Reviving Linear Elamite (2300–1880 BCE)

The Oldest Known Phonetic Writing System

Sina Fakour

Abstract. This paper presents the outcome of a two-year research and design project centered on the Linear Elamite script, an ancient phonetic writing system used in Elam (present-day Iran) at the end of the 3rd millennium BCE. Although first discovered in the early 20th century, Linear Elamite remained undeciphered until 2017, when French archaeologist François Desset began its systematic study. In 2020, Desset, along with Kambiz Tabibzadeh, Matthieu Kervran, Gian Pietro Basello, and Gianni Marchesi, announced the successful decipherment of approximately 95% of the script. This significant achievement repositions Linear Elamite as the earliest known phonetic writing system, transforming our understanding of the origins of writing.

In 2021, as part of the "Missing Scripts" program at ANRT (Atelier National de Recherche Typographique), I began a typographic research project aimed at developing a digital typeface for Linear Elamite. The project involved a detailed analysis of the inscriptions, materials, and engraving tools used, in order to create an inclusive typographic solution. The result is Hatamti, a font family consisting of approximately 400 glyphs in four styles. This paper documents the design process, the visual characteristics of the script, and the rationale behind each design decision, with the goal of supporting archaeologists, linguists, historians, philologists, and type designers in preserving and working with this ancient script.

1. Introduction

At the end of the 3rd millennium BCE, Linear Elamite script gave eternal life to the history of the Elamites. Linear Elamite was one of the scripts used in Elam (located in present-day Iran) to transcribe the Elamite language. It was first discovered at the beginning of the 20th century in Susa, Iran (Álvarez-Mon et al., 2018) and up to now, 43 objects containing Linear Elamite inscriptions have been identified. Linear Elamite inscriptions, containing simple and complex geometric signs, are found on different materials (clay, stone, and metal), and they are named by

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alphabet letters (A to Z and A′ to R′). François Desset, a French archaeologist working in Iran for years, started the decipherment of LE in 2017. In 2020, François Desset, with Kambiz Tabibzadeh, Matthieu Kervran, Gian Pietro Basello, and Gianni Marchesi, announced that they had deciphered about 95% of the Linear Elamite signs. This decipherment is of importance as it can change our current understanding of the development of writing. It is the oldest known phonetic writing system, showing that the phonetization of writing was achieved from the early stages of its invention. The decipherment has also become a reason for a preliminary Unicode proposal to be made.

In October 2021, I started to work on Linear Elamite as a part of the “Missing Scripts” program at ANRT (Atelier National de Recherche Typographique). The project was guided by François Desset. He is an archaeologist specializing in the Middle East and attached to the CNRS Archéorient team and the University of Tehran.

His presence from the beginning of the project allowed me to have access to the most up-to-date archeological resources and to understand the specific needs of an archeologist working with Linear Elamite.

The purpose of this project is to design an inclusive typographic solution based on comprehensive research and careful analysis of the inscriptions that would make the digital transmission and reproduction of Linear Elamite possible. Among others, it would help archeologists, linguists, philologists, historians and type researchers during the process of redacting and publishing their research. It could also help preserve this ancient script and give it a new life through contemporary media.

In this project I investigated the role of the engraving tool and the material on the quality of the signs, and I tried to achieve a methodology of work that can be applied to similar ancient scripts.

The research and design process took about two years under the supervision of professors Thomas Huot-Marchand, Jérôme Knebusch, Charles Mazé, Émilie Rigaud, and Alice Savoie. The outcome is “Hatamti”. A font family that includes about 400 glyphs in four different styles, which will be released under an open-source license. Another, equally important, outcome of this project is the present paper, which aims to analyze the graphical aspects of the Linear Elamite script and show the arguments and observations behind every design decision.

2. A brief history of Elam

Mesopotamian sources allow us to locate the ancient civilisation of Elam, which covered nearly the entire southern half of the Iranian plateau in the late 3rd Millennium BCE. The Elamite cultural influence extended beyond this region, reaching central Asia, present-day Afghanistan, Pakistan, and the southern shores of the Persian Gulf. But then it was reduced to only Susa (Susiana) in the Achaemenid period (539-331 BCE) (Vallat, 1998). Elam was the eastern neighbor of Mesopotamia and was often in conflict with it. Geographically, Elam included more than the actual Khuzestan. it was a combination of the lowlands and the immediate highland areas to the north and east (Matthews, 2022). Elam's particularity compared to Mesopotamia was its confederated governmental structure with complex mechanisms (Álvarez-Mon et al., 2018). Different settled and nomadic populations were united within this structure. The Elamite language, which is extinct today, was used by the Elamites to communicate. The vast majority of scholars believe that it is a language isolate. An isolate is a language that has no relatives, that is, it has no demonstrable genetic relationship with any other language. Language isolates are in effect language families with only one member. The best known and most cited language isolates are Basque, ..." (Campbell, 2010).

The name Elam does not come from the local population. It is a name coined by Mesopotamian scribes. It has reached us from Greek Aylam, itself borrowed from Hebrew ʿElām; the Elamites called their country Ha(l)tamti/Hatamti, which the Akkadians rendered Elamtu and the Sumerians designated with the ideogram NIM "high, elevated." (Vallat, 1998). We can divide Elam history into four main periods:

- The Proto-Elamite (Susa III/Banesh) period (ca. 3400/3200-2800 BCE).
- The Old Elamite period (ca. 2400-1600 BCE).
- The Middle Elamite period (ca. 1500-1100 BCE).
- The Neo-Elamite Period (1100-539 BCE).

The Linear Elamite writing system was used during the Old Elamite period. The latter consisted of three dynasties: Awan (ca. 2400-2100 BCE), Simaškian (ca. 2100-1970 BCE), and Eparthids or Sukkalmahs. (ca. 1970-1500) (Vallat, 1998).

3. The first phonetic script

As far as we know, writing was invented separately in three different regions: the Near East, China, and Mesoamerica. The earliest writing systems were invented in the Near East in about 3500 BCE and in three regions: Egypt, Mesopotamia, and Elam.

Not much is known about the origins of Egyptian hieroglyphs. But the origins of Mesopotamian and Elamite pictograms can be traced further back to previous forms of counting in the region (Schmandt-Besserat, 2014).

The Elamites used different writing systems to transcribe the Elamite language. The earliest one is Proto-Elamite, which is one of the oldest

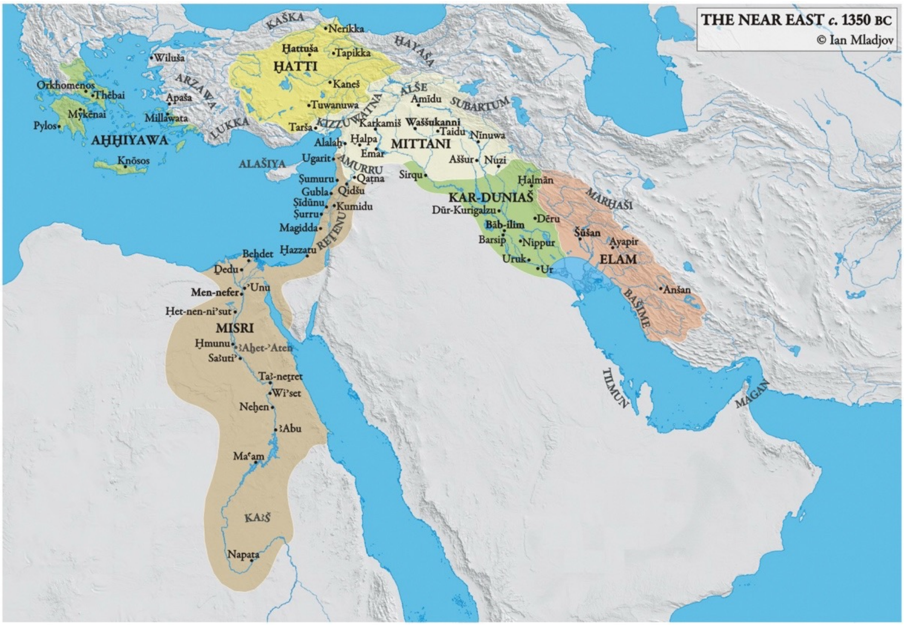

FIG. 1. Elam map in 1350 BCE—Ian Mladjov's Resources, `https://sites.google.com/a/umich.edu/imladjov/maps`

known writing systems, and it was used from about 3300 BCE to 2900 BCE (Desset, 2016). The first Proto-Elamite tablets were published by Vincent Scheil, a French epigraphist, in 1900. Although more than 1600 Proto-Elamite inscriptions have been found (about 88% of the tablets are found in Susa), the script remains undeciphered. In regard to its high number of signs, it is considered to be a system composed of signs with both phonetic and logogrammatic values (Desset, 2016).

Scholars do not share the same opinion about the relationship between Proto-Cuneiform and Proto-Elamite scripts. Some scholars argue that Proto-Elamite is derived from Proto-Cuneiform. But others, including Desset F., believe that they have both originated from older forms of communication and then separated paths. Therefore, they can be considered sister writing systems that coexisted. The relationship between Proto-Elamite and Linear Elamite is also a topic of debate. Some scholars believe that Linear Elamite evolved from Proto-Elamite, while others argue that there is not enough evidence to support this claim.

Linear Elamite was used during the Old Elamite period (2300–1880 BCE). Eventually, it was completely replaced by a slightly modified version of Mesopotamian cuneiform, which had been used in parallel with Linear Elamite even earlier (Bagh-e-Bidi, 1931).

It is Walther Hinz, German scholar of Persian and Elamite studies (b. 19 November 1906 in Stuttgart, d. 12 April 1992 in Göttingen) (Schmitt, 2003) who coined the name Linear Elamite and Desset F. used the abbreviation "LE" for Linear Elamite and "PE" for Proto Elamite as a convention (Desset, 2022). From now on I will use the same conventions in this text.

In Fig. 2, you can see a simplified diagram of the evolution of writing in the Near East. To put it more simply, in Fig. 3, you can see the two parallel paths that writing has passed through in the Near East. We can see that the emergence of Linear Elamite script is particularly interesting as the phonetization of writing happened in Elam much earlier than anywhere else. The Elamites could achieve an efficient writing system containing alphabetic and syllabic signs in 2300 BCE, while Sumerians and Egyptians were using logograms.

The LE writing system works with 5 vowels, 12 consonants, and 60 syllables. [Fig. 4] (Desset F. et al. 2022). Most of the signs have one or more variants. These variations are most significant between objects found in the eastern archeological sites and those found in the western sites. About 75% of the signs are shared between eastern and western inscriptions. In Fig. 5 you can see all the signs attested in all inscriptions.

4. Linear Elamite Inscriptions

Like PE tablets, Most of the LE inscriptions are discovered in Susa. A city established in 4800 BCE alternated between Mesopotamian and Elamite power. Up to today 43 objects containing LE inscriptions have been discovered. LE inscriptions, containing simple and complex geometric signs, are found on different materials (clay, stone and metal). Some inscriptions read from right to left, while others read from left to right, and they are named by alphabet letters (A to Z and A′ to R′).

The inscriptions are found in different archaeological sites across Iran. Some of them have unapproved provenance as they were not found in regulated excavations.[1]. Here are the numbers of inscriptions found in each archeological site:

- Susa: 20;
- Marvdasht: 1;
- Konar Sandal/Jiroft: 4;

1. Before the 60's, there were clandestine digging or commercial excavations in Iran done by non-specialists. These people who paid for the excavations could possess half of the finds and sell them on the open market. - David Stronach, "Excavations I. In Persia," *Encyclopaedia Iranica*, IX/1, pp. 88-94, available online at http://www.iranicaonline.org/articles/excavations-i

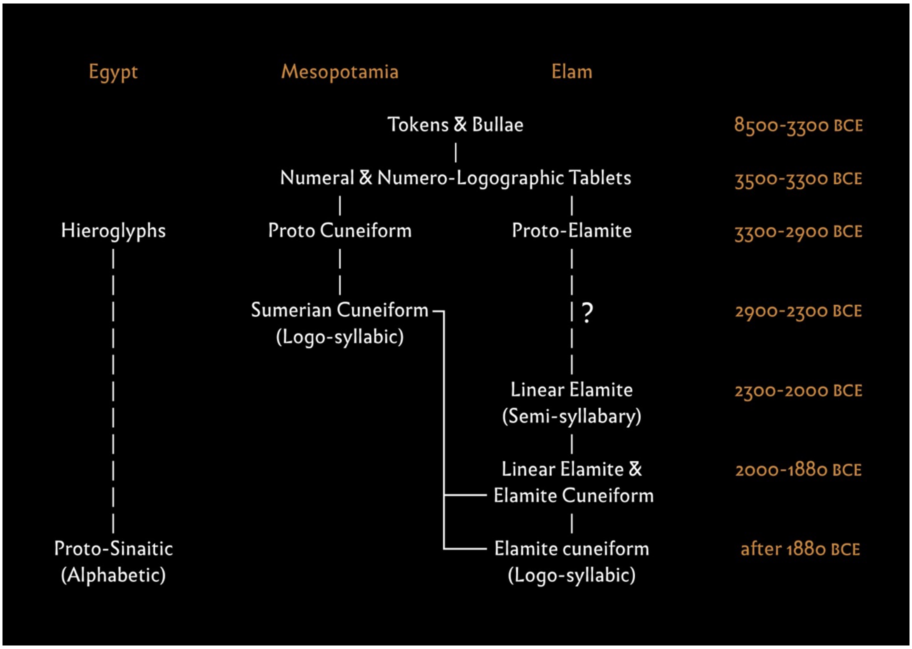

FIG. 2. Diagram of the evolution of writing in the Near East as known today

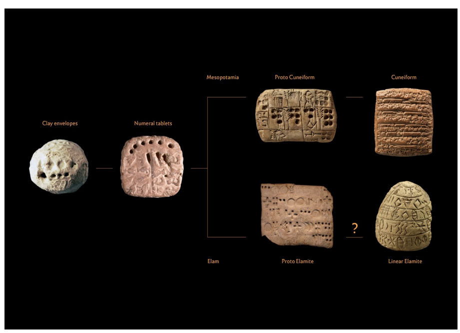

FIG. 3. The evolution of writing in the near east

- Kam firouz: 7;
- Shahdad: 1;
- unapproved: 10.

19 of the inscriptions are kept in the Louvre Museum, 6 are in Iranian museums, 1 is in the Los Angeles County Museum of Art, and the rest of them are in different private collections (Desset, 2022).

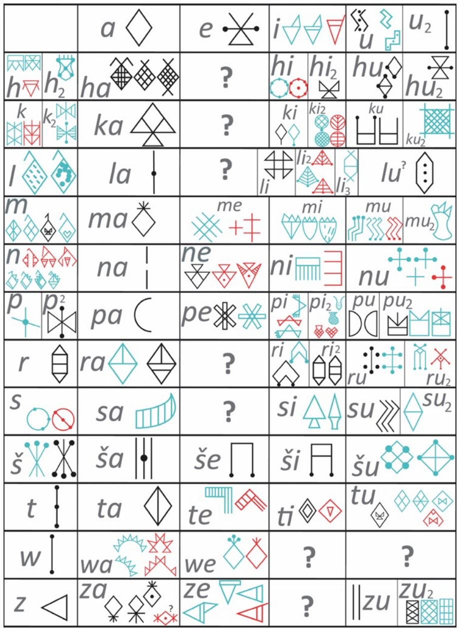

FIG. 4. Grid of the most common variants of deciphered signs with their phonetic values. Blue signs are attested in South-Western Iran, red ones in South-Eastern Iran. Black signs are common in both areas. (Photo: Desset F. et al 2022)

The information regarding each inscription (size, material, dating, provenance, writing direction, etc.) is accessible in the article by Desset F. et al 2022.

5. Design process

5.1. Confronting a new script

Translating the engraved signs into contemporary typographic forms and making a consistent system is a challenging process. Designing a digital font for an ancient writing system, which is obsolete today, imposes a significant change in the context of its use. It would therefore be necessary to question our position and define our relationship with the script. If we think of a writing system as the visual representation of a language, how does our visual perception change our understanding of a language? How do we perceive a writing system to which we are foreign? Is our understanding of a new writing system based on the scripts

FIG. 5. Linear Elamite glyph list. (Photo: Desset F. et al 2022)

we already use? Who are the contemporary users of the writing system and what are the contemporary needs? What medium will it be used in?

The first question that arises while working with a different writing system from ours is our legitimacy. In a hypothetical scenario in which I were to work with a living script that had users, I believe it would be crucial to question my position and my relationship to the script. The question remains relevant even If I came from the same geopolitical area, but I was not a member of the community using the script. In that case, getting in touch with the community and informing myself about different aspects of the culture would be necessary.

In the case of LE, the script went extinct long ago, and today there is no community that identifies itself with it. Consequently, the question of cultural appropriation is out of discussion. But being from the same country where the script was used helped me in the research process and in understanding the place the script takes among people and scholars. It also helped me have access to resources in Persian.

Fig. 6. Left: King Puzur-Sushinak inscription, (Table au lion), in two scripts of Akkadian cuneiform and Linear Elamite. Ca. 2120–2100 BCE, Discovered in Susa. Right: Perforated stone, with Linear Elamite text—Département des Antiquités orientales, Louvre Museum.

Fig. 7. Left: Clay cone with Linear Elamite text, dated to the reign of Puzur-Inshushinak. Right: Clay tablet with Linear Elamite text—Département des Antiquités orientales, Louvre Museum.

Fig. 8. Linear Elamite inscriptions on silver objects—Mahboubian collection <http://mahboubiancollection.com/>

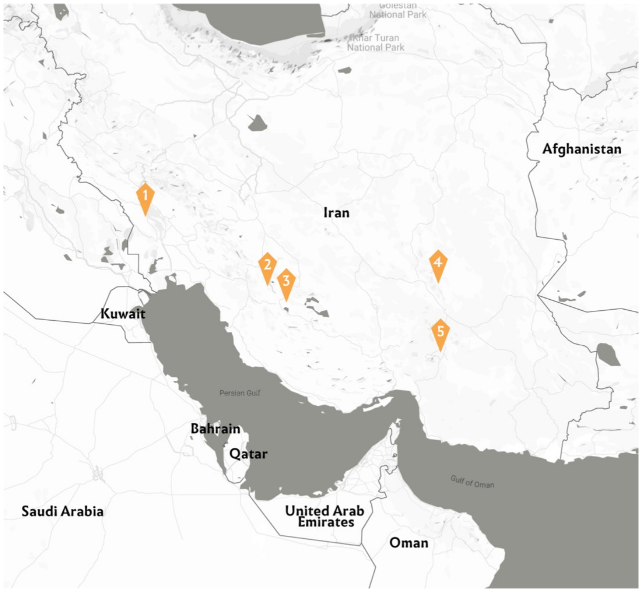

FIG. 9. Archeological sites where LE inscriptions were discovered: 1. Susa, 2. Kam Firouz, 3. Marvdasht, 4. Shahdad, 5. Konar Sandal/Jiroft.

Drawing on my past experiences designing Latin and Arabic types, it has become clear that transposing the typographic rules from one system to another would be irrelevant, as they are completely different. In my encounter with LE, I tried to be as neutral as possible and to base my design choices on arguments rather than the typographic rules I am used to. For example, the notion of type color does not seem to be relevant for LE, as we cannot have the same density throughout all signs. Some of the signs consist of numerous strokes that make them dense, and some others have very few strokes.

The main media on which the typeface would be used are paper and screen. This shift in medium, from engraved signs to printed/rendered characters, is considerable. For instance, the engraved signs react to the light in a different way than ink on paper or pixels on screen. So, the stroke thickness should not necessarily be the same (see chapter 5.4).

Another important consideration was to think about the contemporary use of the typeface. The main use of an ancient writing system today would be for academic purposes. The principal users would be archeologists, linguists, historians, philologists, and type researchers. Having their feedback and considering their needs was at the core of the project. Working with François Desset as one of the main users of this writing

FIG. 10. Excavations to the east of the Achaemenid palace, Susa 1924—Álvarez-Mon, J., Basello, G.P., & Wicks, Y. (Eds.). (2018). "The Elamite World" (1st ed.). Routledge. (photographic archives of the Département des Antiquités orientales, Musée du Louvre).

system allowed me to understand particular needs that the font should meet. (More details in chapter 5.7).

The typeface can also be used by editors, museums, and archives to transcribe the inscriptions. But in some conditions, the sphere of the use of an ancient script can go beyond the academic sphere. Some ancient scripts, such as Cuneiform, have witnessed a wider range of enthusiasts. Some people try to learn how to engrave cuneiform on clay, and others tattoo the signs on their skin. It is not hard to observe the global fascination for a past, considered "grandiose". There is a wave of nostalgia and desire to revive the glory of the ancestors among nations. The amazing nature of a writing system is that it can become a part of the identity of a community. I cannot neglect this possibility for LE twice as much because of its phonetic nature. Meaning that any language can be written with this writing system. Whether I, as a designer, approve of this usage or not, once the typeface is published, I no longer have control over the usage. What I have control over is trying to assure coherence in the design process and basing my decisions on reason. And eventually provide a typeface with legibility and accuracy. But a certain degree of subjectivity is unavoidable, even in such a rational and methodical approach.

5.2. General analysis of the inscriptions

In the beginning of my research, alongside reading the archeological references, I spent quite a while observing the inscriptions. This played

FIG. 11. Reproduction of Shuwar-asu's clothes on the silver cup. The last king of Iran had a vast program to create an identity based on the ancient history of Iran. A book called Negar-e-Zan "Image of woman—An historical pageant of women's dress in Iran"' was published in 1973 (Negar-e-Zan, 1973), in which women's clothing on ancient artefacts was reproduced.

an important role in getting familiar with the signs. This was especially helpful in understanding their proportions and skeletons (see chapter 5.5). I also tried to draw them on paper. Despite the good quality of the photos I had from all of the objects (see section 5.7), grasping the real dimensions of the inscriptions could only be achieved by seeing the real objects. A considerable number of the objects containing LE inscriptions are in the Louvre Museum. I managed to closely observe the inscriptions accessible to the public (about 9 objects).

Almost all of the LE signs seem to be abstract and very geometric.[2] But since they are engraved by hand, they are not completely regular and symmetrical. My first instinct was to design symmetrical geometric signs. An approach that seems to be evident. But was this really the intention of the engravers? Was making perfectly geometric signs desired by the Elamites? Today it seems natural for us to use the word geometric, but were the Elamites aware of this notion?

2. Characterized by or using straight lines, triangles, circles, or similar regular shapes or forms.—Collins, Geometric in the Collins dictionary, Retrieved January 15, 2023, from: `https://www.collinsdictionary.com/dictionary/english/geometric`.

To be able to answer this question, I followed a rational approach by trying to answer the five following questions:

a. Was the notion of geometry known by the Elamites?
b. Was achieving symmetry desired?
c. Was achieving consistency desired?
d. Is there any exceptional inscription?
e. What are the origins of the signs?

5.2.1. *Was the notion of geometric abstraction known by the Elamites?*

Today it seems natural for us to call a shape geometric after the achievements of the Greeks. Notably because of Euclid's *Elements*[3]. But was the notion of geometrical abstract shapes comprehended by the Elamites, too?

As preserved in Herodotus History (5th century BCE), the earliest traces of geometrical calculations go back to the Egyptians. They used geometric calculations for their everyday needs, such as religious matters, construction, or timekeeping. Additionally, the Babylonian clay tablets (ca. 1700–1500 BCE) give us the clue that the Pythagorean theorem and some special triads were known way before the Greeks.[4]

But the story of geometric signs goes much further back. Genevieve von Petzinger is a paleoanthropologist and rock art researcher. In her book, The First Signs: Unlocking the Mysteries of the World's Oldest Symbols, she studies Paleolithic cave paintings from 40,000 to 10,000 years ago with a particular focus on geometric paintings.[5]

She made a database of more than 5000 geometric paintings from 146 European caves. The result was the observation of 26 signs repeated across different sites over more than 20,000 years. She considers them to be the first traces of graphic communication and symbolism. From the repetition of the same signs in different sites, she concludes the existence of intentionality in drawing these abstract geometric forms. She suggests that the origin of this behavior comes from earlier ages and possibly before our ancestors left Africa.[6]

Although we do not know if these drawings have abstract meanings or not, they do show the capacity of humans to make geometric abstract shapes and reproduce them.

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3. Mathematical treatise of 300 BCE, attributed to Euclid. Euclid compiled his Elements from a number of works of earlier scientists (Waerden et al., n.d.).

4. Heilbron, J.L. "Geometry". *Encyclopedia Britannica*, `https://www.britannica.com/science/geometry`.

5. Genevieve von Petzinger [WWW Document], 2016. URL `https://www.bradshawfoundation.com/news/archaeology.php?id=Genevieve-von-Petzinger`

6. Genevieve von Petzinger [WWW Document], 2016. URL `https://www.bradshawfoundation.com/news/archaeology.php?id=Genevieve-von-Petzinger`

Ralph Abraham[7] goes further and argues that the cave abstract geometric forms are proto-geometric primitives and believes that:

"These archetypal patterns that archeologists call geometric forms completed an evolutionary process of abstraction in which an iconic language became a mathematical language" (Abraham, 2015).

Abstract thinking has been a part of human behavior for a long time. Geometric abstraction was one of the first keys in the invention of writing when daily life concepts were translated into geometric markings. Also, these concepts were detached from their context. The emergence of phonetic units shows another level of abstraction where the signs no longer represent real objects (Schmandt-Besserat, 2014).

Therefore, the origins of geometric thinking go way beyond the Elamites. Abstract geometric patterns have been around for tens of thousands of years. The Elamites' understanding of geometry is probably different from Euclidean calculations, but the existence of these abstract geometric signs on Elamite tablets is not just a simple coincidence but may come from strong intentions.

FIG. 12. Chamber of Spanish tectiforms, El Castillo, Spain—Von Petzinger, Genevieve. "The first signs: unlocking the mysteries of the world's oldest symbols". First Atria Books hardcover edition. New York: Atria Books, 2016.

5.2.2. *Was achieving symmetry desired?*

Carving signs on stone or metal is a laborious task, and achieving perfection needs effort. My main question was whether or not the engraver

7. Professor Emeritus of Mathematics at UC Santa Cruz.

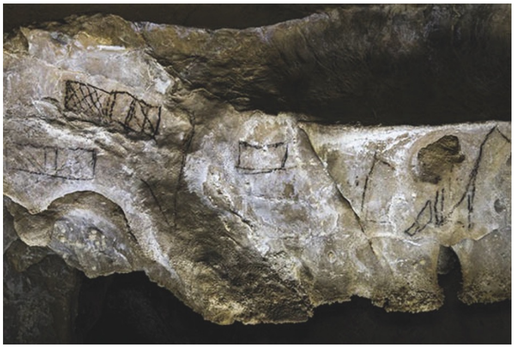

Fig. 13. Panel of black Spanish tectiforms, Las Chimeneas, Spain—Von Petzinger, Genevieve. "The first signs: unlocking the mysteries of the world's oldest symbols". First Atria Books hardcover edition. New York: Atria Books, 2016.

Fig. 14. The St. Germain-la-Rivière teeth, France. Deer teeth decorated with geometric signs—Von Petzinger, Genevieve. "The first signs: unlocking the mysteries of the world's oldest symbols". First Atria Books hardcover edition. New York: Atria Books, 2016.

Fig. 15. The "La Pasiega Inscription," La Pasiega, Spain. A unique occurrence in Ice Age art—Von Petzinger, Genevieve. "The first signs: unlocking the mysteries of the world's oldest symbols". First Atria Books hardcover edition. New York: Atria Books, 2016.

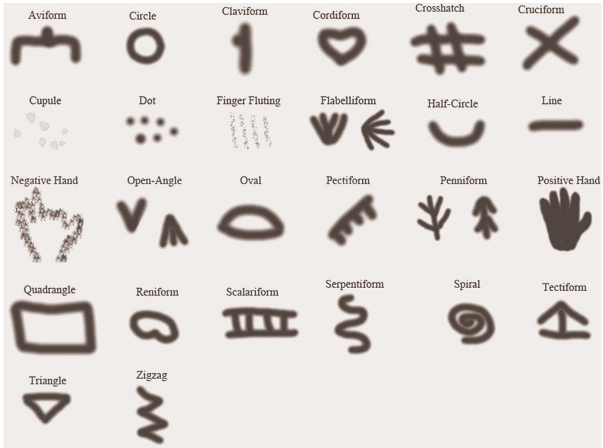

FIG. 16. 26 Non-Figurative Signs repeated in French sites across 25,000 years of prehistory—Von Petzinger, Genevieve. “Geometric Signs & Symbols in Rock Art,” Bradshaw foundation, [WWW Document], n.d. URL `https://www.bradshawfoundation.com/geometric_signs/index.php`

intended to make completely symmetrical and regular shapes. To answer this question, I followed two different approaches. One based on observation and the other on practical tests.

In the first step, I tried to detach the signs from several inscriptions to be able to analyze them separately. In Figs. 17 and 18, you can see this process for inscription A.

In order to have more material for comparison I chose the signs used the most in all inscriptions which are ◇ (representing the sound a), ⍬ (representing the sound r), ┆ (representing the sound t) and the dividing sign | [Fig. 19]. The sign t and the dividing sign do not contain considerable geometric data to analyze. Consequently, I focused on ◇ and ⍬. The diamond shape of the sign a is the dominant shape in the LE script. Not only because it represents one of the most repeated sounds, but also because by adding elements to it, some other signs such as ◈, ◇, ◇, ◇, ◇, ◇, ◇, ◇, ◇, ◇, ◇ and ◇ are formed. Also, by removing or adding elements to the sign ⍬, we have the signs ⬯ and ⍬.

I detached these two signs from all of the inscriptions to make the comparison possible. Their sizes vary across the inscriptions. By scaling them to the same size, I tried to remove the proportion factor and just focused on the sign shape. [Figs. 20, 21]

The aim was to verify the existence of any asymmetrical patterns shared between all or some of the signs. For example, if we look at the sign ◇, in inscription C′ we can see that the top part of the diamond shape is longer than the bottom part. I then investigated whether this

FIG. 17. King Puzur-Sushinak inscription, (Table au lion), in two scripts of Akkadian cuneiform and Linear Elamite. Ca. 2120–2100 BCE, Discovered in Susa—Département des Antiquités orientales, Louvre Museum.

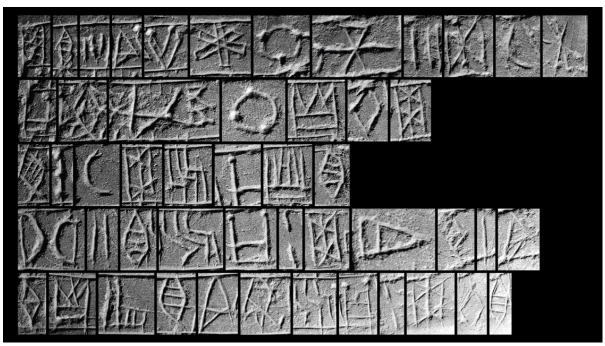

FIG. 18. Detached signs of the inscription A (Table de lion)

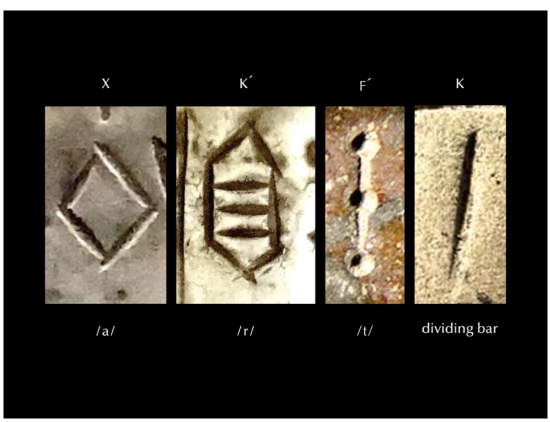

FIG. 19. The signs attested the most in inscriptions

FIG. 20. The sign detached from different inscriptions

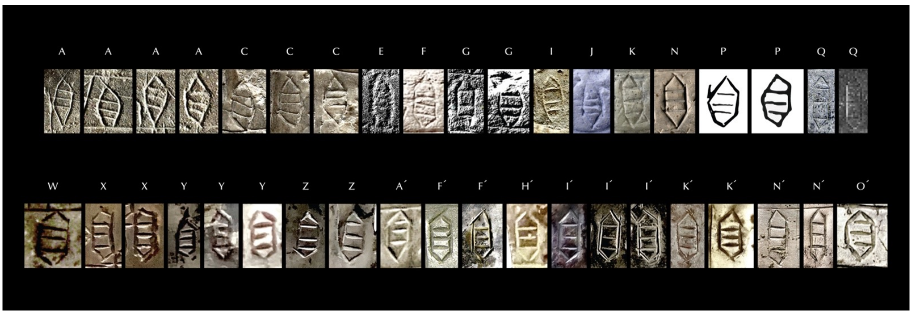

FIG. 21. The sign detached from different inscriptions

characteristic was repeated in other inscriptions. The result is that I did not find any asymmetrical pattern shared between more than 2 or 3 signs. The same approach was done with the sign and the result was the same.

The next step was tracing the signs with a line, trying to be as loyal as possible to the inscriptions. [Figs. 22, 23]

I superimposed the drawings to achieve the average shape of the sign ◇. The result (the denser area) shows that the average shape tends to be a symmetrical diamond. [Fig. 24]

Despite the fact that the sign is more complex in terms of geometry, the same result is achieved by superimposing its drawings. [Fig. 25]

Consequently, I could deduce that symmetry is one of the characteristics of the LE signs.

5.2.3. *Was achieving consistency desired?*

The process of designing a typeface includes not only designing individual signs but also making a system in which all the signs work together in

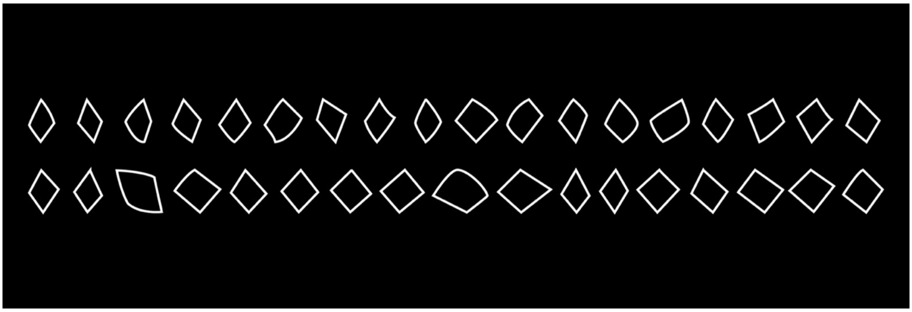

FIG. 22. Tracing the sign ◇ from all inscriptions and scale them into the same height

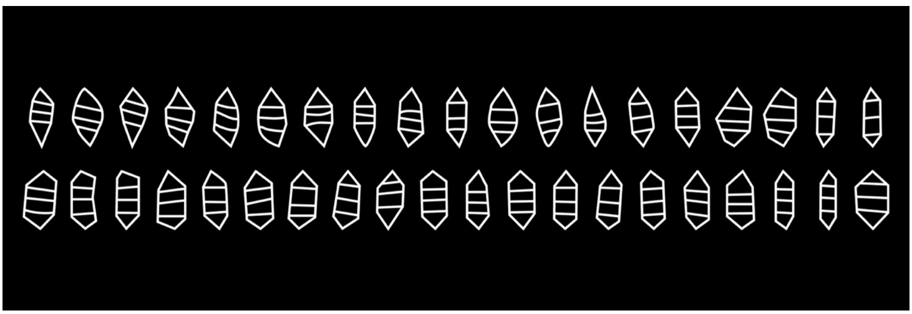

FIG. 23. Tracing the sign from all inscriptions and scale them into the same height

a coherent way. What makes the typeface a system is the characteristics shared between different signs.

But is this idea relevant for one of the first writing systems known so far? Is consistency a requisite for LE to form a writing system?

Defining the word consistency is necessary in order to investigate it. What I describe as "consistency" here is the similarities between different signs that give a homogenous nature to the script. In other words, consistency is "agreement or harmony of parts or features to one another or a whole".[8]

To investigate this quality, different signs needed to be compared to each other. Meaning I now had to work with lines of text rather than one particular sign.

First, I tried to find signs that appear more than once in each inscription. I observed that the similarities between them are not negligible. As

8. Meriam-Webster dictionary. `https://www.merriam-webster.com/dictionary/consistency`.

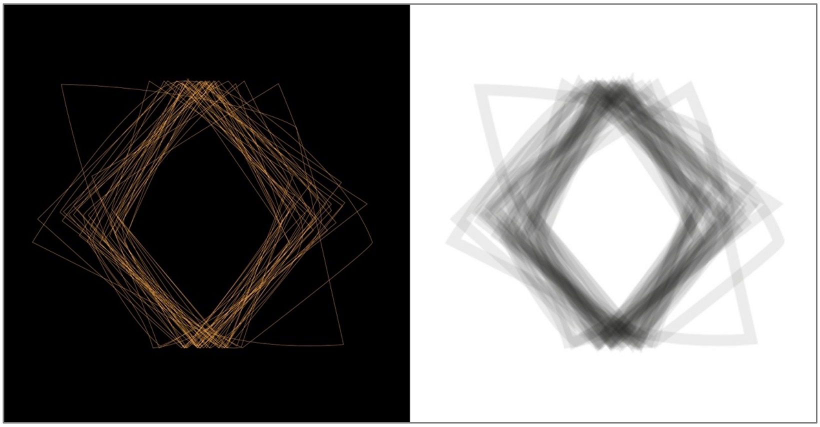

Fig. 24. Superimposition of the skeleton of the signs ♢ from all inscriptions in order to achieve the average shape

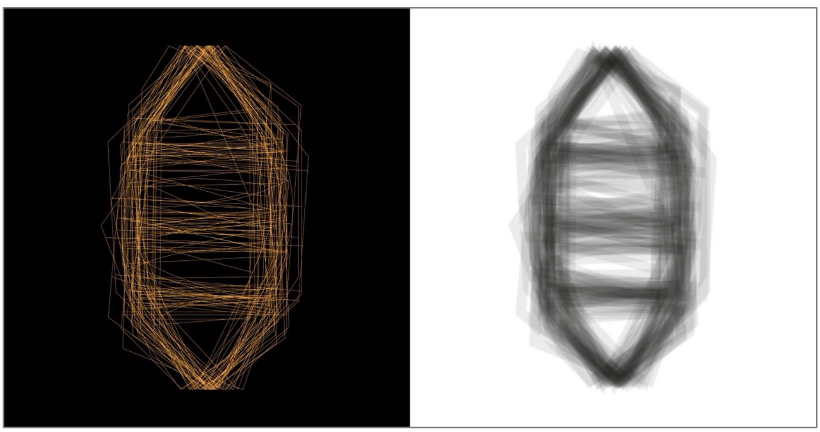

Fig. 25. Superimposition of the skeleton of the signs ⍚ from all inscriptions in order to achieve the average shape

an example, in Fig. 26, object K, you can see the almost identical shape of the sign ♢ attested twice.

But as the number of identical signs in each inscription is limited, to push the argument further, different signs made with similar shapes needed to be investigated too [Fig. 27]. I could also observe a convincing level of shared features between them, making each object coherent as a whole. Keeping the forms similar in repetition is an important element in bringing consistency to the script. A phenomenon that cannot be ac-

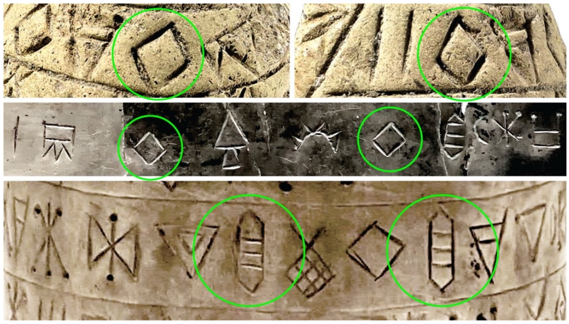

FIG. 26. Analysing identical shapes in each inscription

cidental. In Fig. 28, you can see the analysis of both identical and similar forms for various inscriptions.

FIG. 27. Analysing different signs made with similar shapes

5.2.4. *Is there any exceptional inscription?*

As mentioned before, the resemblance between identical or similar signs in each inscription is not negligible. I tend to think that the irregularities can be the result of other factors, such as the engraver's skill. One argument is the existence of the inscription Q or the Marvdasht vessel (21st century BCE). The inscription on this object seems to be meticulously planned. Similar forms are almost identical in terms of shape and size. The spacings are well calculated, the signs are centered vertically between the two lines, and the symmetry is obvious in almost all of the signs.

FIG. 28. Analysing identical and similar shapes in each inscription

The existence of the Marvdasht vessel is an important clue about the intention of the engraver to achieve geometric forms that are symmetrical and consistent. [Figs. 29, 30]

FIG. 29. Silver cup from Marvdasht, Fars, with linear-Elamite inscription on the top part. Late 3rd Millennium BCE, National Museum of Iran. (Photo courtesy of François Desset.)

But when we compare similar forms on different objects, despite the same skeleton, we can see more differences in size, position, and relative

Fig. 30. Silver cup from Marvdasht, Fars, with linear-Elamite inscription on the top part. Late 3rd Millennium BCE, National Museum of Iran. (Photo courtesy of François Desset.)

proportions. I believe there are several factors that influence the emergence of these irregularities:

Material

Engraving on deformable materials such as metal or clay is easier than on stone, and erosion affects these materials differently. The inscriptions on metal have remained sharper than those on stone. Also, the engraving space on each object varies, and consequently, the size and proportions of the signs are adapted to each object.

Time and Geography

The area in which LE was used is vast. The inscriptions are found in distant archeological sites and dated within a span of 420 years. This distance in time and place has led to the appearance of different variations for some signs. For example, the sign (representing the sound n) is completely different in the inscriptions found in the east and the west of Iran (Desset et al., 2022). [Fig. 31]. Temporal and geographical distance may have also influenced the writing habits. However, this argument needs further investigation with more inscriptions that might be discovered in the future.

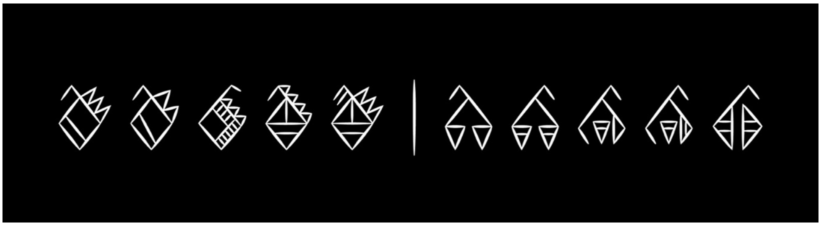

Fig. 31. Variants of the sign representing the sound “n”. Left: Western variants. Right: Eastern variants

Engraver’s skill

The engravers had different skills. This can especially be observed by comparing the Marvdasht Vessel with other metal inscriptions of the same period.

5.2.5. *What are the origins of the signs?*

Although there is debate over whether LE is a developed form of the PE script, scholars agree that there is a visual connection between the signs in the two scripts. Most LE signs have potential visual equivalents in PE. What is noticeable in PE inscriptions is the trace of the tool. PE inscriptions are made by pressing a reed stylus on clay tablets. The signs are made by marking their individual strokes one by one, which makes the triangular shape of the stylus wedge noticeable. The round shapes are also done in the same way but with a circular tool.

Most of the PE signs seem to be abstract forms. And even if they have hypothetically represented different kinds of beings or objects, they have been simplified to the level that they no longer have the direct evocative value (Ifrah, 1987, p. 174).

In the process of evolution from PE to LE, the forms become more simplified and stylized. In LE, the presence of the tool is blurred, and we are facing more stylized contours of the shapes rather than embossed imprints. As an example, the round imprint in PE tablets has evolved to just the contour of the circle, and the triangular strokes are simplified to thin lines. Also, the detached strokes become more connected to form integrated shapes.

This transition from 3D to 2D further shows the abstract nature of the LE signs and the fact that they did not mean to reproduce organic objects or beings. Thereupon, it seems relevant not to consider organic forms for the signs and go toward geometric, stylized, abstract forms.

FIG. 32. Proto-Elamite tablet (ca. 3100-2900 BC), Louvre Museum, Paris

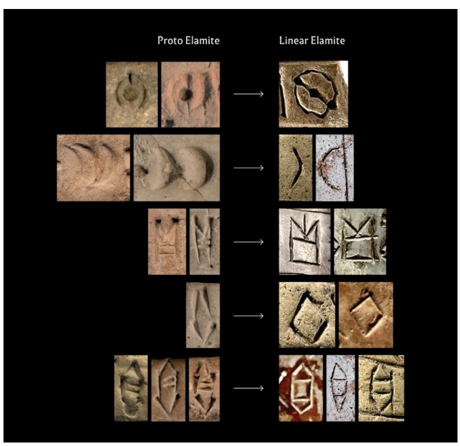

FIG. 33. Evolution of signs from PE to LE

5.3. Analyzing sign details based on the material

When working on an engraved script, the analysis of the materials and tools used can help the designer gain a better understanding of how the forms were shaped. However, there is no information about the engraving tools used to engrave LE, but based on observations, practical tests, and also by looking at early Greek inscriptions, I could make some hypotheses. We should note that LE was developed and used in the Bronze Age when Humans employed stone or clay moulds to shape sophisticated metal tools and weapons.

In the following paragraphs I analyze the quality of the signs based on each material and I investigate what tool could have been used to produce such traits.

FIG. 34. Susa IVA (ca) 2700-2500 BCE), metal objects—Matthews, R., & Fazeli Nashli, H. (2022). "The Archaeology of Iran from the Palaeolithic to the Achaemenid Empire" (1st ed.). Routledge. (image: Javier Álvarez-Mon).

5.3.1. *Metal*

In most of the metal inscriptions, it seems that the strokes were made by putting a blunt chisel-like tool on the surface and hitting it like a punch. In order to have lines with different lengths, one may have used tools with different sizes or used just a part of the width of the tool. Also, in some inscriptions, it appears that the tool was struck a couple of times to extend the line. But what seems more probable is that the lines were not made by scraping or chasing (cutting material by moving forward with numerous small taps). Chasing on metal results in wider endings with accumulation of material and traces of the steps along the stroke [Fig. 36]. For the curved lines, in most cases, we can see the trace of small straight lines joining together to form the curve. This shows that the same technique for straight lines was used, but with a narrower tool. In some instances, the curved lines of the signs are seamless, which suggests the use of a curved tool (Casson, 1935). [Fig. 35]

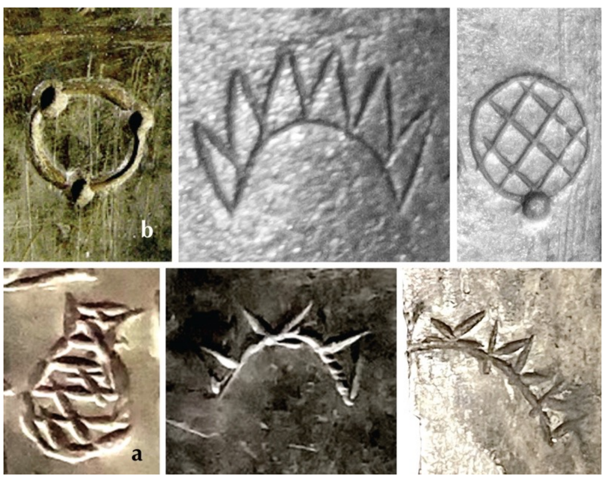

FIG. 35. Quality of the curved lines. In most cases, the trace of several taps is obvious (a), while in a few others the curves are seamless (b)

The strokes are punched separately. Consequently, in their junctions, we see the strokes meet either seamlessly or with a gap.

The other notable phenomenon is that the strokes are the thickest somewhere in the middle, and they fade away at their extremities. [Fig. 36]

This might be due to the fact that the objects have curved surfaces (Casson, 1935). The tool, when put vertically, cannot lie completely flat on the surface. Additionally, the first strokes create a curved surface around themselves, which accentuates the aforementioned phenomena in secondary strokes. Also, the distribution of the force is not homogeneous, and it is at its minimum in the extremities. The other reason for the thin endings of the strokes could be the use of a round tool that did not have defined edges.

In my experiment with engraving on metal (Zinc), I tried both flat and curved tools [Fig. 37]. A curved tool allows for an easy extension of the line by rotating the tool without removing it from the surface [Fig. 33]. As a result, the long strokes remain seamless, and strokes with different lengths can be done with just one tool. A curved tool also facilitates the rotation of curved signs. With a flat tool, on the other hand, to extend a line I had to remove it from the surface, which caused discontinuity in the stroke. It was also more difficult to achieve curved lines with a flat tool. But I could achieve the best results for the curved lines by using an arc-shaped tool.

The round dots all have the same diameter, showing that they are made by striking a round, pointed tool on the metal.

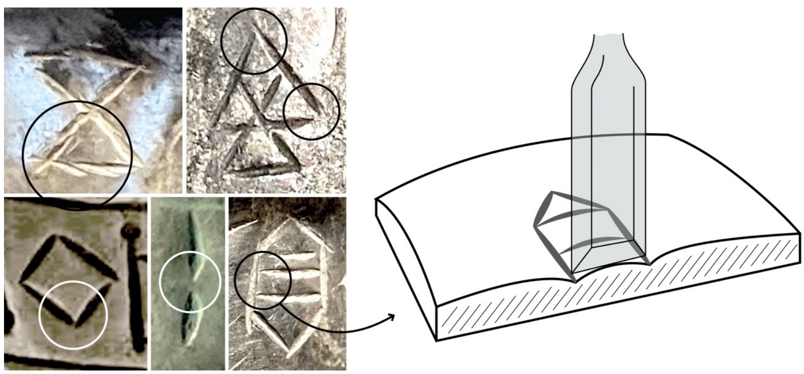

Fig. 36. Left: The quality of straight strokes, their junctions, and their faded extremities in metal inscriptions. Right: Touching points of a flat tool with a curved surface.

5.3.2. *Clay*

Due to the soft nature of clay, signs could be produced by pressing a wide tool (presumably a wooden or reed tool) on the surface, the same way it was done in PE inscriptions. Another method could be scraping using a pointed tool. But this method would cause the accumulation of material at the end of the strokes, which is rarely seen in the inscriptions.

In the case of a tool pressed on clay, what happens is similar to metal, and the stroke extremities look alike. Especially for the secondary

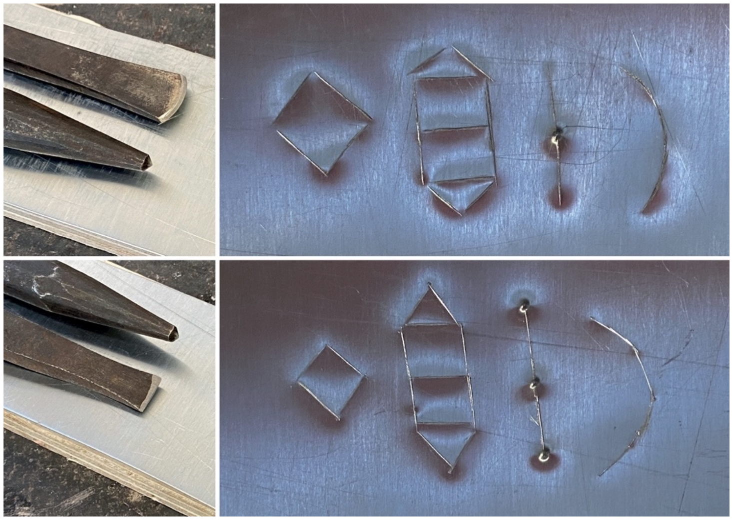

Fig. 37. Experimenting engraving on metal with round and flat tools

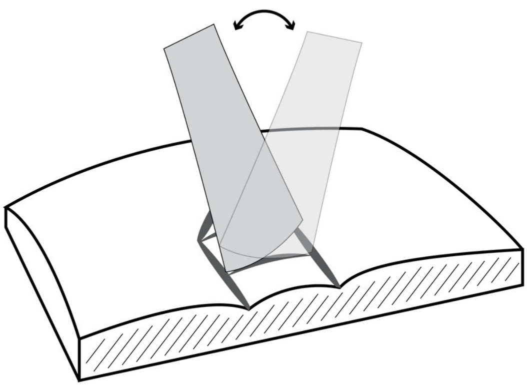

Fig. 38. Extending lines by rotating a curved tool

strokes of a sign, because the first strokes make a cushion-like surface on clay, and the tool in secondary strokes cannot reach everywhere [Fig. 36]. In the case of scraping, the endings would look more defined, which is not the case seen in the inscriptions.

I experimented with clay engraving in practice, and I tried to use three different wooden tools:

FIG. 39. Formation of cushion surfaces and thin extremities in clay inscriptions

Wide rounded tool

The results I achieved with this method are the closest to the inscriptions. In this method, the length of the strokes can be varied based on the degree of pressure and by rolling the tool along its blade. The curved tool makes the strokes thin at the extremities, as the tool does not have defined edges. By pressing the tool deeper, more parts of the curved blade reach the clay, and the stroke becomes longer. Then, by rotating the tool along the stroke to both sides, it can be extended even further. For short strokes, a smaller, similar curved tool can be used. [Fig. 40]

Extension of the strokes can also be achieved by pressing the tool several times along the stroke. Using a wide, rounded tool for engraving is versatile and rather fast.

Wide flat tool

In this method, to alter the length of the strokes, only part of the tool is used. This makes one extremity defined and deep, and the other one, thinner and less profound. Having good control over the length and pressure is more difficult in this method, and the result is less similar to the inscriptions.

Pointed tool

This seems to be the fastest method, but the quality achieved is the farthest to what we observe in the inscriptions. The endings are more defined and have the same thickness as the middle of the strokes. Additionally, material is carried away with the tool, which makes it hard to have defined junctions.

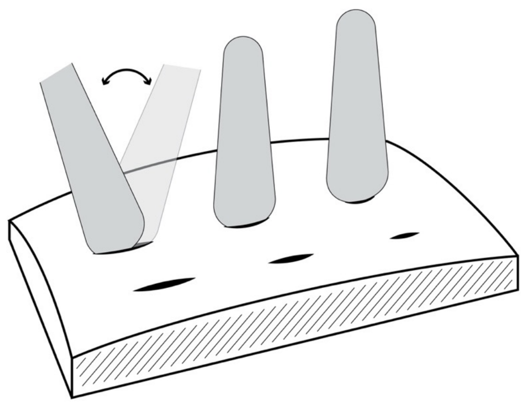

Fig. 40. Thin exterimities in using a rounded tool and how rotation of the tool extends the stroke length

5.3.3. *Stone*

Stone inscriptions (A to I & T to V) are more worn out and less well-preserved, which makes it harder to determine the techniques used. However, the chasing method seems more relevant. In close observation of the objects in the Louvre Museum [Fig. 42] I could see the trace of the taps with which the strokes were carved, probably with a burin-like tool.

However, the thin, less profound lines in softer stones (Such as object C) evoke that the theory of scraping with a sharp tool can also be relevant in some inscriptions. [Fig. 43]

For the curved lines, another possible technique, which was used in Paeonian or early Greek inscriptions, is using a pointed tool vertical to the stone. A laborious work requiring hundreds of punches for each curve (Casson, 1935). [Fig. 44]

Here we can see the same phenomenon of thinner endings in strokes, but less accentuated, and for a different reason. I tried to engrave LE signs on two different stones. One is a soft limestone and the other one has a harder surface. When beginning a stroke, I tended to start with weaker taps so as not to break the stone. In the middle, automatically, I taped harder to advance more quickly. Reaching the end of the stroke, I reduced the force not to miss the ending. [Figs. 45 & 47]

On the stone, all of the round dots also have the exact same size. From what I have tried, the best way to achieve this is to scrape the stone with a pressing, rotating a pointed tool. Because by hitting the tool (The method used on metal), there would be small breaks on the stone, and we have less control over the perfect shape of the dot.

FIG. 41. Experimenting engraving on clay with different tools

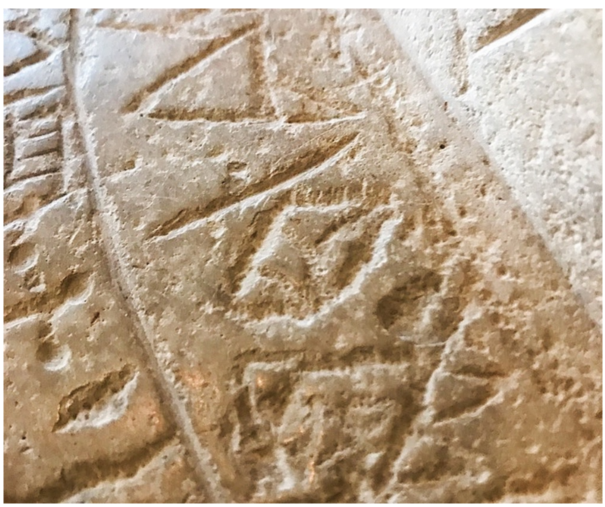

FIG. 42. Trace of the taps in the sign and thin extremities in the sign—Inscription D. Louvre Museum

FIG. 43. Thin lines in inscription C. (Photo courtesy of François Desset)

FIG. 44. Quality of the round shapes. Bottom: Inscription B. Louvre Museum. Top: Inscription on the basis of the Stele of Megakles, ca. 530 BCE, Attica. (Photo: Casson, Stanley. 1935.)

Fig. 45. Top: engraving test on soft limestone. Bottom: engraving test on harder limestone

Fig. 46. Tools used for engraving tests. The left one was used for the dots and the right one for the strokes

FIG. 47. Thin endings of the strokes. Left: Stone inscriptions A & B. Right: Engraving test on soft limestone

After the analysis of different materials, it seemed a relevant decision to keep the concept of the individual strokes, but the question was whether they should be connected or not. Based on what I already discussed in chapter 5.2.I believe that in LE, achieving stylized forms and fading the tool's presence are more important than in PE. This is why I think the desired sign should represent a shape as a whole.

Drawing on what I argued in part 5.2, we can deduce that the inscriptions done more carefully and meticulously are more symmetrical and harmonious. They are those with more homogenous and regular positioning of the signs (like the silver vessel—object Q). We can observe that the more we have these qualities in an inscription, the less we see disconnectivity in the junction of the strokes. This may be another clue to know that the intention has been to make continuous contours. [Fig. 48]

My decision for Hatamti was therefore to keep the contrast between the middle and the end of the strokes, but keep the thin extremities connected. The contrast gives the materiality present in the inscriptions to the typeface. The weight of the connections was chosen in a way so that they wouldn't be lost in small text, and allow the strokes to remain connected in all sizes.

5.4. In pursuit of the suitable weight

Determining the stroke thickness was the other essential question in the early stages of the design process. I found it challenging to define the most suitable value without having at least several signs to compose a text and look at it in print. The main reason for this difficulty is that I was working with a script completely alien to my eyes. No typeface has ever been designed for LE to compare with. So, I could not apprehend how bold or light my drawings are. The only references were the engravings with different line thicknesses on different materials. My solution was

Fig. 48. More detached junctions can be observed in inscriptions with less regularity and harmony. Top: Inscription J', Bottom: Inscription Q (Marvdasht silver vessel)

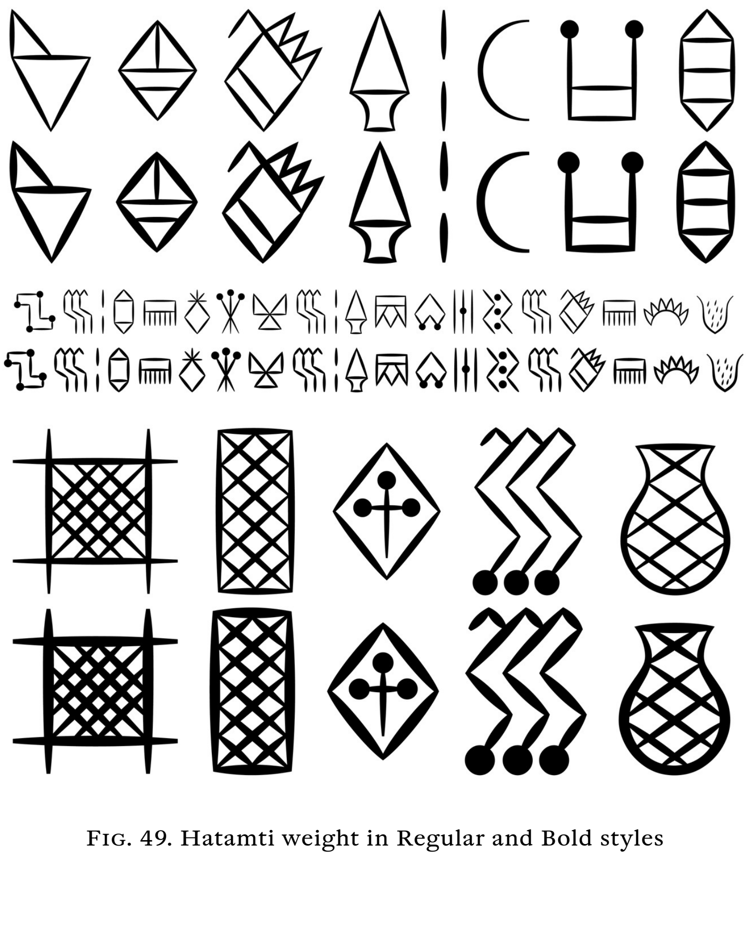

Fig. 49. Hatamti weight in Regular and Bold styles

to draw two different weights as masters and achieve the most relevant weight by interpolating between them later. A necessary but laborious decision, as it doubled the amount of work. This helped me define an intermediate weight as the Regular style for Hatamti. Observation guided this decision: the weight I chose can contain all the complex elements of signs without issues, whilst simultaneously not being so light that we would lose details in print or on screen. It aims to be the closest to the visual perception of the engravings, although it does not have the same thickness. I also decided to export a bolder version for particular uses. The Regular weight I defined for LE is lighter in comparison to text typefaces in modern scripts such as Latin or Arabic (which is the specific nature of this writing system). The Bold version will be useful in pairings with bold texts of Latin or Arabic so that the LE script doesn't appear so weak in the line. It could also be used to emphasize certain signs and establish hierarchy in text.

5.5. Relative proportions of the signs compared to each other

At first glance, it seemed hard to find any pattern for the proportions of the LE signs in relation to each other. The signs share the same shape, but their relative sizes vary from one object to another.

After having the inscriptions under the eyes for quite a long time, eventually some patterns started to merge. While analyzing the most frequent signs (◇ and ⬡), I figured out that in most cases the sign ⬡ occupies more vertical space than ◇. This seems logical because if ◇ were as high as ⬡, it would be too large and occupy too much horizontal space. [Fig. 50]

Fig. 50. The signs r and a (or forms similar to a), beside each other in different inscriptions

Despite the consistency between the signs of a single inscription, each object has its own accent. In object W, for example, the signs occupy the whole vertical space, which makes them pretty large horizontally. But in object Z, the signs are narrower and have variable heights.

[Fig. 51] We cannot find all of the signs on each object. Some of the signs have even been attested only once and on a single object (like the sign representing the sound "sa"). Consequently, the main challenge was to establish a harmony between all the signs coming from different objects with different proportions.

Fig. 51. Different sign proportions in each inscription. Wide signs in object W (right) compared to small and narrow signs in object Z (left).

5.6. A system to harmonize the signs

To find a system that harmonizes all of the signs, first I started by drawing the signs ◇ and . As explained in chapter 5.2.b, by adding elements on top, at the bottom, or inside of ◇ we achieve numerous other signs. By reserving some space on top and at the bottom of ◇ I could have the same optical size of this component shared between different signs. By repeating this form, I aimed to add consistency and homogeneity to the typeface. For and , however, as they should be higher, I drew them in a way to fill these spaces. [Fig. 52]

I applied the same logic to the other characters, and eventually, a system emerged in which we can have four main heights for the signs. [Fig. 53]

In this system, the baseline is positioned in the middle, and the signs are aligned vertically in the center. We can see this clearly in most of the inscriptions and especially in the inscription Q. In about half of the inscriptions, there are lines on top and at the bottom of the signs. We can notice that the smaller signs in these inscriptions are placed in the middle and have the same space above and below [for example, see inscriptions D, Q, A′, O′, N′, and W in Fig. 28].

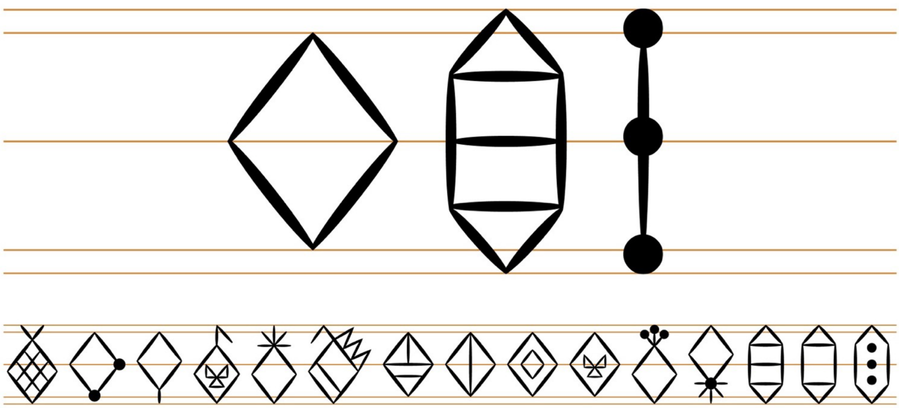

FIG. 52. Defining the proportions of the signs ◇, ⌸ and the signs similar to them

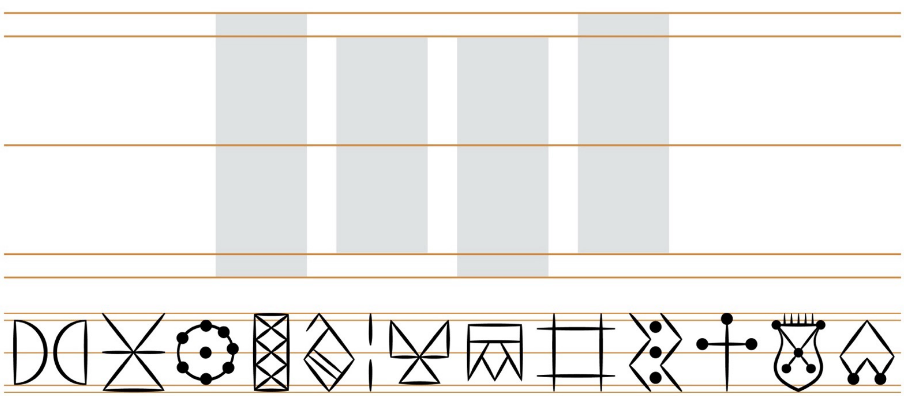

FIG. 53. A system for four main heights of the signs. Baseline positioned in the middle

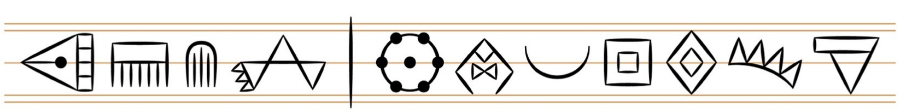

FIG. 54. Some exceptions that do not fit in the grid system

Most signs easily fit into this system. But I did not want the grid to determine the design. Therefore, some smaller signs (about 5% of them) make the inevitable exceptions. The only sign that exceeds the guidelines is a variant of the dividing sign (|), which needed to be distinguishable. [Fig. 54]

The main usage of the typeface being academic papers, I had to consider how it interacts with Latin and Arabic scripts. These two scripts are used the most in academic papers related to LE and the Elam civilisation. For Latin, I did comparisons with Times New Roman as the typeface used the most in academic articles. For Arabic, the comparison was made with Adobe Arabic, Nazanin, and Mitra (the latter two are widely used in Iran for academic purposes).

As LE signs do not have any diacritics or elements added on top or at the bottom, I made the highest signs to occupy all the vertical space from ascenders to descenders. This makes the LE signs taller than Latin characters. The reason is that Hatamti Regular is much lighter than Times, and by making it vertically bigger, it will not appear unnoticeable in the middle of the Latin text. In this way, neither of them dominates the other, but they are easily distinguishable from each other. [Fig. 55]

The same happens with Arabic. The LE signs are bigger to compensate for their lighter weight. Arabic fonts, however, are mostly horizontal and positioned on the baseline. Additionally, the descenders go lower than Latin descenders. This makes LE look positioned higher and somehow on the same baseline as Arabic. [Fig. 56]

5.7. Technical Methodology

In order to begin the design process, I had to observe each sign in detail. Thanks to François Desset, I could have access to high-resolution photos of all of the inscriptions from the early stages of the project. I could also take closer photos of some of the objects during my visit to the Louvre Museum. With the help of the inventory table made by Desset (Desset F. et al 2022), I could trace the objects where each sign can be found.

The process of drawing each sign started with observing it in all its occurrences and comparing them to find the most representative shape. Soon, I understood how difficult it is to control the workflow while having several images open alongside font design software on the screen (if we ignore the music app). So, I printed all of the inscriptions on A3 paper (to preserve the details). For each sign, I put all of the corresponding images beside each other on the table.

I used the Glyphs 3 software to design the font, and I worked with 1000 units per Em scale. To achieve the best proportions, I started with the drawing of the monoline version with a stroke that would form the skeleton of the typeface. Then from the monoline version I drew the

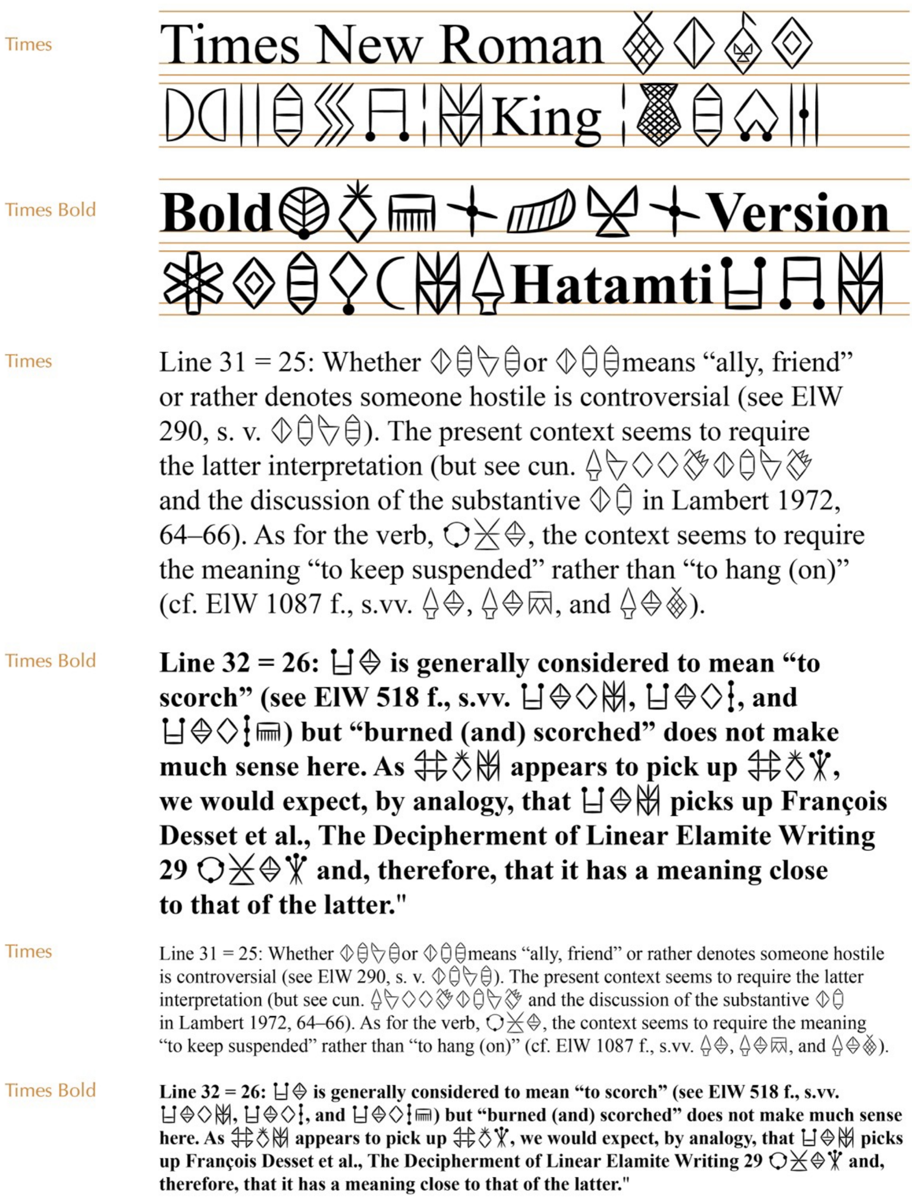

FIG. 55. Hatamti in use with Time New Roman

FIG. 56. Hatamti in use with Adobe Arabic, Nazanin and Mitra

main style, which is the contrasted one. Therefore, I defined four masters with two axes (weight and optical size). I set the masters' weight values to 500 and 100. The master's optical size values were set to 200 (without contrast) and 100 (with contrast). The weight axis numbers should not be compared to Latin. In Latin, 100 would be considered thin, and 500 would be Medium. However, due to the thin nature of LE, I considered 100 as light and 500 as bold. Then I exported the 250 instance as regular and 500 as bold for the contrasted version. For the monoline version, the instances for regular and bold are 200 and 450. The reason for this difference is that thick junctions and the lack of contrast made the monoline version look bolder, and so I tried to compensate by reducing the values by 50.

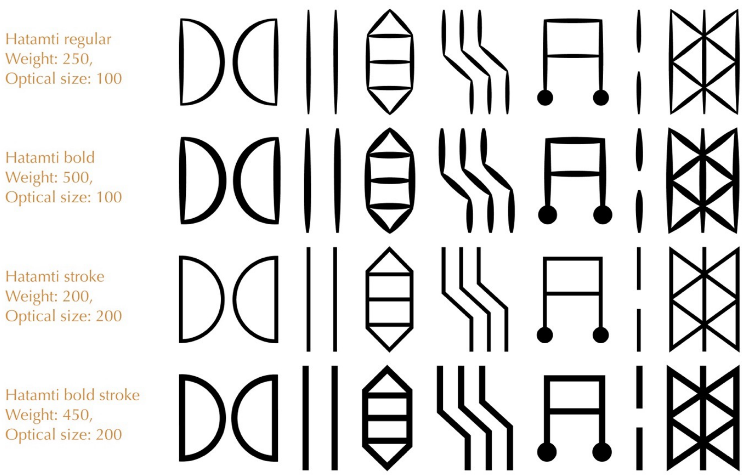

FIG. 57. Weight and optical size values for different Hatamti styles

As LE is not yet in the Unicode Standard, I put the glyphs in the Latin codepoints. LE is an alpha-syllabic system, so I put the signs in the Latin glyphs that have the same phonetic values proposed by Desset F. et al. For the syllabic characters, I used standard ligatures (.liga) of the Latin letters. For example, a "s_i" ligature was made for the sign which has the phonetic value of "si". In this way, typing in LE with a standard Latin keyboard is possible. Even after the integration of LE in Unicode, keeping this feature would be helpful as it is an intuitive way of typing. Also, the integration of a script in Unicode would not necessarily guarantee the emergence of keyboards for the script. [Fig. 58]

For different variations of each sign, I used the ".cv" suffix so that they could be accessed on different applications. In order to distinguish the sign variants, I made a guide (that would be published alongside the font) in which all the variants of a sign are shown in a table. This document also shows what keyboard keys should be used to access each sign.

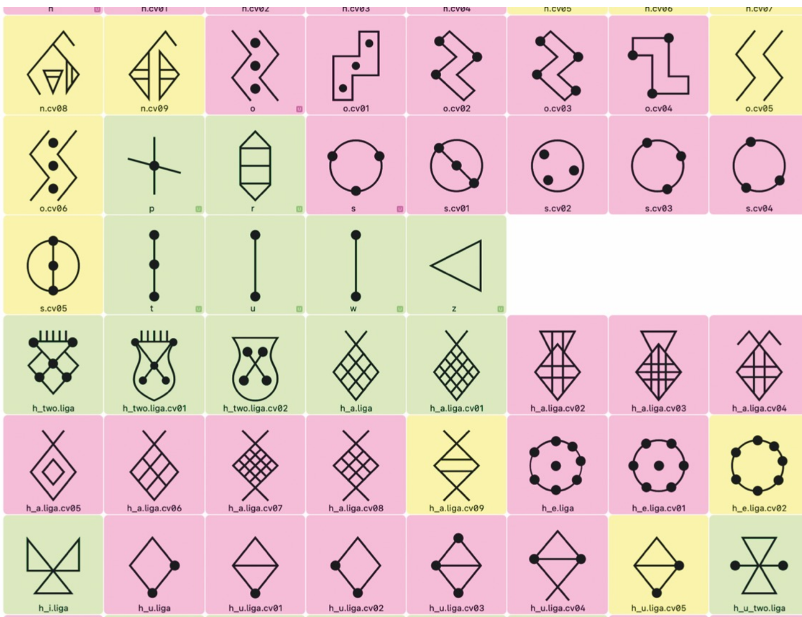

FIG. 58. A preview of the Glyphs application workflow. The glyphs in purple are the western variants, and the glyphs in yellow are the eastern ones. Those in green are common between the east and the west

In transcribing archeological inscriptions, we often face some signs with less legibility due to corrosion and scratches. To be able to represent this, I introduced different hachures representing three degrees of corrosion. By typing an asterisk once after a sign, a hachure superimposes on the glyph. Typing an asterisk twice substitutes the hachure with a denser one. And typing an asterisk three times results in having only the dense hachure without the sign underneath. This feature was achieved by using the "ccmp" feature. same OpenType feature used for Arabic diacritics. This allows for the superimposed hachure on the center of the sign. [Fig. 59]

While reading archeological articles, I observed that some signs like comma, dot, plus, equal, arrow, and dash are used frequently with LE.

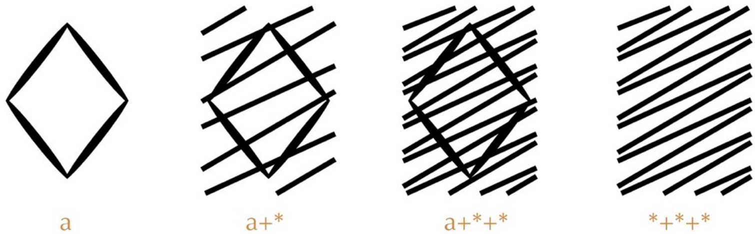

FIG. 59. Scratch superimposition functionality

Therefore, I included them in Hatamti to avoid the need to change the font for such punctuations while typing. You can see the complete glyphset in Fig. 61.

Before the official release of the typeface, I shared a beta version with François Desset so that he could try it in practice and report any possible problems. But I also had a couple of meetings with François during the project, in which I presented the drawn glyphs and discussed my design decisions. During our meetings, François provided me with phonetic values of the signs, and we discussed the shape of the signs that are less legible in engravings. Some of the proportions of the signs were perceived differently by each of us, and discussing them better informed my decision-making. As one of the main users of the font, he also expressed his needs in using the font. This led to the implementation of the OpenType features.

5.8. Keeping the skeleton (monoline version)

The monoline (stroke) font was first designed as the skeleton and a way to achieve the main design (contrasted style). But later on, the need to keep it as a separate style was felt by François Desset. This version represents the skeleton and complete abstraction of the LE signs. The traces of the carving tool and the material are completely erased in this version, and it represents a graphic representation of the signs. Keeping this style gives more choice to the users of the font. Consequently, the final font family has four styles: Hatamti Regular, Hatamti Bold, Hatamti Stroke, and Hatamti Stroke Bold. [Fig. 60]

6. Conclusion

The decipherment of the most ancient phonetic writing system is an important achievement in the history of writing. Making the first LE

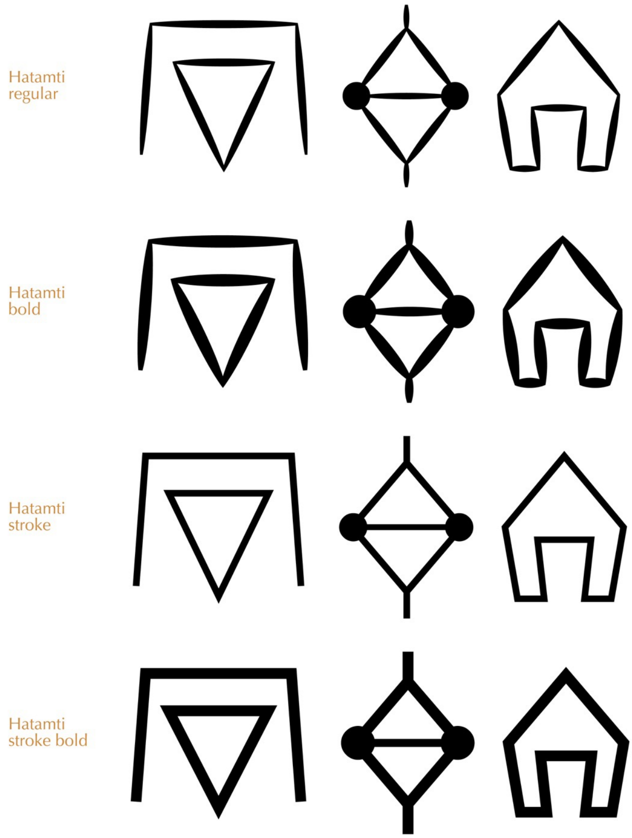

FIG. 60. Hatamti font family

typeface is a delicate task, as it will be the first contemporary visual representation of this writing system. In other words, for the public, LE would be associated with this typeface.

Reviving an ancient writing system requires reconsidering modern typographic principles, including geometry, weight, type color, proportions, contrast, and baseline. These concepts should be evaluated based on the nature of the writing system, but should also be adapted to contemporary media such as print and screen.

In the case of LE, after careful observation and historical analysis, I figured out that achieving consistent, abstract geometric forms is relevant to the nature of the writing system. The regular weight of the typeface is lighter than modern alphabet fonts. Some characters are denser than others, and the type color is not homogeneous everywhere.

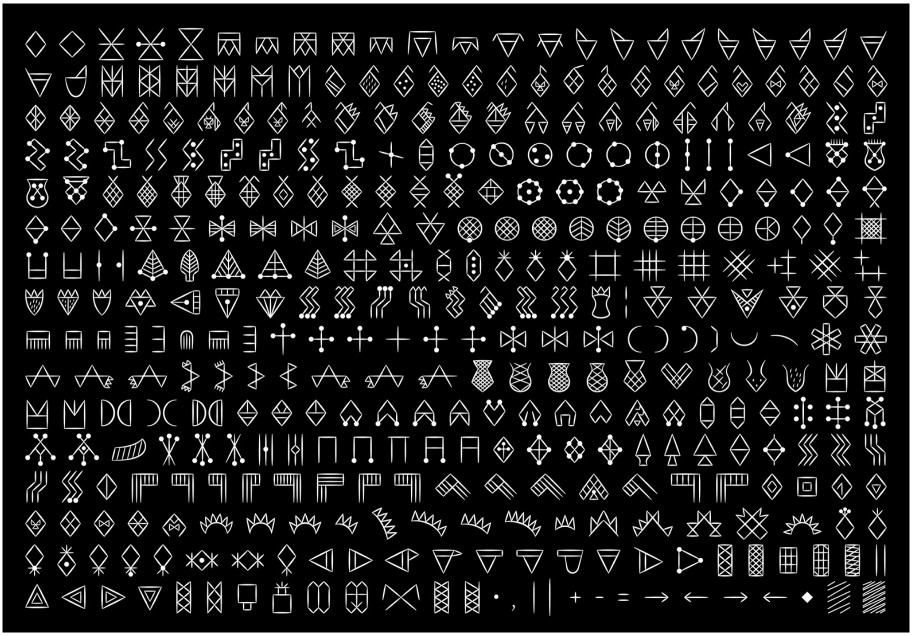

FIG. 61. Hatamti glyph-set

To work on an engraved script, the analysis of the material and tools can help the designer through a better understanding of the forms. This analysis can be done by consulting archaeological references and also by observation, comparison, and tests. In Hatamti, analysis of the tool and material has led to the decision of implementing a contrast and keeping the strokes attached.

Understanding the contemporary users of the typeface and their needs is an important factor in design decisions and the implementation of features. Having François Desset as the archeological advisor made this matter possible.

In the near future, publication of the Hatamti font-family under an open-source license, and its integration in Unicode, would make the digital transmission and reproduction of Linear Elamite possible. Among others, it would help archeologists, linguists, philologists, historians and type researchers during the process of redacting and publishing their research. It could also help preserve this ancient script and give it a new life through contemporary media.

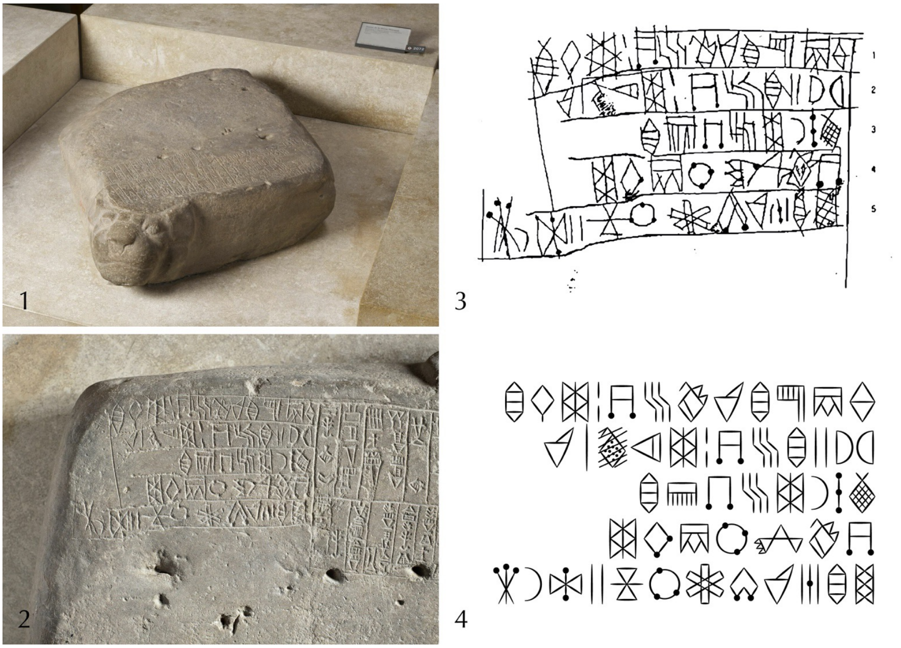

FIG. 62. Four levels of reading an archeological artefact: 1. Object – 2. Inscription photo – 3. Facsimile – 4. Transcription

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