter half of the period at many sites. However, the number of seals with short character strings did not decrease accordingly, and continued to be used at a constant rate.

From the above, it is evident that the characteristics of the types of characters and the lengths of the character strings differ from period to period, and it is highly possible that the Indus script changed throughout the period.

The purpose of this study was to examine the possibility that the Indus script changed by classifying the seals into three periods based on their characteristics and analyzing the periodic changes in the characters inscribed on them. Based on the results of the analysis in Section 3 and the discussion in Section 4, it is highly probable. However, this study is based on a hypothesis regarding the period characteristics of seals, and this hypothesis should continue to be examined.

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## Appendix

In the Appendix 1-25, the type of characters used at each site from each period is shown together with the character number in the character list of Parpola (1994), and the number of times the character was used is showed in the center box. In the right frame, the frequency of use is shown as a percentage, which is the number of times a character was used divided by the total number of characters in the seal during that period. Those with above-average frequency of use in each period are shaded.

**Appendix 1**. Characters used in the Early Period in Mohenjodaro

| Character | Count | Frequency |
|---|---|---|
| 27 | 1 | 2.08 |
| 60 | 1 | 2.08 |
| 68 | 1 | 2.08 |
| 70 | 1 | 2.08 |
| 91 | 4 | 8.33 |
| 94 | 1 | 2.08 |
| 97 | 1 | 2.08 |
| 104 | 1 | 2.08 |
| 118 | 1 | 2.08 |
| 127 | 4 | 8.33 |
| 130 | 1 | 2.08 |
| 131 | 1 | 2.08 |
| 162 | 1 | 2.08 |
| 175 | 1 | 2.08 |
| 192 | 1 | 2.08 |
| 216 | 1 | 2.08 |

| Character | Count | Frequency |
|---|---|---|
| 222 | 1 | 2.08 |
| 225 | 1 | 2.08 |
| 229 | 1 | 2.08 |
| 236 | 1 | 2.08 |
| 270 | 3 | 6.25 |
| 272 | 1 | 2.08 |
| 277 | 1 | 2.08 |
| 278 | 1 | 2.08 |
| 302 | 1 | 2.08 |
| 311 | 7 | 14.58 |
| 354 | 1 | 2.08 |
| 361 | 1 | 2.08 |
| 367 | 1 | 2.08 |
| 368 | 4 | 8.33 |
| *5 | 1 | 2.08 |

**Appendix 2**. Characters used in the Middle Period in Mohenjodaro

| Character | Count | Frequency |
|---|---|---|
| 1 | 6 | 1.47 |
| 4 | 1 | 0.25 |
| 7 | 3 | 0.74 |
| 9 | 3 | 0.74 |
| 13 | 4 | 0.98 |
| 38 | 2 | 0.49 |

| Character | Count | Frequency |
|---|---|---|
| 47 | 1 | 0.25 |
| 48 | 1 | 0.25 |
| 51 | 1 | 0.25 |
| 54 | 1 | 0.25 |
| 58 | 1 | 0.25 |
| 59 | 2 | 0.49 |

| Character | Count | Frequency |
|---|---|---|
| 60 | 11 | 2.70 |
| 61 | 1 | 0.25 |
| 66 | 4 | 0.98 |
| 68 | 1 | 0.25 |
| 70 | 9 | 2.21 |
| 72 | 6 | 1.47 |
| 77 | 2 | 0.49 |
| 81 | 1 | 0.25 |
| 83 | 1 | 0.25 |
| 88 | 7 | 1.72 |
| 89 | 2 | 0.49 |
| 91 | 11 | 2.70 |
| 93 | 1 | 0.25 |
| 97 | 10 | 2.45 |
| 101 | 2 | 0.49 |
| 105 | 2 | 0.49 |
| 107 | 1 | 0.25 |
| 108 | 1 | 0.25 |
| 109 | 3 | 0.74 |
| 114 | 1 | 0.25 |
| 116 | 2 | 0.49 |
| 118 | 2 | 0.49 |
| 120 | 2 | 0.49 |
| 125 | 5 | 1.23 |
| 126 | 11 | 2.70 |
| 127 | 29 | 7.11 |
| 129 | 14 | 3.43 |
| 130 | 3 | 0.74 |
| 131 | 1 | 0.25 |
| 132 | 1 | 0.25 |
| 134 | 2 | 0.49 |
| 147 | 2 | 0.49 |
| 150 | 7 | 1.72 |
| 155 | 1 | 0.25 |
| 156 | 2 | 0.49 |
| 162 | 2 | 0.49 |
| 171 | 1 | 0.25 |
| 173 | 2 | 0.49 |
| 176 | 1 | 0.25 |

| Character | Count | Frequency |
|---|---|---|
| 177 | 1 | 0.25 |
| 187 | 2 | 0.49 |
| 189 | 11 | 2.70 |
| 190 | 2 | 0.49 |
| 192 | 3 | 0.74 |
| 194 | 1 | 0.25 |
| 198 | 2 | 0.49 |
| 200 | 1 | 0.25 |
| 211 | 1 | 0.25 |
| 214 | 4 | 0.98 |
| 215 | 1 | 0.25 |
| 216 | 2 | 0.49 |
| 217 | 3 | 0.74 |
| 222 | 1 | 0.25 |
| 225 | 6 | 1.47 |
| 226 | 1 | 0.25 |
| 232 | 1 | 0.25 |
| 233 | 2 | 0.49 |
| 236 | 2 | 0.49 |
| 237 | 1 | 0.25 |
| 241 | 2 | 0.49 |
| 250 | 1 | 0.25 |
| 261 | 6 | 1.47 |
| 266 | 1 | 0.25 |
| 270 | 3 | 0.74 |
| 272 | 11 | 2.70 |
| 273 | 2 | 0.49 |
| 277 | 1 | 0.25 |
| 278 | 9 | 2.21 |
| 283 | 3 | 0.74 |
| 285 | 1 | 0.25 |
| 288 | 1 | 0.25 |
| 289 | 4 | 0.98 |
| 292 | 1 | 0.25 |
| 296 | 2 | 0.49 |
| 297 | 2 | 0.49 |
| 302 | 11 | 2.70 |
| 311 | 41 | 10.05 |
| 312 | 9 | 2.21 |

| Character | Count | Frequency |
|---|---|---|
| 313 | 1 | 0.25 |
| 319 | 6 | 1.47 |
| 323 | 1 | 0.25 |
| 330 | 1 | 0.25 |
| 337 | 1 | 0.25 |
| 341 | 5 | 1.23 |
| 350 | 1 | 0.25 |
| 354 | 3 | 0.74 |

| Character | Count | Frequency |
|---|---|---|
| 355 | 1 | 0.25 |
| 358 | 2 | 0.49 |
| 368 | 9 | 2.21 |
| 373 | 1 | 0.25 |
| 376 | 22 | 5.39 |
| 381 | 1 | 0.25 |
| *7 | 1 | 0.25 |

**Appendix 3**. Characters used in the Late Period in Mohenjodaro

| Character | Count | Frequency |
|---|---|---|
| 1 | 8 | 0.64 |
| 3 | 3 | 0.24 |
| 4 | 14 | 1.12 |
| 6 | 1 | 0.08 |
| 7 | 11 | 0.88 |
| 8 | 2 | 0.16 |
| 9 | 15 | 1.20 |
| 11 | 1 | 0.08 |
| 12 | 1 | 0.08 |
| 13 | 7 | 0.56 |
| 15 | 2 | 0.16 |
| 21 | 1 | 0.08 |
| 27 | 2 | 0.16 |
| 28 | 1 | 0.08 |
| 33 | 5 | 0.40 |
| 37 | 1 | 0.08 |
| 38 | 6 | 0.48 |
| 41 | 1 | 0.08 |
| 42 | 1 | 0.08 |
| 46 | 2 | 0.16 |
| 48 | 2 | 0.16 |
| 53 | 1 | 0.08 |
| 54 | 8 | 0.64 |
| 55 | 1 | 0.08 |
| 56 | 1 | 0.08 |
| 60 | 34 | 2.72 |
| 61 | 2 | 0.16 |

| Character | Count | Frequency |
|---|---|---|
| 62 | 1 | 0.08 |
| 63 | 2 | 0.16 |
| 66 | 7 | 0.56 |
| 68 | 34 | 2.72 |
| 69 | 2 | 0.16 |
| 70 | 22 | 1.76 |
| 71 | 2 | 0.16 |
| 72 | 31 | 2.48 |
| 73 | 1 | 0.08 |
| 75 | 1 | 0.08 |
| 77 | 2 | 0.16 |
| 80 | 1 | 0.08 |
| 81 | 2 | 0.16 |
| 83 | 9 | 0.72 |
| 86 | 3 | 0.24 |
| 87 | 21 | 1.68 |
| 88 | 17 | 1.36 |
| 89 | 5 | 0.40 |
| 90 | 2 | 0.16 |
| 91 | 36 | 2.88 |
| 95 | 2 | 0.16 |
| 96 | 1 | 0.08 |
| 97 | 5 | 0.40 |
| 98 | 2 | 0.16 |
| 101 | 16 | 1.28 |
| 102 | 1 | 0.08 |
| 103 | 2 | 0.16 |

| Character | Count | Frequency |
|---|---|---|
| 104 | 5 | 0.40 |
| 105 | 3 | 0.24 |
| 107 | 11 | 0.88 |
| 109 | 4 | 0.32 |
| 114 | 6 | 0.48 |
| 116 | 5 | 0.40 |
| 117 | 1 | 0.08 |
| 120 | 12 | 0.96 |
| 123 | 2 | 0.16 |
| 125 | 18 | 1.44 |
| 126 | 14 | 1.12 |
| 127 | 84 | 6.73 |
| 129 | 29 | 2.32 |
| 130 | 11 | 0.88 |
| 131 | 7 | 0.56 |
| 132 | 5 | 0.40 |
| 133 | 3 | 0.24 |
| 134 | 6 | 0.48 |
| 135 | 2 | 0.16 |
| 140 | 1 | 0.08 |
| 142 | 2 | 0.16 |
| 143 | 1 | 0.08 |
| 145 | 4 | 0.32 |
| 147 | 21 | 1.68 |
| 150 | 24 | 1.92 |
| 151 | 2 | 0.16 |
| 153 | 3 | 0.24 |
| 156 | 4 | 0.32 |
| 157 | 1 | 0.08 |
| 162 | 13 | 1.04 |
| 167 | 1 | 0.08 |
| 172 | 1 | 0.08 |
| 175 | 5 | 0.40 |
| 177 | 11 | 0.88 |
| 178 | 1 | 0.08 |
| 179 | 1 | 0.08 |
| 180 | 1 | 0.08 |
| 181 | 1 | 0.08 |
| 185 | 1 | 0.08 |

| Character | Count | Frequency |
|---|---|---|
| 187 | 3 | 0.24 |
| 189 | 29 | 2.32 |
| 190 | 2 | 0.16 |
| 192 | 8 | 0.64 |
| 193 | 1 | 0.08 |
| 195 | 1 | 0.08 |
| 196 | 1 | 0.08 |
| 197 | 3 | 0.24 |
| 198 | 6 | 0.48 |
| 202 | 1 | 0.08 |
| 204 | 5 | 0.40 |
| 210 | 1 | 0.08 |
| 211 | 1 | 0.08 |
| 214 | 10 | 0.80 |
| 215 | 3 | 0.24 |
| 216 | 12 | 0.96 |
| 217 | 9 | 0.72 |
| 223 | 1 | 0.08 |
| 224 | 1 | 0.08 |
| 225 | 5 | 0.40 |
| 226 | 2 | 0.16 |
| 228 | 1 | 0.08 |
| 229 | 1 | 0.08 |
| 231 | 2 | 0.16 |
| 237 | 1 | 0.08 |
| 238 | 4 | 0.32 |
| 241 | 2 | 0.16 |
| 242 | 1 | 0.08 |
| 245 | 2 | 0.16 |
| 247 | 3 | 0.24 |
| 250 | 1 | 0.08 |
| 251 | 1 | 0.08 |
| 255 | 3 | 0.24 |
| 260 | 6 | 0.48 |
| 261 | 4 | 0.32 |
| 269 | 1 | 0.08 |
| 270 | 1 | 0.08 |
| 272 | 11 | 0.88 |
| 273 | 8 | 0.64 |

| Character | Count | Frequency |
|---|---|---|
| 276 | 2 | 0.16 |
| 277 | 3 | 0.24 |
| 278 | 7 | 0.56 |
| 279 | 1 | 0.08 |
| 283 | 2 | 0.16 |
| 288 | 4 | 0.32 |
| 289 | 7 | 0.56 |
| 291 | 1 | 0.08 |
| 292 | 5 | 0.40 |
| 294 | 1 | 0.08 |
| 295 | 1 | 0.08 |
| 296 | 2 | 0.16 |
| 297 | 1 | 0.08 |
| 298 | 1 | 0.08 |
| 300 | 1 | 0.08 |
| 301 | 1 | 0.08 |
| 302 | 32 | 2.56 |
| 307 | 6 | 0.48 |
| 309 | 2 | 0.16 |
| 311 | 116 | 9.29 |
| 312 | 22 | 1.76 |
| 313 | 2 | 0.16 |
| 314 | 5 | 0.40 |
| 319 | 14 | 1.12 |
| 320 | 1 | 0.08 |

| Character | Count | Frequency |
|---|---|---|
| 321 | 1 | 0.08 |
| 327 | 4 | 0.32 |
| 330 | 3 | 0.24 |
| 333 | 3 | 0.24 |
| 334 | 3 | 0.24 |
| 337 | 6 | 0.48 |
| 340 | 3 | 0.24 |
| 341 | 8 | 0.64 |
| 344 | 2 | 0.16 |
| 351 | 1 | 0.08 |
| 354 | 29 | 2.32 |
| 355 | 4 | 0.32 |
| 358 | 4 | 0.32 |
| 360 | 2 | 0.16 |
| 361 | 4 | 0.32 |
| 364 | 2 | 0.16 |
| 366 | 1 | 0.08 |
| 368 | 20 | 1.60 |
| 369 | 1 | 0.08 |
| 373 | 4 | 0.32 |
| 375 | 2 | 0.16 |
| 376 | 48 | 3.85 |
| 377 | 2 | 0.16 |
| *2 | 1 | 0.08 |
| *3 | 1 | 0.08 |

**Appendix 4**. Characters used in the Early Period in Harappa

| Character | Count | Frequency |
|---|---|---|
| 1 | 1 | 7.14 |
| 66 | 1 | 7.14 |
| 70 | 1 | 7.14 |
| 91 | 1 | 7.14 |
| 127 | 1 | 7.14 |
| 130 | 1 | 7.14 |
| 156 | 1 | 7.14 |

| Character | Count | Frequency |
|---|---|---|
| 214 | 1 | 7.14 |
| 270 | 1 | 7.14 |
| 278 | 1 | 7.14 |
| 311 | 2 | 14.29 |
| 368 | 1 | 7.14 |
| 376 | 1 | 7.14 |

**Appendix 5**. Characters used in the Middle Period in Harappa

| Character | Count | Frequency |
|---|---|---|
| 1 | 1 | 1.41 |
| 9 | 2 | 2.82 |
| 13 | 1 | 1.41 |
| 33 | 2 | 2.82 |
| 38 | 2 | 2.82 |
| 72 | 2 | 2.82 |
| 81 | 1 | 1.41 |
| 87 | 2 | 2.82 |
| 88 | 1 | 1.41 |
| 91 | 3 | 4.23 |
| 107 | 1 | 1.41 |
| 108 | 1 | 1.41 |
| 118 | 1 | 1.41 |
| 126 | 1 | 1.41 |
| 127 | 9 | 12.68 |
| 129 | 3 | 4.23 |
| 130 | 1 | 1.41 |
| 131 | 1 | 1.41 |

| Character | Count | Frequency |
|---|---|---|
| 147 | 1 | 1.41 |
| 150 | 5 | 7.04 |
| 189 | 2 | 2.82 |
| 214 | 1 | 1.41 |
| 216 | 4 | 5.63 |
| 239 | 1 | 1.41 |
| 241 | 1 | 1.41 |
| 261 | 1 | 1.41 |
| 274 | 2 | 2.82 |
| 275 | 1 | 1.41 |
| 277 | 1 | 1.41 |
| 278 | 2 | 2.82 |
| 302 | 2 | 2.82 |
| 311 | 7 | 9.86 |
| 333 | 1 | 1.41 |
| 337 | 1 | 1.41 |
| 376 | 2 | 2.82 |

**Appendix 6**. Characters used in the Late Period in Harappa

| Character | Count | Frequency |
|---|---|---|
| 3 | 2 | 0.62 |
| 4 | 2 | 0.62 |
| 7 | 6 | 1.85 |
| 8 | 1 | 0.31 |
| 9 | 5 | 1.54 |
| 13 | 1 | 0.31 |
| 15 | 1 | 0.31 |
| 21 | 1 | 0.31 |
| 25 | 1 | 0.31 |
| 33 | 2 | 0.62 |
| 38 | 1 | 0.31 |
| 45 | 1 | 0.31 |
| 48 | 2 | 0.62 |
| 49 | 1 | 0.31 |
| 54 | 2 | 0.62 |

| Character | Count | Frequency |
|---|---|---|
| 59 | 1 | 0.31 |
| 60 | 9 | 2.77 |
| 66 | 4 | 1.23 |
| 67 | 1 | 0.31 |
| 68 | 4 | 1.23 |
| 70 | 9 | 2.77 |
| 72 | 12 | 3.69 |
| 73 | 1 | 0.31 |
| 83 | 2 | 0.62 |
| 86 | 1 | 0.31 |
| 87 | 3 | 0.92 |
| 88 | 4 | 1.23 |
| 91 | 13 | 4.00 |
| 96 | 1 | 0.31 |
| 97 | 1 | 0.31 |

| Character | Count | Frequency |
|---|---|---|
| 101 | 4 | 1.23 |
| 104 | 1 | 0.31 |
| 105 | 2 | 0.62 |
| 107 | 1 | 0.31 |
| 116 | 3 | 0.92 |
| 118 | 1 | 0.31 |
| 120 | 1 | 0.31 |
| 123 | 1 | 0.31 |
| 124 | 1 | 0.31 |
| 125 | 4 | 1.23 |
| 126 | 7 | 2.15 |
| 127 | 14 | 4.31 |
| 129 | 9 | 2.77 |
| 130 | 5 | 1.54 |
| 131 | 5 | 1.54 |
| 134 | 2 | 0.62 |
| 135 | 1 | 0.31 |
| 136 | 1 | 0.31 |
| 145 | 4 | 1.23 |
| 146 | 1 | 0.31 |
| 147 | 2 | 0.62 |
| 150 | 5 | 1.54 |
| 156 | 2 | 0.62 |
| 162 | 10 | 3.08 |
| 165 | 1 | 0.31 |
| 166 | 1 | 0.31 |
| 167 | 1 | 0.31 |
| 175 | 1 | 0.31 |
| 176 | 1 | 0.31 |
| 177 | 1 | 0.31 |
| 181 | 1 | 0.31 |
| 189 | 5 | 1.54 |
| 190 | 1 | 0.31 |
| 192 | 1 | 0.31 |
| 193 | 1 | 0.31 |
| 197 | 1 | 0.31 |
| 200 | 1 | 0.31 |
| 202 | 1 | 0.31 |
| 204 | 2 | 0.62 |

| Character | Count | Frequency |
|---|---|---|
| 209 | 2 | 0.62 |
| 210 | 1 | 0.31 |
| 211 | 3 | 0.92 |
| 216 | 3 | 0.92 |
| 217 | 2 | 0.62 |
| 225 | 1 | 0.31 |
| 226 | 2 | 0.62 |
| 238 | 1 | 0.31 |
| 241 | 1 | 0.31 |
| 247 | 1 | 0.31 |
| 260 | 3 | 0.92 |
| 261 | 1 | 0.31 |
| 272 | 3 | 0.92 |
| 273 | 1 | 0.31 |
| 277 | 4 | 1.23 |
| 278 | 4 | 1.23 |
| 284 | 2 | 0.62 |
| 287 | 1 | 0.31 |
| 288 | 1 | 0.31 |
| 289 | 1 | 0.31 |
| 292 | 1 | 0.31 |
| 294 | 1 | 0.31 |
| 297 | 1 | 0.31 |
| 302 | 6 | 1.85 |
| 307 | 2 | 0.62 |
| 311 | 34 | 10.46 |
| 312 | 6 | 1.85 |
| 314 | 2 | 0.62 |
| 319 | 3 | 0.92 |
| 337 | 1 | 0.31 |
| 341 | 2 | 0.62 |
| 345 | 1 | 0.31 |
| 354 | 10 | 3.08 |
| 358 | 1 | 0.31 |
| 368 | 6 | 1.85 |
| 371 | 1 | 0.31 |
| 376 | 6 | 1.85 |
| 385 | 1 | 0.31 |

**Appendix 7**. Characters used in the Early Period in Kalibangan

| Character | Count | Frequency |
|---|---|---|
| 9 | 1 | 2.70 |
| 13 | 1 | 2.70 |
| 60 | 1 | 2.70 |
| 72 | 1 | 2.70 |
| 91 | 1 | 2.70 |
| 118 | 1 | 2.70 |
| 125 | 1 | 2.70 |
| 126 | 1 | 2.70 |
| 127 | 3 | 8.11 |
| 198 | 1 | 2.70 |
| 214 | 1 | 2.70 |
| 216 | 1 | 2.70 |
| 217 | 1 | 2.70 |

| Character | Count | Frequency |
|---|---|---|
| 222 | 1 | 2.70 |
| 225 | 1 | 2.70 |
| 233 | 1 | 2.70 |
| 270 | 1 | 2.70 |
| 278 | 1 | 2.70 |
| 307 | 2 | 5.41 |
| 311 | 5 | 13.51 |
| 319 | 1 | 2.70 |
| 322 | 1 | 2.70 |
| 330 | 1 | 2.70 |
| 341 | 2 | 5.41 |
| 368 | 2 | 5.41 |
| 376 | 3 | 8.11 |

**Appendix 8**. Characters used in the Middle Period in Kalibangan

| Character | Count | Frequency |
|---|---|---|
| 60 | 1 | 6.67 |
| 69 | 1 | 6.67 |
| 97 | 1 | 6.67 |
| 123 | 1 | 6.67 |
| 127 | 1 | 6.67 |
| 156 | 2 | 13.33 |
| 188 | 1 | 6.67 |

| Character | Count | Frequency |
|---|---|---|
| 196 | 1 | 6.67 |
| 236 | 1 | 6.67 |
| 311 | 1 | 6.67 |
| 356 | 1 | 6.67 |
| 357 | 1 | 6.67 |
| 376 | 1 | 6.67 |
| 381 | 1 | 6.67 |

**Appendix 9**. Characters used in the Late Period in Kalibangan

| Character | Count | Frequency |
|---|---|---|
| 1 | 1 | 4.76 |
| 9 | 1 | 4.76 |
| 38 | 1 | 4.76 |
| 68 | 1 | 4.76 |
| 72 | 1 | 4.76 |
| 77 | 1 | 4.76 |
| 91 | 1 | 4.76 |
| 126 | 1 | 4.76 |
| 127 | 1 | 4.76 |
| 129 | 1 | 4.76 |

| Character | Count | Frequency |
|---|---|---|
| 132 | 1 | 4.76 |
| 147 | 1 | 4.76 |
| 153 | 1 | 4.76 |
| 162 | 1 | 4.76 |
| 189 | 1 | 4.76 |
| 193 | 1 | 4.76 |
| 273 | 1 | 4.76 |
| 312 | 2 | 9.52 |
| 346 | 1 | 4.76 |
| 354 | 1 | 4.76 |

**Appendix 10**. Characters used in the Early Period in Banawali

| Character | Count | Frequency |
|---|---|---|
| 13 | 1 | 3.33 |
| 17 | 1 | 3.33 |
| 60 | 2 | 6.67 |
| 71 | 1 | 3.33 |
| 88 | 1 | 3.33 |
| 91 | 4 | 13.33 |
| 127 | 5 | 16.67 |
| 131 | 2 | 6.67 |

| Character | Count | Frequency |
|---|---|---|
| 134 | 1 | 3.33 |
| 214 | 1 | 3.33 |
| 216 | 1 | 3.33 |
| 217 | 1 | 3.33 |
| 225 | 1 | 3.33 |
| 311 | 3 | 10.00 |
| 368 | 2 | 6.67 |
| 376 | 3 | 10.00 |

**Appendix 11**. Characters used in the Middle Period in Lothal

| Character | Count | Frequency |
|---|---|---|
| 41 | 1 | 3.45 |
| 61 | 1 | 3.45 |
| 72 | 1 | 3.45 |
| 83 | 1 | 3.45 |
| 88 | 1 | 3.45 |
| 91 | 3 | 10.34 |
| 124 | 1 | 3.45 |
| 126 | 2 | 6.90 |
| 127 | 1 | 3.45 |
| 129 | 1 | 3.45 |
| 130 | 1 | 3.45 |
| 131 | 1 | 3.45 |

| Character | Count | Frequency |
|---|---|---|
| 200 | 1 | 3.45 |
| 204 | 1 | 3.45 |
| 215 | 1 | 3.45 |
| 249 | 1 | 3.45 |
| 295 | 1 | 3.45 |
| 302 | 1 | 3.45 |
| 306 | 1 | 3.45 |
| 311 | 1 | 3.45 |
| 312 | 1 | 3.45 |
| 330 | 1 | 3.45 |
| 376 | 2 | 6.90 |
| 380 | 1 | 3.45 |

**Appendix 12**. Characters used in the Late Period in Lothal

| Character | Count | Frequency |
|---|---|---|
| 1 | 1 | 2.00 |
| 4 | 3 | 6.00 |
| 7 | 1 | 2.00 |
| 23 | 1 | 2.00 |
| 33 | 1 | 2.00 |
| 54 | 2 | 4.00 |
| 68 | 4 | 8.00 |
| 71 | 1 | 2.00 |
| 72 | 1 | 2.00 |

| Character | Count | Frequency |
|---|---|---|
| 87 | 2 | 4.00 |
| 91 | 4 | 8.00 |
| 101 | 1 | 2.00 |
| 116 | 1 | 2.00 |
| 126 | 2 | 4.00 |
| 127 | 3 | 6.00 |
| 130 | 1 | 2.00 |
| 131 | 2 | 4.00 |
| 143 | 1 | 2.00 |

| Character | Count | Frequency |
|---|---|---|
| 147 | 1 | 2.00 |
| 162 | 1 | 2.00 |
| 192 | 1 | 2.00 |
| 225 | 1 | 2.00 |
| 273 | 1 | 2.00 |
| 278 | 1 | 2.00 |
| 283 | 1 | 2.00 |

| Character | Count | Frequency |
|---|---|---|
| 311 | 3 | 6.00 |
| 312 | 2 | 4.00 |
| 314 | 1 | 2.00 |
| 337 | 1 | 2.00 |
| 361 | 1 | 2.00 |
| 368 | 2 | 4.00 |
| 376 | 1 | 2.00 |

**Appendix 13.** Characters used in the Middle Period in Dholavira

| Character | Count | Frequency |
|---|---|---|
| 1 | 2 | 14.29 |
| 91 | 1 | 7.14 |
| 116 | 1 | 7.14 |
| 117 | 1 | 7.14 |
| 127 | 2 | 14.29 |
| 129 | 1 | 7.14 |

| Character | Count | Frequency |
|---|---|---|
| 147 | 1 | 7.14 |
| 150 | 1 | 7.14 |
| 241 | 1 | 7.14 |
| 270 | 1 | 7.14 |
| 302 | 1 | 7.14 |
| 376 | 1 | 7.14 |

**Appendix 14**. Characters used in the Late Period in Dholavira

| Character | Count | Frequency |
|---|---|---|
| 68 | 1 | 8.33 |
| 91 | 2 | 16.67 |
| 127 | 2 | 16.67 |
| 131 | 1 | 8.33 |
| 175 | 1 | 8.33 |

| Character | Count | Frequency |
|---|---|---|
| 219 | 1 | 8.33 |
| 278 | 1 | 8.33 |
| 302 | 1 | 8.33 |
| 311 | 1 | 8.33 |
| 376 | 1 | 8.33 |

**Appendix 15**. Characters used in the Early Period in Others

| Character | Count | Frequency |
|---|---|---|
| 7 | 1 | 0.2 |
| 13 | 1 | 0.2 |
| 101 | 1 | 0.2 |
| 189 | 1 | 0.2 |
| 311 | 1 | 0.2 |

**Appendix 16**. Characters used in the Middle Period in Others

| Character | Count | Frequency |
|---|---|---|
| 3 | 1 | 0.02 |
| 9 | 2 | 0.04 |
| 13 | 1 | 0.02 |
| 53 | 1 | 0.02 |
| 60 | 2 | 0.04 |
| 67 | 1 | 0.02 |
| 72 | 1 | 0.02 |
| 91 | 2 | 0.04 |
| 125 | 1 | 0.02 |
| 126 | 3 | 0.06 |
| 127 | 3 | 0.06 |
| 130 | 1 | 0.02 |
| 133 | 1 | 0.02 |
| 144 | 1 | 0.02 |
| 147 | 1 | 0.02 |

| Character | Count | Frequency |
|---|---|---|
| 150 | 1 | 0.02 |
| 162 | 2 | 0.04 |
| 192 | 1 | 0.02 |
| 201 | 1 | 0.02 |
| 214 | 1 | 0.02 |
| 217 | 2 | 0.04 |
| 223 | 1 | 0.02 |
| 272 | 1 | 0.02 |
| 273 | 2 | 0.04 |
| 278 | 2 | 0.04 |
| 307 | 1 | 0.02 |
| 311 | 6 | 0.13 |
| 319 | 1 | 0.02 |
| 368 | 2 | 0.04 |
| 376 | 1 | 0.02 |

**Appendix 17**. Characters used in the Late Period in Others

| Character | Count | Frequency |
|---|---|---|
| 7 | 1 | 0.02 |
| 25 | 1 | 0.02 |
| 60 | 1 | 0.02 |
| 66 | 1 | 0.02 |
| 68 | 1 | 0.02 |
| 70 | 3 | 0.06 |
| 72 | 1 | 0.02 |
| 86 | 1 | 0.02 |
| 87 | 1 | 0.02 |
| 91 | 2 | 0.04 |
| 120 | 1 | 0.02 |
| 127 | 3 | 0.06 |
| 129 | 1 | 0.02 |
| 133 | 1 | 0.02 |
| 134 | 1 | 0.02 |
| 143 | 1 | 0.02 |

| Character | Count | Frequency |
|---|---|---|
| 150 | 1 | 0.02 |
| 162 | 1 | 0.02 |
| 175 | 1 | 0.02 |
| 192 | 1 | 0.02 |
| 201 | 1 | 0.02 |
| 278 | 2 | 0.04 |
| 283 | 1 | 0.02 |
| 292 | 1 | 0.02 |
| 302 | 1 | 0.02 |
| 311 | 9 | 0.19 |
| 312 | 3 | 0.06 |
| 336 | 1 | 0.02 |
| 337 | 1 | 0.02 |
| 354 | 1 | 0.02 |
| 376 | 2 | 0.04 |

# インダス式印章の編年案に基づいた インダス文字の通時的変化

菅　彩葉

インダス文字についてはさまざまな研究がなされてきたが、時期を通じて文字が変化した可能性を考慮した研究はほとんどなく、文字が刻まれた印章の層位的な研究もなされてこなかった。しかし、紀元前 2600 年-1900 年の約 700 年の間に文字の形や数、用法が変化した可能性は大いにある。本研究は「インダス式印章に刻まれた文字の編年研究」をテーマに、Kenoyer and Meadow (2010)、Kenoyer (2020)、Konasukawa (2020) の仮説に基づいて分析を行い、それぞれの時期にどのような文字がどのように使用されていたかを明らかにすることを目的としている。その結果、文字の種類や文字列の長さは時代によって異なることが明らかになった。このことから、インダス文字が時期を通じて変化していった可能性は高いといえる。