information

Article

Decipherment Challenges Due to Tamga and Letter Mix-Ups in an Old Hungarian Runic Inscription from the Altai Mountains

Peter Z. Revesz

School of Computing, College of Engineering, University of Nebraska-Lincoln, Lincoln, NE 68588, USA; revesz@cse.unl.edu; Tel.: +1-402-421-6990

Abstract: An Old Hungarian Runic inscription from the Altai Mountains with 40 signs has posed some special challenges for decipherment due to several letter mix-ups and the use of a tamga sign, which is the first reported use of a tamga within this type of script. This paper gives a complete and correct translation and draws some lessons that can be learned about decipherment. It introduces sign similarity matrices as a method of detecting accidental misspellings and shows that sign similarity matrices can be efficiently computed. It also explains the importance of simultaneously achieving the three criteria for a valid decipherment: correct signs, syntax, and semantics.

Keywords: decipherment; error correction; inscription; Old Hungarian Runic script; sign; similarity matrix; tamga

Citation: Revesz, P.Z. Decipherment Challenges Due to Tamga and Letter Mix-Ups in an Old Hungarian Runic Inscription from the Altai Mountains. *Information* **2022**, *13*, 422. https://doi.org/10.3390/info13090422

Academic Editors: Francesco Fontanella and Arkaitz Zubiaga

Received: 2 June 2022
Accepted: 6 September 2022
Published: 7 September 2022

1. Introduction

The history of paleography never saw a case when a scribe came alive and told the would-be decipherers that they were wrong. Embarrassingly, something like that happened to us after we published [1] our decipherment of a puzzling Old Hungarian Runic (Hungarian: *székely írás* [2], *székely-magyar rovás* or *rovásírás* [3]) inscription that was previously described by Karžaubaj Sartkožauly, a member of the Kazakhstan Academy of Sciences, in a three-volume monograph on the Orkhon script [4], where he presumed the inscription to be from the seventh century BC.

The Hungarian name is alternatively translated as Székely-Hungarian Rovash [5] or Old Hungarian [3]. The term 'Old Hungarian' may be confusing because it is used by some scholars to refer to the Latin alphabet-based script that was used from the 10th to the 16th century in Hungary. The extended name 'Old Hungarian Runic' inscription is clearer because 'runic' means 'relating to runes (magic marks or letters, especially the letters of an ancient alphabet cut into stone or wood in the past)' according to the Cambridge Dictionary. Hence, English 'runes' and Hungarian 'rovás' both refer to the same means of writing.

Our journal article generated much public interest in Hungary. It was also featured in a popular YouTube video on Hungarian history. Eventually, one viewer left a comment, which can be translated into English as follows: 'I carved this inscription into the rock at the Mongolian Altai Mountains in the Bayan-Ölgii Province, near the upper flow of the Uygariin River in June 2000'.

Finding the scribe allowed a unique opportunity to check our translation and ask some details about the circumstances of the inscription. This was important because the inscription consists of 40 signs, and, out of those 40 signs, a sequence of three signs remained uncertain. The goal of this paper is to describe the problem with that sequence of signs in our earlier paper and to propose a complete and correct translation. As part of the analysis, the paper introduces the use of similarity matrices to check for misspellings and draws some general lessons for decipherers of ancient inscriptions.

This paper is organized as follows: Section 2 gives some background information on the Old Hungarian Runic script; Section 3 describes the data source and data curation;

Section 4 gives a transliteration of the signs. A sign similarity matrix is used to show that the inscription contains some common misspellings; Section 5 reviews earlier decipherment proposals and evaluates them according to the criteria of correct signs, syntax, and semantics; Section 6 gives the correct identification of the disputed sign group as a tamga; Section 7 presents some lessons learned about decipherment; lastly, Section 8 presents some conclusions and future work.

2. Background on the Old Hungarian Script

The Old Hungarian Runic script (Hungarian: *székely írás* or *rovásírás*) has been the subject of many studies [2,3,5]. An early book about the subject by Sebestyén [6] popularized the idea that the Old Hungarian Runic script is a descendant of the Old Turkic Orkhon. This origin theory developed even before the Minoan civilization, and its scripts were discovered on the island of Crete by Sir Arthur Evans. During a cryptographic study of the Minoan Linear A script, the author discovered its relationship with the Old Hungarian Runic script. More precisely, it was shown that the Minoan Linear A script is an ancestor of the Carian script, which is the ancestor of the Old Hungarian Runic script [7].

As the above history suggests, the Old Hungarian Runic script has developed considerably from its earliest form to the present. Table 1 shows its current state that is also part of the Unicode standard. Even the two-letter Hungarian transliterations denote single phonemes [8]. There is only one remarkable exception to the pure alphabetic nature of the script. K^1 and K^2 are used with front and back vowels, respectively. This feature may hark back to an era when these were syllabic signs denoted KE and KA, respectively.

Table 1. The Old Hungarian Runic script with its Hungarian transliteration.

Old Hungarian Runic Sign	Hungarian Transliteration	Old Hungarian Runic Sign	Hungarian Transliteration
𐲀	A	𐲘	LY
𐲁	Á	𐲙	M
𐲂	B	𐲚	N
𐲃	C	𐲛	NY
𐲄	CS	𐲜, 𐲝	O, Ó
𐲅	D	𐲞, 𐲟	Ö, Ő
𐲆	E	𐲠	P
𐲇	É	𐲡	R
𐲈	F	𐲢	S
𐲉	G	𐲣	SZ
𐲊	GY	𐲤	T
𐲋	H	𐲥	TY

Table 1. *Cont.*

ᛏ	I	ᚢ	U
ᛁ	J	ᚣ	Ü
ᛜ	K¹ (front-vowel)	ᛘ	V
ᛋ	K² (back vowel)	ᛉ	Z
ᛚ	L	ᛦ	ZS

3. Data Sources and Data Curation

Karžaubaj Sartkožauly's drawing had some minor inaccuracies. He included a photograph in his work. A new drawing based on that photo is shown in Figure 1. The drawing shows that some parts of the inscription are unclear because of the drawings of the deer and some cracks in the rock.

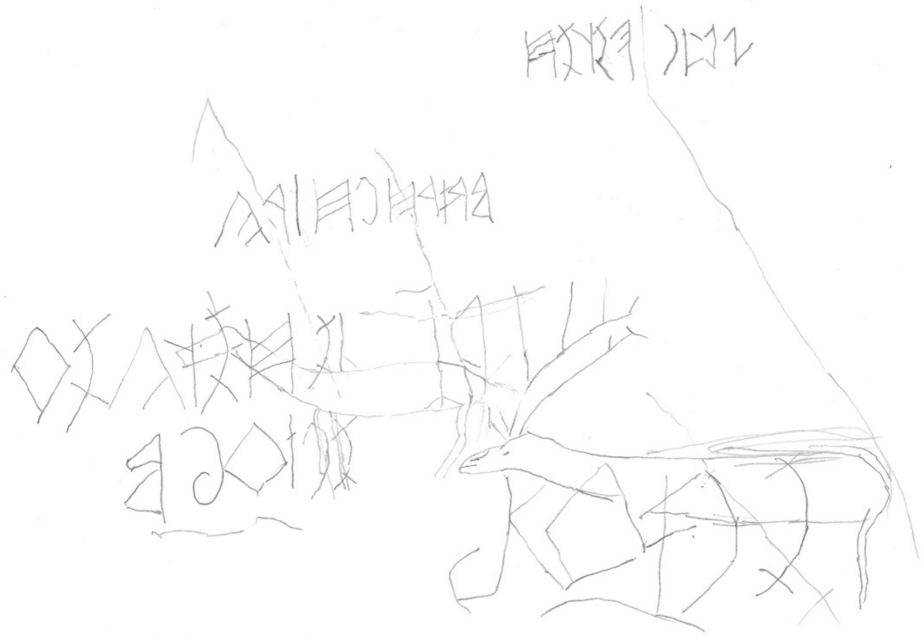


Figure 1. The author's redrawing of the inscription based on the photograph in Sartkožauly [4].

Figure 2 shows an enhanced drawing with red highlighting of those elements that clearly belong to the inscription and labeling the various groups of signs.

Those who are familiar with the Old Hungarian Runic script can easily recognize many of the signs. Hence, one can suspect that some more elements also belong to the Old Hungarian signs in sign group (d) in the middle of the drawing, where unfortunately the tail of the female deer on the left and the antler of the stag on the right interfere with the Old Hungarian signs. This interference results in at least two different interpretations as shown in Figure 3.

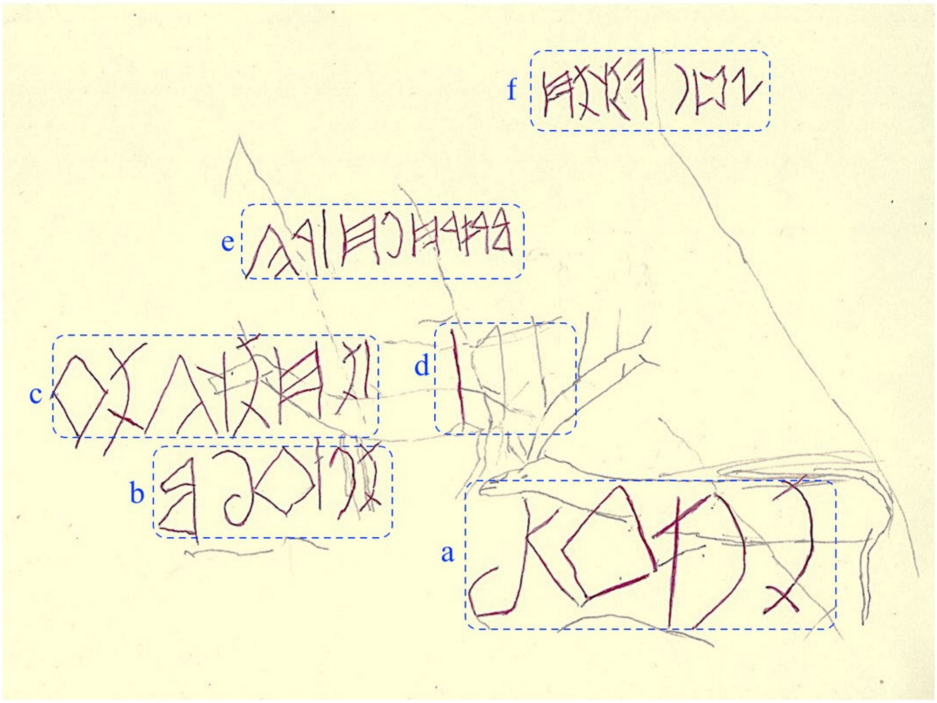


Figure 2. An enhanced drawing of the inscription with red highlighting of those elements that undisputedly belong to the inscription. The six sign groups are also labeled (a–f).

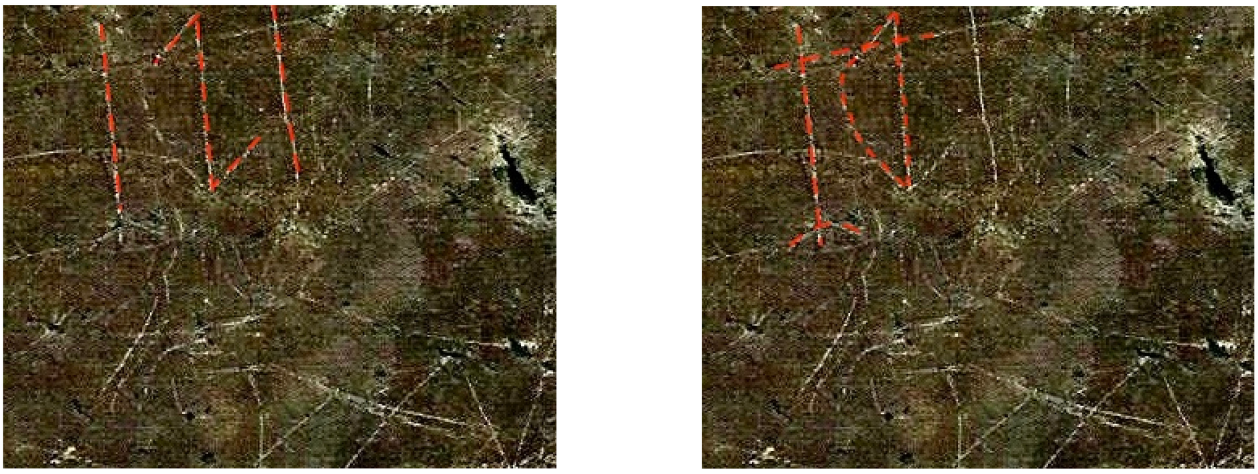


Figure 3. Two interpretations of sign group (d) in the middle of the photograph.

The first interpretation of sign group (d) leads to the following sign sequence:

The second interpretation, which contains an Old Hungarian A and N ligature, leads to the following sign sequence:

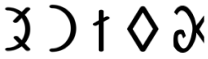
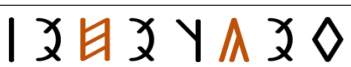
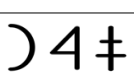
While the N sign normally looks as shown above, a scribe could reverse the direction for the sake of a ligature. The scribe also used an Ő-K[1] ligature in sign group (b). The difference in these two interpretations is a subtle matter of interpreting a few faintly scratched lines. What the first interpretation considers the Old Hungarian S, the second interpretation considers part of the antler of the stag.

The most logical way to handle ambiguities is to proceed further in the decipherment because the context of the other words can help to choose among the choices. Hence, for now, let us simply refer to these two sign group options as (d1) and (d2), respectively.

4. Transliteration and Correction of the Signs

Since Old Hungarian inscriptions are written from right to left, we first convert the sign groups into a left-to-right order as shown in Table 2. Next, we also attempted a transliteration to find the meaning of the words.

Table 2. The Altai Mountain inscription with incorrect signs highlighted in brown.

Row	Inscription	Transliteration	Meaning
a		E N I K^1 Ő	Enikő
b		E N I K^1 Ő M	my Enikő
c		SZ E Z E T G E K^1	
d1		SZ K^2 SZ	
d2		N A GY	great
e		M A GY A Z O Z SZ Á L	
f		K^2 U N P É T E Z	Kun

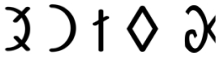
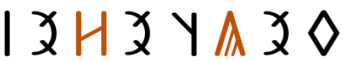
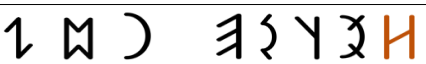
It is apparent to Hungarian language speakers that some words do not make sense, although they are close to common Hungarian words. For example, in sign group (f), the intended name PÉTER can be easily recognized instead of the nonsense string PÉTEZ. This suggests that the scribe made a spelling mistake. In particular, the scribe wrote the Old Hungarian Z sign instead of the Old Hungarian R sign.

These two signs look similar; hence, it is understandable that such a mistake can be made by someone who is not completely familiar with the script. The Altai Mountain inscription uses a form of Z that has two legs. In many texts, including this paper, the following slightly different form of Z is used:

Apparently, the scribe also mixed up the Old Hungarian signs G and L in the words MAGYARORSZÁG and SZERETLEK. These two signs also look similar.

The incorrect signs and transliterated letters are highlighted in brown in Table 2. Those signs and letters can be corrected to their intended versions as shown in Table 3.

Table 3. The Altai Mountain inscription after replacing incorrect signs with intended ones.

Row	Inscription	Transliteration	Meaning
a		E N I K^1 Ő	Enikő
b		E N I K^1 Ő M	my Enikő
c		SZ E R E T L E K^1	I love you
d1		SZ K^2 SZ	
d2		N A GY	great
e		M A GY A R O R SZ Á G	Hungary
f		K^2 U N P É T E R	Kun

The mix-up of the above pairs of Old Hungarian signs is a natural consequence of their similar look. Nevertheless, it is possible to ask why exactly these signs are mixed up in the inscription. To answer that question, we can apply a mathematically based approach to sign similarities. This approach was developed in an earlier paper that compared the Minoan Linear A, the Carian, and the Old Hungarian script [7]. The approach starts by identifying which sign has which of the following thirteen features:

1. The symbol contains some curved line.
2. The symbol encloses some region.
3. The symbol has a slanted straight line.
4. The symbol contains parallel lines.
5. The symbol contains crossing lines.
6. The symbol's top is a wedge $\wedge$.
7. The symbol's bottom is a wedge $\vee$.
8. The symbol's right side is a wedge $>$.
9. The symbol contains a stem, a straight vertical line that runs across the middle.
10. The symbol's bottom has two legs, two single lines touching the bottom.
11. The symbol's bottom has three legs, three single lines touching the bottom.
12. The symbol contains a hair, a small line extending from an enclosed space.
13. The symbol contains two triangles.

Figure 4 shows a matrix that results from a feature analysis of the Old Hungarian Runic signs in terms of the above 13 features.

Figure 5 shows a similarity matrix of the Old Hungarian signs. Each entry shows the number of features on which the row and the column signs agree. Two signs agree on a feature if they both contain the feature or both lack the feature. This means that they both have a value of 1 or they both have a value of -1 for the same feature in the feature table in Figure 4. We can propose the theorem below.

	1	2	3	4	5	6	7	8	9	10	11	12	13
𐰀	-1	1	1	-1	-1	1	-1	-1	-1	-1	-1	1	-1
𐰁	-1	1	1	-1	-1	1	-1	-1	-1	-1	-1	1	-1
𐰂	-1	-1	1	-1	1	-1	-1	-1	-1	1	-1	-1	-1
𐰃	-1	-1	1	-1	-1	1	-1	-1	1	-1	-1	-1	-1
𐰄	-1	1	1	1	-1	-1	-1	-1	-1	1	-1	1	-1
𐰅	-1	-1	-1	-1	1	-1	-1	-1	1	-1	-1	-1	-1
𐰆	1	-1	1	-1	1	-1	-1	-1	-1	1	-1	-1	-1
𐰇	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰈	1	1	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1
𐰉	-1	-1	1	1	-1	1	-1	-1	-1	-1	1	-1	-1
𐰊	-1	-1	-1	1	1	-1	-1	-1	1	-1	-1	-1	-1
𐰋	1	1	-1	-1	1	-1	-1	-1	-1	1	-1	1	-1
𐰌	-1	-1	1	-1	1	-1	-1	-1	1	-1	-1	-1	-1
𐰍	-1	-1	1	-1	-1	1	-1	-1	-1	-1	-1	-1	-1
𐰎	-1	1	1	1	-1	1	1	1	-1	-1	-1	-1	-1
𐰏	-1	-1	1	1	-1	1	1	-1	1	-1	-1	-1	-1
𐰐	-1	-1	1	1	-1	1	-1	-1	-1	-1	-1	-1	-1
𐰑	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰒	-1	1	1	1	-1	1	1	-1	-1	-1	-1	-1	1
𐰓	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰔	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰕	1	-1	-1	-1	-1	1	1	-1	-1	-1	-1	-1	-1
𐰖	1	-1	1	-1	-1	1	1	-1	-1	-1	-1	-1	-1
𐰗	-1	-1	1	1	-1	1	-1	-1	-1	1	-1	-1	-1
𐰘	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1	-1	-1
𐰙	-1	-1	1	-1	-1	1	-1	-1	-1	1	-1	-1	-1
𐰚	-1	-1	-1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1
𐰛	-1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰜	-1	-1	1	1	1	-1	-1	-1	-1	-1	1	-1	-1
𐰝	-1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1
𐰞	-1	-1	1	1	1	-1	-1	-1	-1	-1	-1	-1	1
𐰟	-1	-1	1	1	-1	-1	-1	-1	-1	1	-1	-1	-1
𐰠	-1	1	1	1	-1	-1	-1	-1	-1	1	-1	1	-1
𐰡	-1	-1	1	-1	-1	-1	-1	-1	1	-1	-1	-1	-1

Figure 4. A feature analysis of the Old Hungarian Runic signs: 1 indicates that the sign in the row contains the feature in the column; −1 indicates that it does not contain the feature. This analysis uses the Altai Mountain version of the Z sign.

Theorem 1. *Let A be an n × m feature matrix with n signs and m features. Furthermore, let A^T be the transpose of A, and let M be the n × n similarity matrix for the n signs. Then, the following formula holds:*

$$M = 0.5\,((A \times A^T) + C), \tag{1}$$

where C is a matrix in which each entry is m.

Proof. Consider any entry $M[i, j]$ of the similarity matrix. This entry has the value of

$$M[i, j] = 0.5\,((\mathrm{A[i]} \cdot \mathrm{A[j]}) + \mathrm{m}), \tag{2}$$

where the dot indicates the dot product of the two vectors. The inner parenthesis in Equation (2) contains the number of times signs *i* and *j* that either both contain or both lack a feature minus the number of times they disagree on a feature as follows:

$$1 \times 1 = 1 \text{ when } i\text{and } j \text{ both contain a feature.} \tag{3}$$

$$(-1) \times (-1) = 1 \text{ when } i\text{and } j \text{ both lack a feature.} \tag{4}$$

$$(-1) \times 1 = -1 \text{ when } i\text{lacks and } j\text{contains a feature.} \tag{5}$$

$$1 \times (-1) = -1 \text{ when } i\text{contains and } j\text{lacks a feature.} \tag{6}$$

Let *agree* be the number of times that cases (3) and (4) occur. Let *disagree* be the number of times that cases (5) and (6) occur. Then, the following must hold for any number of features m because the two signs must either agree or disagree on each feature:

$$m = agree + disagree. \tag{7}$$

Hence, according to the above observation and Equation (7), the inner parenthesis has the following value:

$$agree - disagree = agree - (m - agree) = 2agree - m. \tag{8}$$

From Equation (8), it can be also seen that

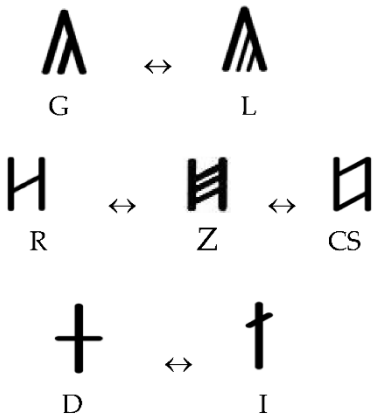
$$M[i, j] = 0.5((2agree - m) + m) = agree. \tag{9}$$

Therefore, the value of $M(i, j)$ is the total number of features on which signs i and j agree as required for the similarity matrix. QED.

Theorem 1 is useful for the fast calculation of the similarity matrix given any feature matrix. Theorem 1 was used to calculate the similarity matrix shown in Figure 5 from the feature matrix shown in Figure 4. After the similarity matrix was calculated, the entries with a similarity value of 12 or 13 between two different signs were highlighted in pink as shown in Figure 5.

The similarity matrix had 34 × 33 = 1122 nondiagonal entries. Out of those, 52 (4.63%) were marked pink. Intuitively, these pairs were those most likely to be confused with each other according to this mathematical model.

At my request, Klara Friedrich, a prominent researcher and teacher of the Old Hungarian Runic script, verified that, in her decades of experience, it is common to mix up the following letters:

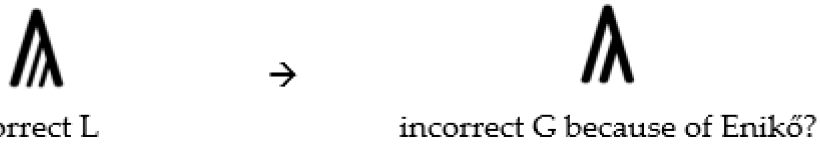


Among the above, the G–L pair has a similarity of 12, the R–Z and the Z–CS pairs have similarities 11 and 13, respectively, and the D–I pair has a similarity of 12. Hence, these frequently mixed up pairs also have high similarity scores according to the similarity matrix in Figure 5. Hence, the strong agreement between the mathematical model and the teacher's experience shows that the G–L and R–Z pair mix-ups in the Old Hungarian Runic inscription in Figure 1 were likely due to an accident. □

	𐰀	𐰁	𐰂	𐰃	𐰄	𐰅	𐰆	𐰇	𐰈	𐰉	𐰊	𐰋	𐰌	𐰍	𐰎	𐰏	𐰐	𐰑	𐰒	𐰓	𐰔	𐰕	𐰖	𐰗	𐰘	𐰙	𐰚	𐰛	𐰜	𐰝	𐰞	𐰟	𐰠
𐰀	13	13	8	10	10	7	7	9	9	9	6	8	8	11	9	8	10	9	9	8	9	8	9	9	8	10	8	10	7	10	8	8	10	9
𐰁	13	13	8	10	10	7	7	9	9	9	6	8	8	11	9	8	10	9	9	8	9	8	9	9	8	10	8	10	7	10	8	8	10	9
𐰂	8	8	13	9	9	10	12	10	10	8	9	9	11	10	6	7	9	8	6	9	8	7	8	10	11	11	9	11	10	9	9	11	9	10
𐰃	10	10	9	13	7	10	8	10	8	10	9	5	11	12	8	11	11	8	8	9	8	9	10	10	9	11	11	11	8	9	7	9	7	12
𐰄	10	10	9	7	13	6	8	8	8	8	7	9	7	8	8	7	9	8	8	7	8	5	6	10	11	9	7	9	8	11	9	11	13	8
𐰅	7	7	10	10	6	13	9	9	9	7	12	8	12	9	5	8	8	9	5	10	9	8	7	7	8	8	12	10	9	8	8	8	6	11
𐰆	7	7	12	8	8	9	13	11	11	7	8	10	10	9	5	6	8	9	5	10	9	8	9	9	10	10	8	10	9	8	8	10	8	9
𐰇	9	9	10	10	8	9	11	13	11	9	8	8	10	11	7	8	10	11	7	12	11	10	11	9	10	10	10	12	9	10	8	10	8	11
𐰈	9	9	10	8	8	9	11	11	13	7	8	10	10	9	7	6	8	11	7	10	11	8	9	7	8	8	8	10	9	10	10	8	8	9
𐰉	9	9	8	10	8	7	7	9	7	13	8	4	8	11	9	10	12	7	9	8	7	8	9	11	10	10	8	10	11	10	8	10	8	9
𐰊	6	6	9	9	7	12	8	8	8	8	13	7	11	8	6	9	9	8	6	9	8	7	6	8	9	7	11	9	10	9	9	9	7	10
𐰋	8	8	9	5	9	8	10	8	10	4	7	13	7	6	4	3	5	10	4	9	10	7	6	6	7	7	7	7	6	7	7	7	9	6
𐰌	8	8	11	11	7	12	10	10	10	8	11	7	13	10	6	9	9	8	6	9	8	7	8	8	9	9	11	11	10	9	9	9	7	12
𐰍	11	11	10	12	8	9	9	11	9	11	8	6	10	13	9	10	12	9	9	10	9	10	11	11	10	12	10	12	9	10	8	10	8	11
𐰎	9	9	6	8	8	5	5	7	7	9	6	4	6	9	13	10	10	7	11	6	7	8	9	9	8	8	6	8	7	10	8	8	8	7
𐰏	8	8	7	11	7	8	6	8	6	10	9	3	9	10	10	13	11	6	10	7	6	9	10	10	9	9	9	9	8	9	7	9	7	10
𐰐	10	10	9	11	9	8	8	10	8	12	9	5	9	12	10	11	13	8	10	9	8	9	10	12	11	11	9	11	10	11	9	11	9	10
𐰑	9	9	8	8	8	9	9	11	11	7	8	10	8	9	7	6	8	13	7	12	13	10	9	7	8	8	10	10	7	10	8	8	8	9
𐰒	9	9	6	8	8	5	5	7	7	9	6	4	6	9	11	10	10	7	13	6	7	8	9	9	8	8	6	8	7	10	10	8	8	7
𐰓	8	8	9	9	7	10	10	12	10	8	9	9	9	10	6	7	9	12	6	13	12	11	10	8	9	9	11	11	8	9	7	9	7	10
𐰔	9	9	8	8	8	9	9	11	11	7	8	10	8	9	7	6	8	13	7	12	13	10	9	7	8	8	10	10	7	10	8	8	8	9
𐰕	8	8	7	9	5	8	8	10	8	8	7	7	7	10	8	9	9	10	8	11	10	13	12	8	7	9	9	9	6	7	5	7	5	8
𐰖	9	9	8	10	6	7	9	11	9	9	6	6	8	11	9	10	10	9	9	10	9	12	13	9	8	10	8	10	7	8	6	8	6	9
𐰗	9	9	10	10	10	7	9	9	7	11	8	6	8	11	9	10	12	7	9	8	7	8	9	13	12	12	8	10	9	10	8	12	10	9
𐰘	8	8	11	9	11	8	10	10	8	10	9	7	9	10	8	9	11	8	8	9	8	7	8	12	13	11	9	11	10	11	9	13	11	10
𐰙	10	10	11	11	9	8	10	10	8	10	7	7	9	12	8	9	11	8	8	9	8	9	10	12	11	13	9	11	8	9	7	11	9	10
𐰚	8	8	9	11	7	12	8	10	8	8	11	7	11	10	6	9	9	10	6	11	10	9	8	8	9	9	13	11	8	9	7	9	7	12
𐰛	10	10	11	11	9	10	10	12	10	10	9	7	11	12	8	9	11	10	8	11	10	9	10	10	11	11	11	13	10	11	9	11	9	12
𐰜	7	7	10	8	8	9	9	9	9	11	10	6	10	9	7	8	10	7	7	8	7	6	7	9	10	8	8	10	13	10	10	10	8	9
𐰝	10	10	9	9	11	8	8	10	10	10	9	7	9	10	10	9	11	10	10	9	10	7	8	10	11	9	9	11	10	13	11	11	11	10
𐰞	8	8	9	7	9	8	8	8	10	8	9	7	9	8	8	7	9	8	10	7	8	5	6	8	9	7	7	9	10	11	13	9	9	8
𐰟	8	8	11	9	11	8	10	10	8	10	9	7	9	10	8	9	11	8	8	9	8	7	8	12	13	11	9	11	10	11	9	13	11	10
𐰠	10	10	9	7	13	6	8	8	8	8	7	9	7	8	8	7	9	8	8	7	8	5	6	10	11	9	7	9	8	11	9	11	13	8
𐰡	9	9	10	12	8	11	9	11	9	9	10	6	12	11	7	10	10	9	7	10	9	8	9	9	10	10	12	12	9	10	8	10	8	13

Figure 5. A similarity matrix of the Old Hungarian Runic signs. Entries that indicate a similarity of 12 or 13 between two different signs are highlighted in pink.

Not everyone agrees with the accidental nature of the letter mix-ups. G. Varga imagined that the inscription had some sexual message. Moreover, he claimed that a male scribe wrote every sign originally correctly, but he later deliberately changed the inscription by adding extra lines for the sake of a woman called *Enikő*, who was embarrassed and 'obviously did not want to make public what happened'. According to Varga, these deliberately added extra lines explain the mix-up of the letters as shown in his figure (Figure 2 in [1]). However, this theory runs into a major problem in explaining the incorrect G in the word SZ E **Z** E T **G** E K[1].



Since scratches and carvings cannot be erased from a rock surface like from a paper, one cannot destroy a correct L into an incorrect G because it requires the deletion instead of the addition of a line. Hence, it is an untenable hypothesis that all spelling mistakes were deliberately introduced to destroy the meaning of the writing.

5. Decipherment Requires Correct Signs, Syntax, and Semantics

Valid decipherment requires correct signs, syntax, and semantics. These can be defined as described below.

1. Signs: This means a combination of two things.

First, the shapes of the signs are visually recognized correctly. As in the case of the Altai Mountain inscription, shape recognition can be hindered by deficiencies in the visual quality of the object (cracks in the rock, weathering, overwriting the signs by other inscriptions and drawings, etc.) and deficiencies in the photographs available to the investigator. An onsite investigation is almost always preferable to even the best available photograph.

Second, the visually correctly identified sign needs to also be correctly transliterated. It is of no use to correctly discern the shape of a sign, and then incorrectly look up its transliteration. Obviously, that cannot lead to a valid decipherment.

2. Syntax: This means that the words fit together according to the accepted grammatical rules. Moreover, the grammar must match the period of the inscription. For example, one cannot use present day Hungarian language grammar for an inscription from the Middle Ages. Translations that add suffixes purely from the imagination of the decipherer cannot be considered valid, even if the root words look acceptable. Even ancient Sumerian pictographs and cuneiforms reflect a well-formed, complex grammar.
3. Semantics: This means that the sentences and story are meaningful. The meaningfulness of the text needs to be evaluated in terms of the time and other circumstances of writing. For example, there should not be any anachronisms such as talking about dinosaurs in an ancient text because those became extinct long before the first scripts were developed.

In the Altai Mountain inscription, all the sign groups have an unambiguous reading except sign group (d). Now, let us evaluate the proposal (d2), which is equivalent to the word NAGY. If we read the sign groups in order from bottom up as shown in Figure 2, then we obtain the following Hungarian sentence:

E N I K^1 Ő, E N I K^1 Ő M, SZ E R E T L E K^1.

N A GY- M A GY A R O R SZ Á G, K^2 U N P É T E R.

Here, the Hungarian compound word *Nagy-Magyarország* 'Greater Hungary' refers to the historical Hungary, which includes present day Hungary and territories in neighboring countries where Hungarians live as minorities. It is necessary to add as an explanation that a literary reference to *Nagy-Magyarország* does not mean territorial aspirations but is only a reference to the international Hungarian ethnic community to which many minority Hungarians feel they belong. Hence, the inscription can be translated as a grammatically and semantically correct message as follows:

I love you Enikő, my Enikő!

–Peter Kun, Greater Hungary.

Now, let us consider the proposal (d1), which was SZ K^2 SZ. One can immediately see that this proposal has a weakness because this is not a meaningful word. It lacks vowels. In the older, mostly medieval examples of Old Hungarian Runic inscriptions, the vowels were often omitted when they did not affect the readability of the text. However, this is clearly not a medieval text. Some orthographic considerations regarding the form of the Old Hungarian signs support this assertion, but we can skip those considerations because there is a simpler explanation of recentness, i.e., that the name *Enikő* was created by the poet Vörösmarty (1800–1855) [9]. That linguistic consideration alone helps date the text

to after the latter half of the 19th century. Hence, we need to consider a period when the omission of vowels was no longer practiced. This period includes a considerable revival of interest in the Old Hungarian Runic script in the past 30 years.

It is unlikely that the scribe wrote down each vowel in every other word except in SZ K^2 SZ. However, let us entertain this idea by trying to find a word. Since K^2 requires a back-vowel, a word that may be found is SZaK^2aSZ or *szakasz* (International Phonetic Alphabet notation:/sakas/) with the meaning 'segment'. However, this lacks correct semantics because the phrase SZeReTLeK^1 SZaK^2aSZ 'I love you segment' makes no sense.

Mr. Varga suggested the Hungarian word *szex* (International Phonetic Alphabet notation:/seks/) with the meaning 'sex'. Since letter X does not occur in the Old Hungarian Runic script, words with X are written down by a K SZ combination. Hence, let us try to write down the word as SZeK^2SZ. That would violate the second condition of sign correctness because one needs to transliterate K^2 as a consonant that occurs with a back-vowel, while *e* is a front-vowel.

The argument can be made that the scribe forgot about the differences between K^1 and K^2. However, it is unlikely because everywhere else the scribe uses these two signs correctly, as can be easily checked.

Front-vowel words: E N I K^1 Ő, E N I K^1 Ő M, SZ E R E T L E K^1.

Back-vowel word: K^2 U N.

Apparently, the scribe is consistent in the use of K^1 and K^2, and there is no real logic of supposing that they made a mistake just here regarding this usage convention, as well as making a mistake just here regarding explicitly writing down the vowel just in this word. Moreover, SZeK^2SZ is grammatically incorrect. A grammatically correct phrase would be the following:

E N I K^1 Ő, E N I K^1 Ő M, SZeK^2SZ-uálisan SZ E R E T L E K^1,

which means

I love you sexually Enikő, my Enikő.

However, the suffix *-uálisan* is completely absent. Hence, the SZeK^2SZ word proposal is semantically correct, but it is incorrect in signs and syntax. Despite the above concerns, this proposal of my coauthor was kept as an alternative together with my NAGY word proposal. Unfortunately, we omitted to mention that sign group (d) may be a personal sign or tamga, although Varga added the following endnote to his blog entry of 16 March 2022. The top shows a screenshot of the original Hungarian text, with an English translation in italics below.

(3) A szó olvasatát alátámasztja, hogy ez a *szeksz* magyarázza meg, miért is próbálta meg titkosítani a már elkészült feliratot Kun Péter. Ha ez egy tamga lenne, ahogyan azt Révész Péter említette, akkor a titkosítást még meg kellene magyarázni.

(3) The word's reading as 'sex' is supported by the fact that it explains why Peter Kun tried to destroy the readability of the inscription. If this were a tamga, as Peter Revesz once mentioned, then this deliberate destruction would be unexplained.

6. Identification of Sign Group (d) as a Tamga

A *tamga* is an emblem of a family, clan, or tribe. Tamgas were widely used by Eurasian nomads as a mark of personal property such as in branding livestock. For example, the early Bulgarian ruling dynasty, the Dulo clan, used the tamga shown in Figure 6a. For example, this tamga was found on the back of a seventh to ninth century bronze rosette at Pliska, Bulgaria [10] and on a ninth century clay pot fragment at Zalavár, Hungary [11]. The Kayi was one of the 21 Oghuz Turkic tribes. The Kayi tamga is shown in Figure 6b.

(**a**) (**b**) (**c**)

Figure 6. The Dulo clan's tamga (**a**), Kayi tamga (**b**), and Peter Kun's tamga (**c**). Picture credits: Wikipedia https://en.wikipedia.org/wiki/Dulo (accessed on 16 May 2022) and https://en.wikipedia.org/wiki/Tamga (accessed on 16 May 2022).

Thanks to the publicity of our publication [1], as a wonderful crowdsourcing effort, many people sent me various tips about who Peter Kun may be. When I got a tip about his phone number, I called him, and he verified that he was the scribe of the Altai Mountain inscription. I followed up our conversation with an email in which I asked some detailed questions. In his reply, which is shown in Figure 7, he explains that sign group (d) is a tamga. The middle K^2 sign stands for his family name, Kun, which has a back vowel. Hence, K^2 is used instead of K^1, which would be appropriate for a name with a front-vowel.

The two parallel signs on the left and right sides of the tamga are symbols of the Cumans, an ancient steppe people, whose domain extended from Hungary to Mongolia ca. 1200. Sometimes, the parallel lines are replaced by two arrows or spears. The three tamgas of Figure 6 all have two vertical parallel lines on the left and right sides. They differ only in the middle letter that is enclosed between those two parallel lines. These letters are Y-shaped for the Dulo clan, V-shaped for the Kayi tribe, and Z-shaped for Peter Kun. These three tamgas can be classified as members of the same subgroup of Turkic tamgas.

Peter Kun created this tamga for his own use in honor of his Cuman ancestors, who settled in a part of Hungary that is named after them to this day. It is called *Kunság* in Hungarian. The Cuman descendants in Hungary have their own organization, and Peter Kun serves as a leader in that organization. Peter Kun is also a cattle rancher and uses the tamga as a branding sign for his cattle.

Peter Kun verified that he did not make any deliberate alterations of the signs. He also explained that he was longing for *Enikő*, his wife, who was left behind in Hungary, while he was traveling in the Altai Mountains and doing research. He has a doctorate in Turkic studies. He even published a book about his research travels in Asia during which he studied the equestrian culture of the Steppe nomads [12].

Hence, the entire inscription can be seen as follows:

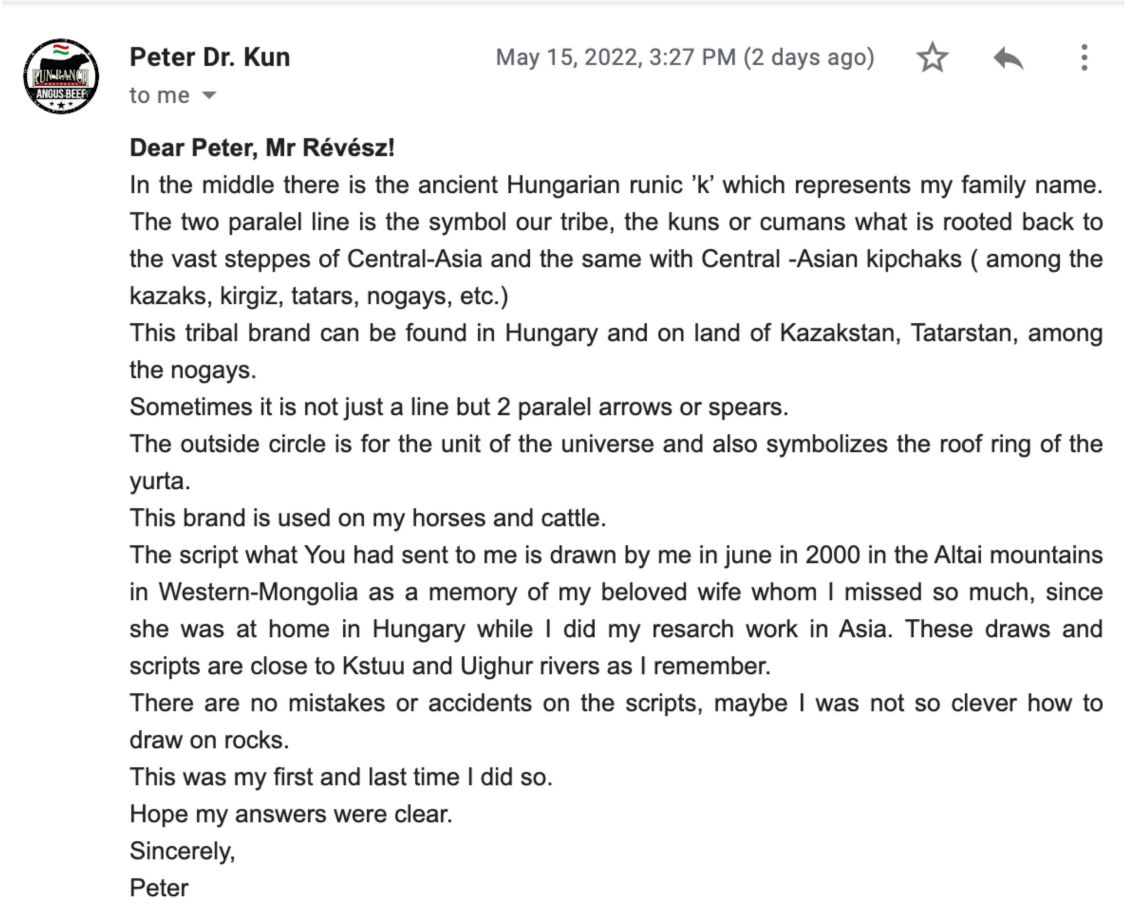
E N I K^1 Ő, E N I K^1 Ő M, SZ E R E T L E K^1.

, M A GY A R O R SZ Á G, K^2 U N P É T E R.

The tamga is not transliterated because it is a personal property symbol or emblem that can stand for 'Kun Ranch'. Hence, the correct translation into English is the following:

I love you Enikő, my Enikő!

–Peter Kun, Kun Ranch, Hungary.



Peter Dr. Kun May 15, 2022, 3:27 PM (2 days ago)

to me

Dear Peter, Mr Révész!

In the middle there is the ancient Hungarian runic 'k' which represents my family name. The two paralel line is the symbol our tribe, the kuns or cumans what is rooted back to the vast steppes of Central-Asia and the same with Central -Asian kipchaks (among the kazaks, kirgiz, tatars, nogays, etc.)

This tribal brand can be found in Hungary and on land of Kazakstan, Tatarstan, among the nogays.

Sometimes it is not just a line but 2 paralel arrows or spears.

The outside circle is for the unit of the universe and also symbolizes the roof ring of the yurta.

This brand is used on my horses and cattle.

The script what You had sent to me is drawn by me in june in 2000 in the Altai mountains in Western-Mongolia as a memory of my beloved wife whom I missed so much, since she was at home in Hungary while I did my resarch work in Asia. These draws and scripts are close to Kstuu and Uighur rivers as I remember.

There are no mistakes or accidents on the scripts, maybe I was not so clever how to draw on rocks.

This was my first and last time I did so.

Hope my answers were clear.

Sincerely,

Peter

Figure 7. Dr. Peter Kun's email that verifies that he wrote the inscription in June 2000. This original email contains some minor misspellings. For example, the names of ethnic groups are written in lowercase letters, which is the common way of writing ethnic names in Hungarian.

7. Lessons Learned about Decipherment

That sign group (d) is a tamga did not seem plausible because there are no other instances of the use of tamga signs within Old Hungarian Runic inscriptions. Hence, this sign triplet can be termed a *hapax legomenon maximus* because it is not only unique within the corpus of Old Hungarian Runic inscriptions, but it is also unique in it being a tamga.

The Kun Ranch tamga is easily confusable with an SZ K^2 SZ sequence of Old Hungarian Runic signs as shown in Figure 8.

Figure 8. Confusability of Peter Kun's tamga (**left**) and Old Hungarian signs (**right**).

The presence of a *hapax legomenon maximus* together with the confusability of its elements with a sequence of Old Hungarian Runic sign made a complete decipherment of the Altai Mountain inscription nearly impossible. It is with luck that the actual scribe could be found and the exact meaning of the tamga was revealed to us.

Decipherers of ancient inscriptions may learn some valuable lessons from this work. As Figure 9 shows, only the tamga is the correct solution in this case. Unfortunately, it was

not pursued enough because other proposals were not rejected earlier. In particular, the SZ eK[1] SZ proposal should have been dropped earlier when its problems became clear. My advice is to always look for a solution that satisfies the three S's of correct sign, syntax, and semantics and not to get stuck with any solution that fails any of these three criteria.

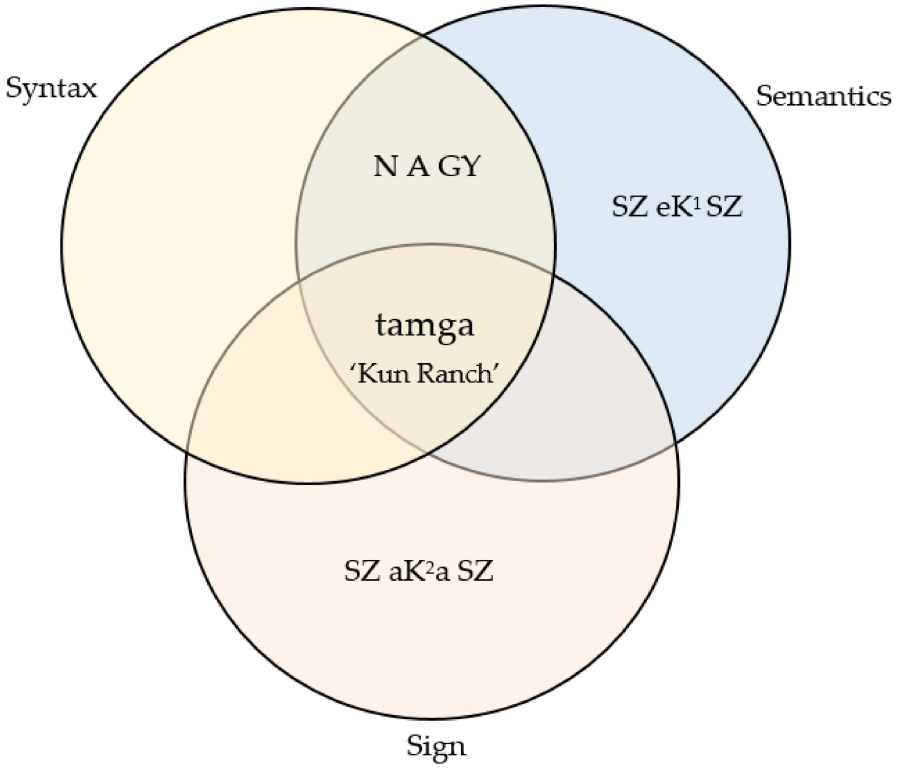


Figure 9. A valid decipherment needs to get three things correct: signs, syntax, and semantics. The above Venn diagram places four proposals for sign group (d) on the basis of correctness according to these three criteria.

8. Conclusions and Further Work

The Old Hungarian Runic inscription from the Altai Mountains now has a complete decipherment. The story of this inscription taught several valuable lessons that may be useful in the decipherment of other inscriptions in any script. Similarity matrices, which can be efficiently calculated using the formula in Theorem 1, may become generally used in future decipherments. It may be considered together with other machine-aided translation methods that use some type of similarity metrics [13,14]. This may aid in the continuing decipherment of the Indus Valley Script [15] and the Minoan scripts [16–18].

The work was also personally satisfying in contacting the scribe, who happened to be a generous and hardworking person, a cattle farmer from the Great Hungarian Plains, an adventurer. He is a great cultural ambassador between the peoples near the Altai Mountains and Hungarians in Central Europe. May this work also help to strengthen the cultural ties between the two regions.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Revesz, P.Z.; Varga, G. A proposed translation of an Altai Mountain inscription presumed to be from the 7th century BC. *Information* **2022**, *13*, 243. [CrossRef]
2. Sartkožauly, K. *Complete Atlas of the Orkhon Monuments*; Almaty Samga Press: Almaty, Kazakhstan, 2019; Volume 3.
3. Benkő, E.; Sándor, K.; Vásáry, I. *A Székely Írás Emlékei*; Bölcsészettudományi Kutatóközpont: Budapest, Hungary, 2021.
4. Wikipedia. Old Hungarian Script. Available online: https://en.wikipedia.org/wiki/OldHungarianscript (accessed on 8 December 2021).
5. Hosszú, G. *Scriptinformatics: Extended Phenetic Approach to Script Evolution*; Nap Kiadó: Budapest, Hungary, 2021.
6. Sebestyén, G. *A Magyar Rovásirás Hiteles Emlékei*; Magyar Tudományos Akadémia: Budapest, Hungary, 1915.
7. Revesz, P.Z. Establishing the West-Ugric language family with Minoan, Hattic and Hungarian by a decipherment of Linear, A. *WSEAS Trans. Inf. Sci. Appl.* **2017**, *14*, 306–335.
8. Wikipedia. Hungarian Phonology. Available online: https://en.wikipedia.org/wiki/Hungarian_phonology (accessed on 14 May 2022).
9. Wikipedia. Enikő. Available online: https://en.wikipedia.org/wiki/Enikő (accessed on 13 January 2022).
10. Wikipedia. Pliska Rosette. Available online: https://en.wikipedia.org/wiki/Pliska_rosette (accessed on 6 July 2022).
11. Szőke, B.M. *A Karoling-kor a Kárpát-Medencében*; Magyar Nemzeti Múzeum: Budapest, Hungary, 2014.
12. Kun, P. *Szelek Szárnyán*; Arcadas Press: Debrecen, Hungary, 2003.
13. Tóth, L.; Hosszú, G.; Kovács, F. Deciphering Historical Inscriptions Using Machine Learning Methods. In *Proceedings of the 10th International Conference on Logistics, Informatics and Service Sciences*; Liu, S., Bohács, G., Shi, X., Shang, X., Huang, A., Eds.; Springer: Singapore, 2020; pp. 419–435. [CrossRef]
14. Daggumati, S.; Revesz, P.Z. Data mining ancient scripts to investigate their relationships and origins. In Proceedings of the 23rd International Database Engineering and Applications Symposium, Athens, Greece, 10–12 June 2019; ACM Press: New York, NY, USA, 2019; pp. 209–218. [CrossRef]
15. Daggumati, S.; Revesz, P.Z. A method of identifying allographs in undeciphered scripts and its application to the Indus Valley Script. *Humanit. Soc. Sci. Commun.* **2021**, *8*, 50. [CrossRef]
16. Revesz, P.Z. Bioinformatics evolutionary tree algorithms reveal the history of the Cretan Script Family. *Int. J. Appl. Math. Inform.* **2016**, *10*, 67–76.
17. Revesz, P.Z. A translation of the Arkalochori Axe and the Malia Altar Stone. *WSEAS Trans. Inf. Sci. Appl.* **2017**, *14*, 124–133.
18. Revesz, P.Z. Experimental evidence for a left-to-right reading direction of the Phaistos Disk. *Mediterr. Archaeol. Archaeom.* **2022**, *22*, 79–96.