TU Delft

Universiteit Leiden
The Netherlands

CENTRE FOR GLOBAL HERITAGE DEVELOPMENT

Rijksmuseum van Oudheden

The animated story of Tell Sabi Abyad clay tablet T98-34

The tablet born again and again!

by Dominique Ngan-Tillard

and

partners of Scanning for Syria

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Rijksmuseum van Oudheden

The animated story of Tell Sabi Abyad clay tablet T98-34

From its recovery, cast, and loss in Syria

to

its 3D digital preservation, reproduction

and

full translation in Europe!

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Rijksmuseum van Oudheden

The animated story of Tell Sabi Abyad clay tablet T98-34

With this tablet in chocolate
you can taste the richness of Syrian cultural heritage
and
you are supporting refugee students
in the Netherlands.

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Rijksmuseum van Oudheden

Chocolate Cuneiform Tablet

This chocolate tablet is a reproduction of a 12th century BCE cuneiform clay tablet found at Tell Sabi Abyad in Syria. It was recovered in the 1990's by Leiden archaeologists and stored locally at Museum Raqqa. The museum was plundered and bombed during the recent Syrian war and this particular clay tablet vanished. Luckily, Leiden archaeologists had already cast the tablets for detailed description. Through 3D digital technology TU Delft was able to reproduce the clay tablets for the Syrian people and for science.

The animated story of T98-34, the clay tablet born again and again

1. • From recovery in Tell Sabi Abyad to loss in Raqqa
   • with silicone rubber casting
2. • Digital preservation techniques
   • X-ray µ-CT scanner, close range light scanner, and portable light dome
3. • From manual decipherment to translation and interpretation
   • Starting from basics of cuneiform writing
4. • Digital processing
   • imperfection removal, digital decipherment and automatic character recognition
5. • 3D printing
6. • Conclusion
7. • Acknowledgements

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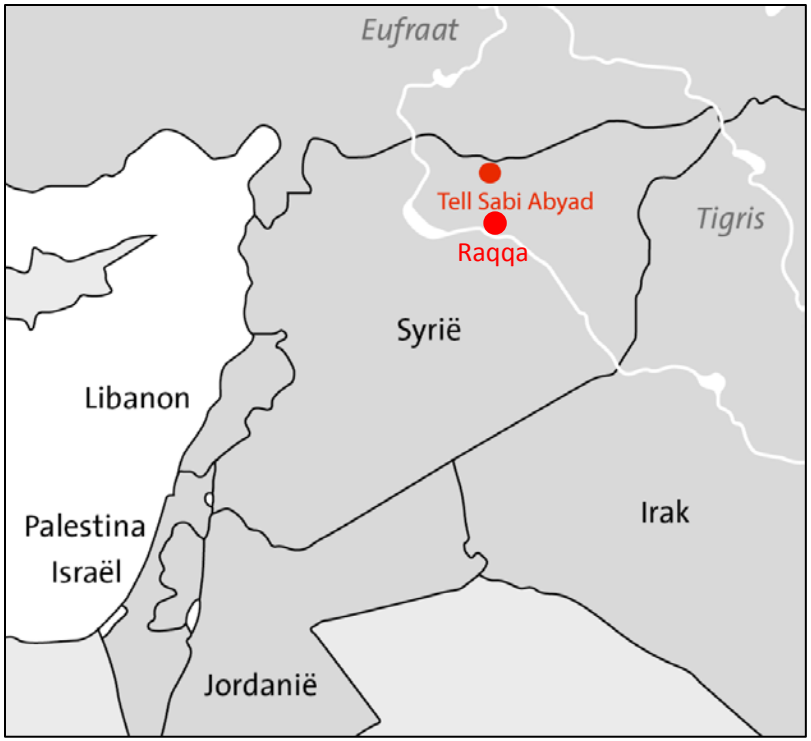
From recovery to loss



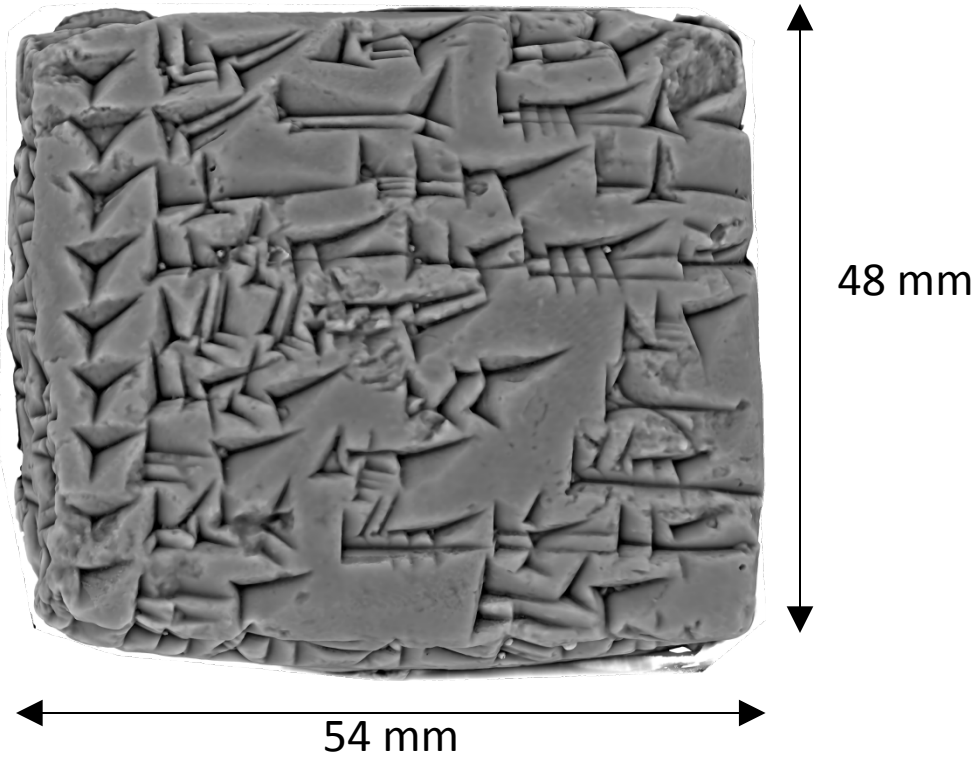
The chocolate tablet is a reproduction of a 12th century BCE cuneiform clay tablet (Tablet T98-34) found at Tell Sabi Abyad in Syria, 80 km North of Raqqa.

From recovery to loss

Image courtesy: Peter Akkermans

Tell Sabi Abyad means the “mound of the white boy” in Arabic. It was a ‘fort’ erected by the royal family to better control newly occupied territories.

From recovery to loss



The tablet was made of clay and the wedge-shaped characters were impressed with the tip of a reed stylus.

From recovery to loss

There was no shortage of clay and reed along the Euphrates river and its tributaries!

From recovery to loss

Images courtesy: Peter Akkermans

The tablet was recovered by Leiden archaeologists in 1998.

Images courtesy: Peter Akkermans

From recovery to loss

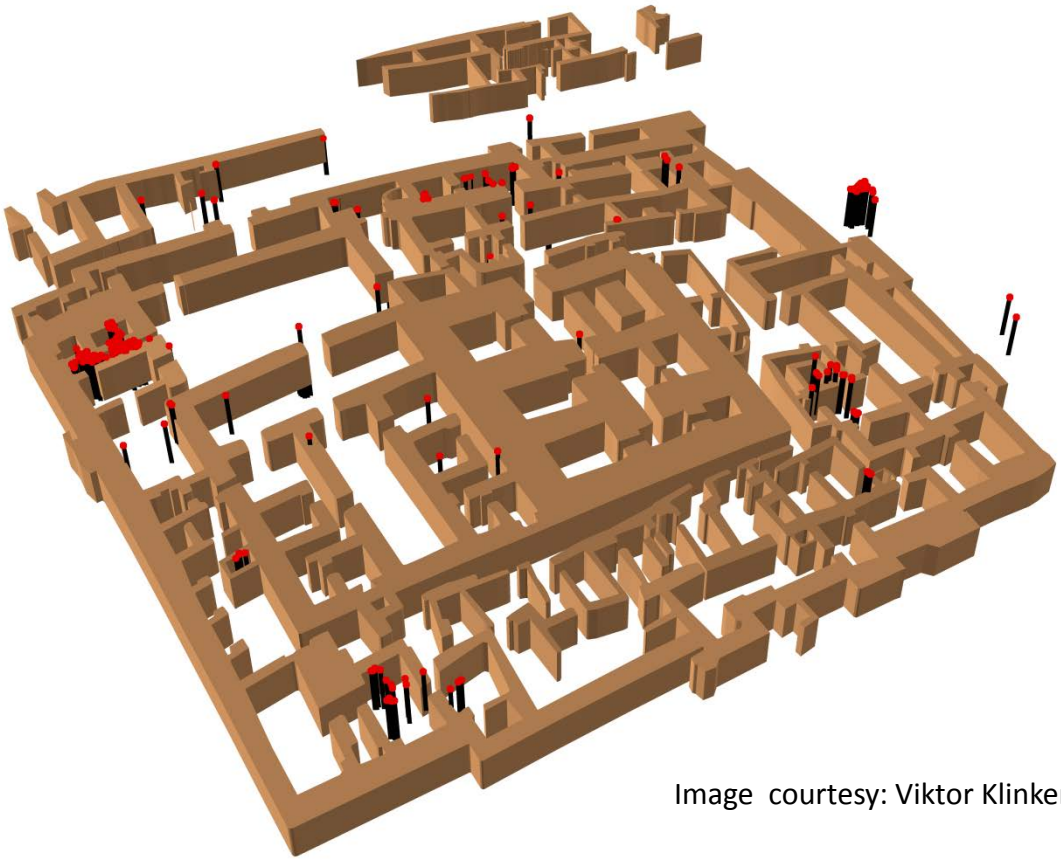


Image courtesy: Viktor Klinkenberg

It had been disposed with 400 other tablets in Tell Sabi Abyad “fort” during Middle Assyrian times (ca. 1200 BCE).

From recovery to loss

Image courtesy: Peter Akkermans

The tablets are a precious testimony on life at Tell Sabi Abyad, 1200 years BCE. Their texts range from personal stories, lists of merchandise, tax levees, to political intrigues.

From recovery to loss

Image courtesy: Olivier Nieuwenhuyse

Tablet T98-34 was stored at Museum Raqqa.

From recovery to loss

Source: Reuters

The museum was plundered and bombed during the Syrian war.

From recovery to loss

Heraqla-2-DGAM-2013

… and this particular clay tablet vanished.

From recovery to loss

Methodology to cast artefacts.
Image courtesy: German Archaeological Institute Berlin.

Luckily, Leiden archaeologists had already cast the tablet (and 19 other tablets) for detailed translation in the Netherlands.

From recovery to loss

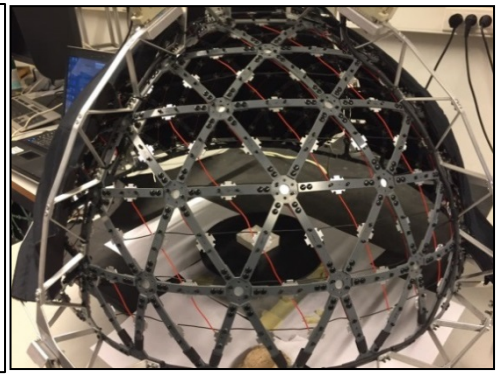
… but the silicone rubber mould will deteriorate within 2 decennia and its precious text will vanish forever, unless…

Digitalisation

The mould is digitized and preserved using one of the tools of modern archaeology:

TU Delft
X-ray µ-CT scanner

Heidelberg University
close range high resolution
light scanner



KU Leuven
portable light dome

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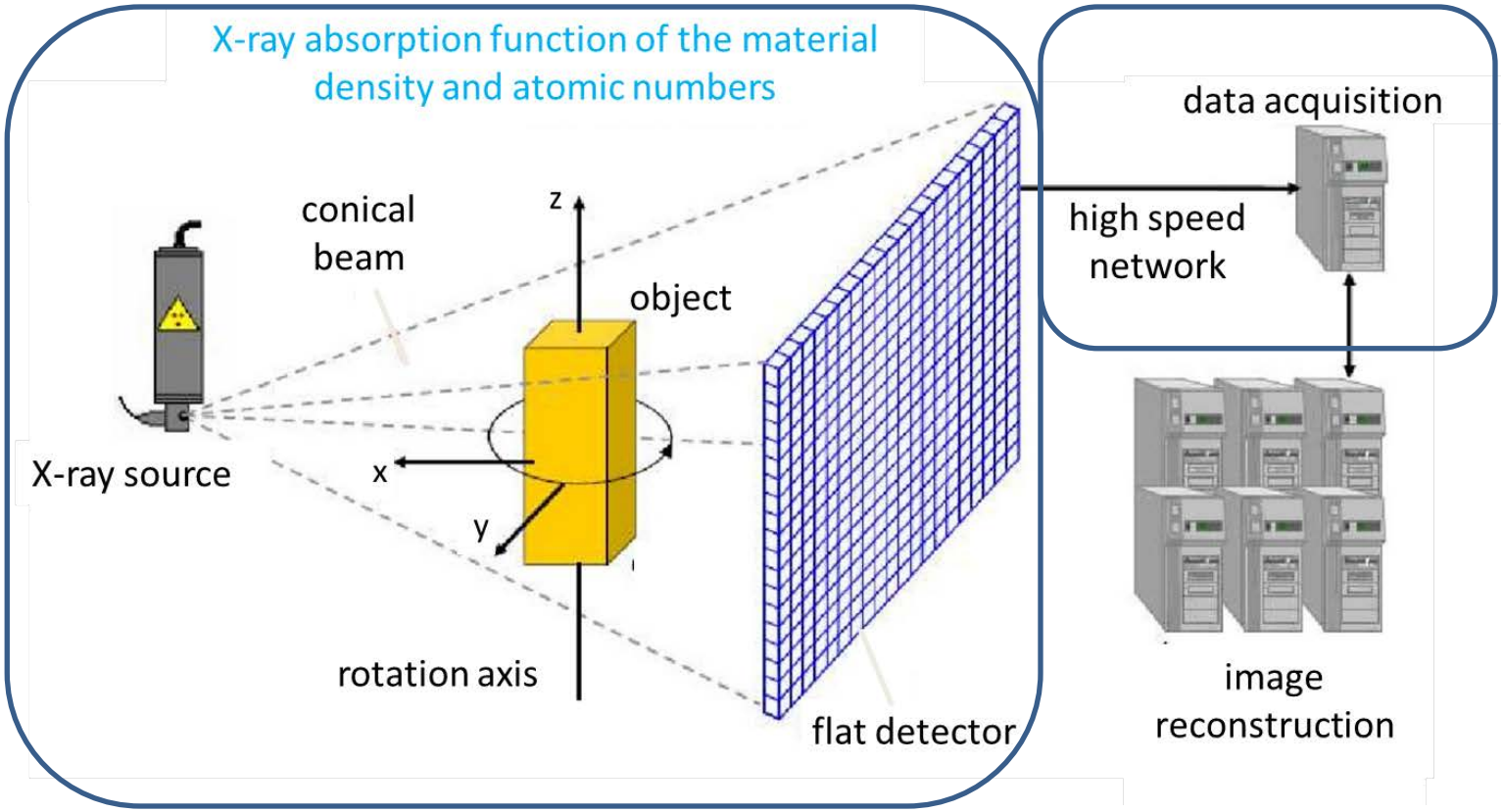
X-ray µ-CT scanner

Using a desktop X-ray µ-CT scanner, TU Delft was able to reproduce the clay tablets from the casts for the Syrian people and for science.

X-ray µ-CT scanner

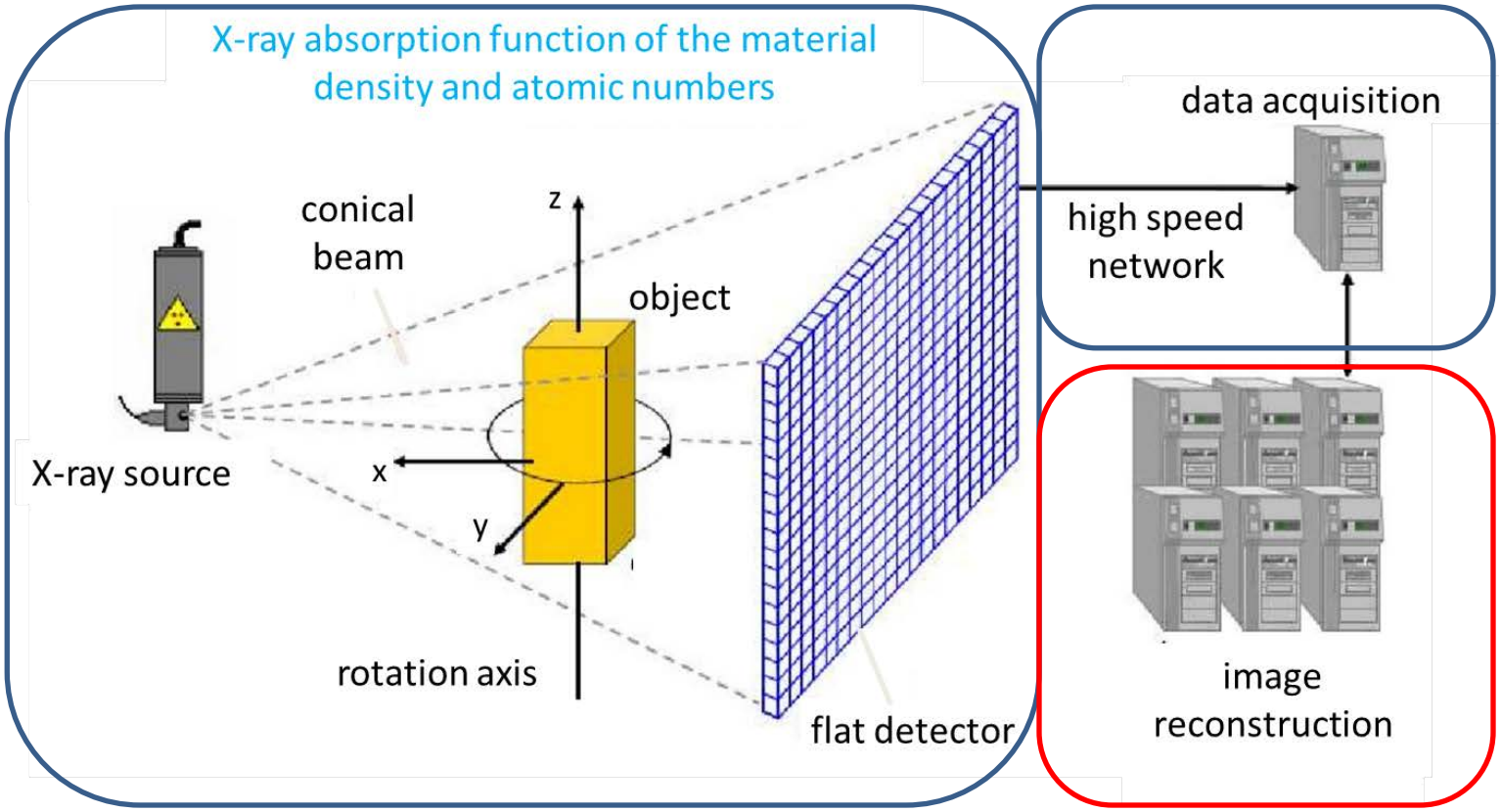
The X-ray µ-CT scanner works using the same principle as medical scanners employed in hospitals, but on a smaller scale and at a much higher resolution, about 1/2000th of the object width.

X-ray µ-CT scanner



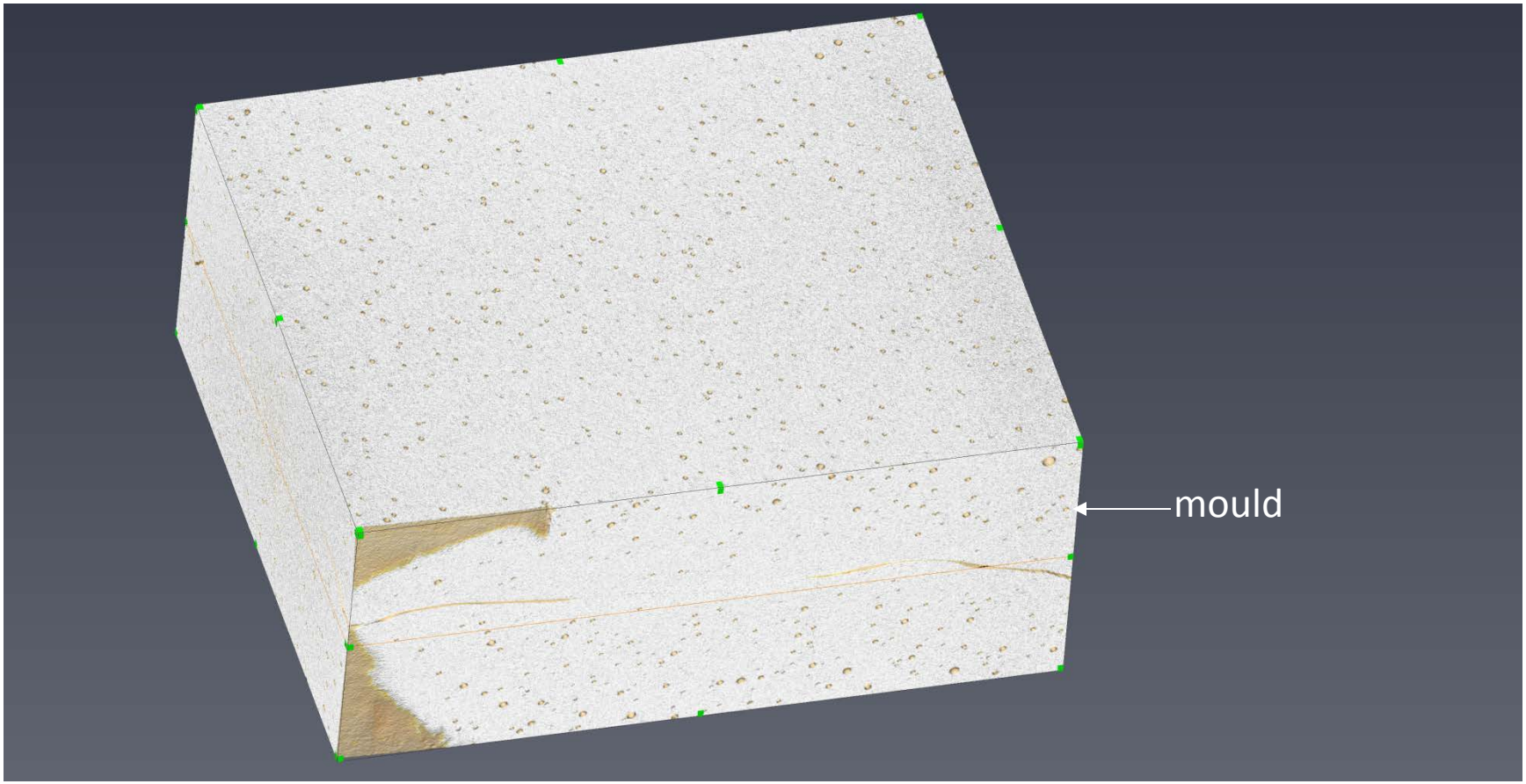
The object is rotated over 360° step by step and at each step, an X-ray image is recorded.

X-ray µ-CT scanner



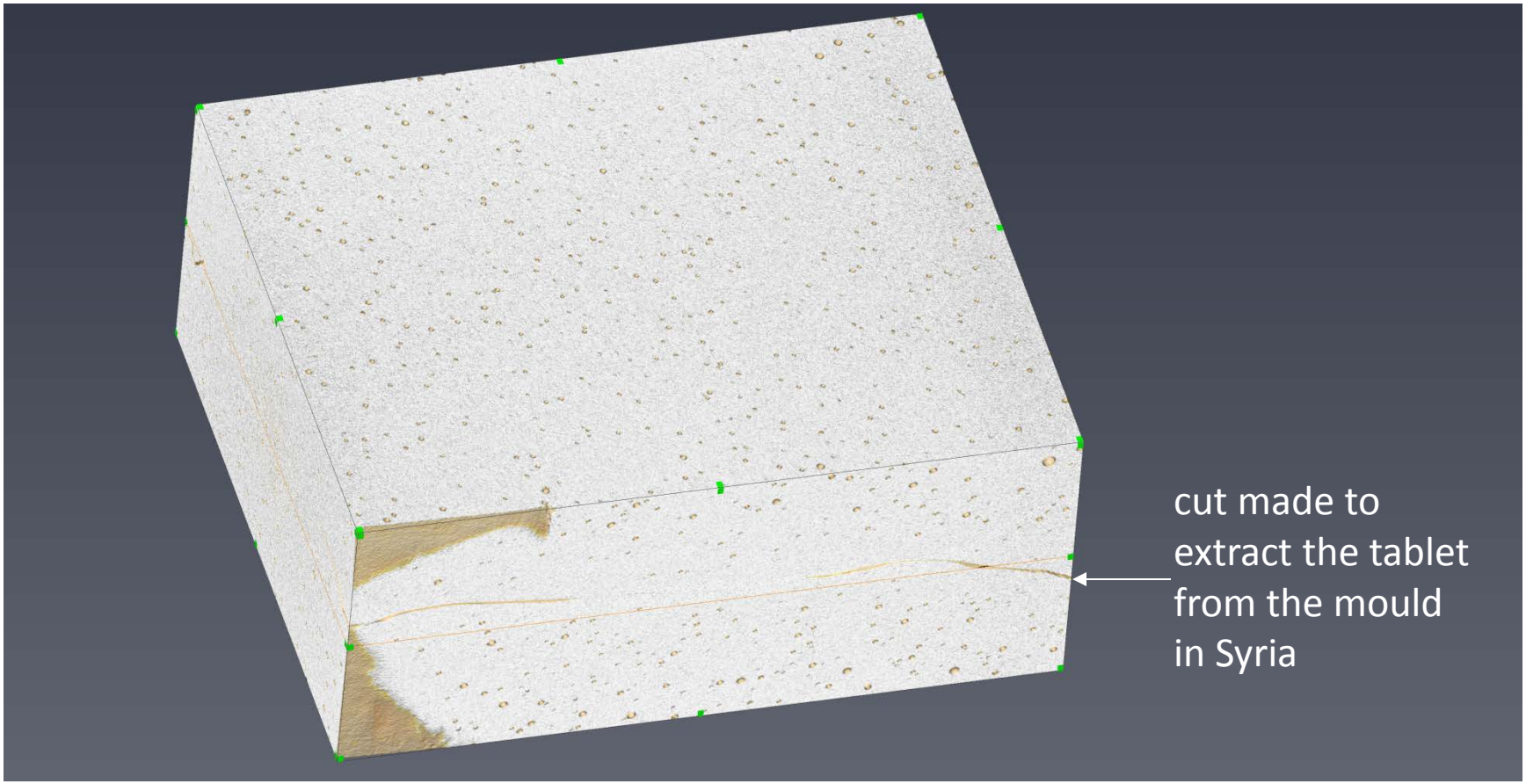
The X-ray images are then combined to re-construct in 3D both the external and internal structures of the object.

X-ray µ-CT scanner

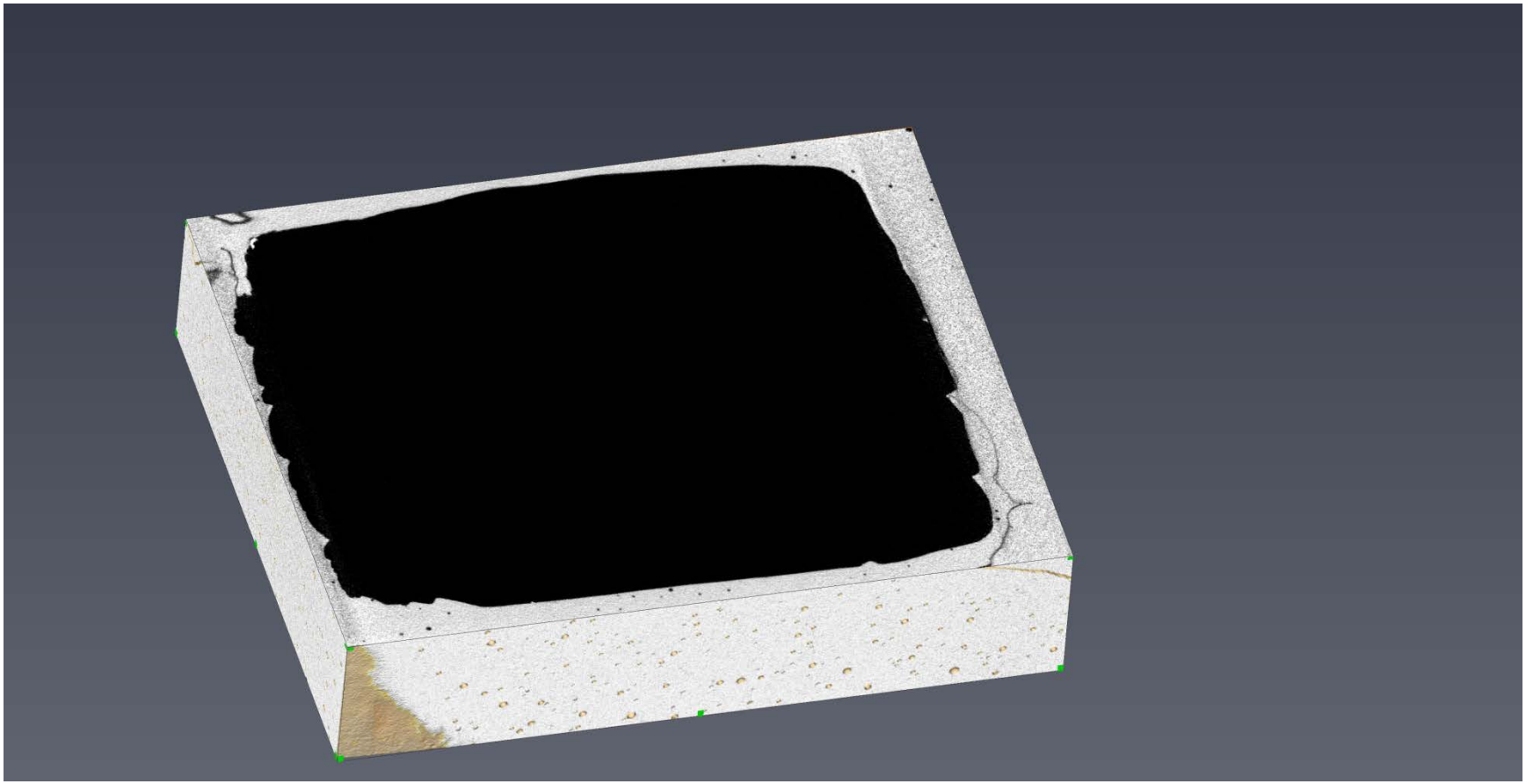


3D reconstruction of the silicone rubber mould from X-ray µ-CT scan.

X-ray µ-CT scanner

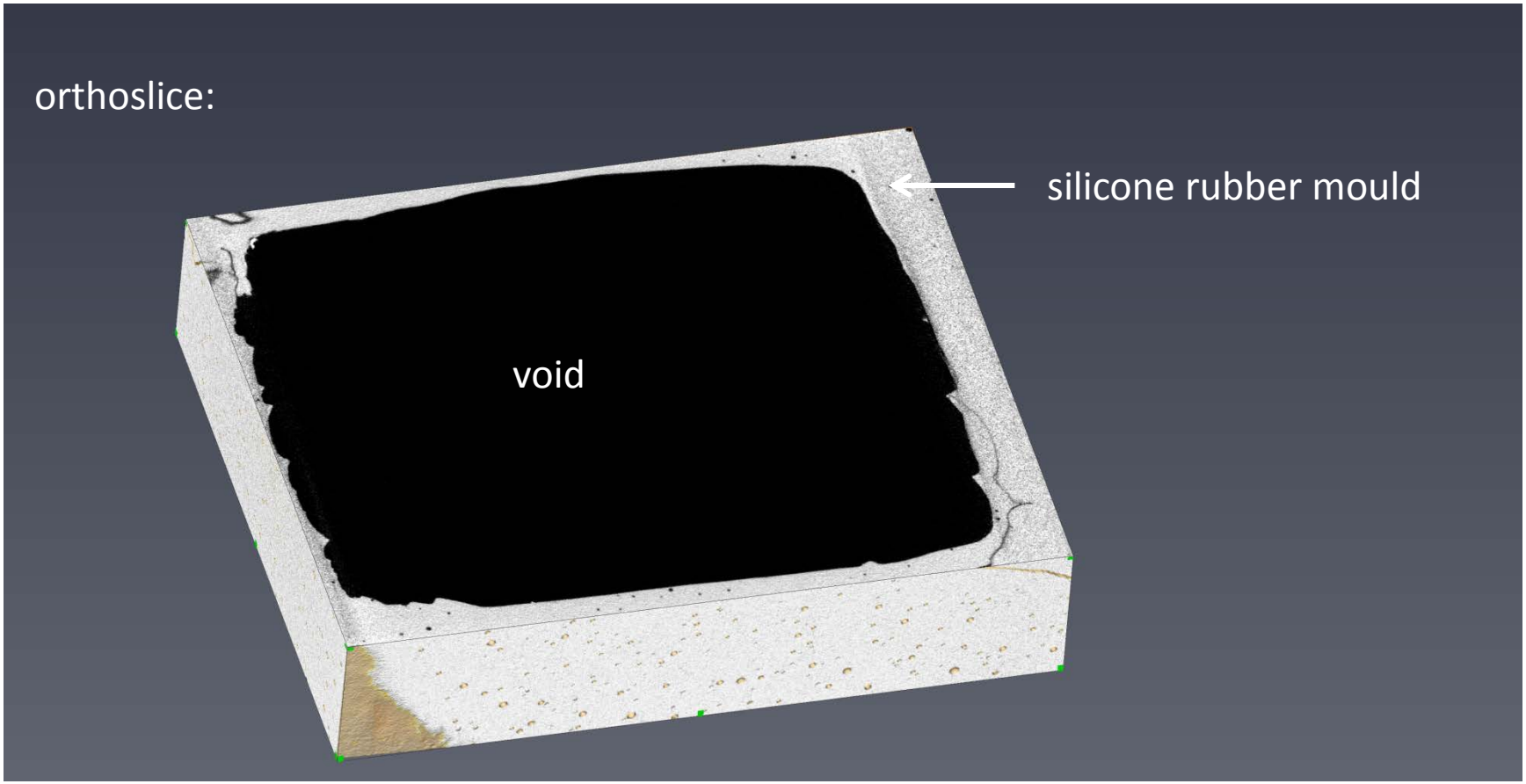


X-ray µ-CT scanner



Mould cut virtually by a horizontal orthoslice.

X-ray µ-CT scanner



The void left by tablet does not attenuate X-ray. It is black.
The silicone rubber of the mould attenuates X-ray. It is grey.

X-ray µ-CT scanner

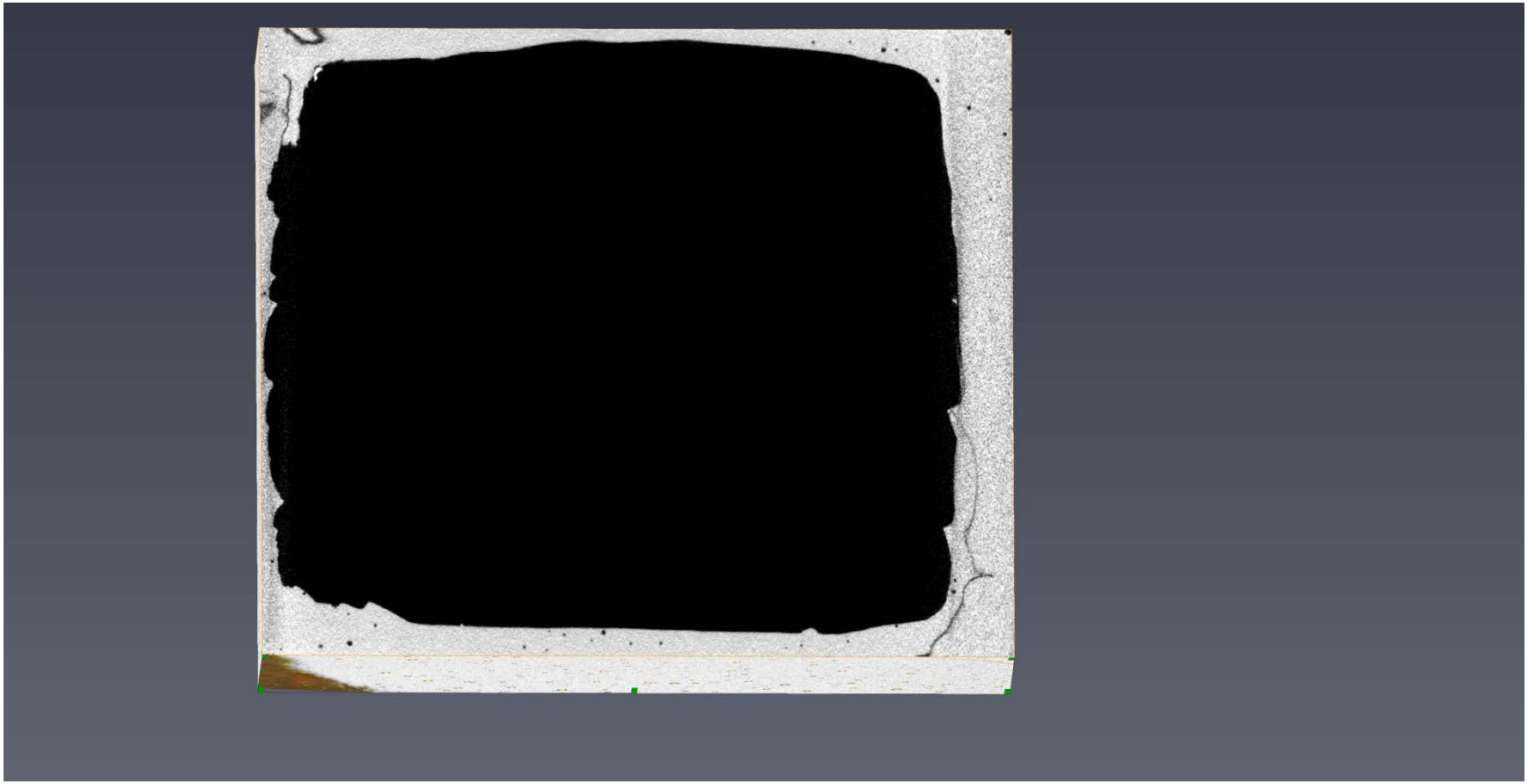
Underneath the orthoslice, the surface of the mould is clearly visible!

X-ray µ-CT scanner

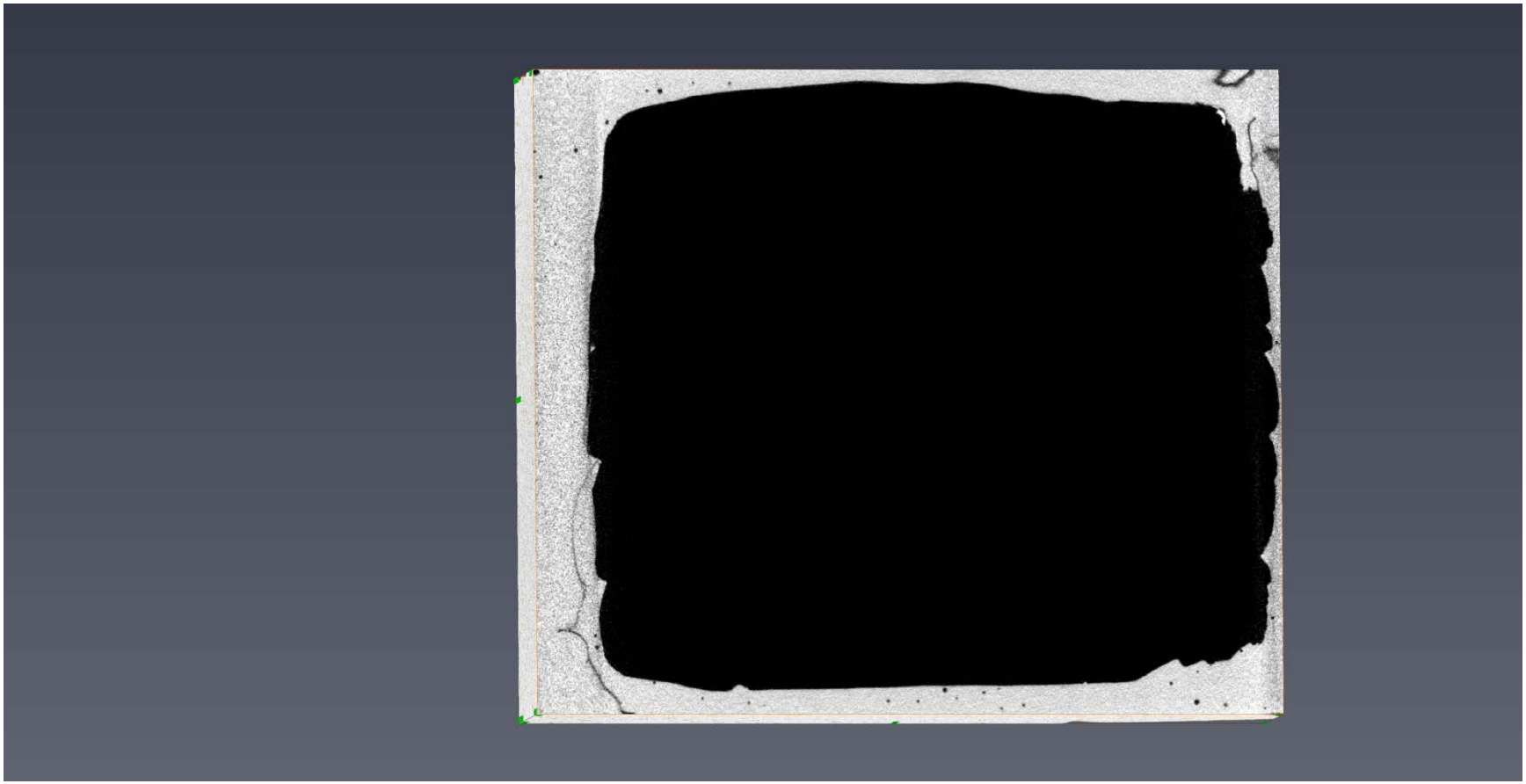
Tablet front face

Note the cuneiform characters on all 4 side faces of T98-34!

X-ray µ-CT scanner



X-ray µ-CT scanner

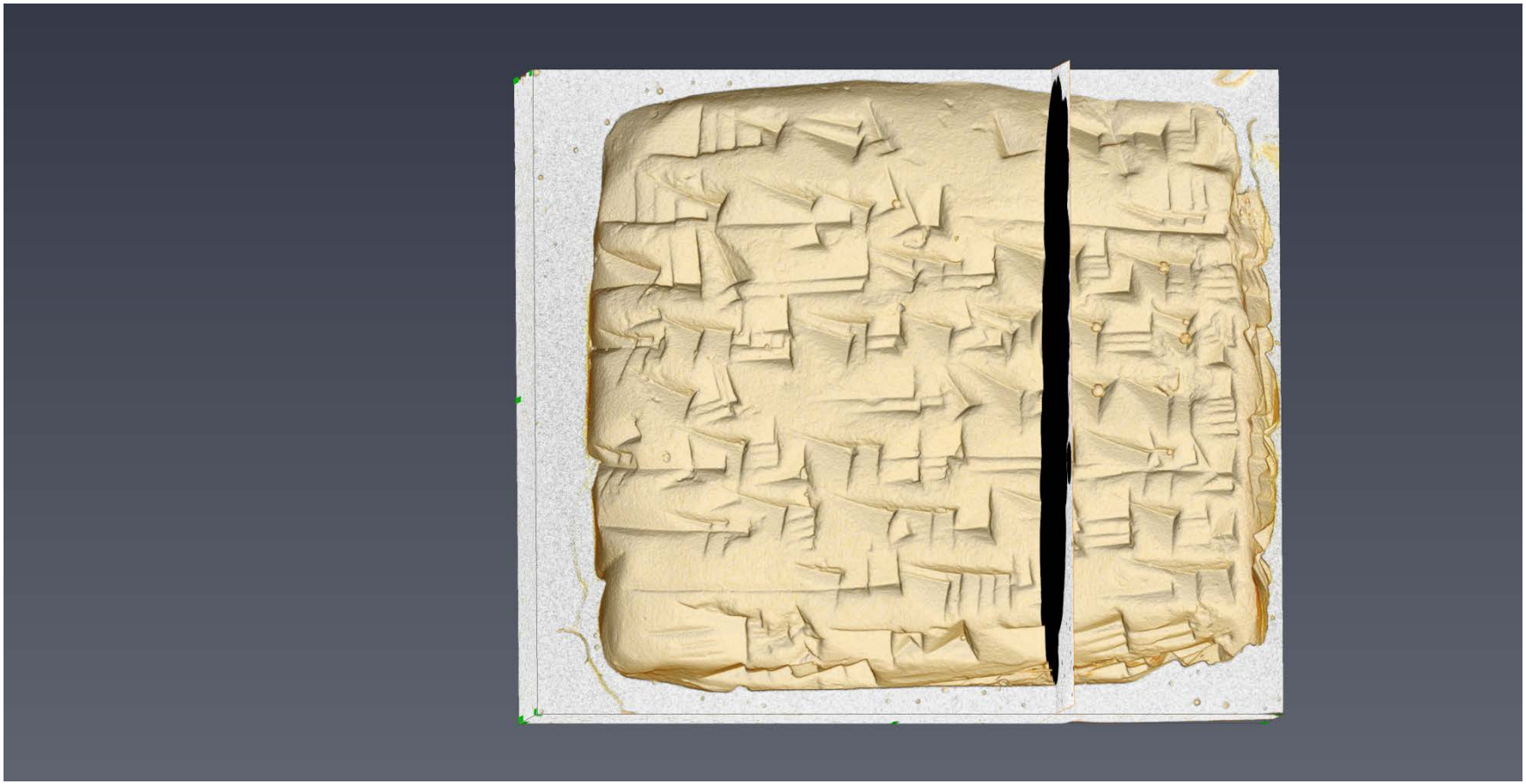


The tablet is turned to see its back face underneath the orthoslice.

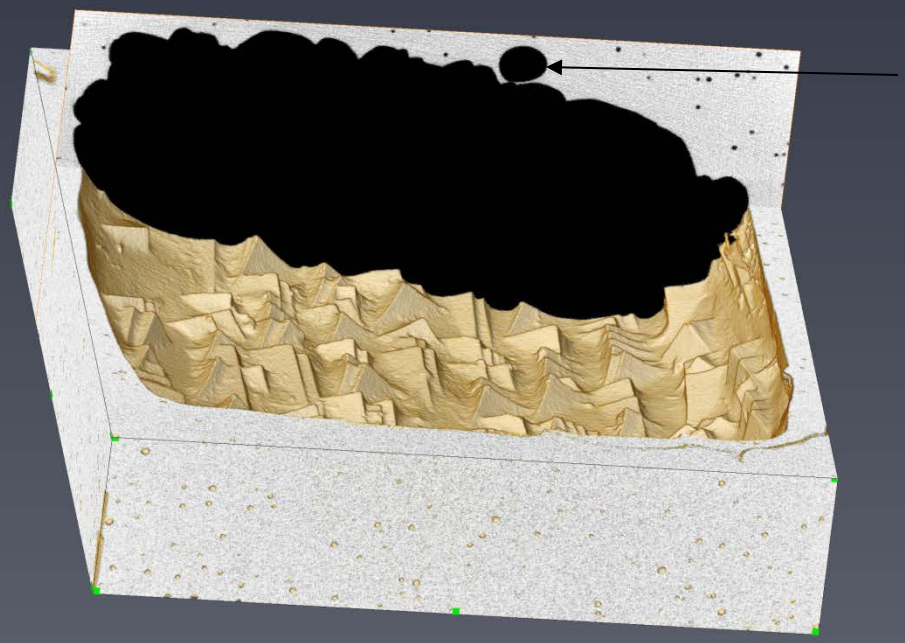
X-ray µ-CT scanner

Tablet back face

X-ray µ-CT scanner



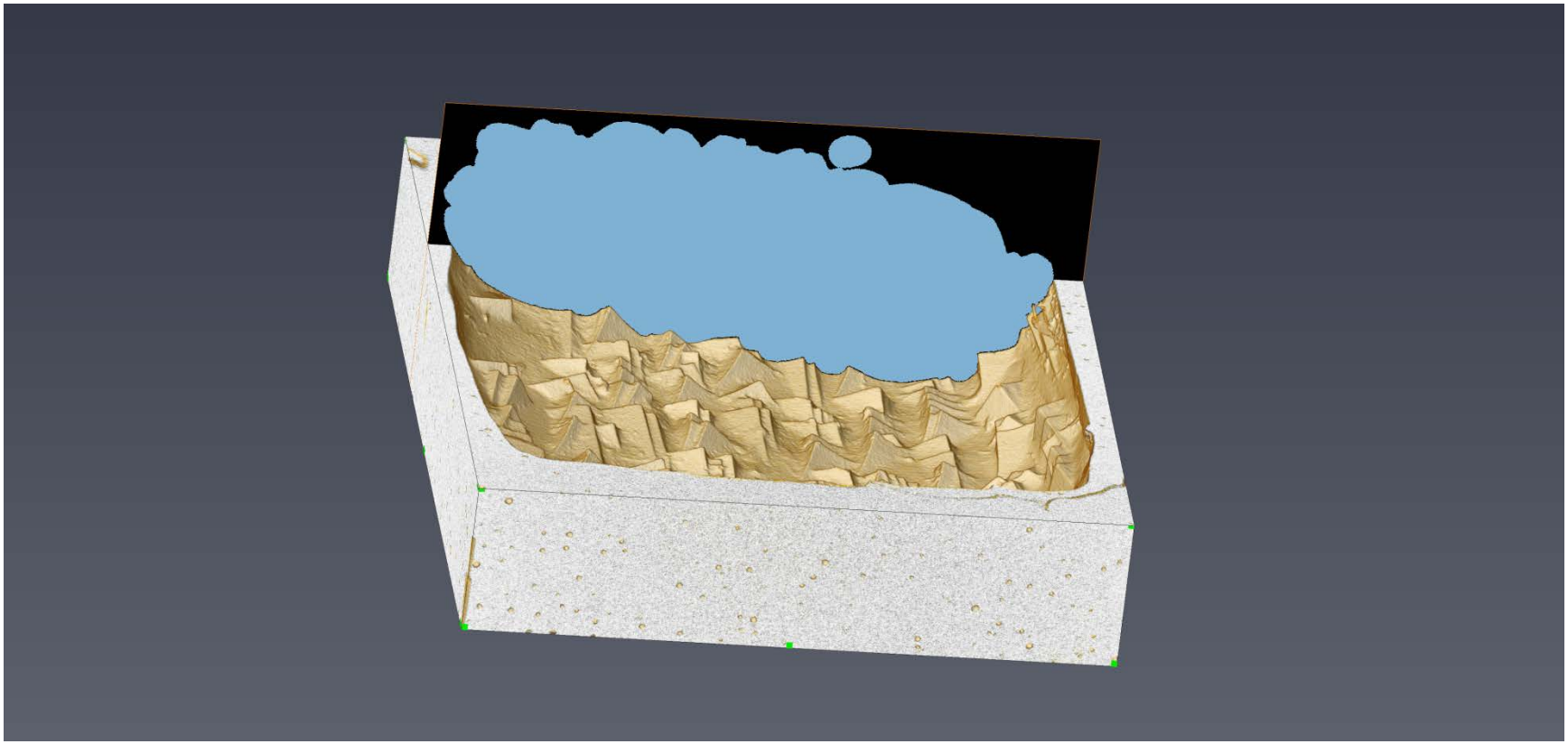
X-ray µ-CT scanner



Large bubble in contact with the mould.
It can be used as marker or digitally cut!

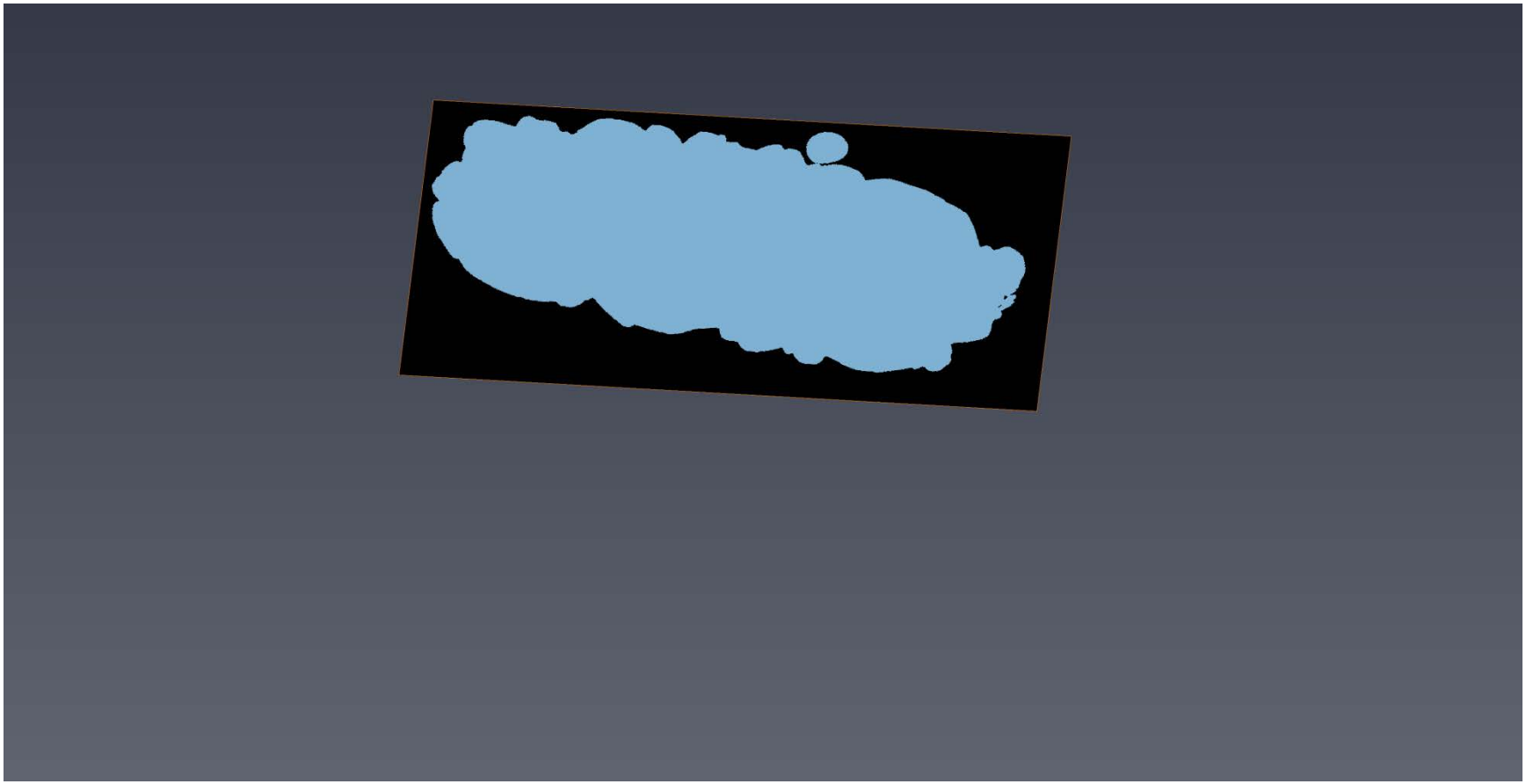
Air bubbles were trapped at the tip of some wedges when the cast was made.

X-ray µ-CT scanner



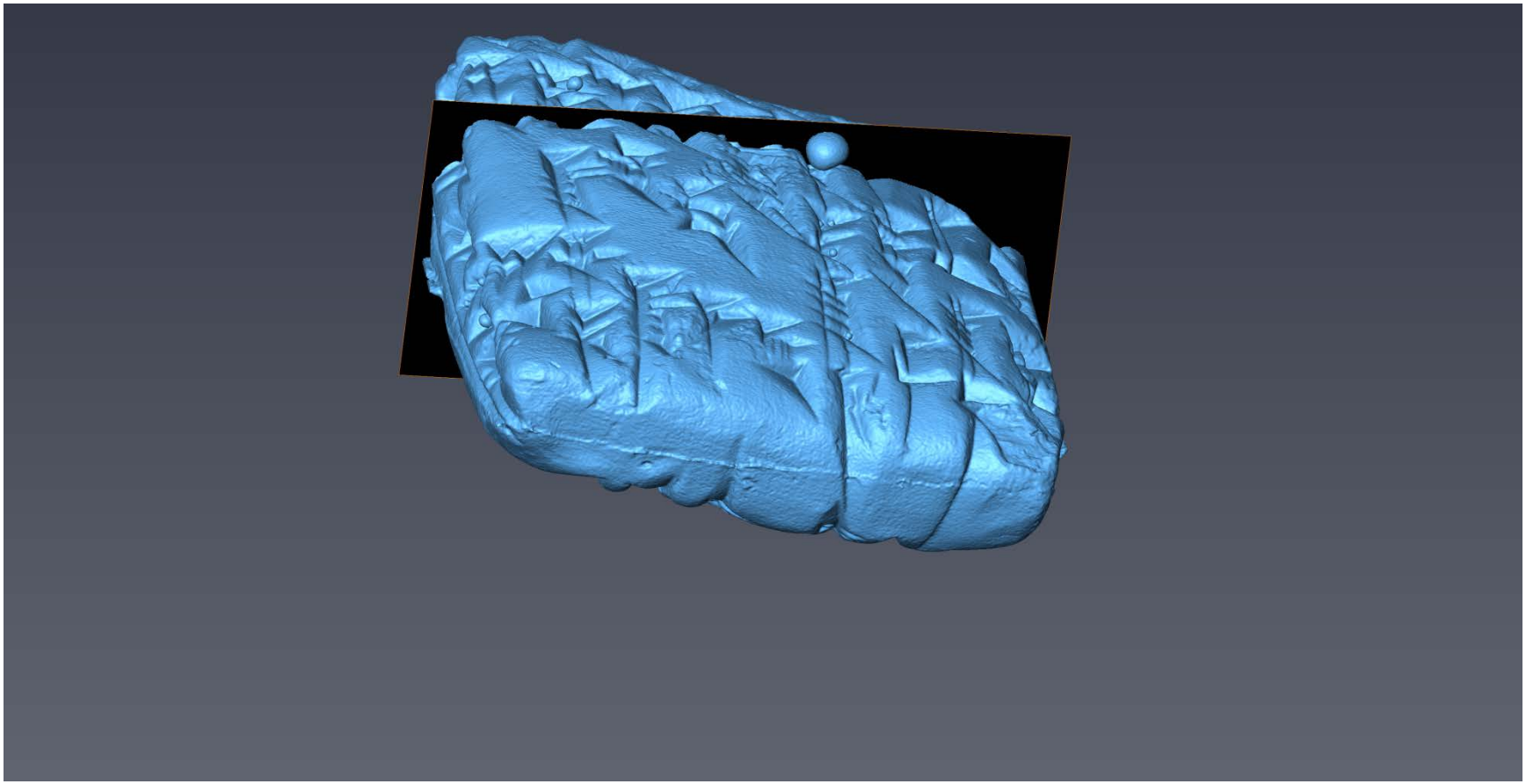
The volume representing the tablet is created by interactive thresholding of grey levels followed by labelling of voids, discarding of external void and bubbles not connected to the tablet .

X-ray μ-CT scanner



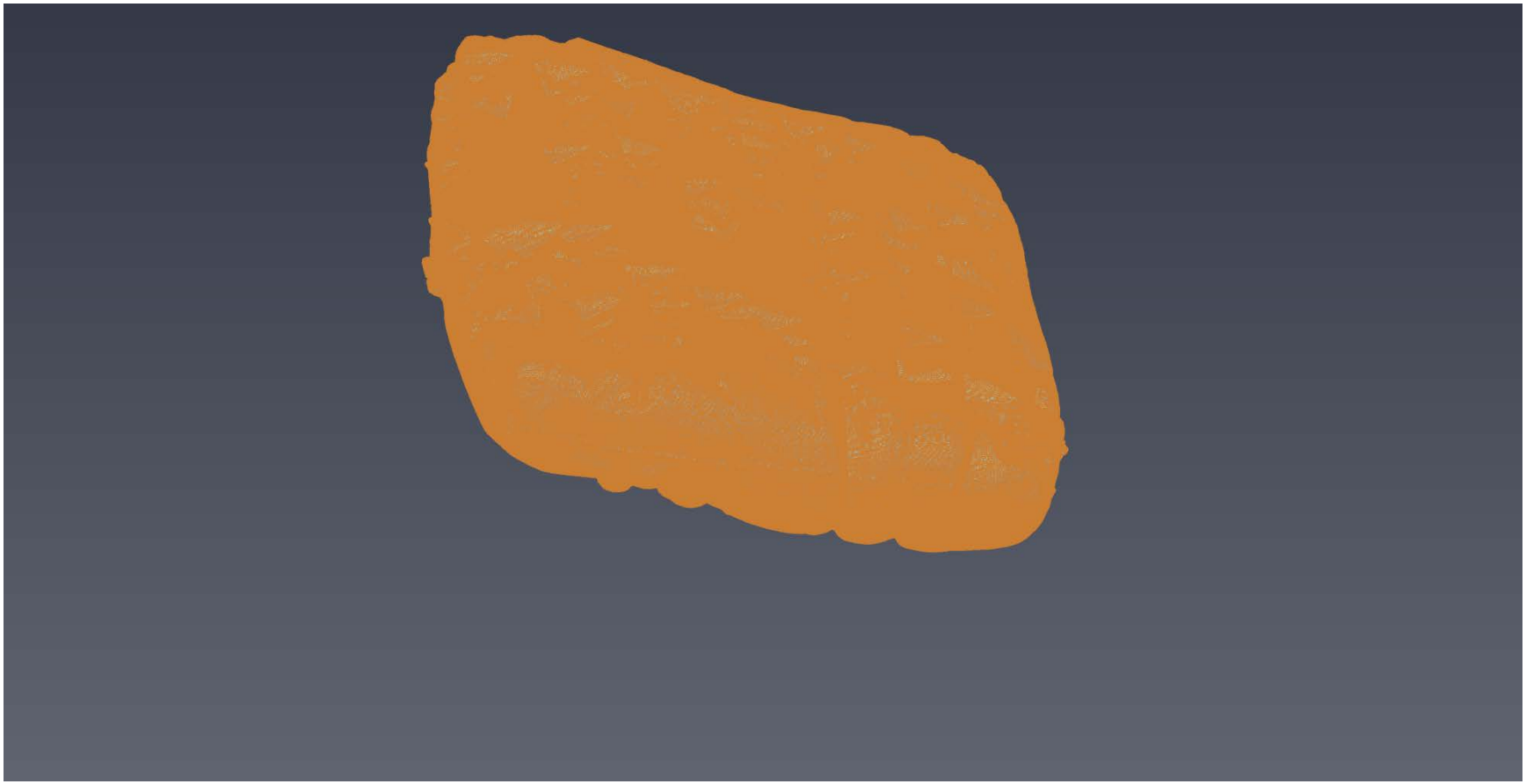
Binary representation of the tablet to produce the 3D model of the tablet.

X-ray µ-CT scanner



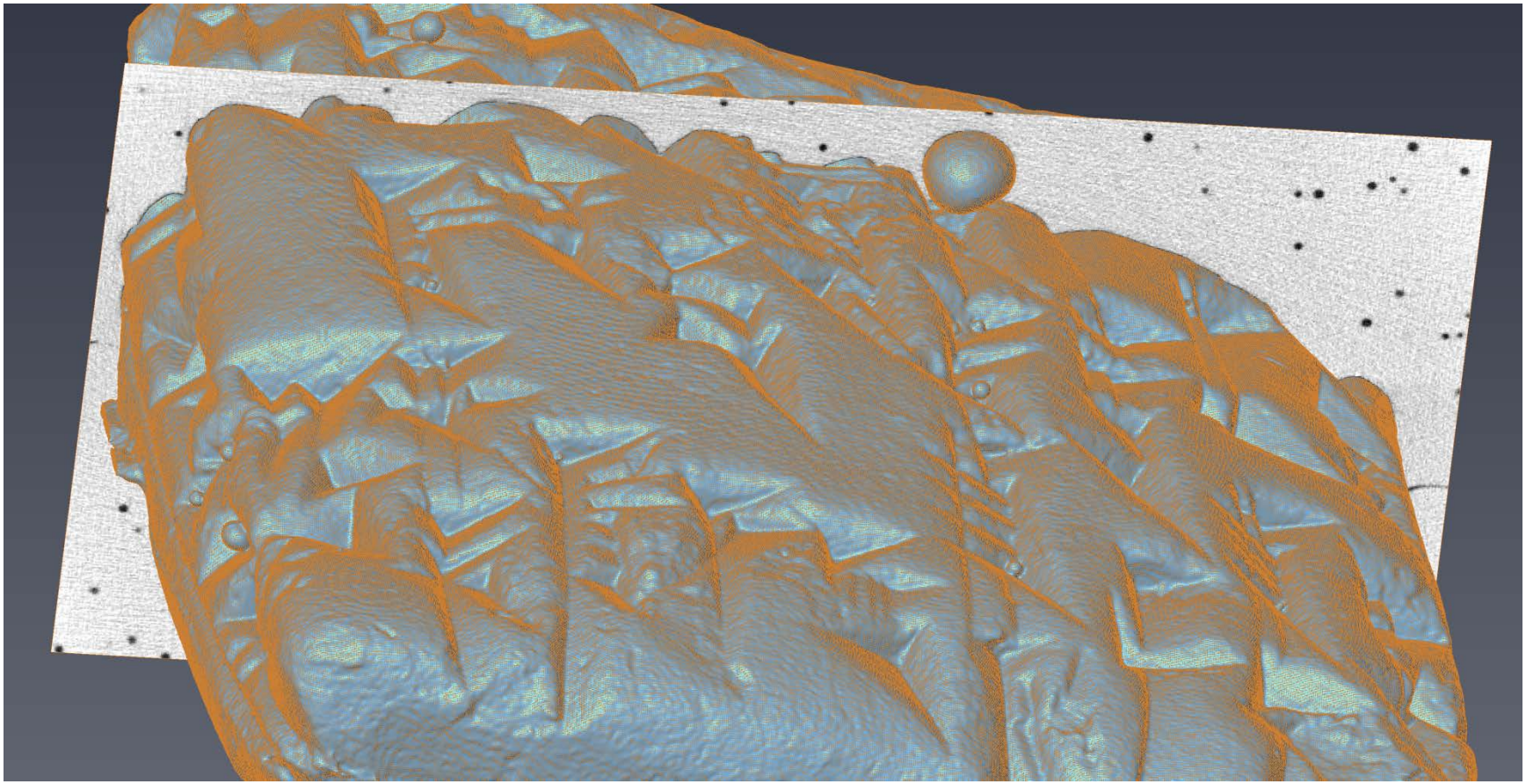
The surface of the tablet is generated from the 3D model.

X-ray µ-CT scanner



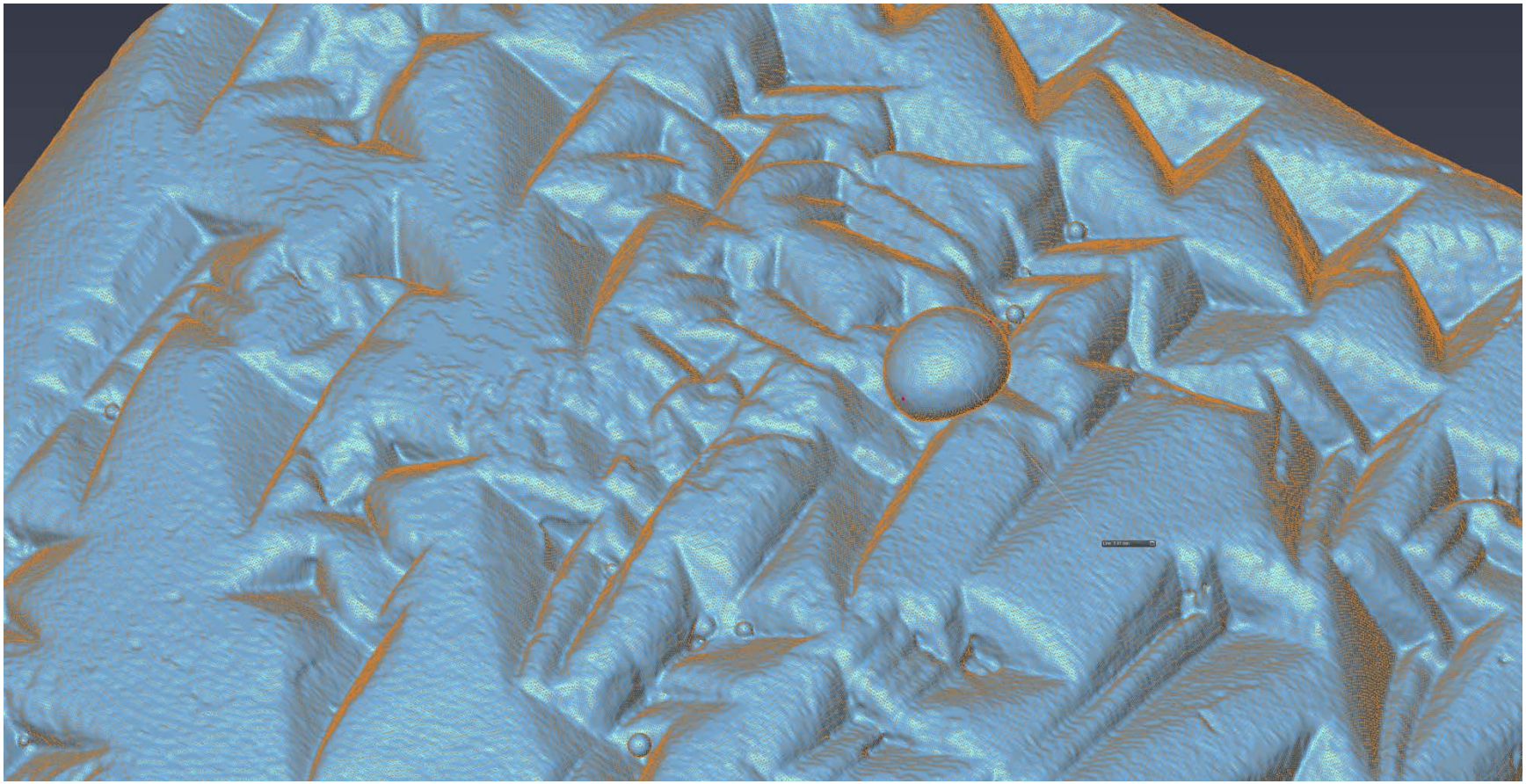
The tablet surface is meshed for further processing and 3D printing.

X-ray µ-CT scanner



Detail of the mesh

X-ray µ-CT scanner



Detail of the mesh

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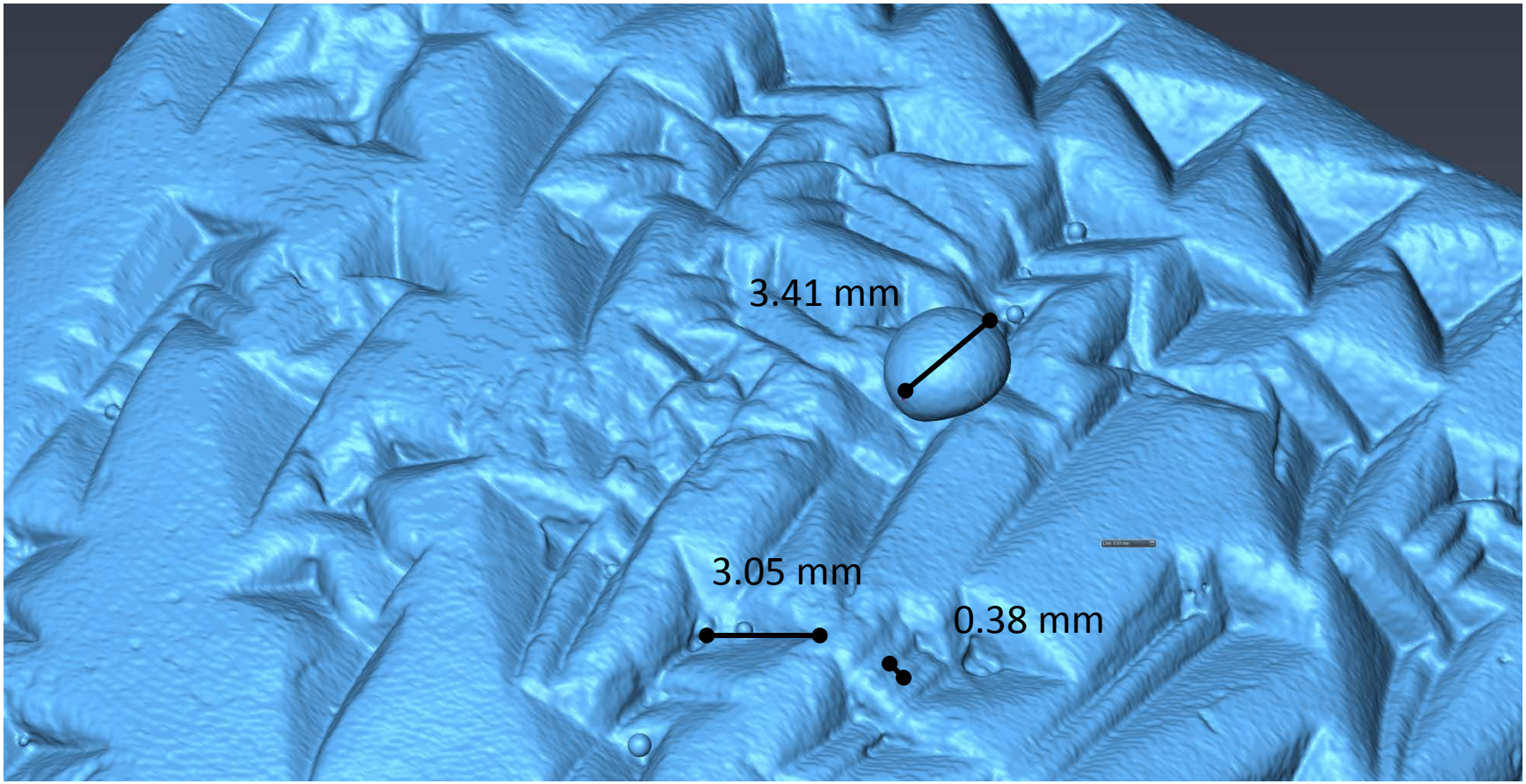
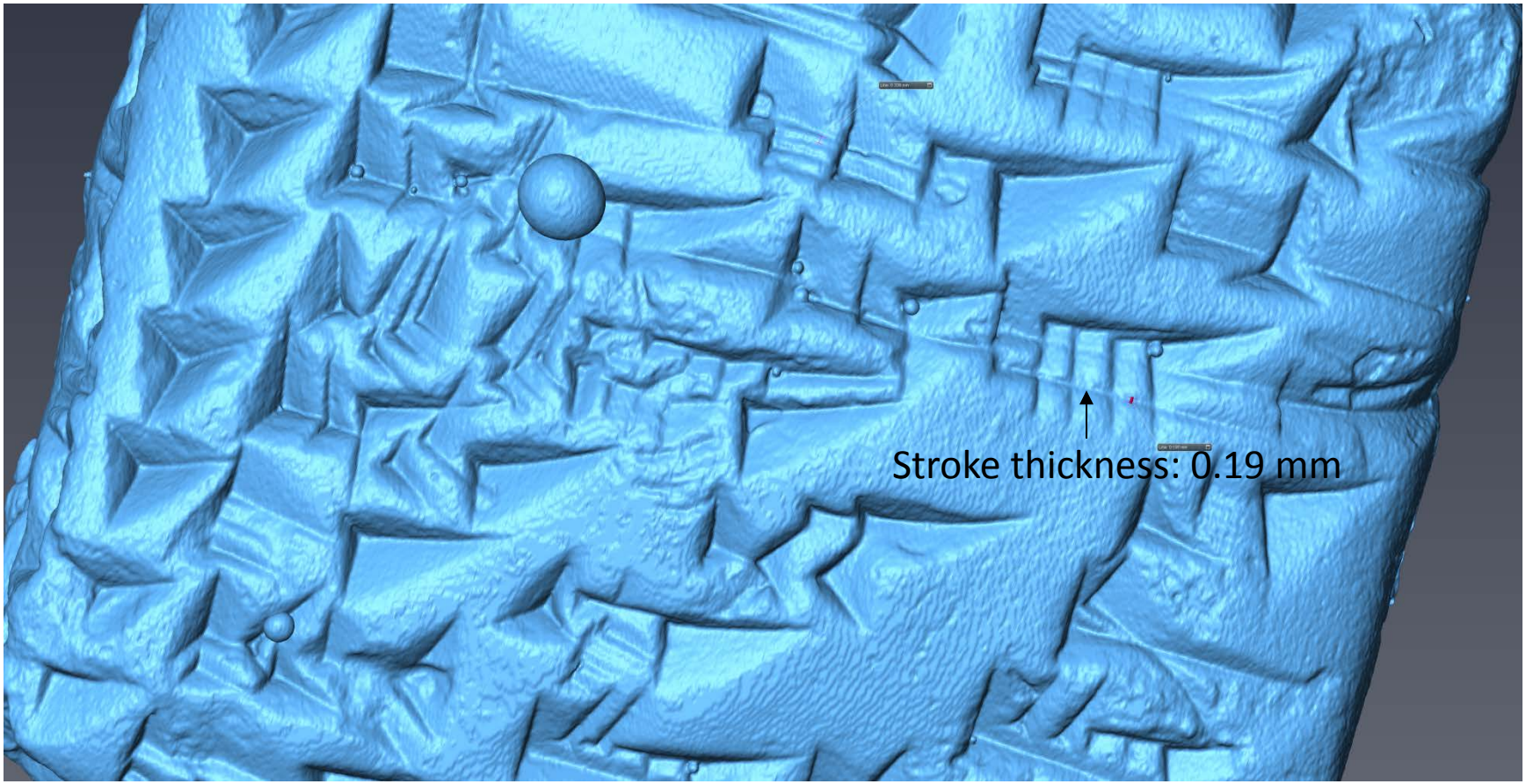


X-ray µ-CT scanner



Very fine and tiny signs are visible on the digital model with a voxel size: 30 x 30 x 30 μm^3!

X-ray µ-CT scanner

Technical details of scan of mould T98-34

- Scan duration = 75 min
- Scan processing = 20 min
- Resolution = 30 µm
- Raw data size = 11 200 MB (30 µm resolution)
  1 400 MB (60 µm resolution)

$\Rightarrow$ Accurate (but voluminous) 3D digital model.

$\Rightarrow$ Very good legibility of the digital model.

$\Rightarrow$ Model can be printed in 3D to obtain a faithful physical replica.

X-ray µ-CT scanner

Evaluation of the digital model of T98-34 by assyriologists:

- Prof van Soldt (Leiden University)

  "Almost as good as the original tablet!"
- Prof Waerzeggers & Theo Krispijn (Leiden University)

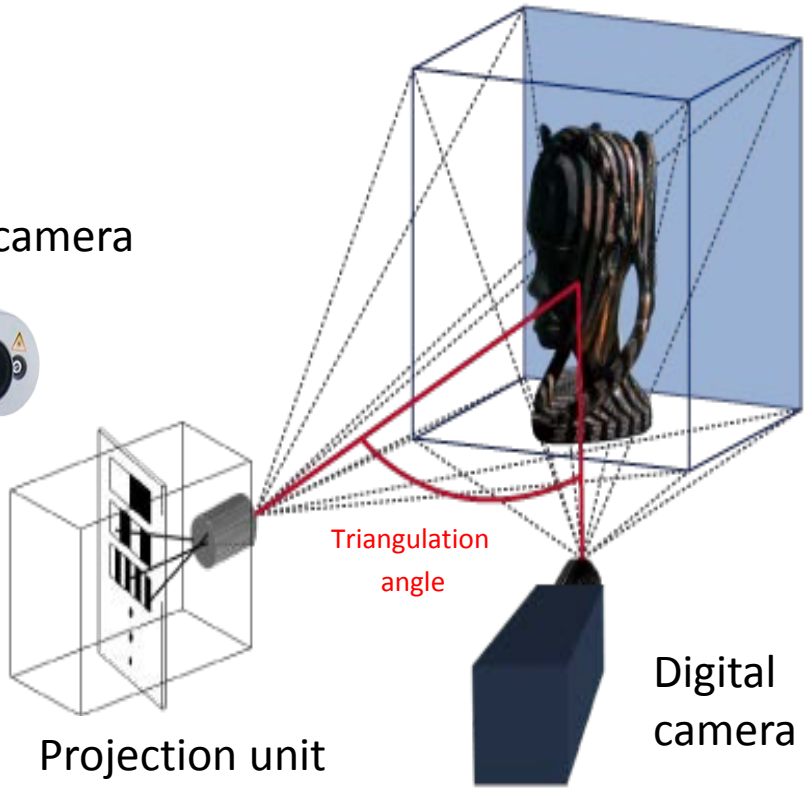
  "We can read it!"
- Dr Rients de Boer (Vrije Universiteit Amsterdam, NINO)

  "Excellent legibility!"
- Prof Stefan Jakob (Heidelberg University)

  "Easy to read!"

Close range high resolution light scanner

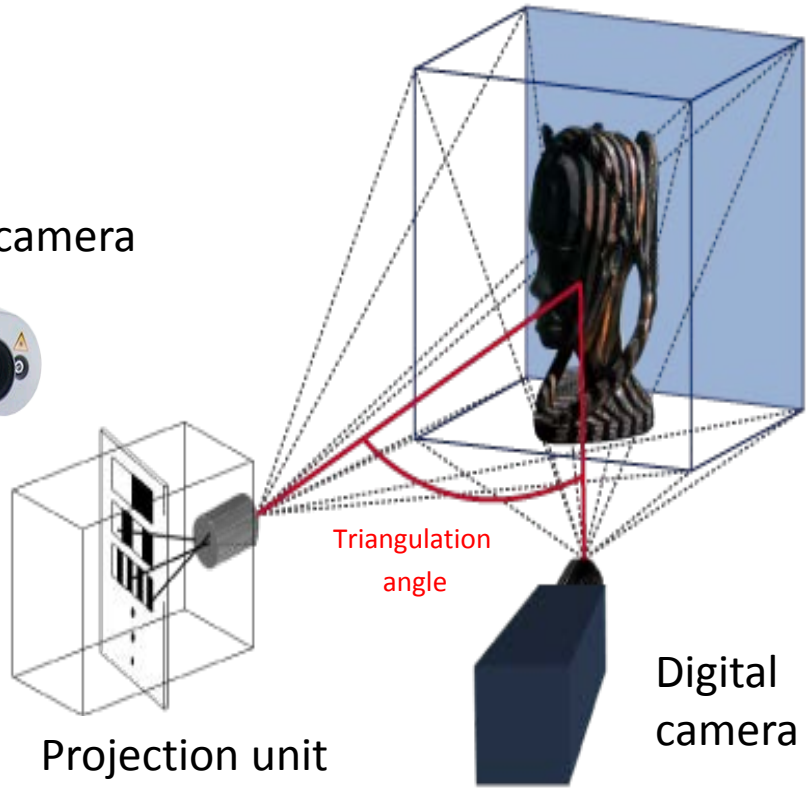
[images courtesy: AICON]



The mould of Tablet T98-34 was also scanned with a close range high resolution light scanner at Heidelberg University, …

Close range high resolution light scanner

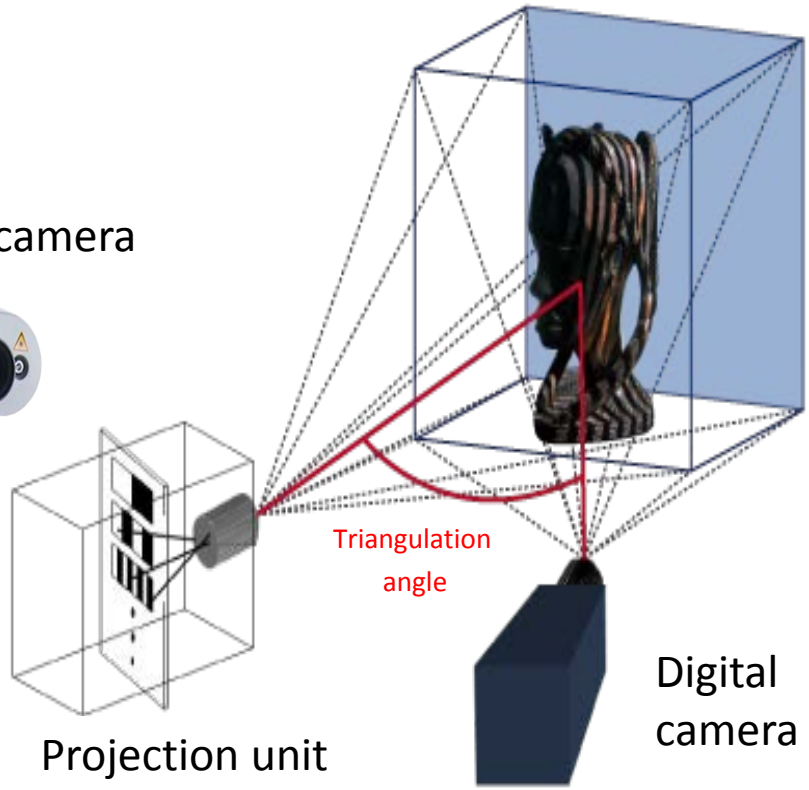
[images courtesy: AICON]



… with the aim of speeding up the digitalization process.

Close range high resolution light scanner

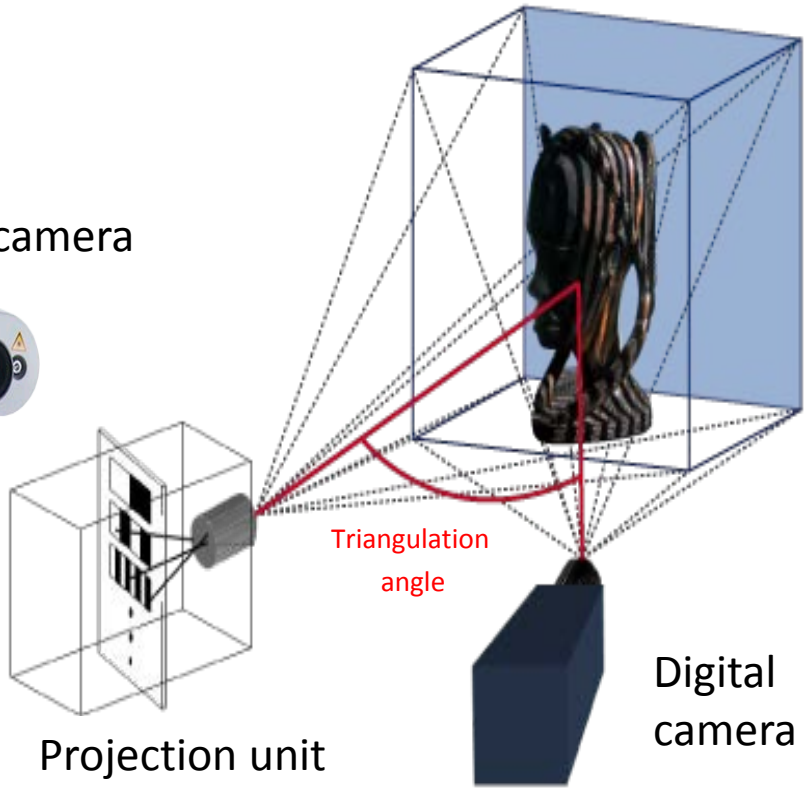
[images courtesy: AICON]



Patterns of stripes of light are projected onto the 3D object.

Close range high resolution light scanner

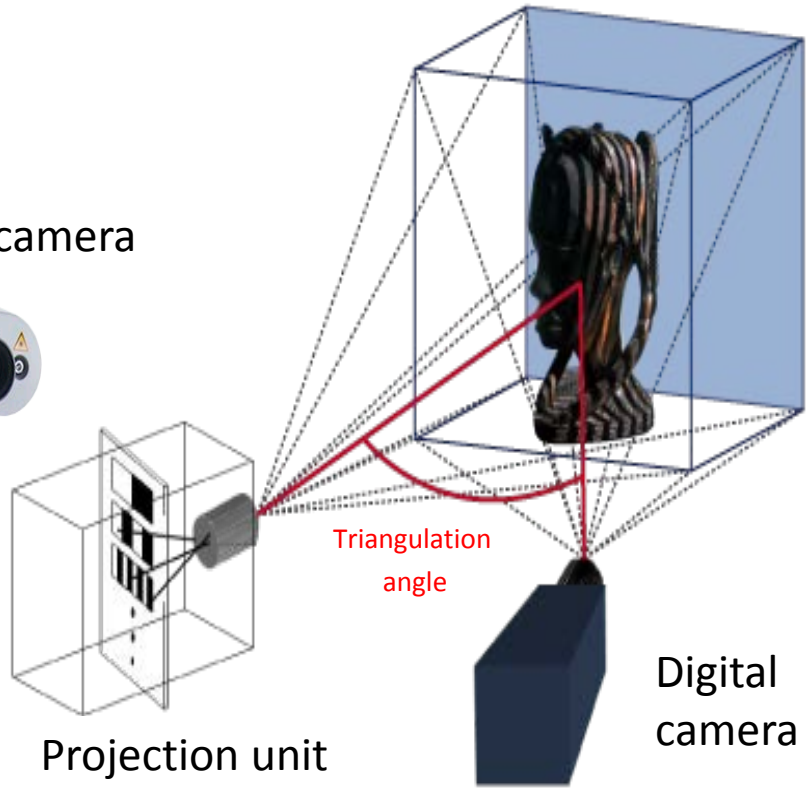
[images courtesy: AICON]



Seen from points of view other than that of the projector, the pattern appears geometrically distorted due to the surface shape of the object.

Close range high resolution light scanner

[images courtesy: AICON]



The distortion is used to retrieve the 3D coordinates of points on the surface of the object.

Close range high resolution light scanner

Technical details of scan of mould T98-34

- Resolution:

  Depends on the optics of the cameras that are used.

  5 µm with the scanner used!

- Duration:

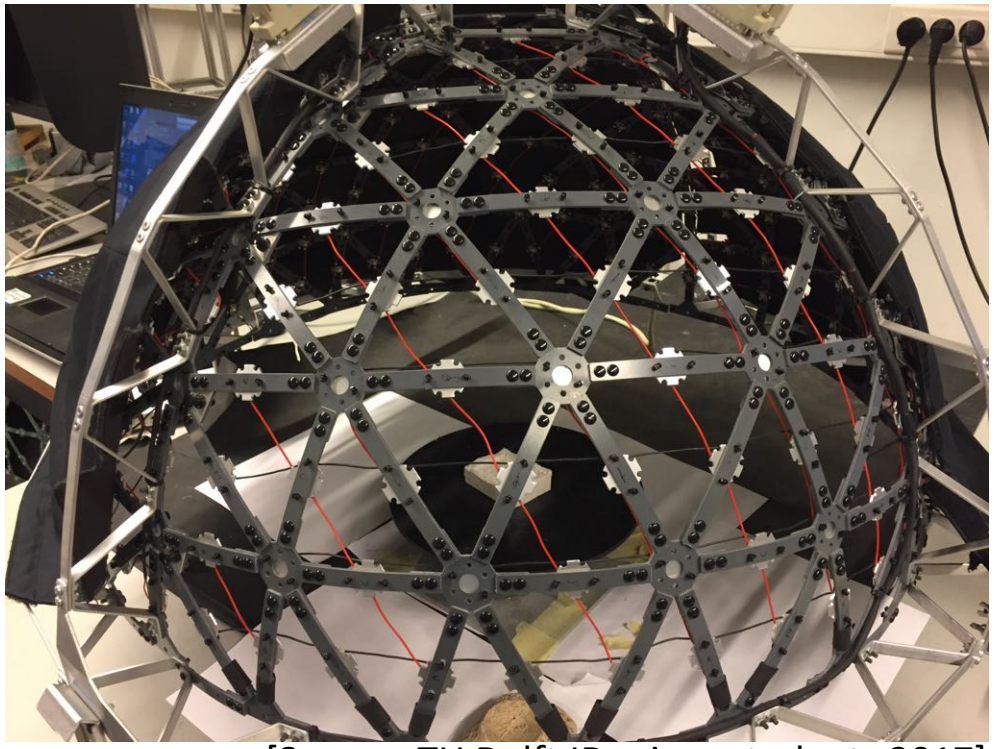
  20 to 90 min, depending on the complexity of the mould geometry, in other words, on the amount of information hidden in mould concavity.

- Processing for 3D model production:

  Depends on number of scans to be stitched!

- Raw data set: 500 MB.

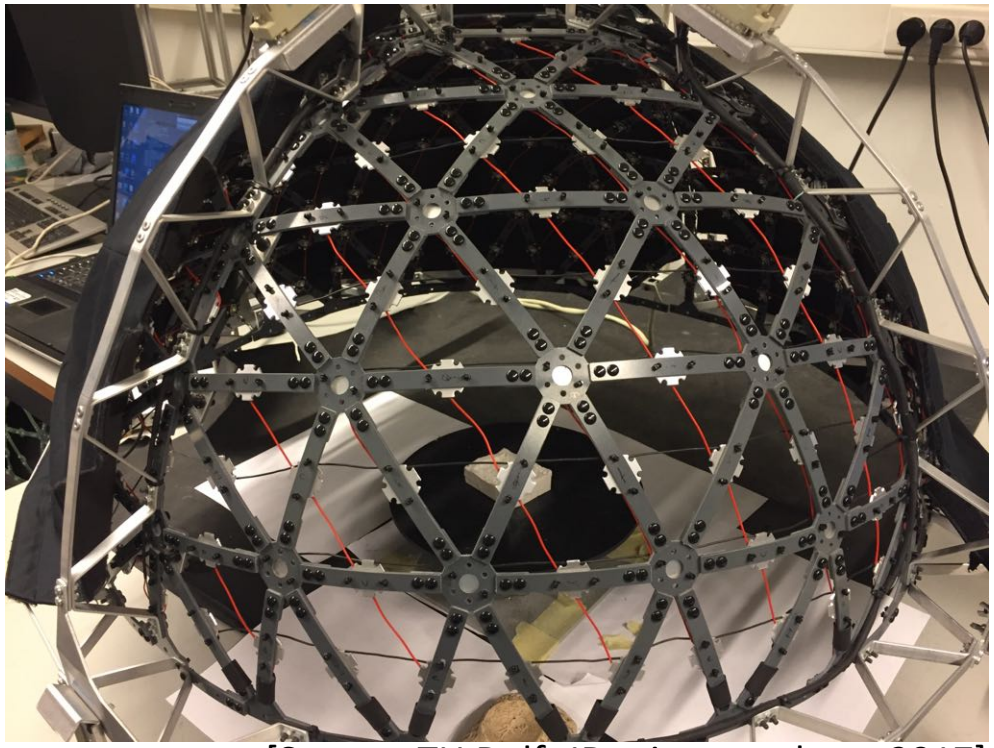
The White Light Portable Light dome



[Source: TU Delft ID minor students 2017]

The mould was also photographed with the 80 cm diameter white light portable light dome (WL PLD) developed by KU Leuven. Again to speed-up the digitalization!

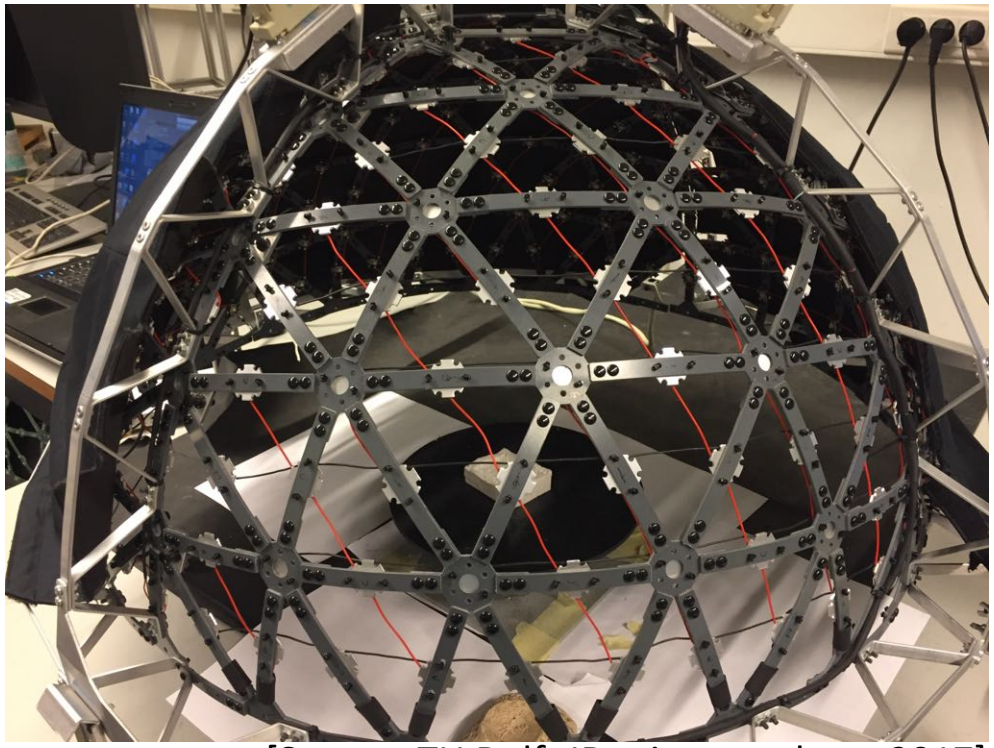
The White Light Portable Light dome



[Source: TU Delft ID minor students 2017]

The WL PLD acquired a dataset of images on which the mould was exposed by LED emitters from 260 different angles.

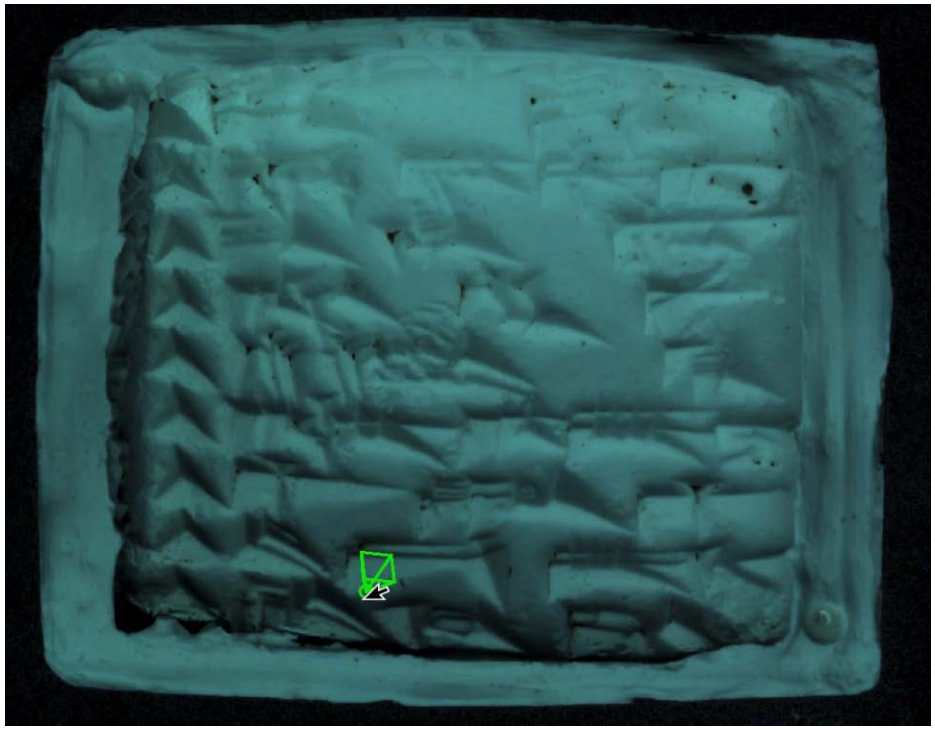
The White Light Portable Light dome



[Source: TU Delft ID minor students 2017]

The true reflection values and surface orientations of every pixel were calculated to obtain 2D and 3D models of the mould.

The White Light Portable Light dome



Virtual illumination of T98-34 front face under various angles.

The White Light Portable Light dome

Technical details of WL PLD images of mould T98-34

- Resolution: More than sufficient even with a 5 millions pixel camera sensor!
- Duration: Quick! Only a few min for scanning each (inner) face of the mould and for processing the images and obtaining the 2D model.
- Excellent legibility using virtual illumination of tablet surfaces under various angles.
- Excellent texture and colour rendering using spectral light.
- Size of raw data: 2 x 5 x 24 LED x 5*= 1200 MB

  * 2 ½ moulds, 5 faces with info each, 24 LED on, 5 MB image.

The White Light Portable Light dome

Technical details of WL PLD images of mould T98-34

Little disadvantages:

- Information hidden in the concavities of the moulds cannot be reached in one recording.
- Several recordings are made with the mould inclined at various angles and then stitched together.
- 3D models can be produced from the photos taken by the WL PLD by integrating the local surface orientation. Fine details like engravings are captured well, but the overall shape (e.g. the curves at the sides) may be distorted.

Digitalization techniques applied to mould with concavities

	X-ray µ-CT scanner	Close range high resolution light scanner	White Light Portable Light dome
Mobility	-	+	++
Acquisition time	-	+	++
No hidden text	++	-	-
Processing time	+	+	++
Resolution	+	++	++
Raw data size	-	+	+
Text legibility	++	++	++
Texture and colour	-	+	++
3D model accuracy	++	++	- -

The animated story of T98-34, the clay tablet born again and again

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Translation process

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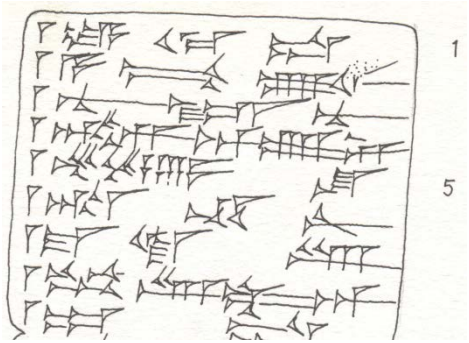


1	^{1}*ia-di-du*	Yadidu
	^{1}*a-bi-šam-ši*	Abi-shamshi
	^{1}*nu-ra-nu*	Nuranu
	^{1d}IM-DINGIR-*ú-ni*	Adad-iluni
5	^{1}*mu-ter-šu*	Mutershu
	^{1d}UTU-EN-PAP	Shamash-bel-ibni
	^{1} *ma-ki-ru*	Makiru
	^{1}*qu-ru-ub*-DINGIR	Qurub-ili
	^{1}*ab-du*	Abdu

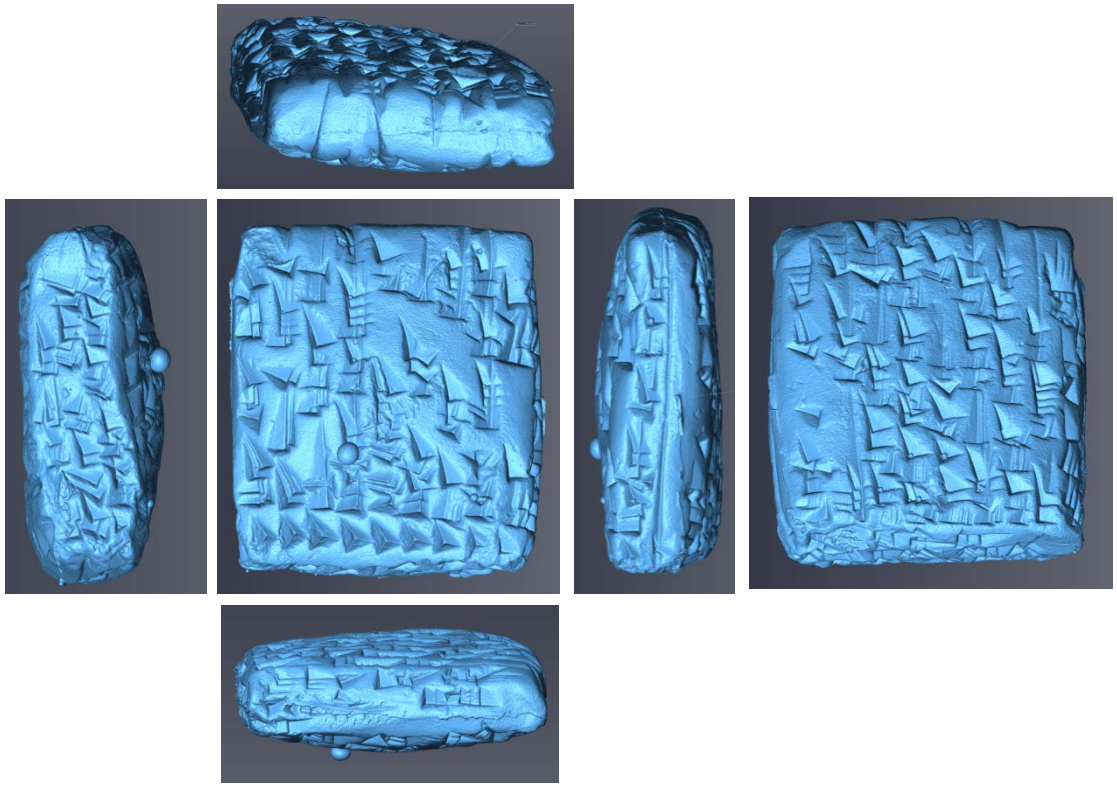
1. tablet reading and decipherment

2. Latin transliteration

3. translation

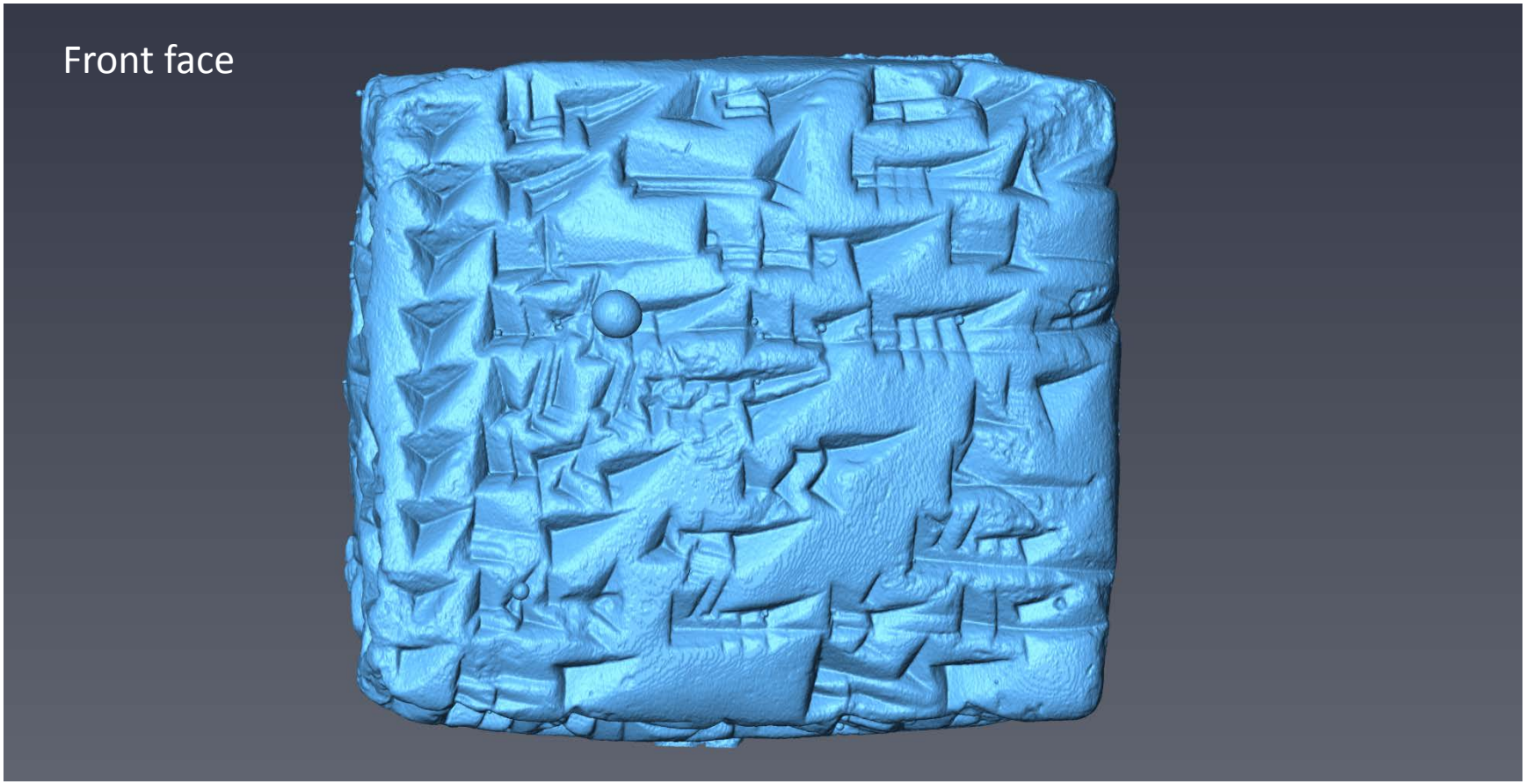
Translation is a time consuming 3-steps process!

Translation process



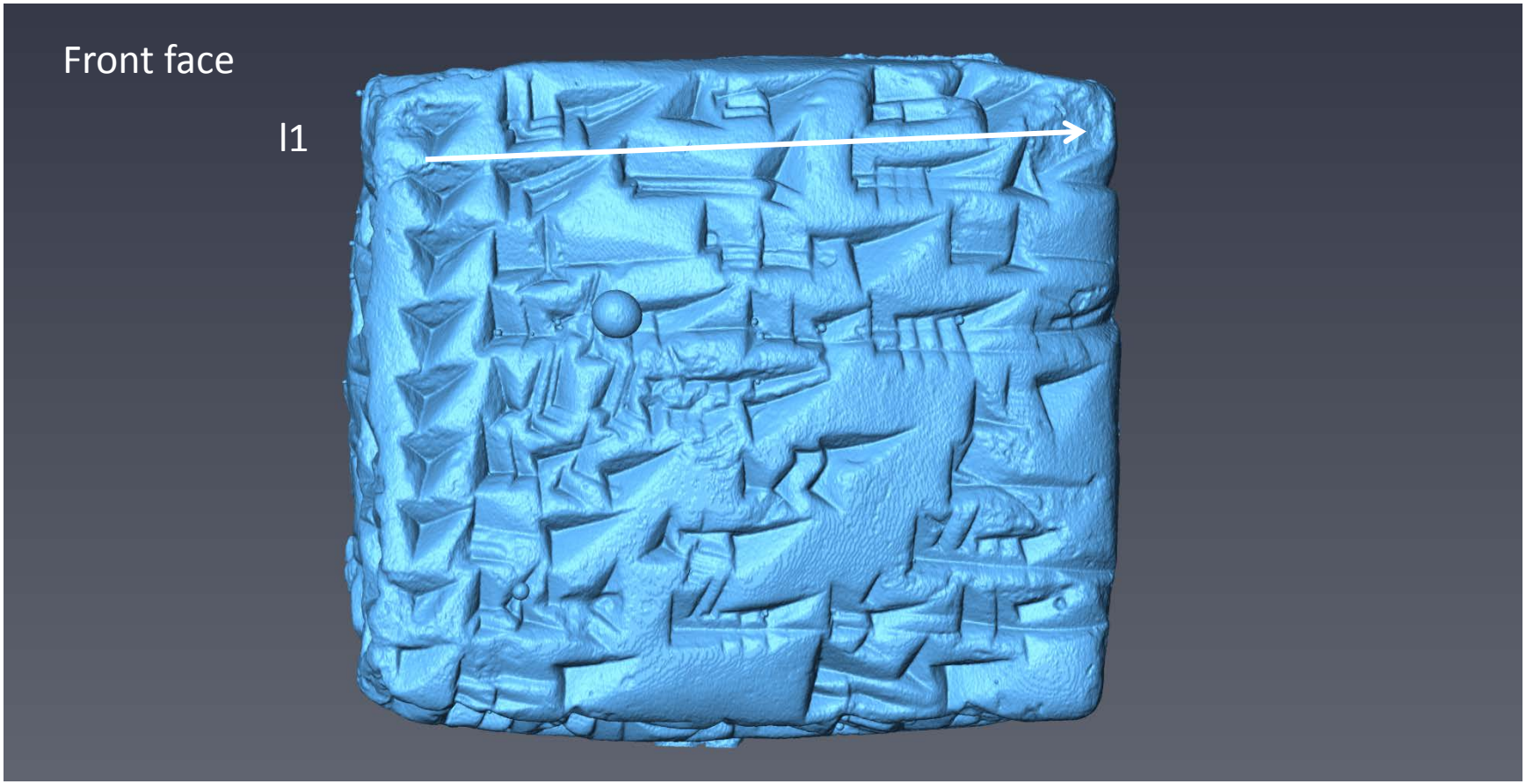
The tablet carries information on its 6 faces!

Translation process



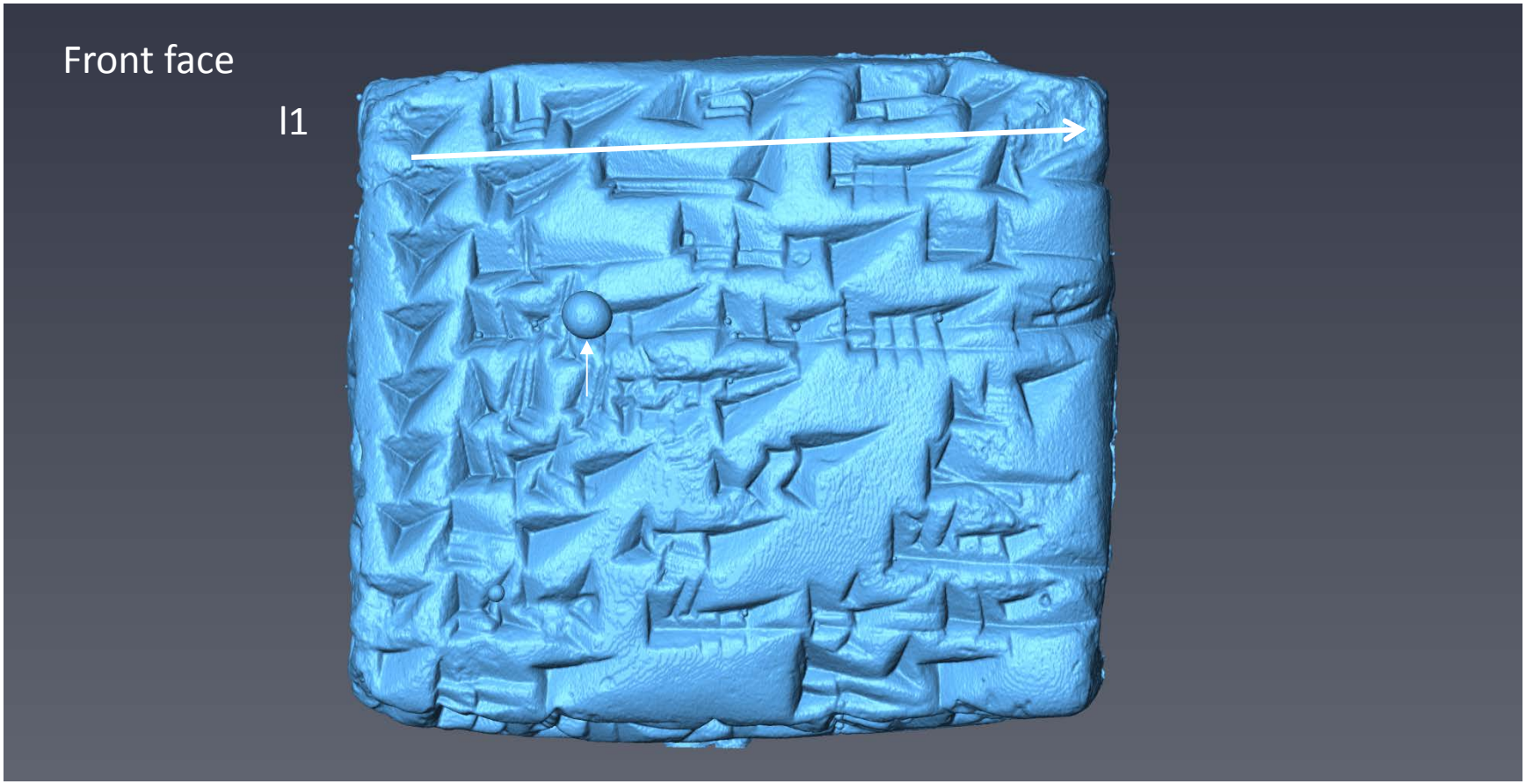
How one can read the 6-faces tablet, line (l) per line (l)?

Translation process



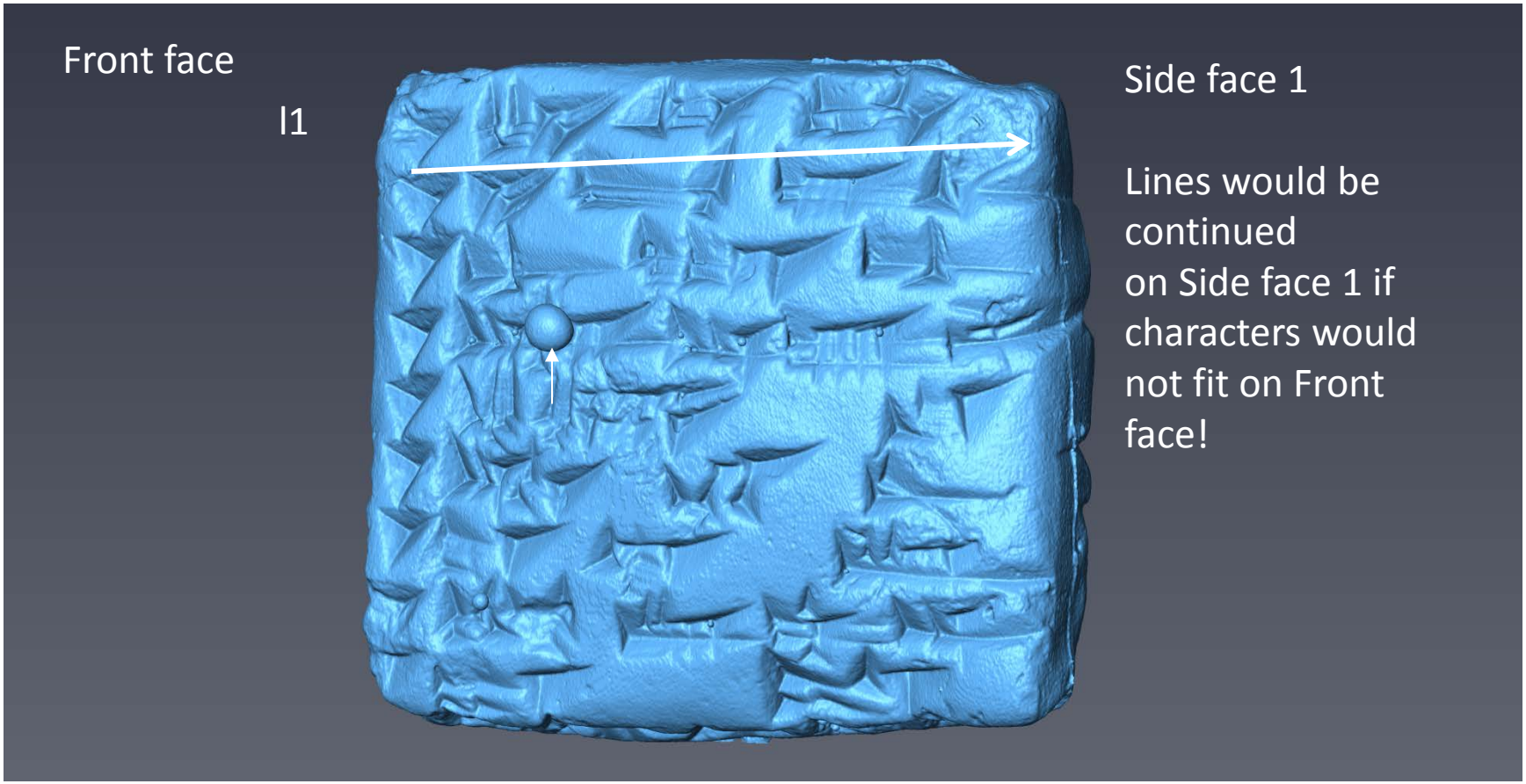
How one can read the 6-faces tablet, line per line?

Translation process



Note the varying inclination of the tablet that changes illumination angle for a better legibility!

Translation process



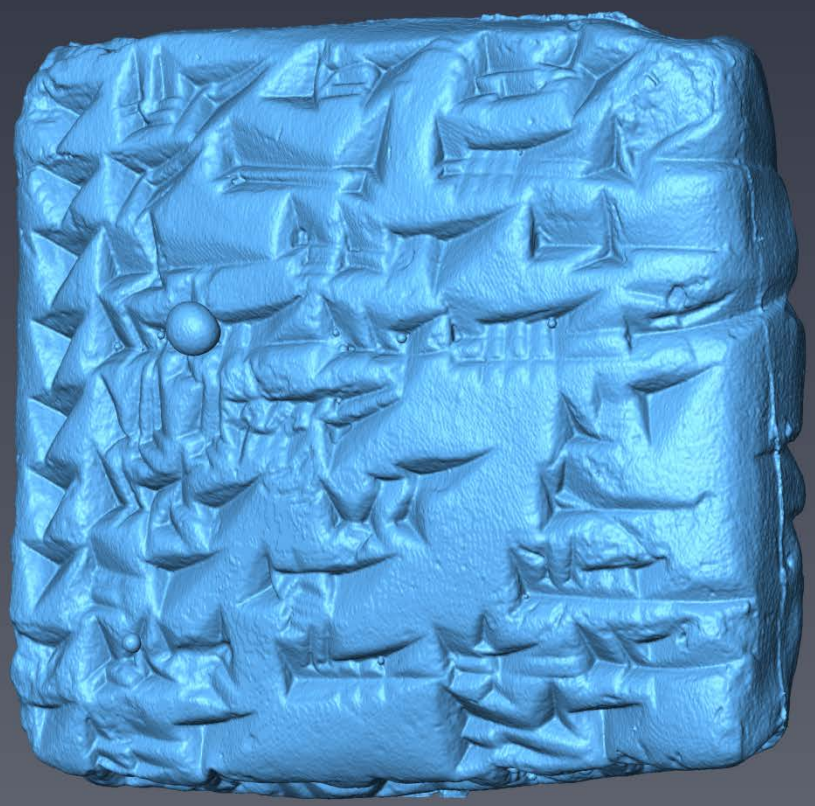
Note the varying inclination of the tablet that changes illumination angle for a better legibility!

Translation process

Note the varying inclination of the tablet that changes illumination for a better legibility!

Translation process

Front face



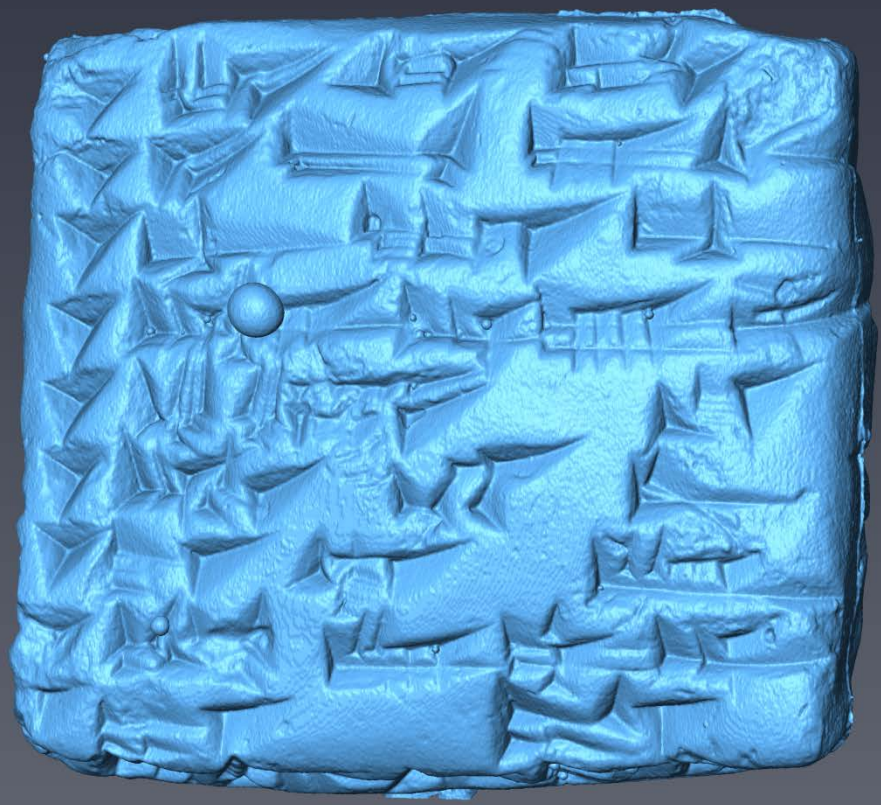
Side face 1

Lines would be continued on Side face 1 if characters would not fit on Front face!

Note the varying inclination of the tablet that changes illumination for a better legibility!

Translation process

Front face

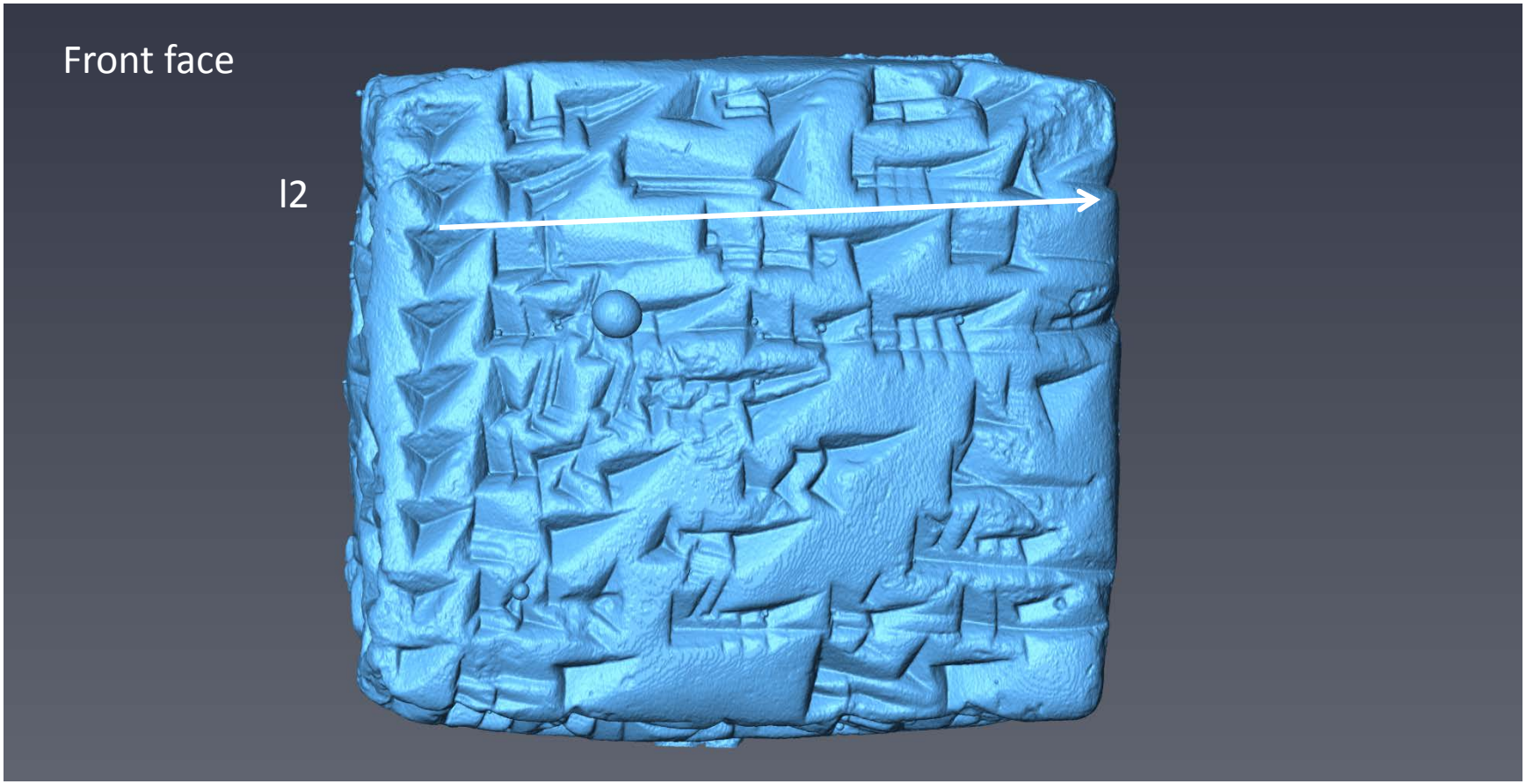


Side face 1

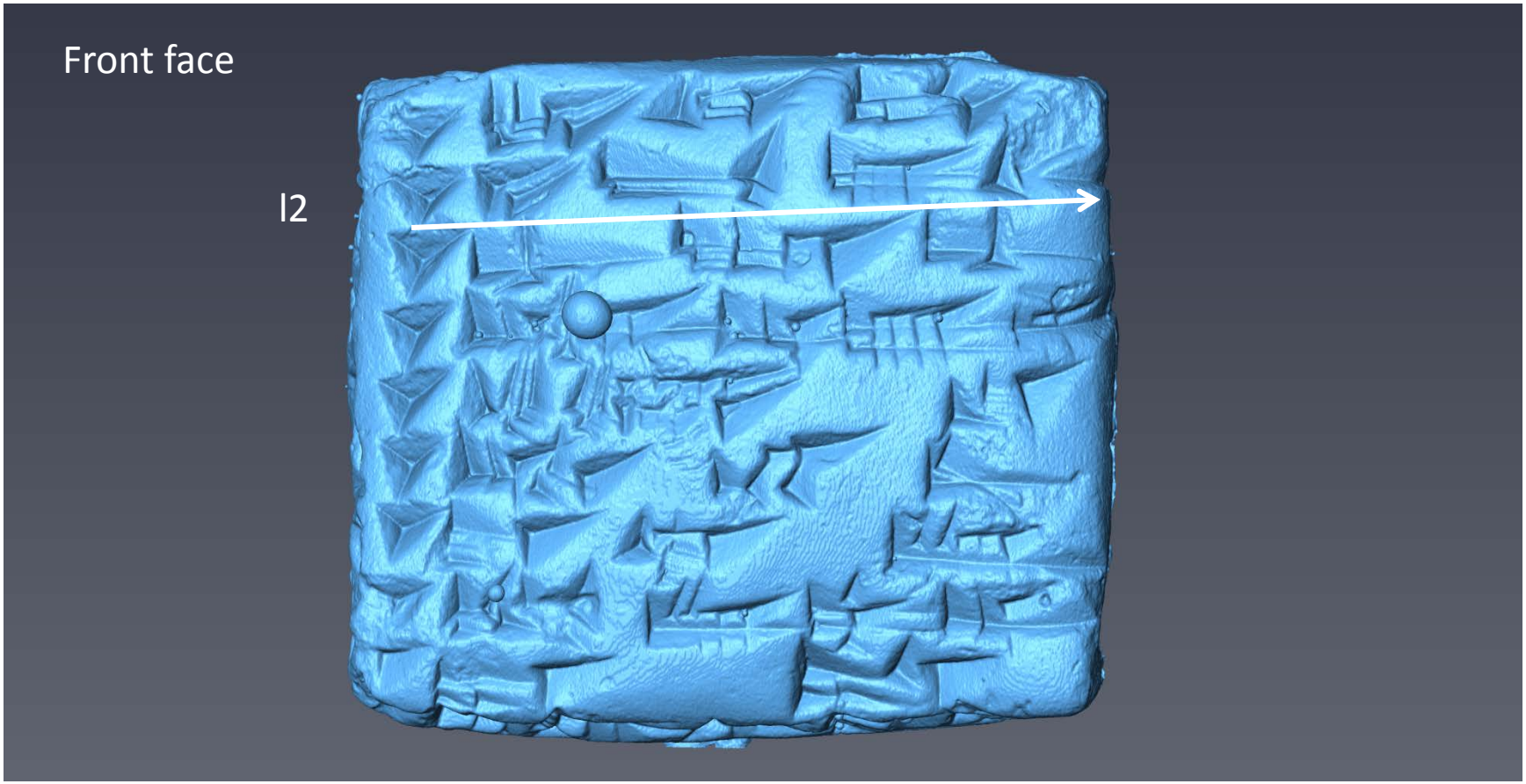
Lines would be continued on Side face 1 if characters would not fit on Front face!

Note the varying inclination of the tablet that changes illumination for a better legibility!

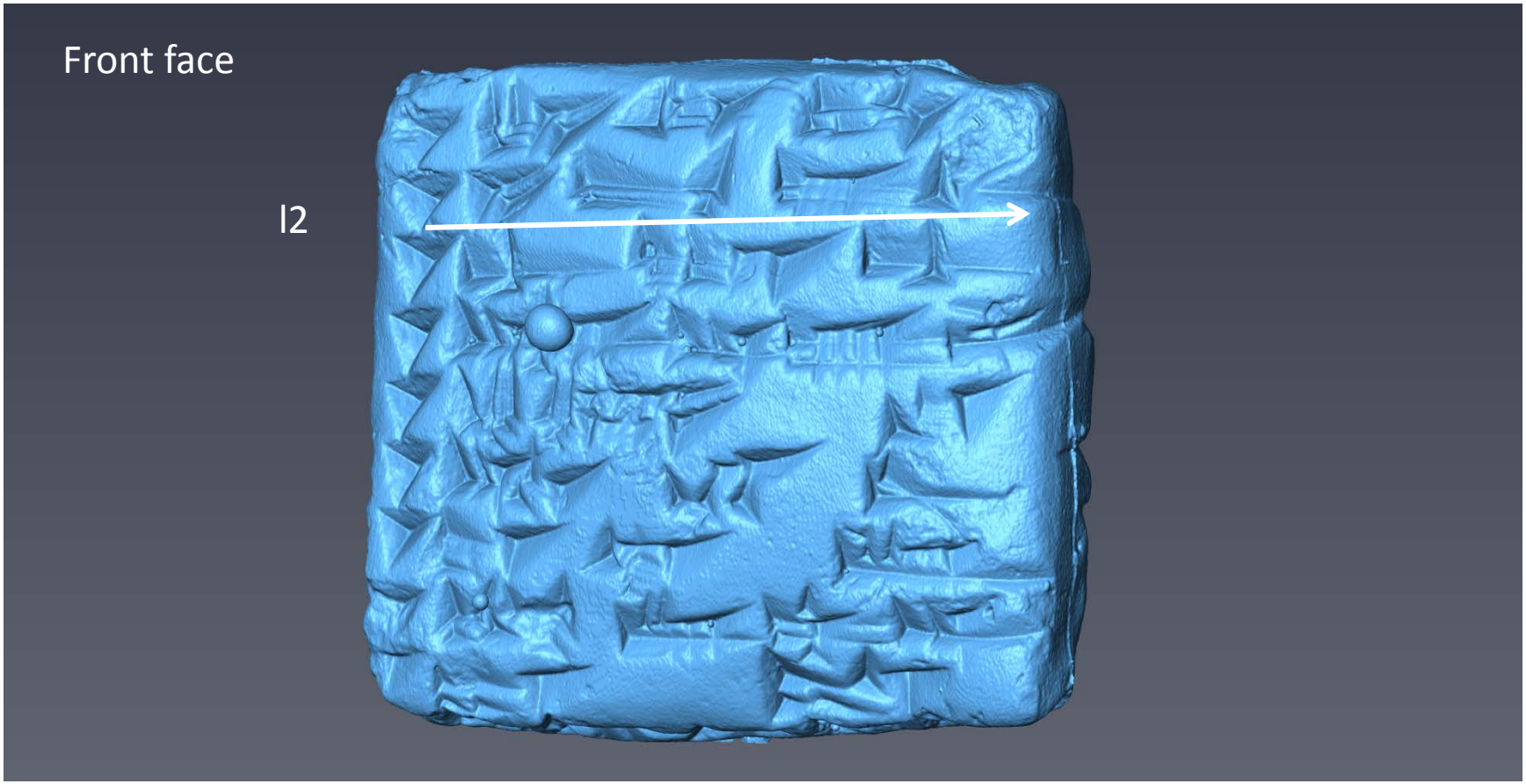
Translation process



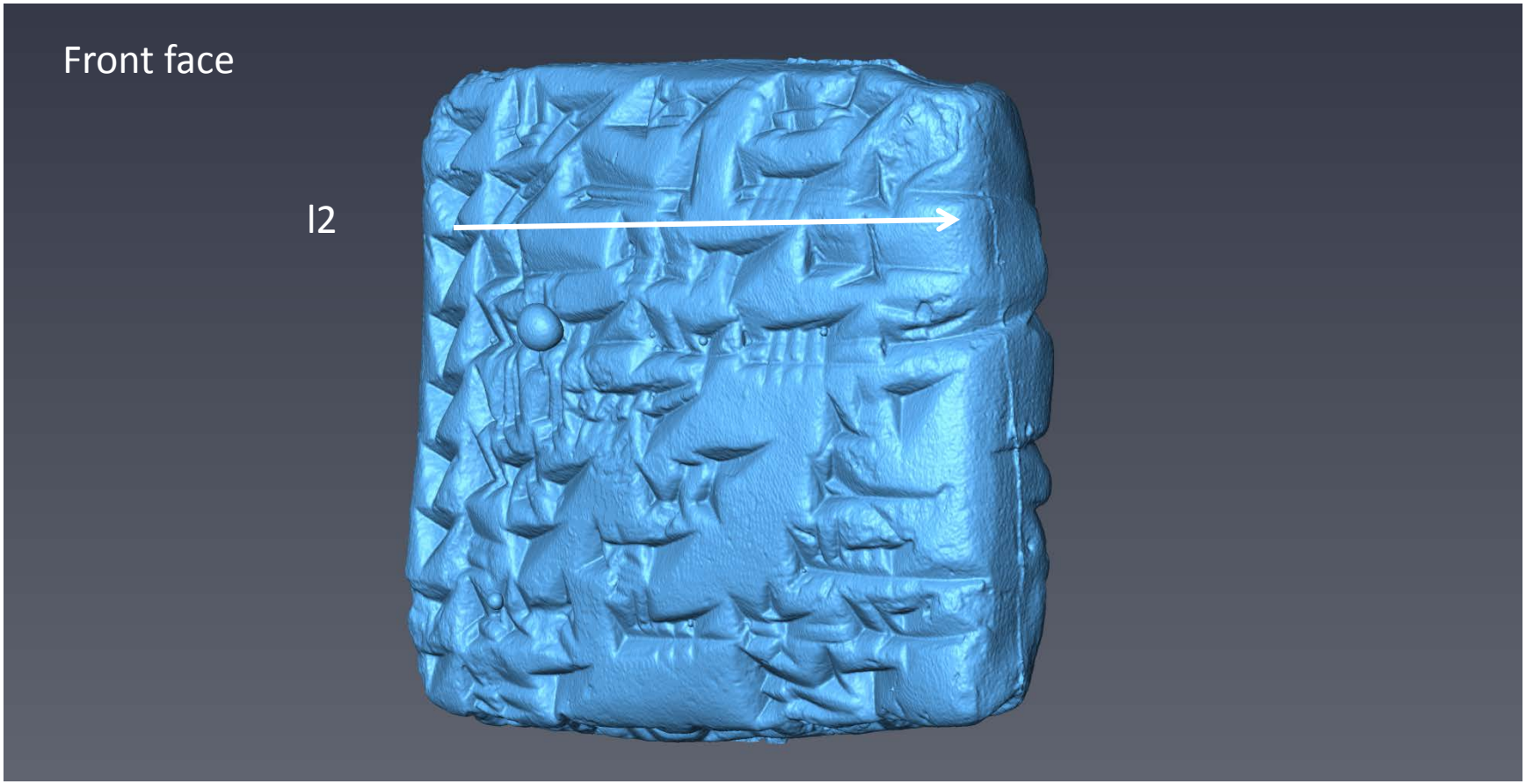
Translation process



Translation process

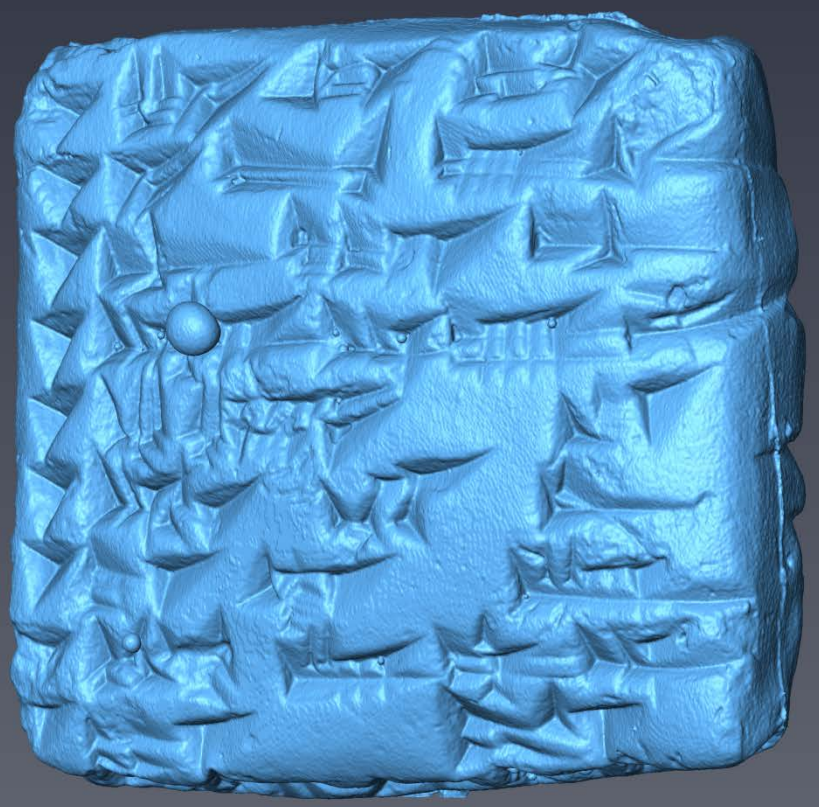


Translation process

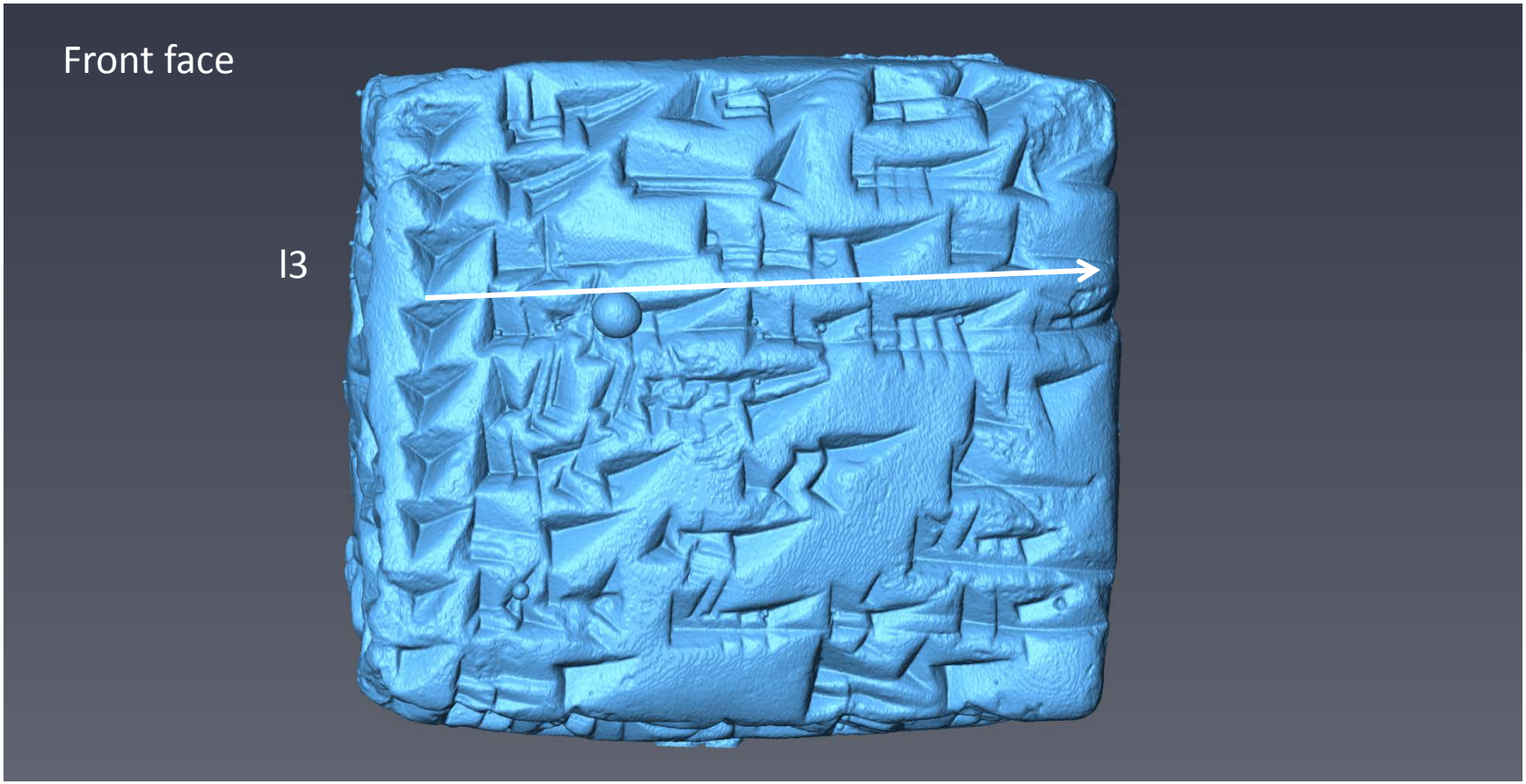


Translation process

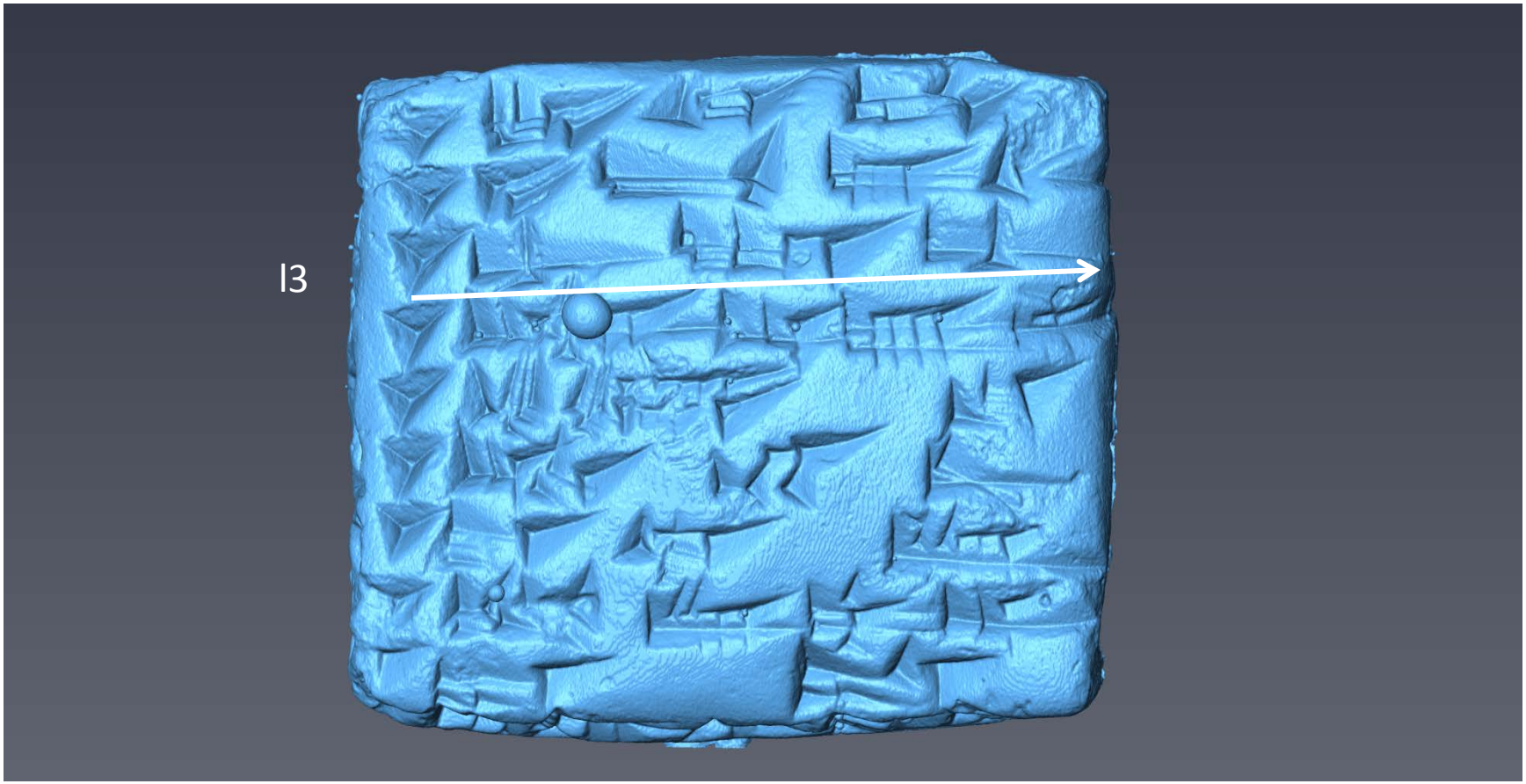
Front face



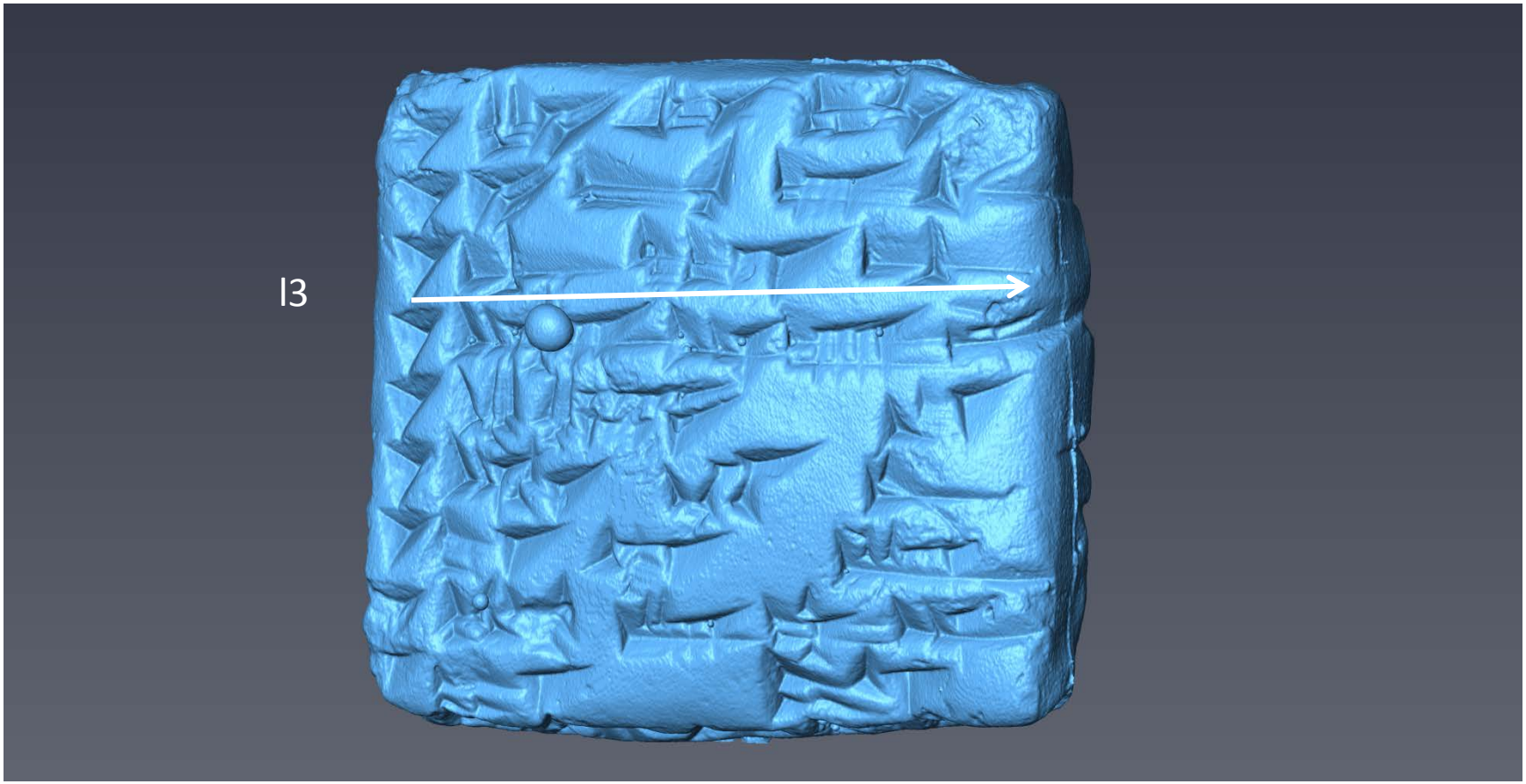
Translation process



Translation process

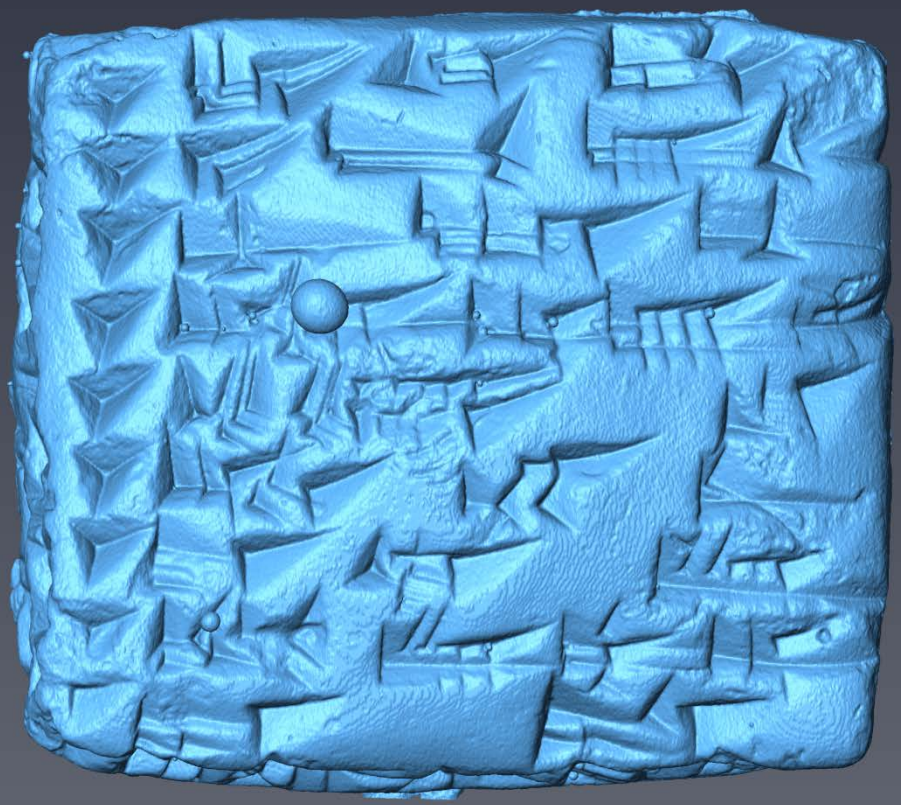


Translation process

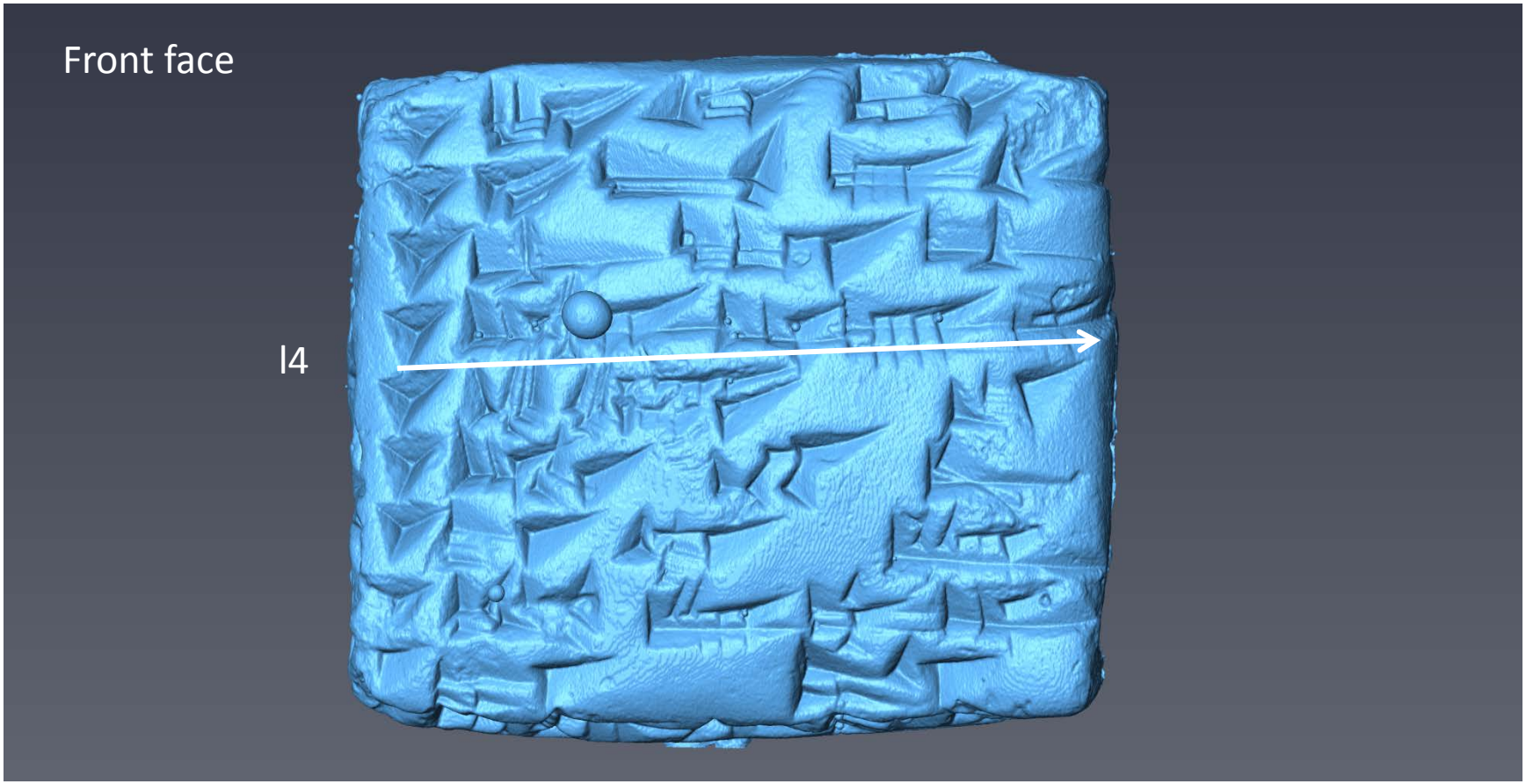


Translation process

Front face



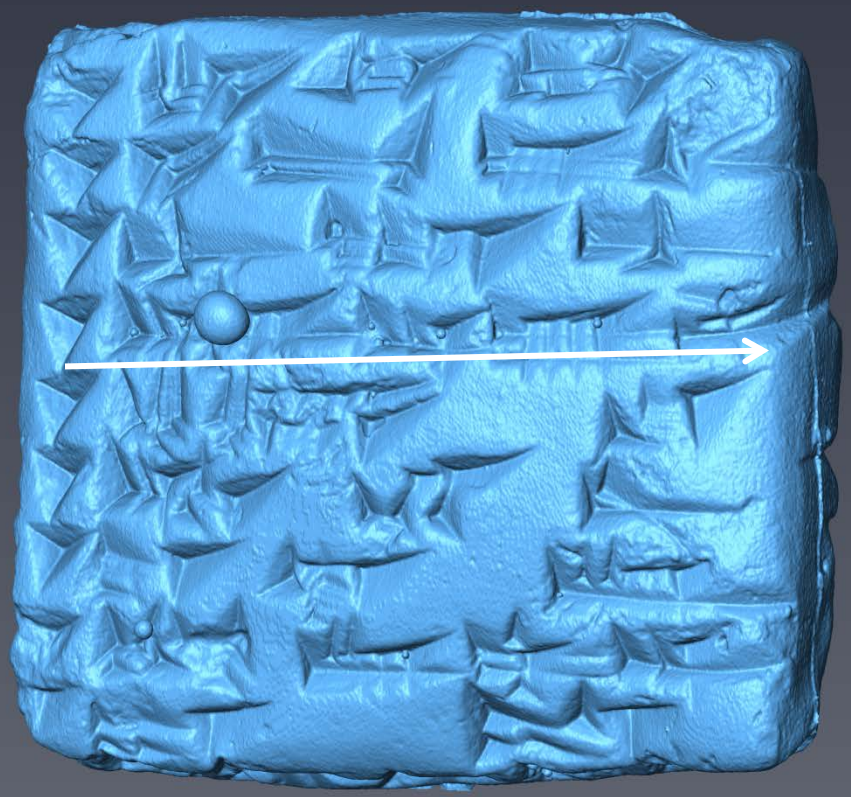
Translation process



Translation process

Front face

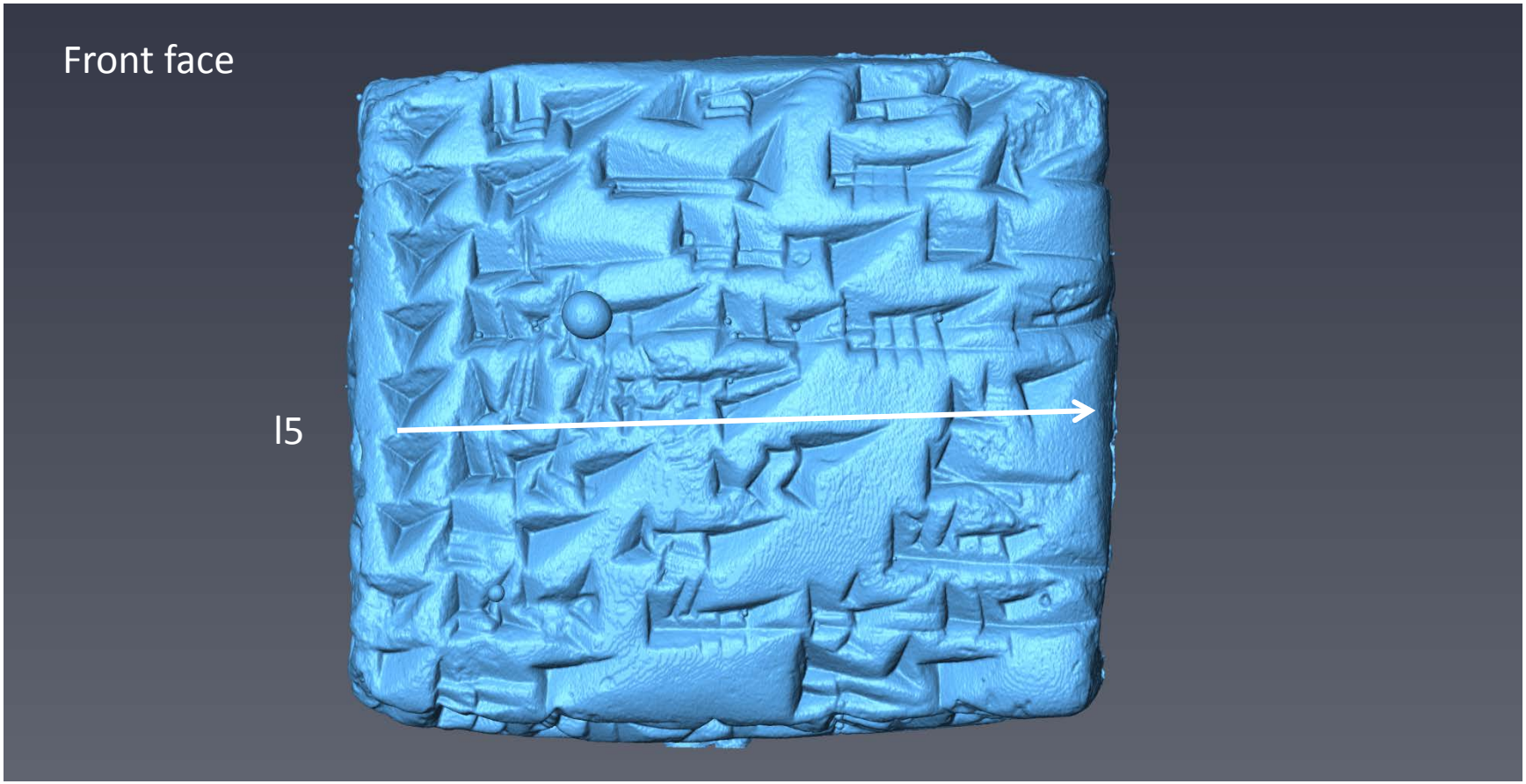
l4



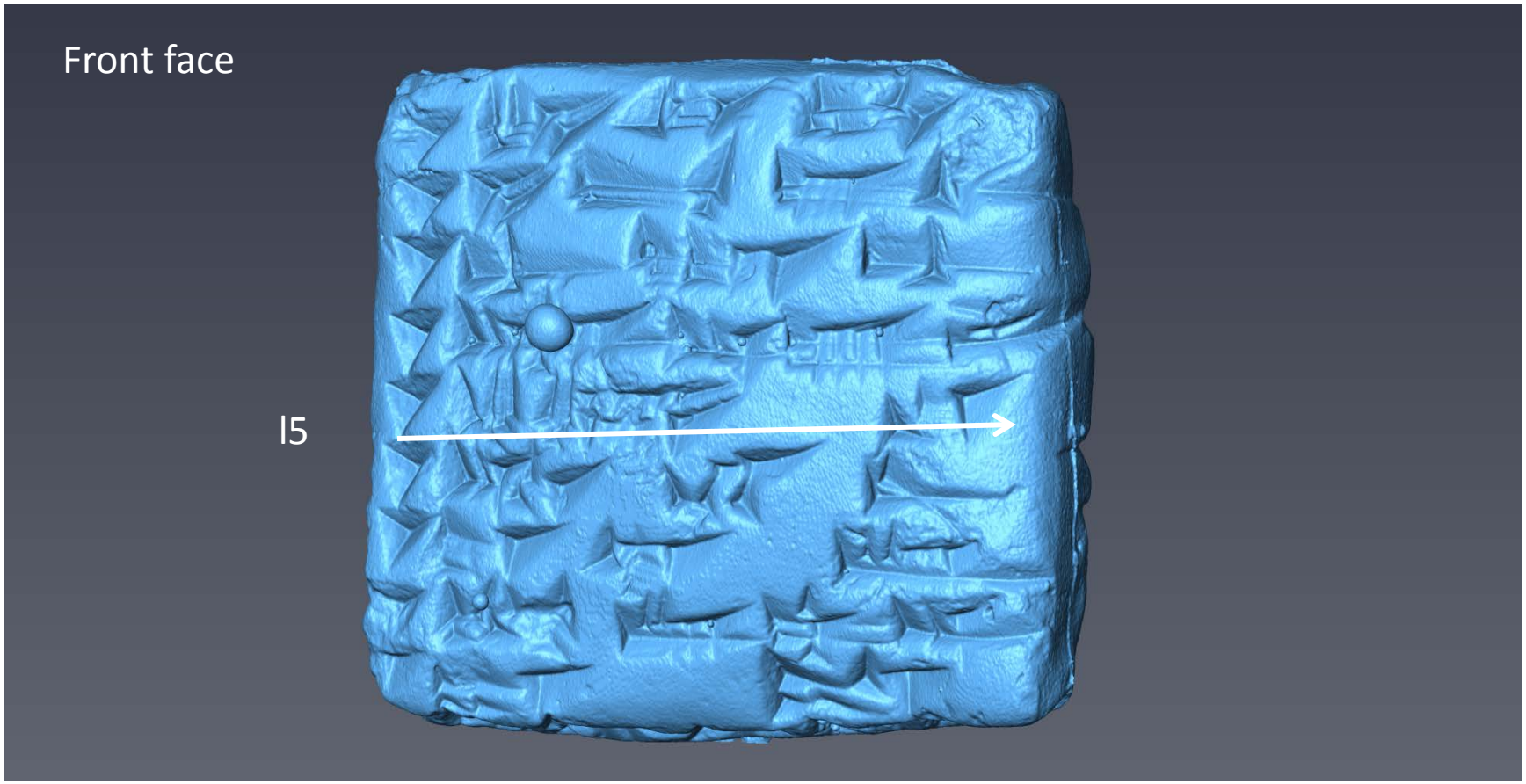
Side face 1

Last character of line 4 finished on Side face 1!

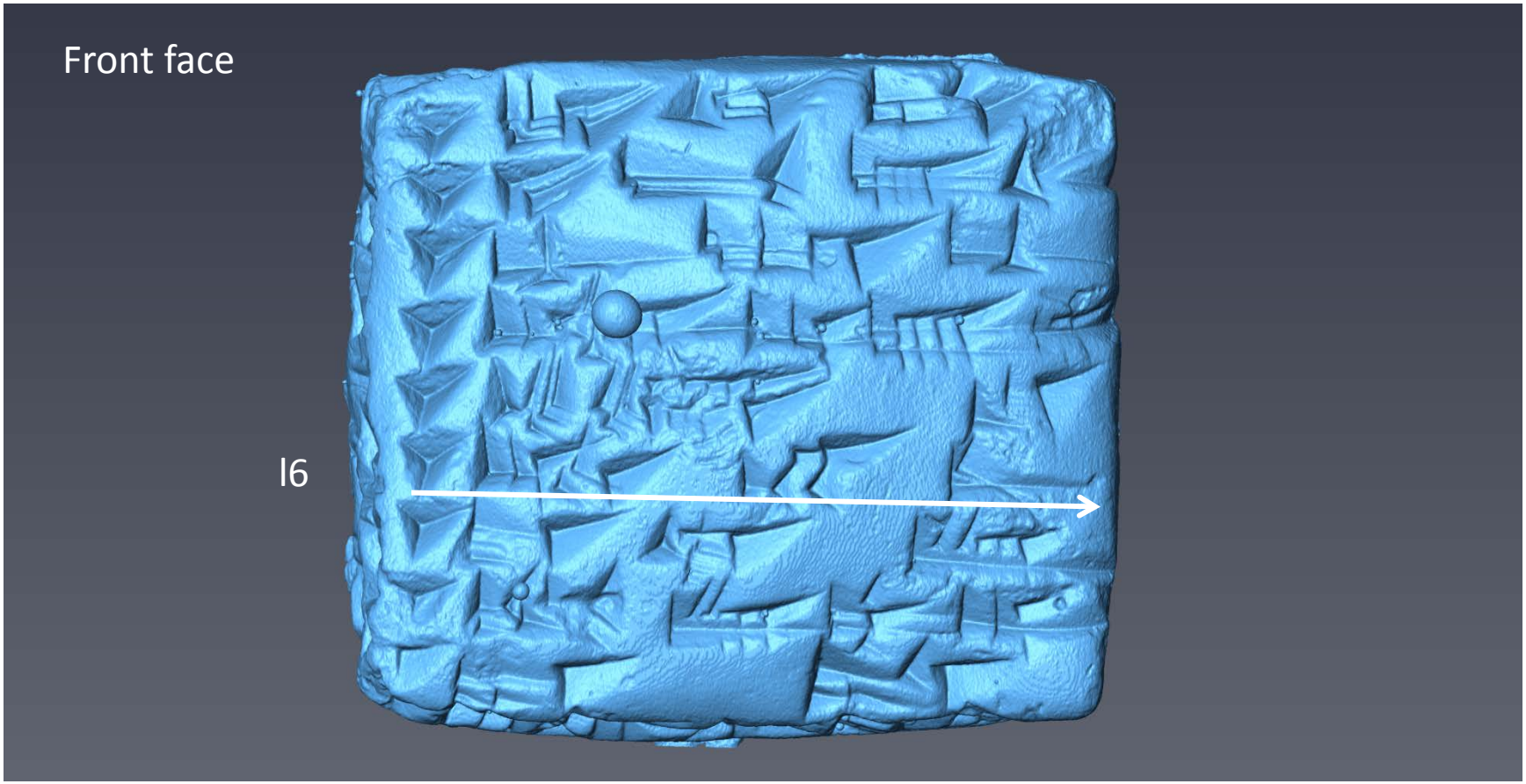
Translation process



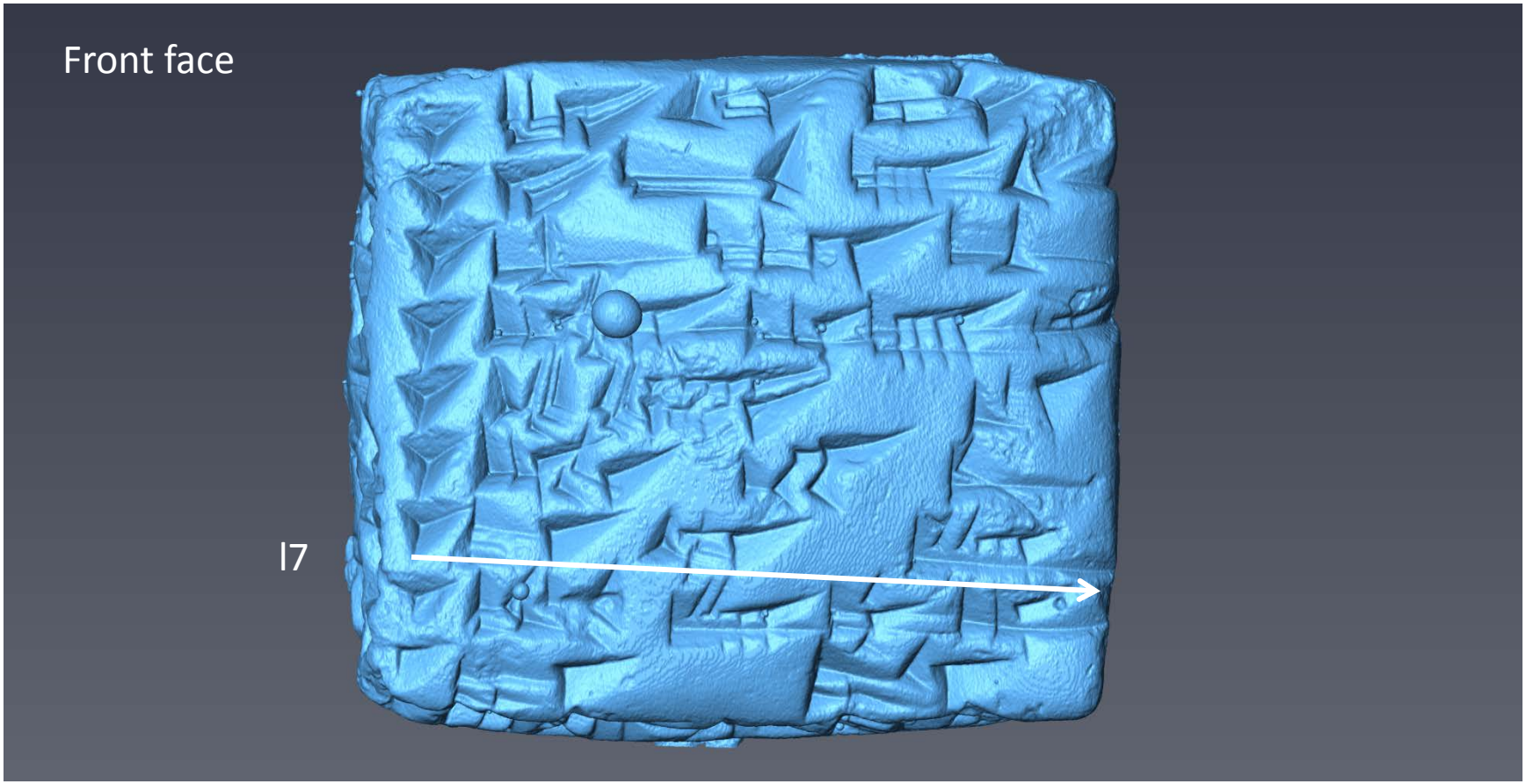
Translation process



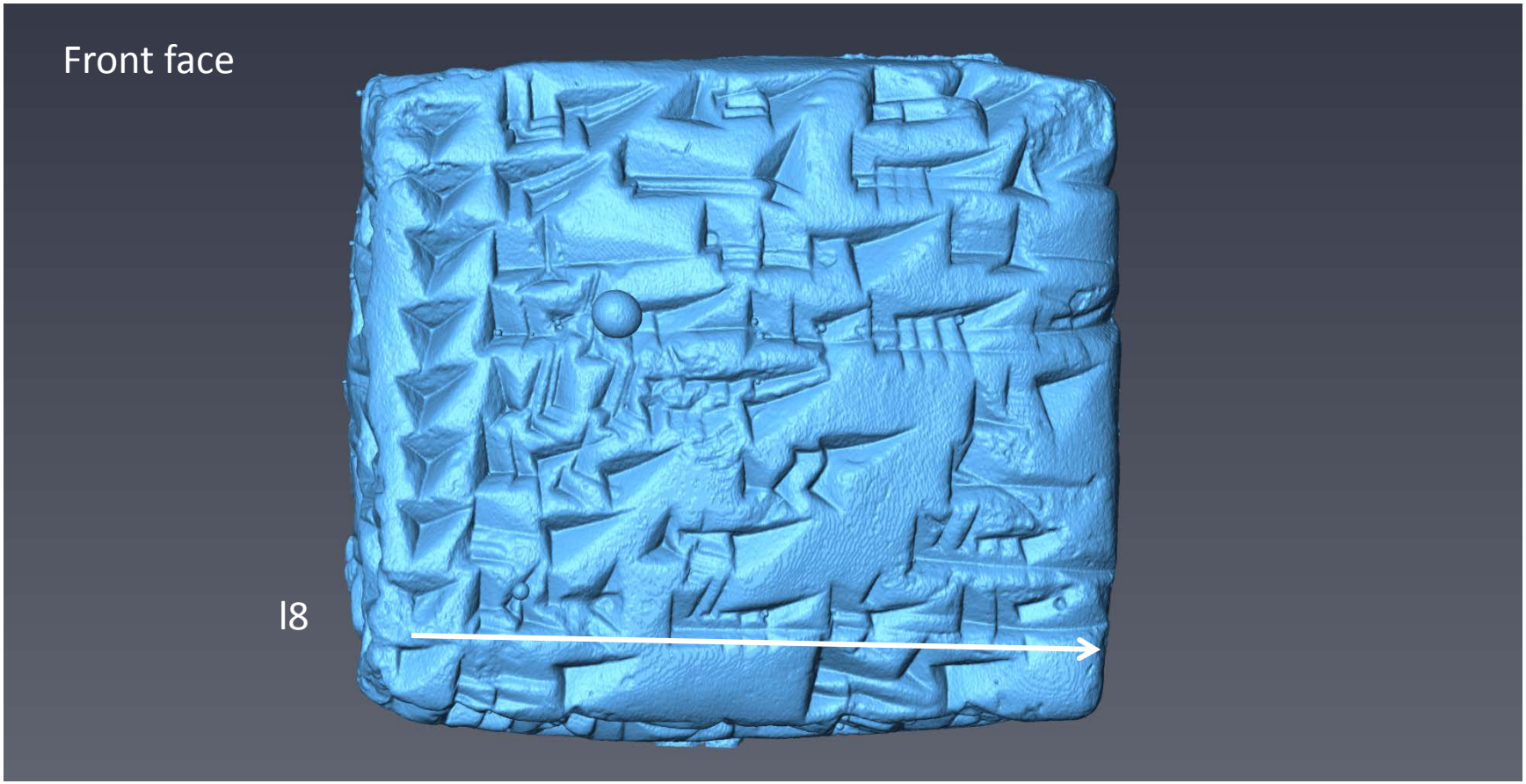
Translation process



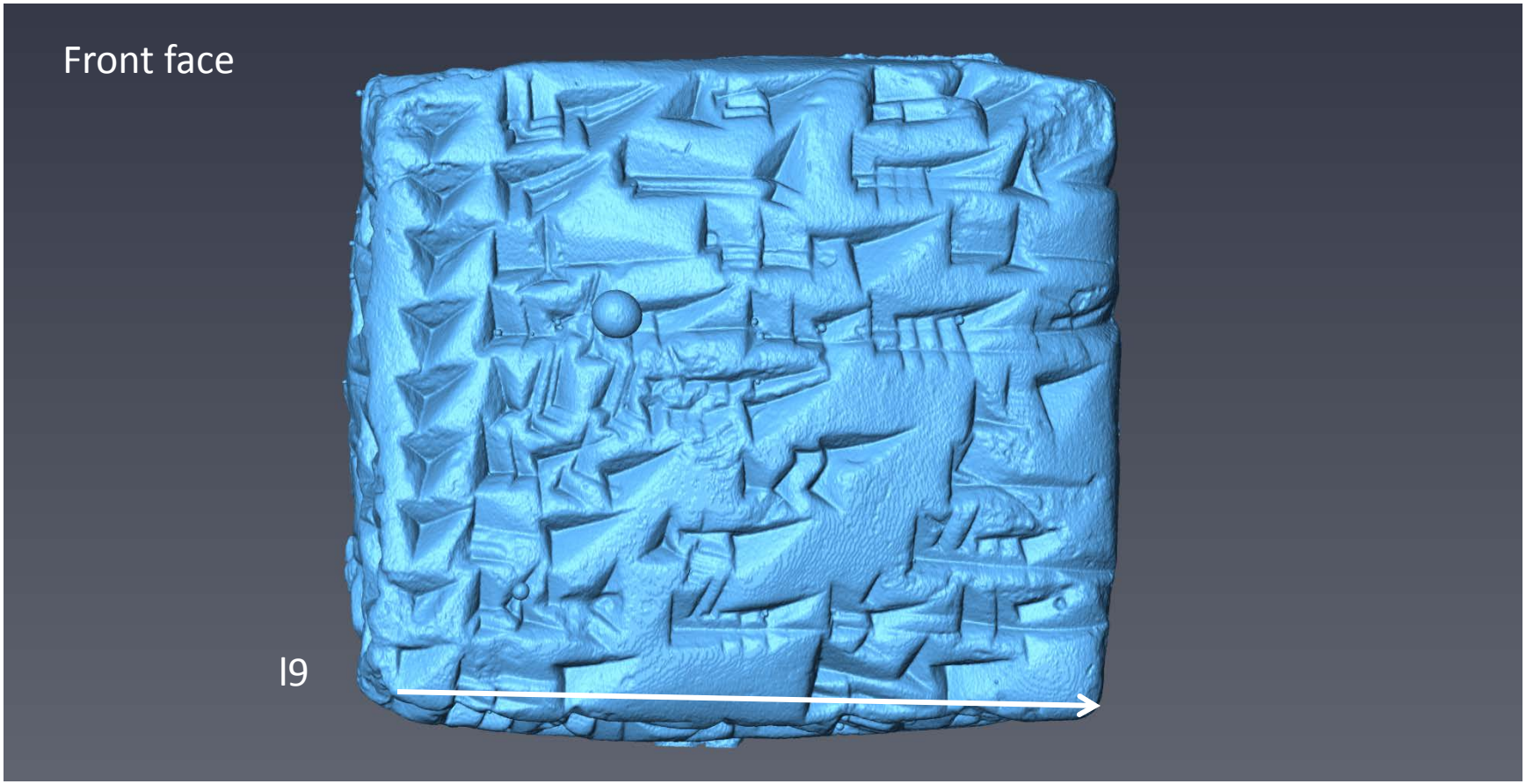
Translation process



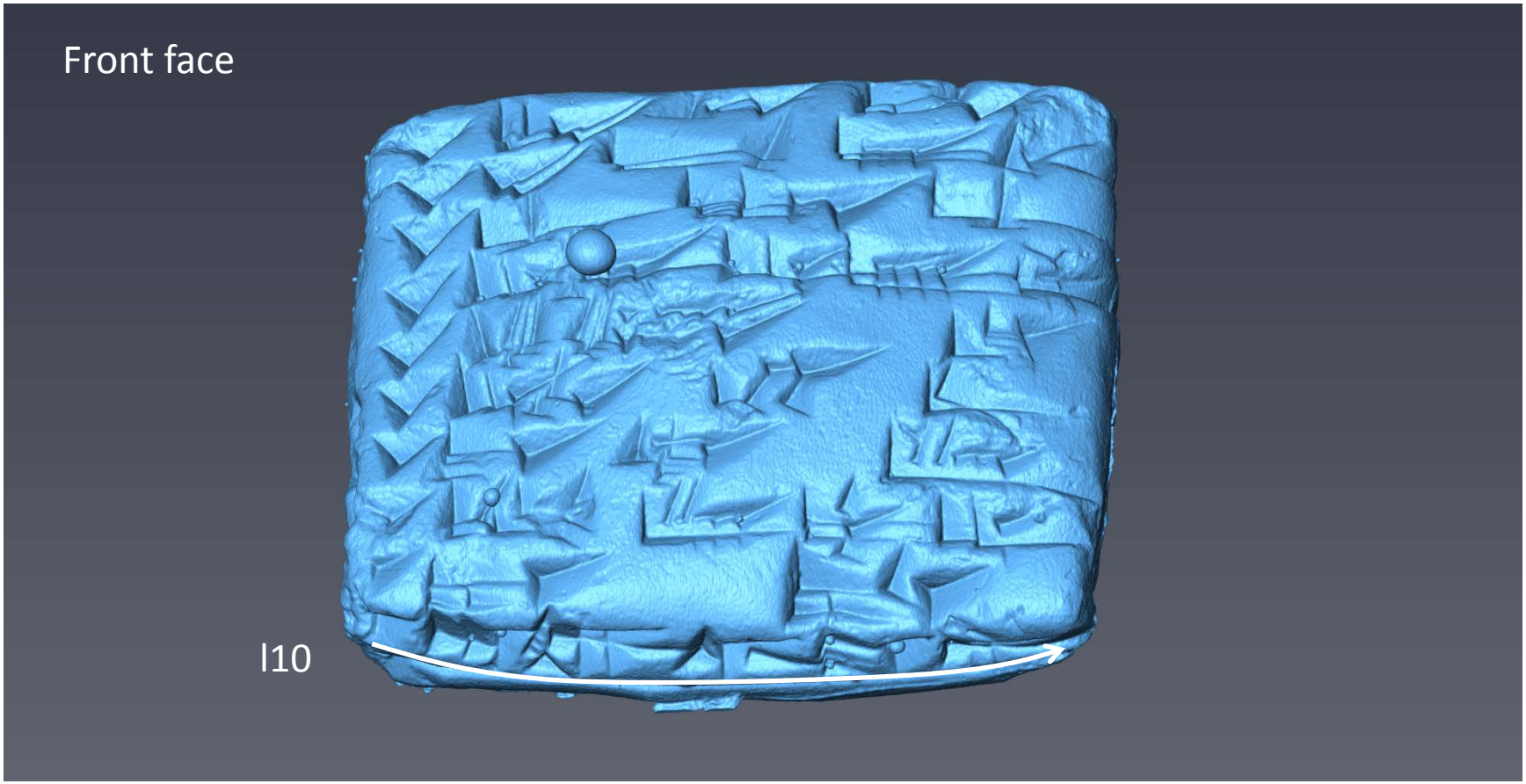
Translation process



Translation process

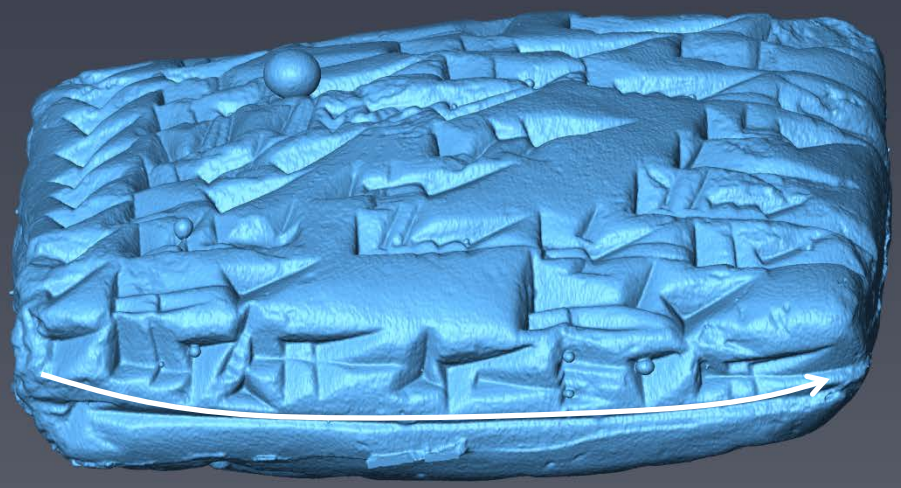


Translation process



Translation process

Front face

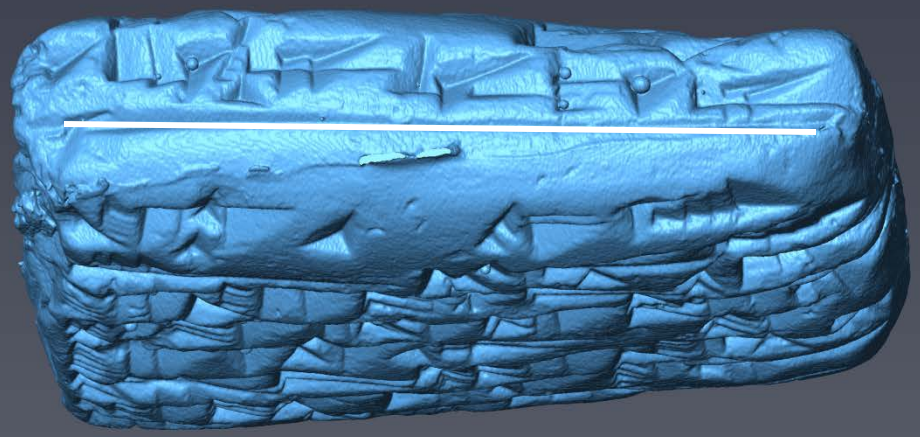


l10

Side face 2

Translation process

Side face 2

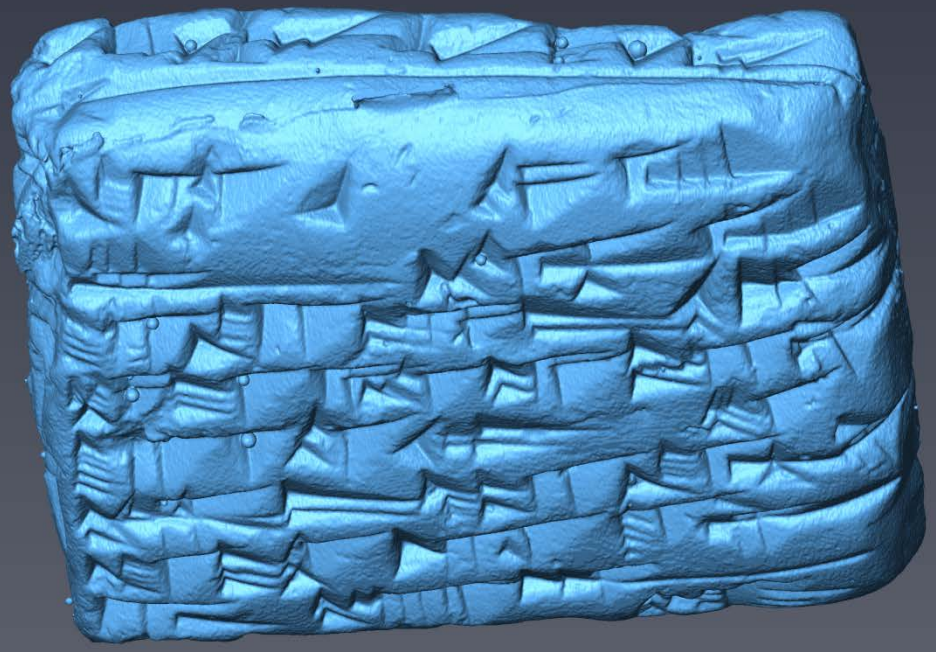


Back face

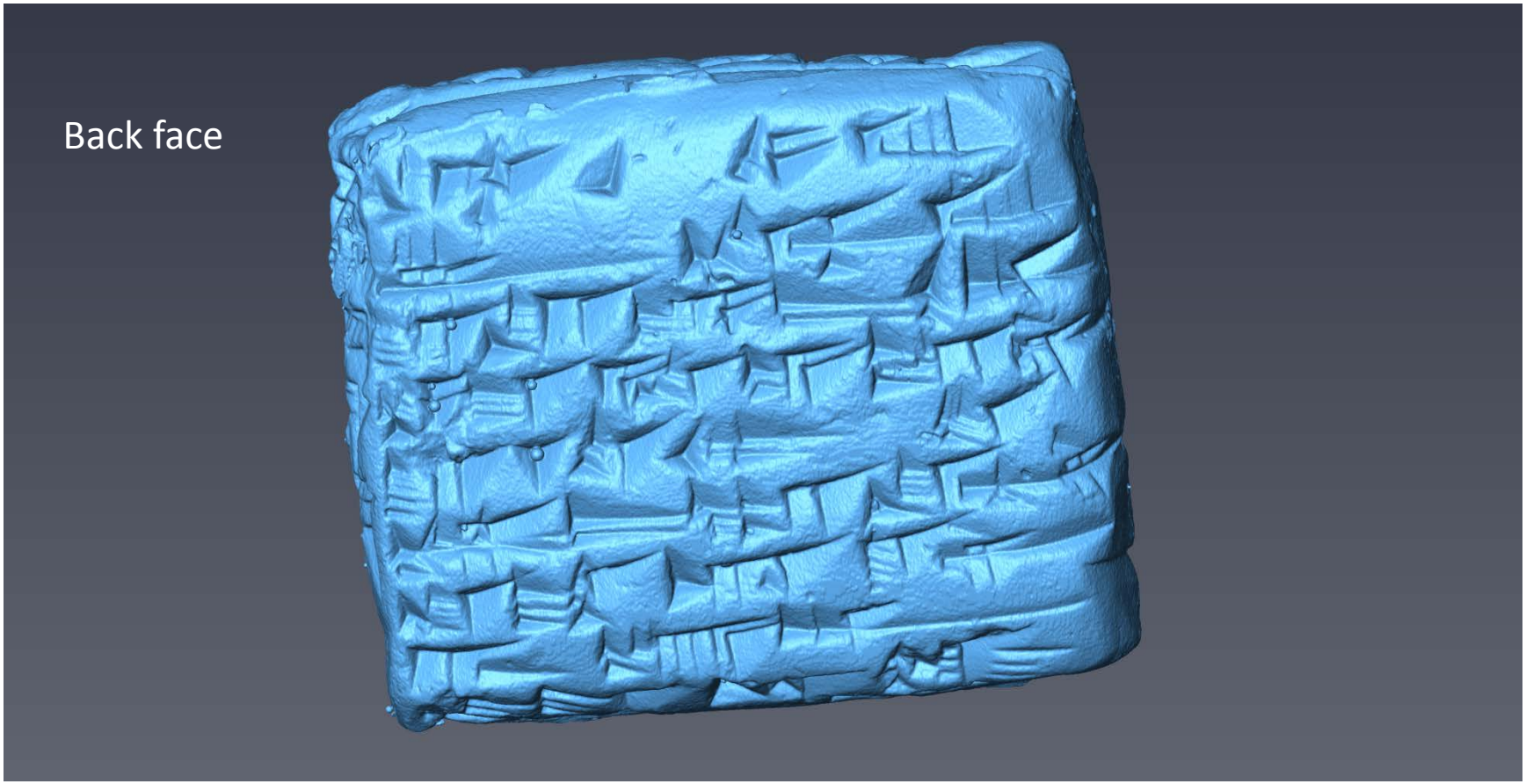
Translation process

Side face 2

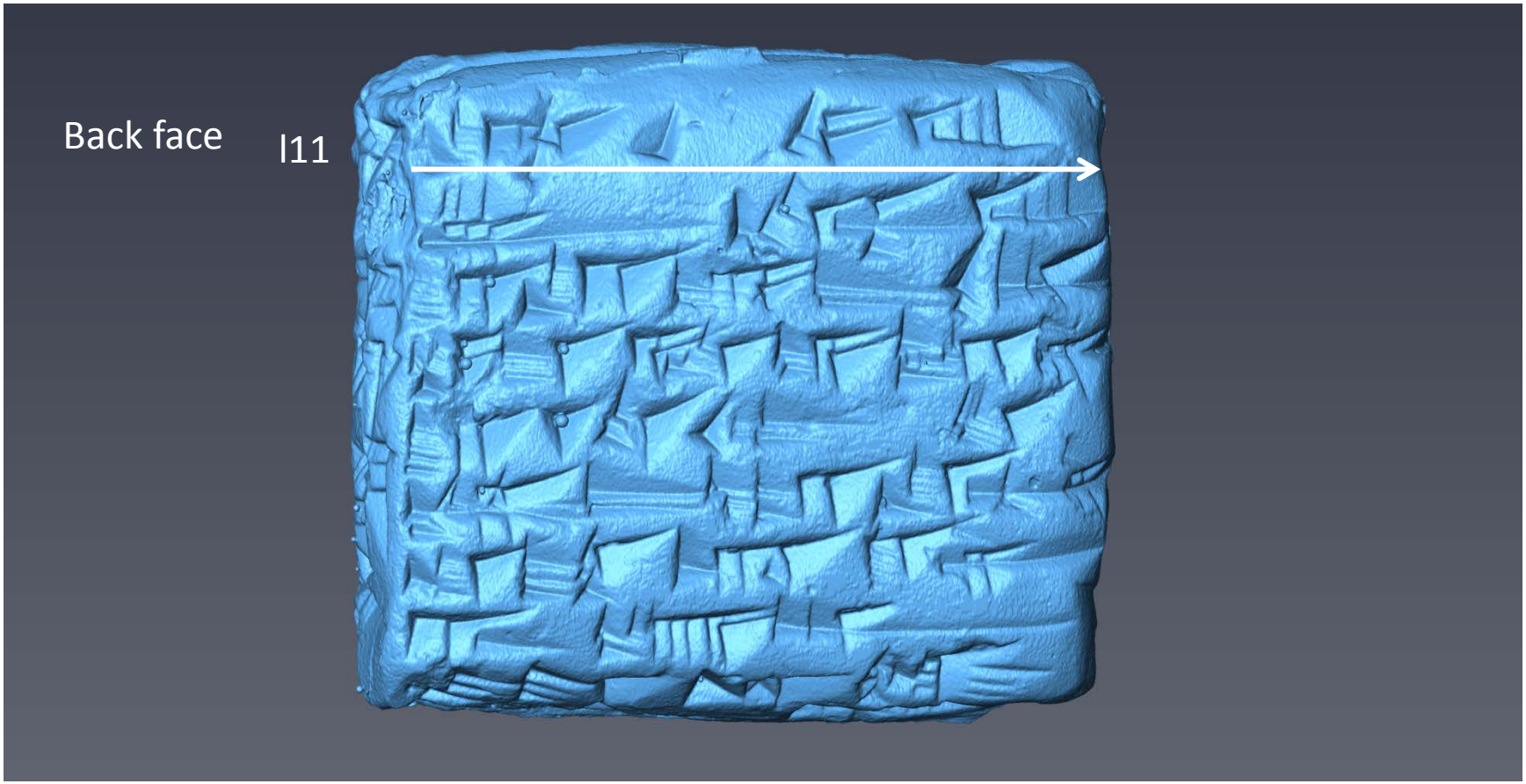
Back face



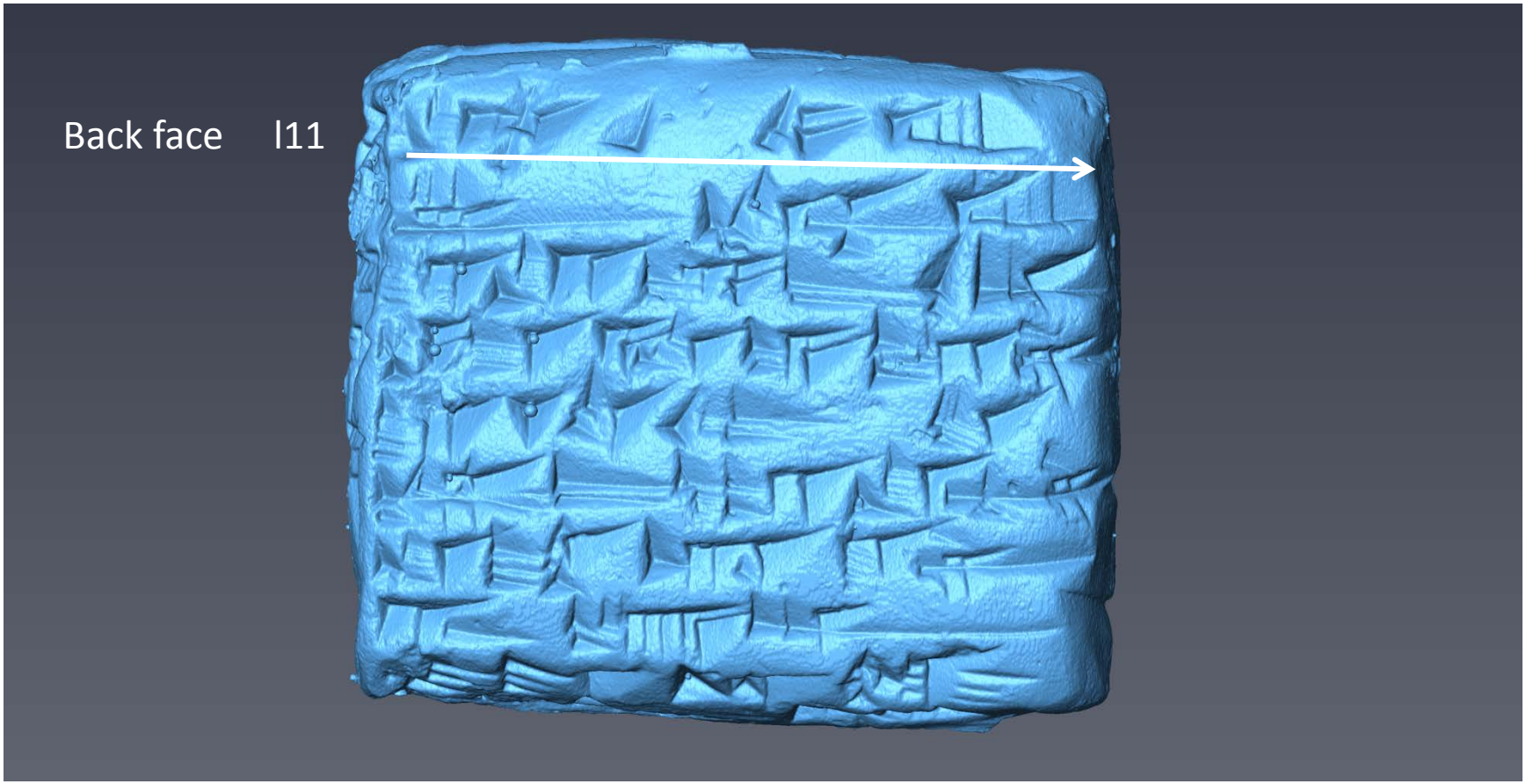
Translation process



Translation process



Translation process



Translation process

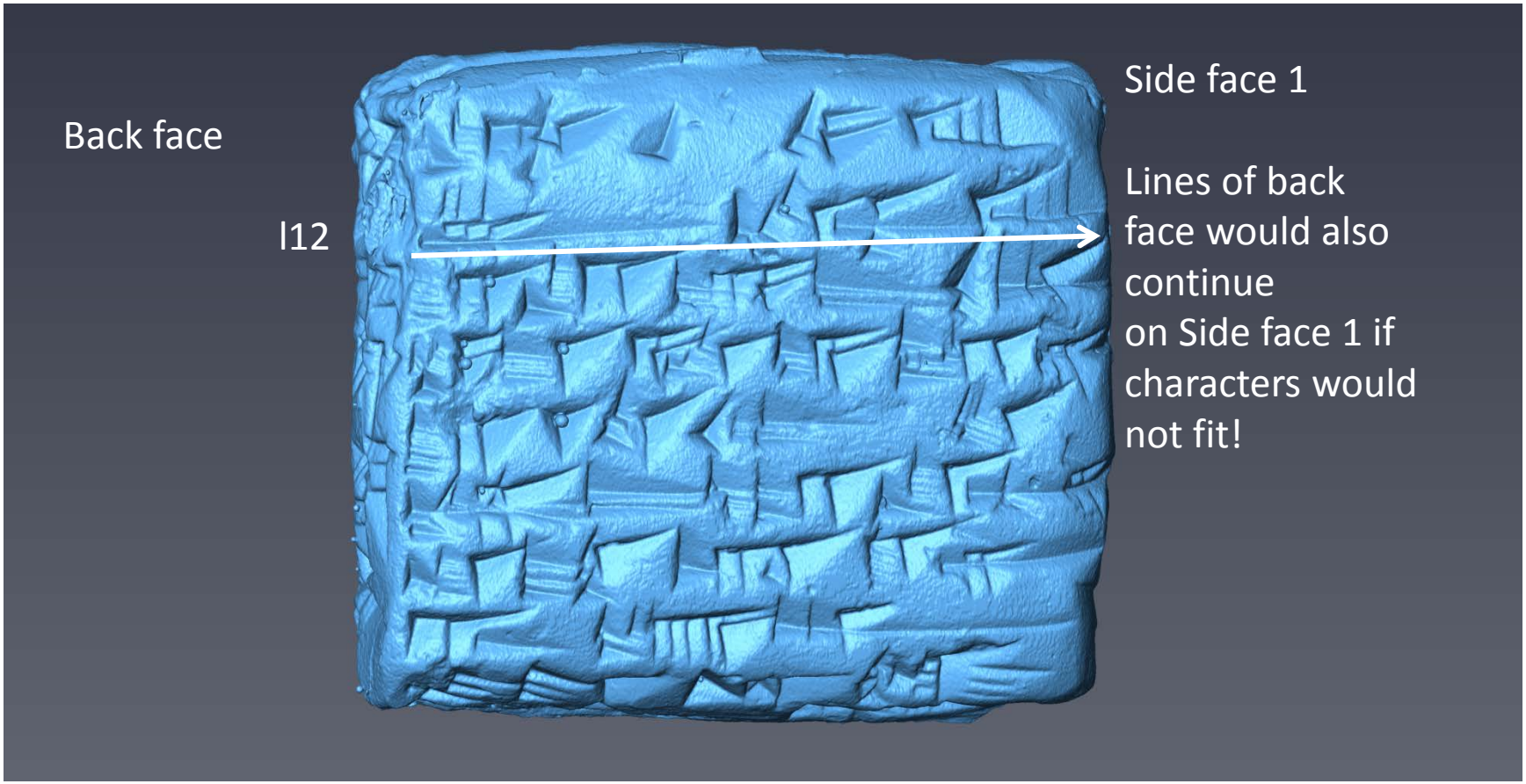
Back face

l11

Side face 1

Lines of back face would also continue on Side face 1 if characters would not fit!

Translation process



Translation process

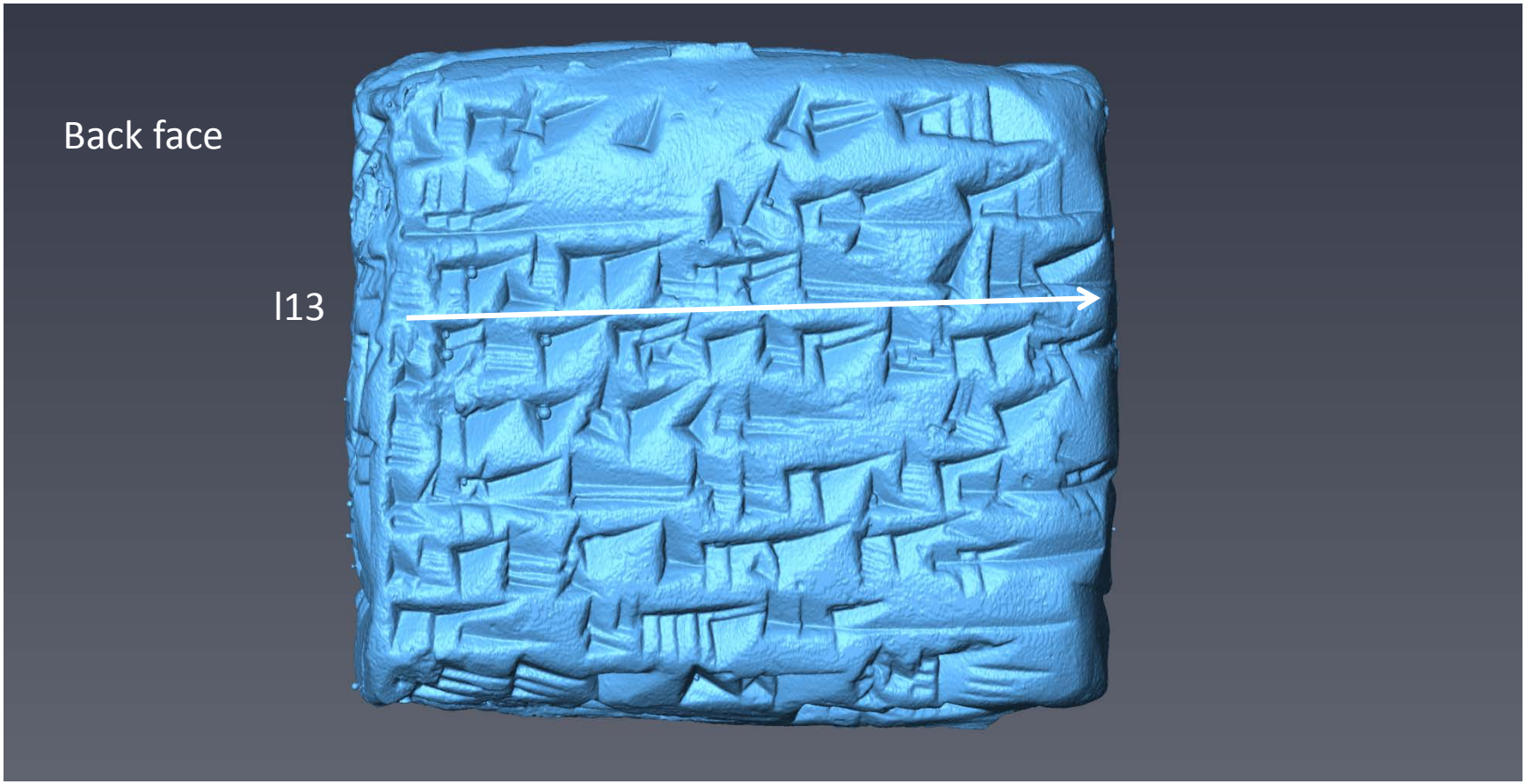
Back face

l12

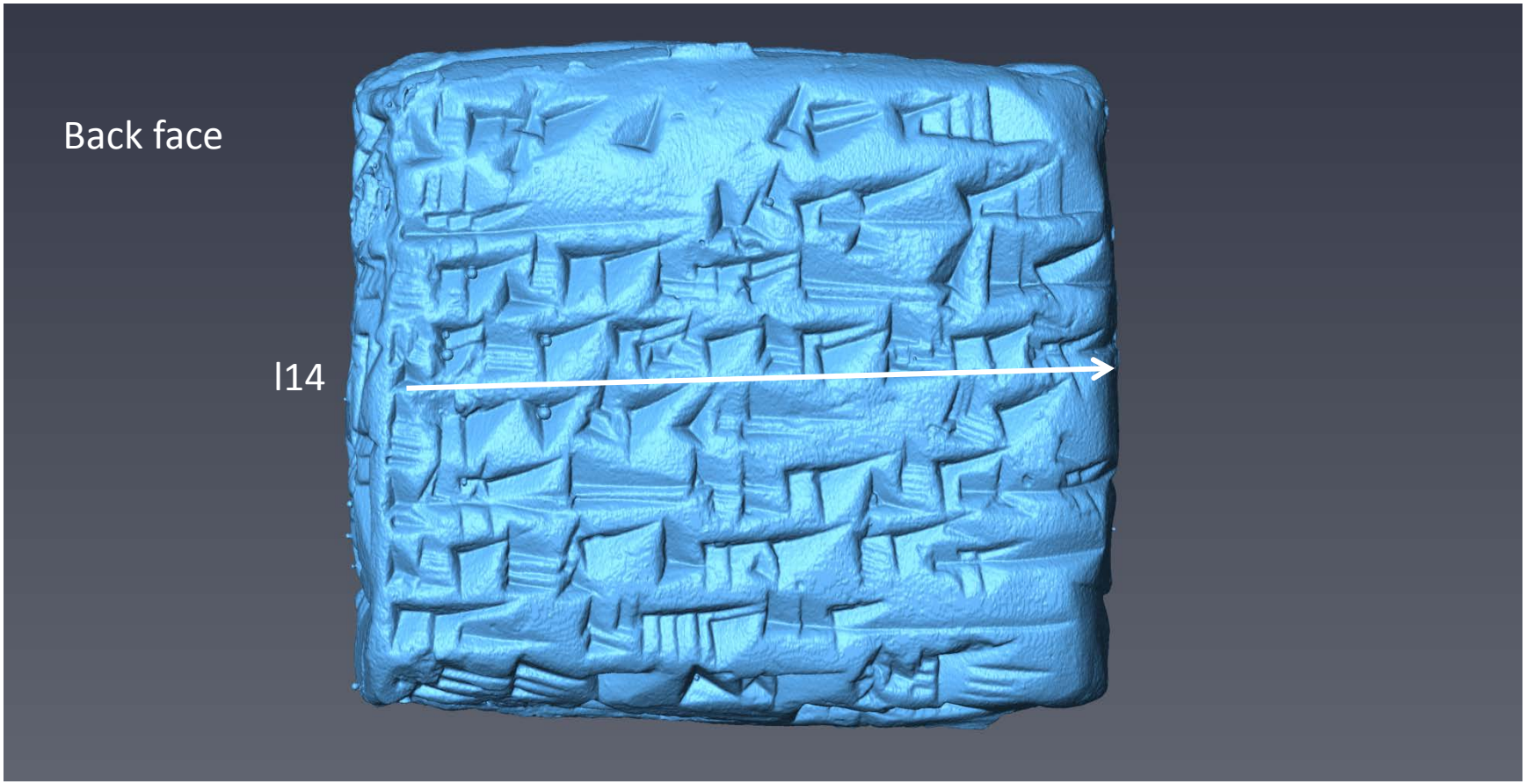
Side face 1

Lines of back face would also continue on Side face 1 if characters would not fit!

Translation process

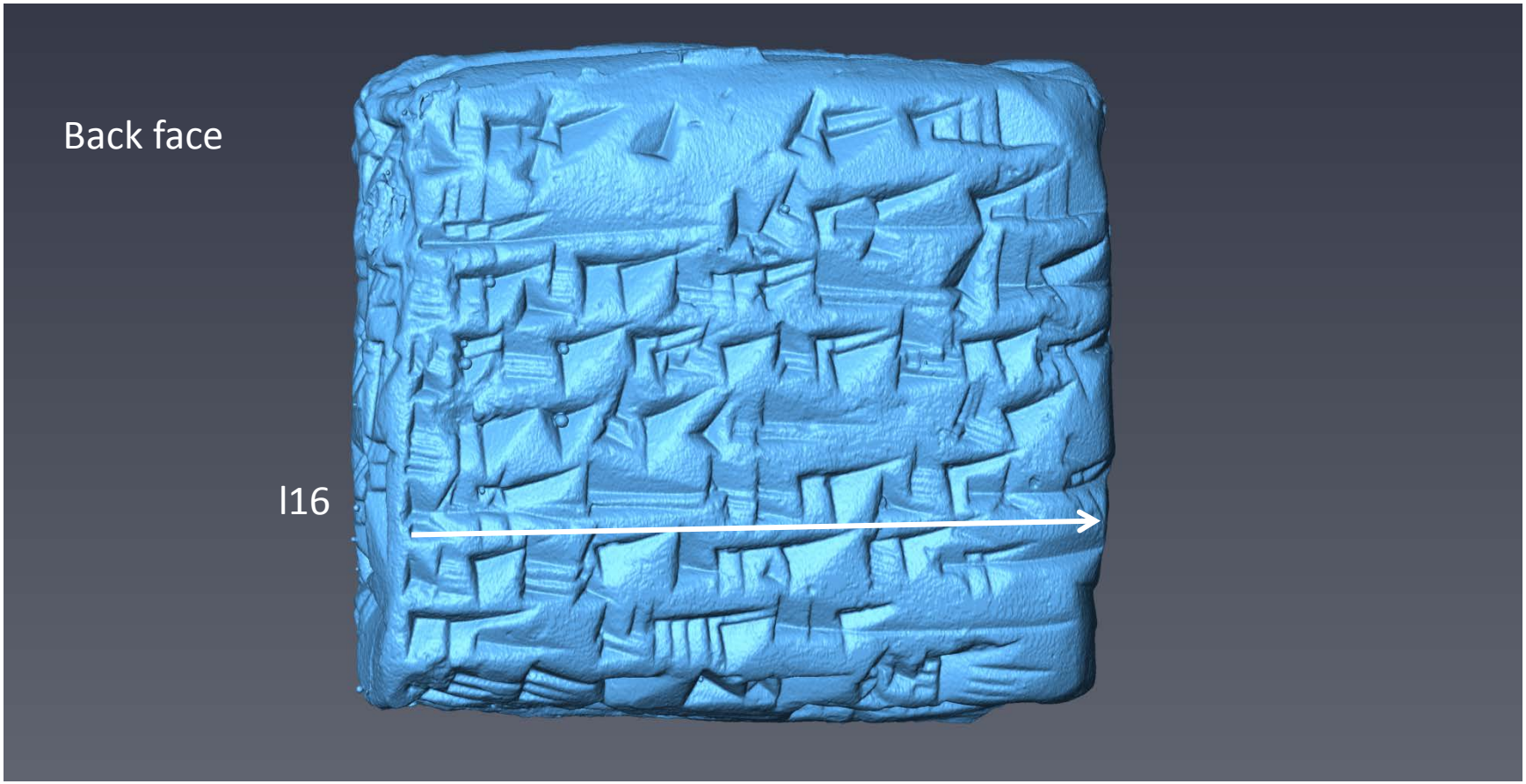


Translation process

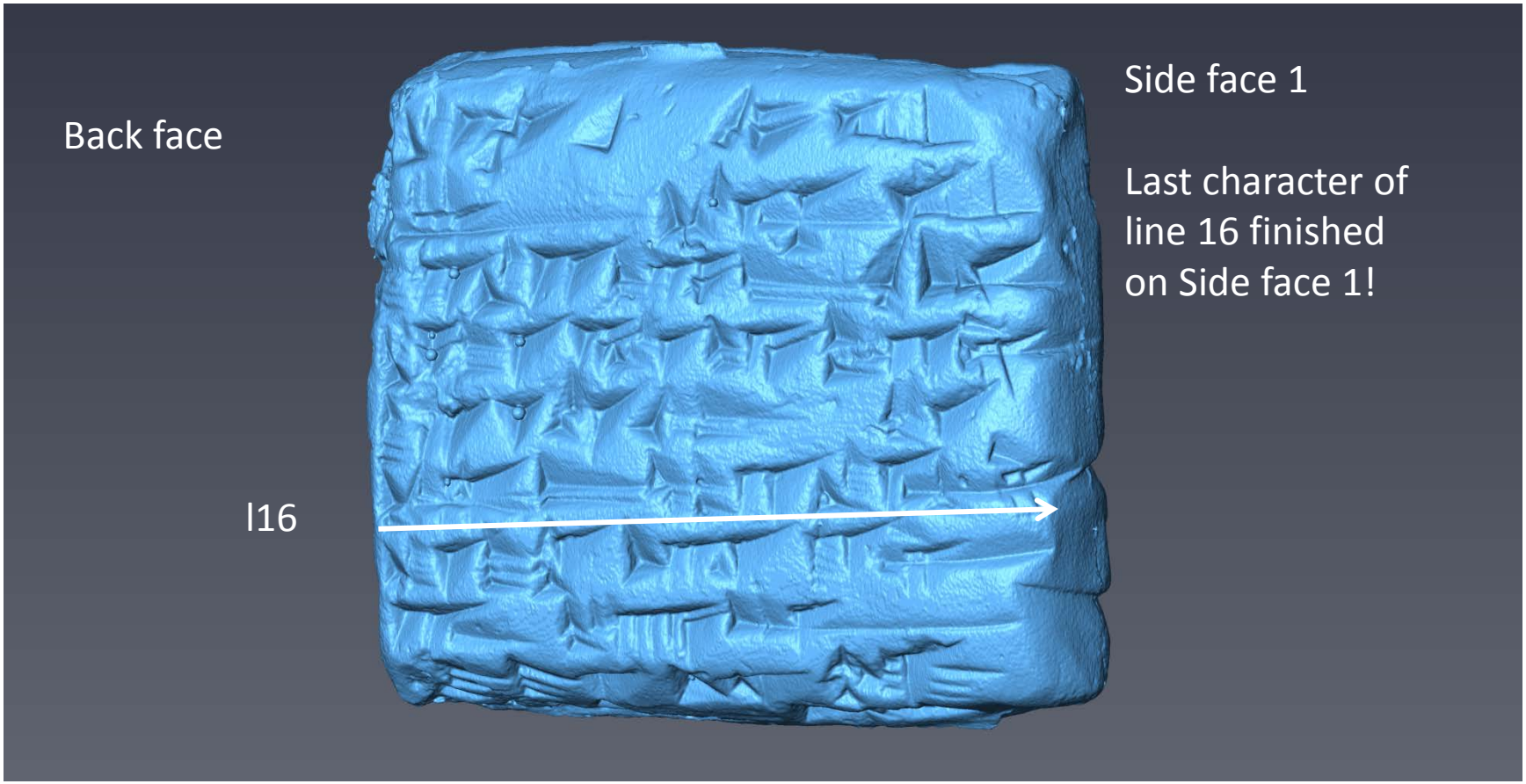


Translation process

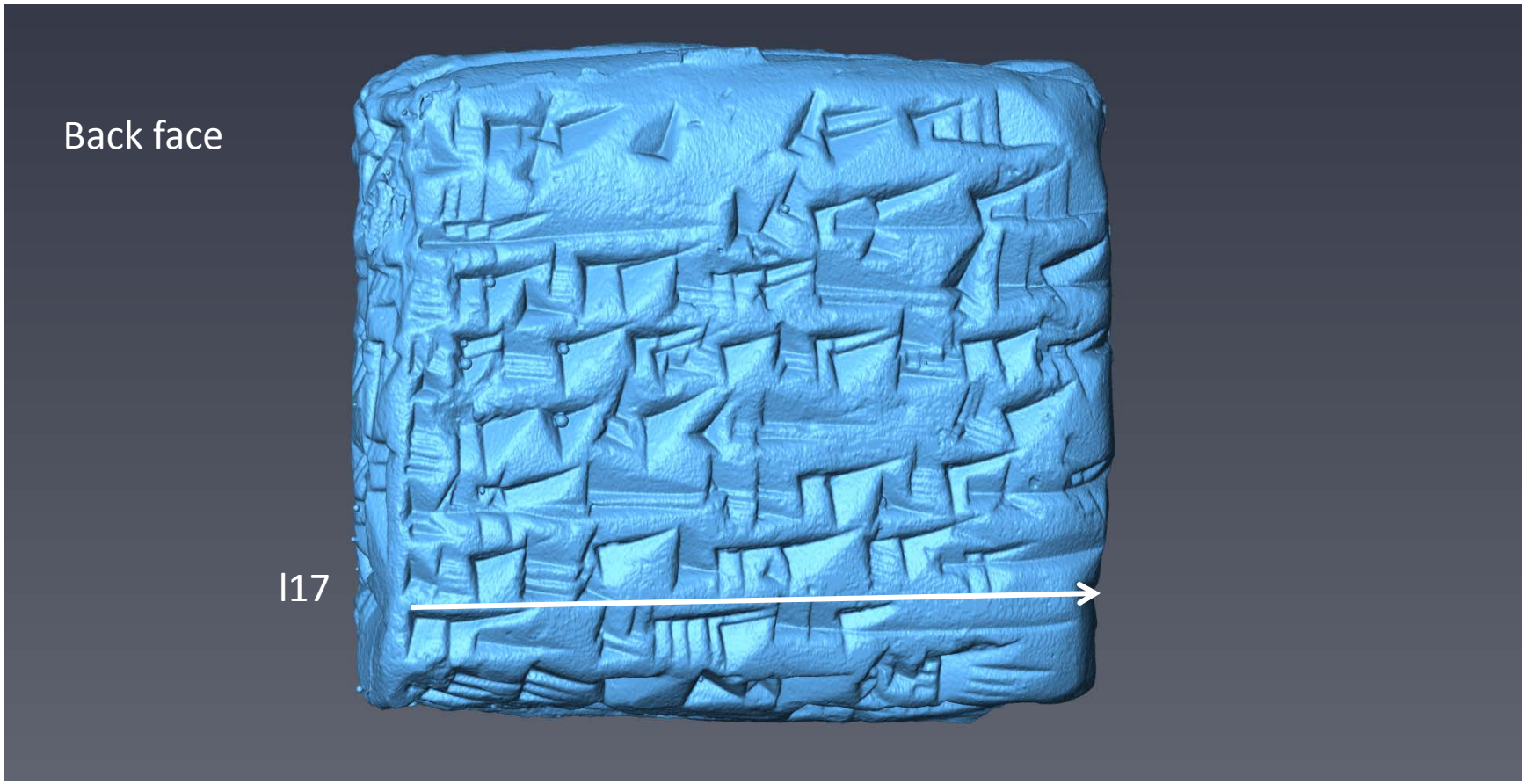
Translation process



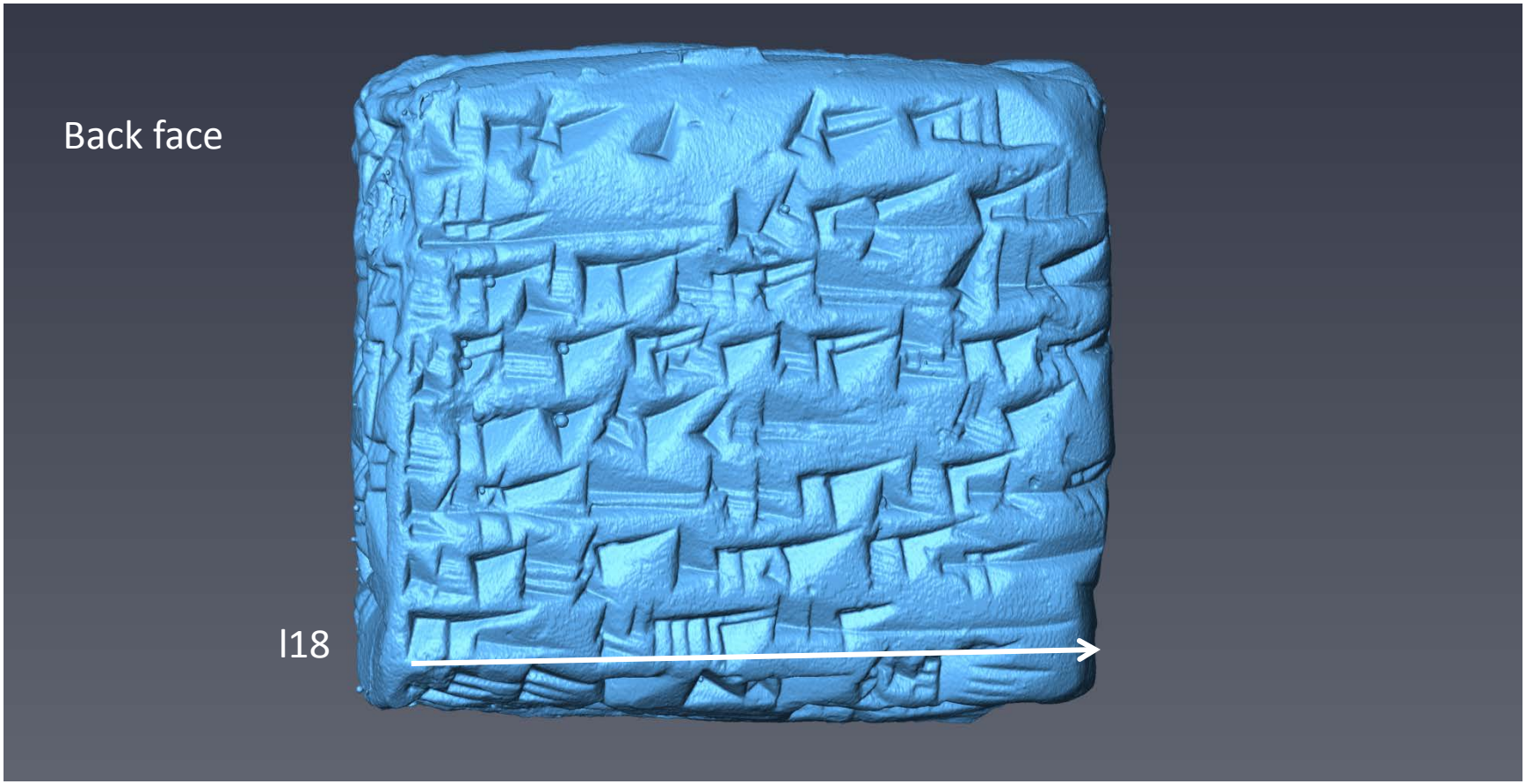
Translation process



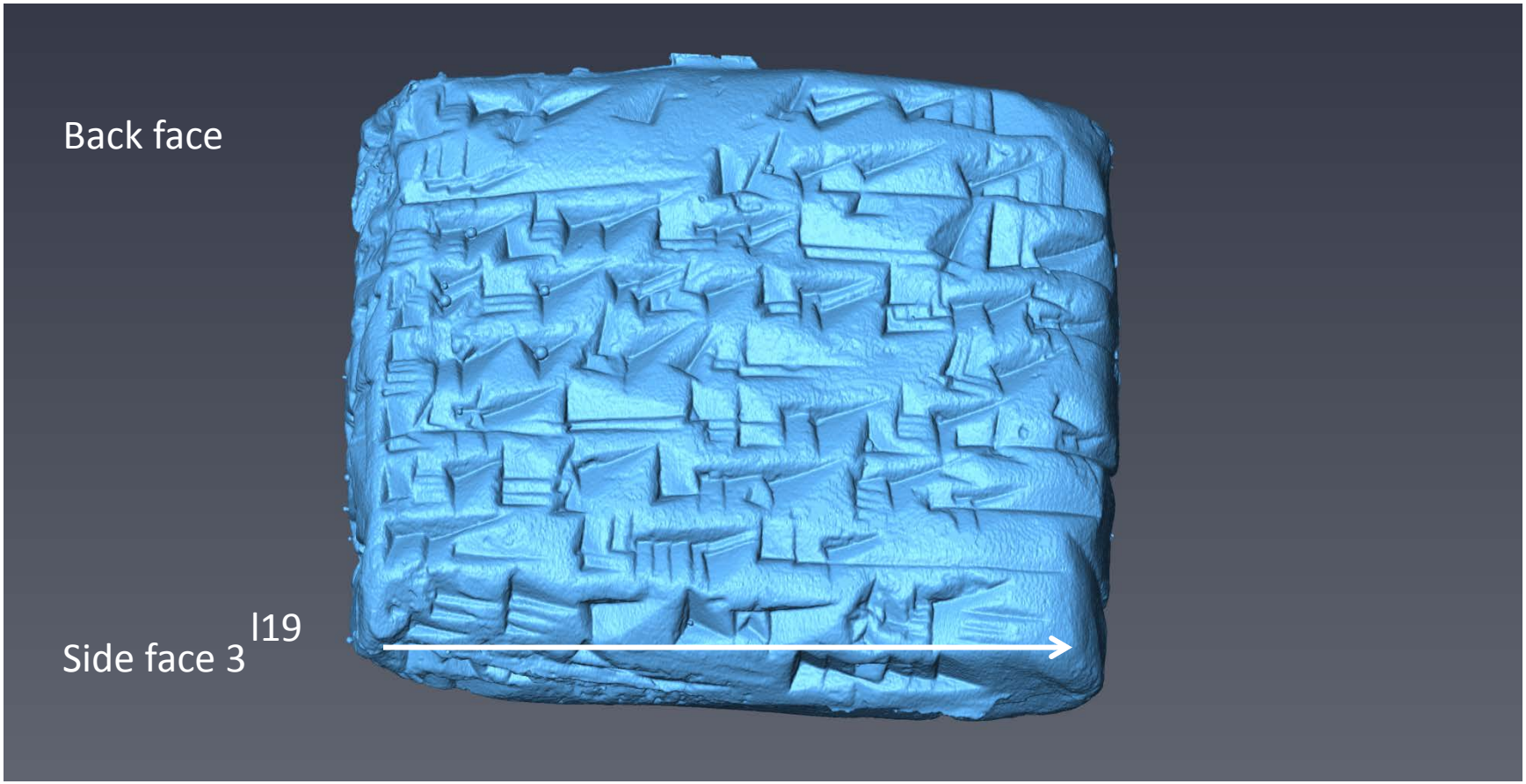
Translation process



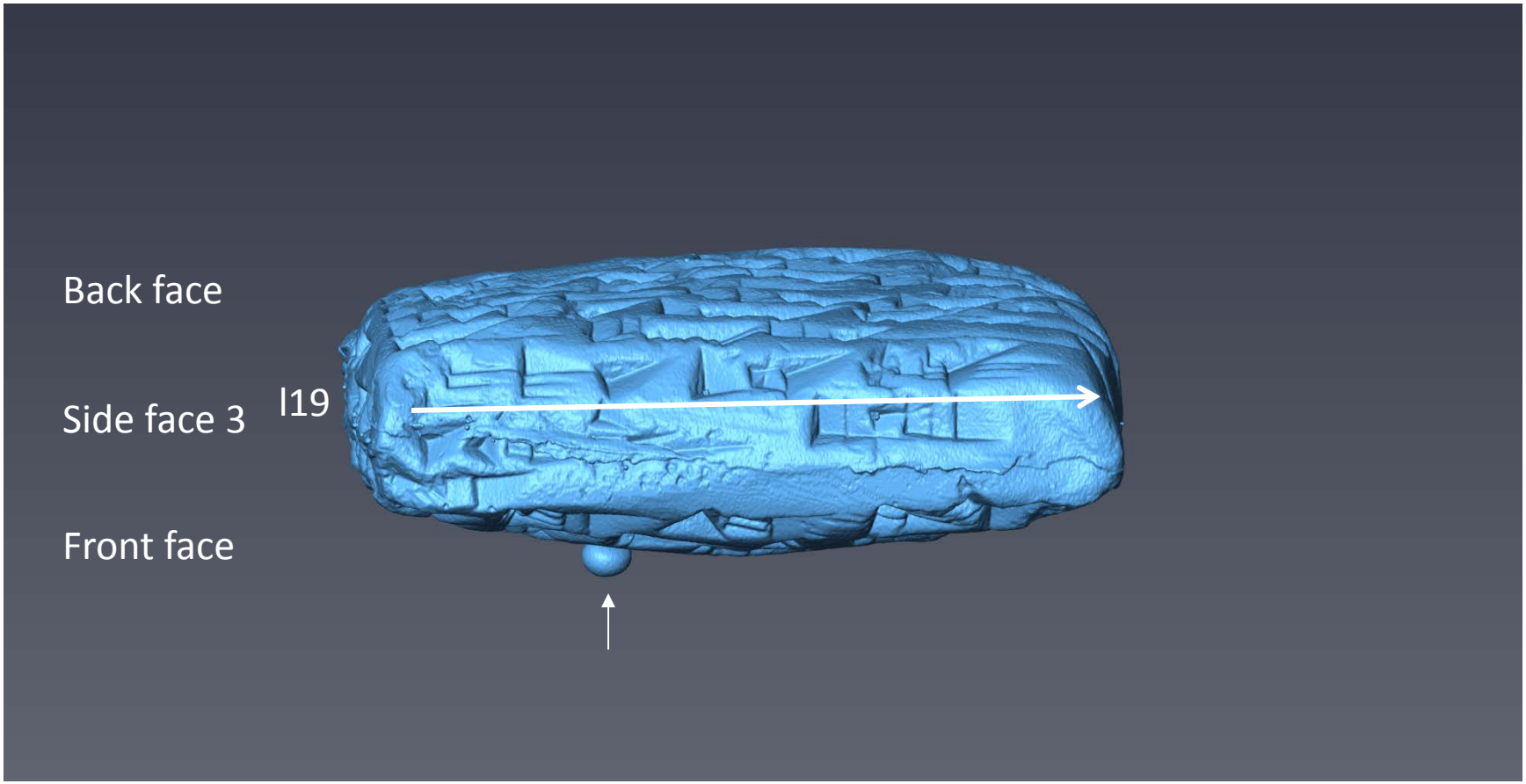
Translation process



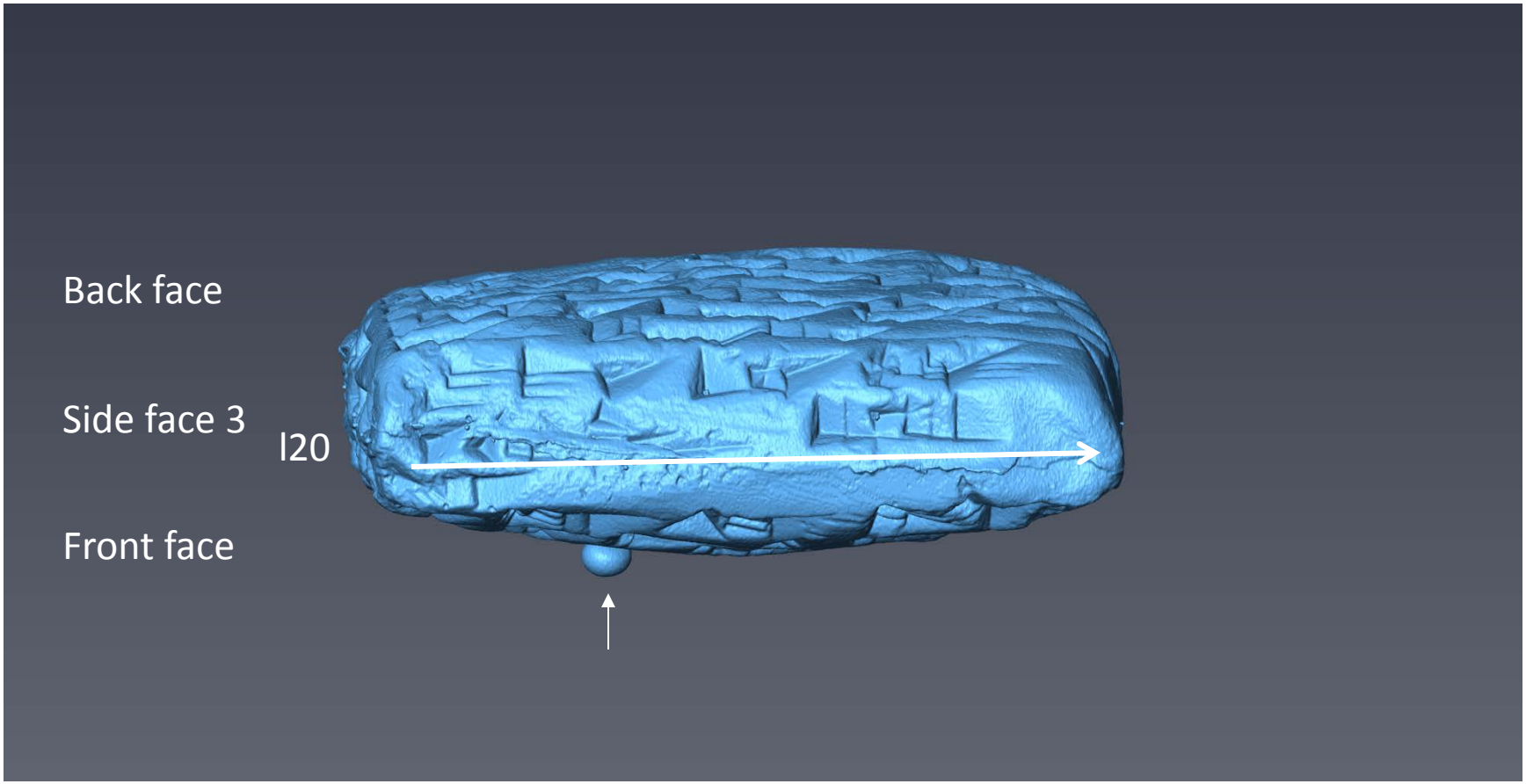
Translation process



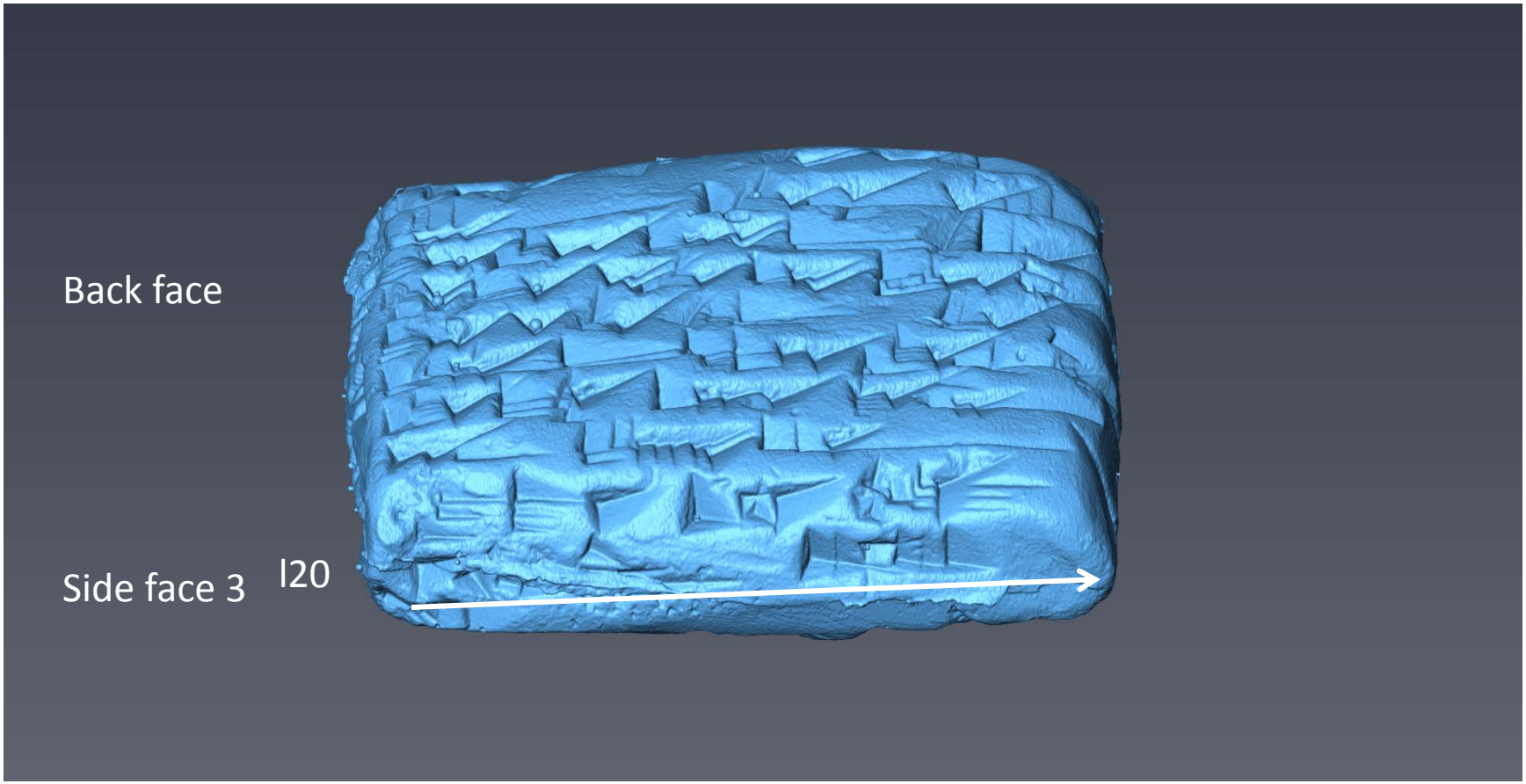
Translation process



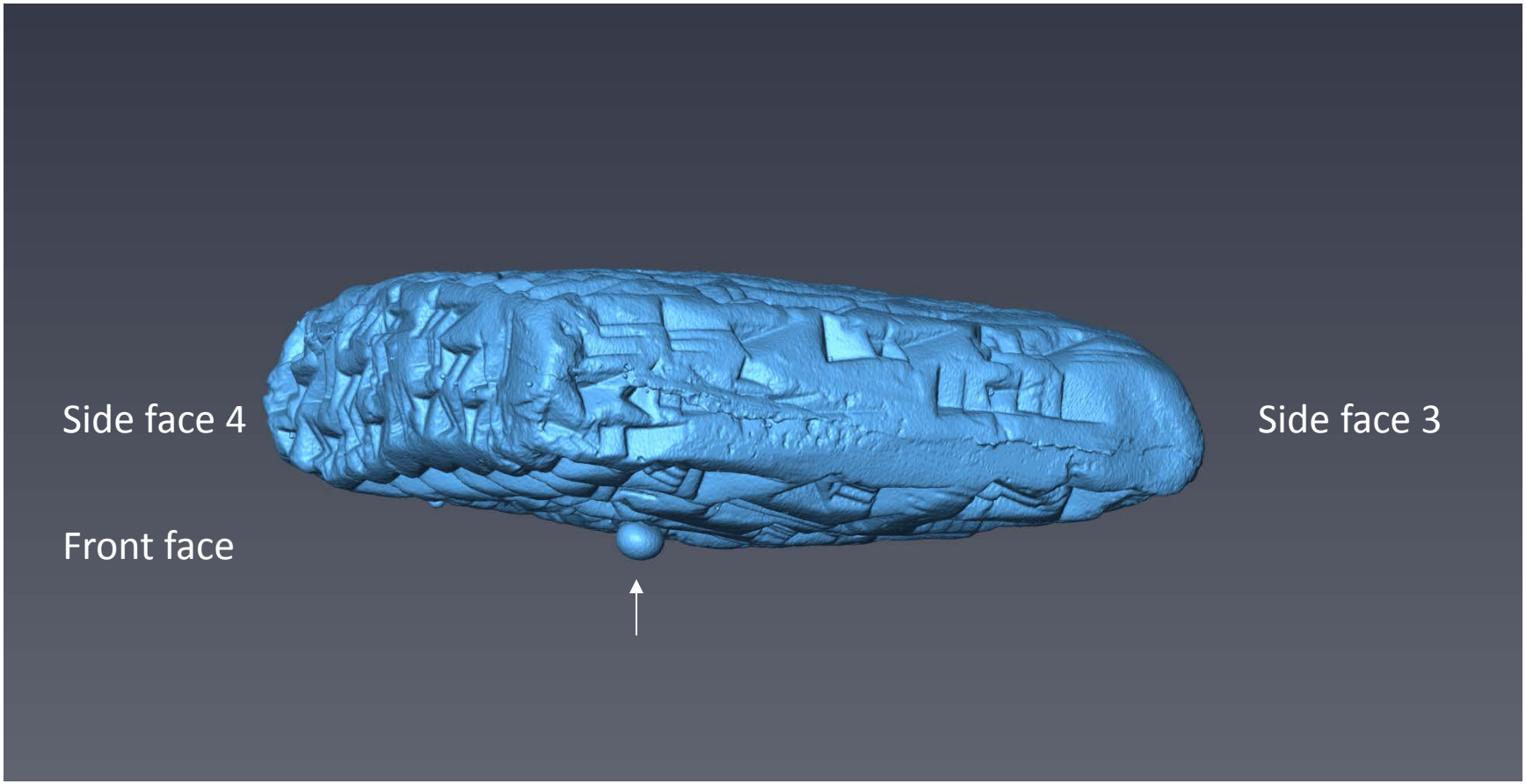
Translation process



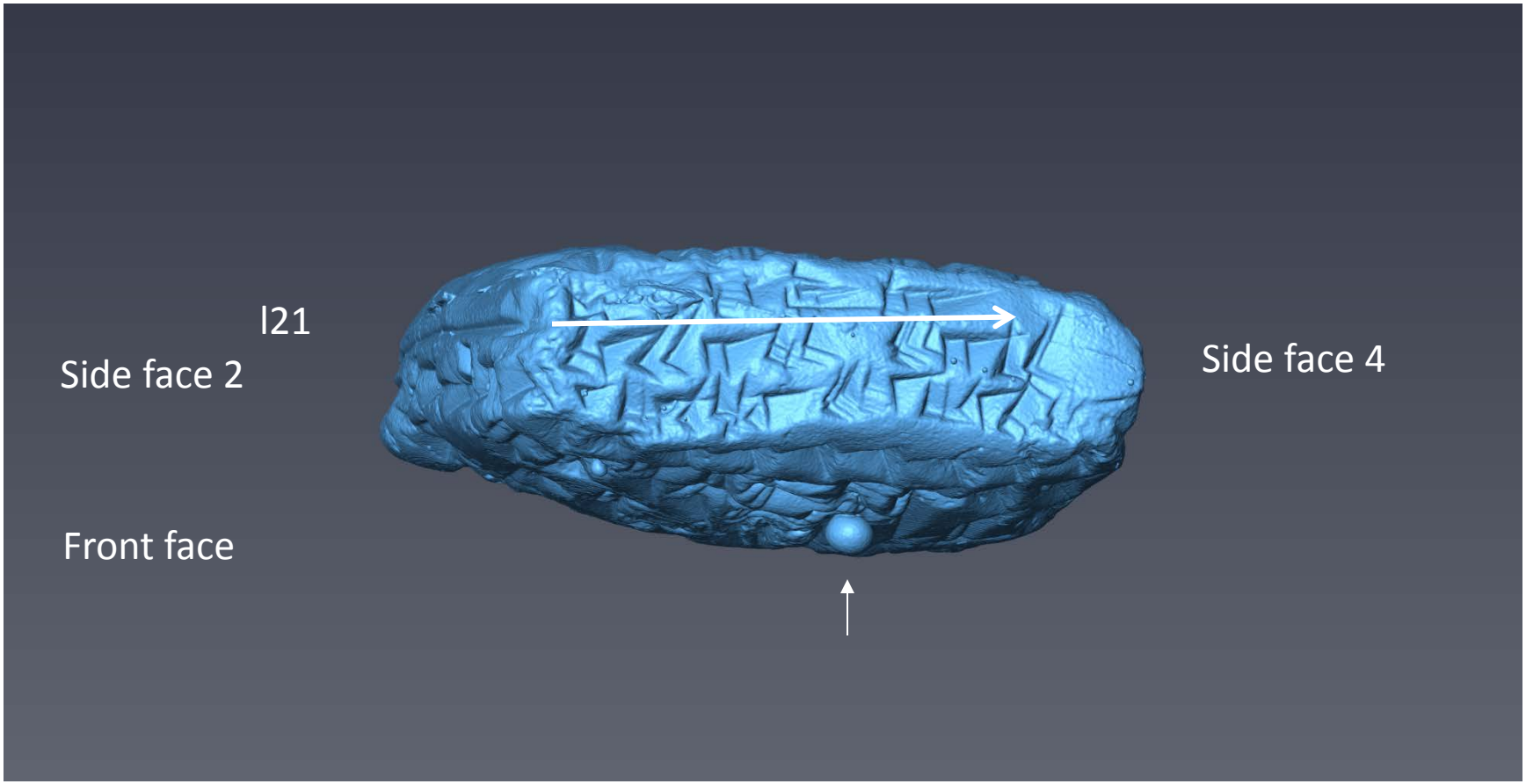
Translation process



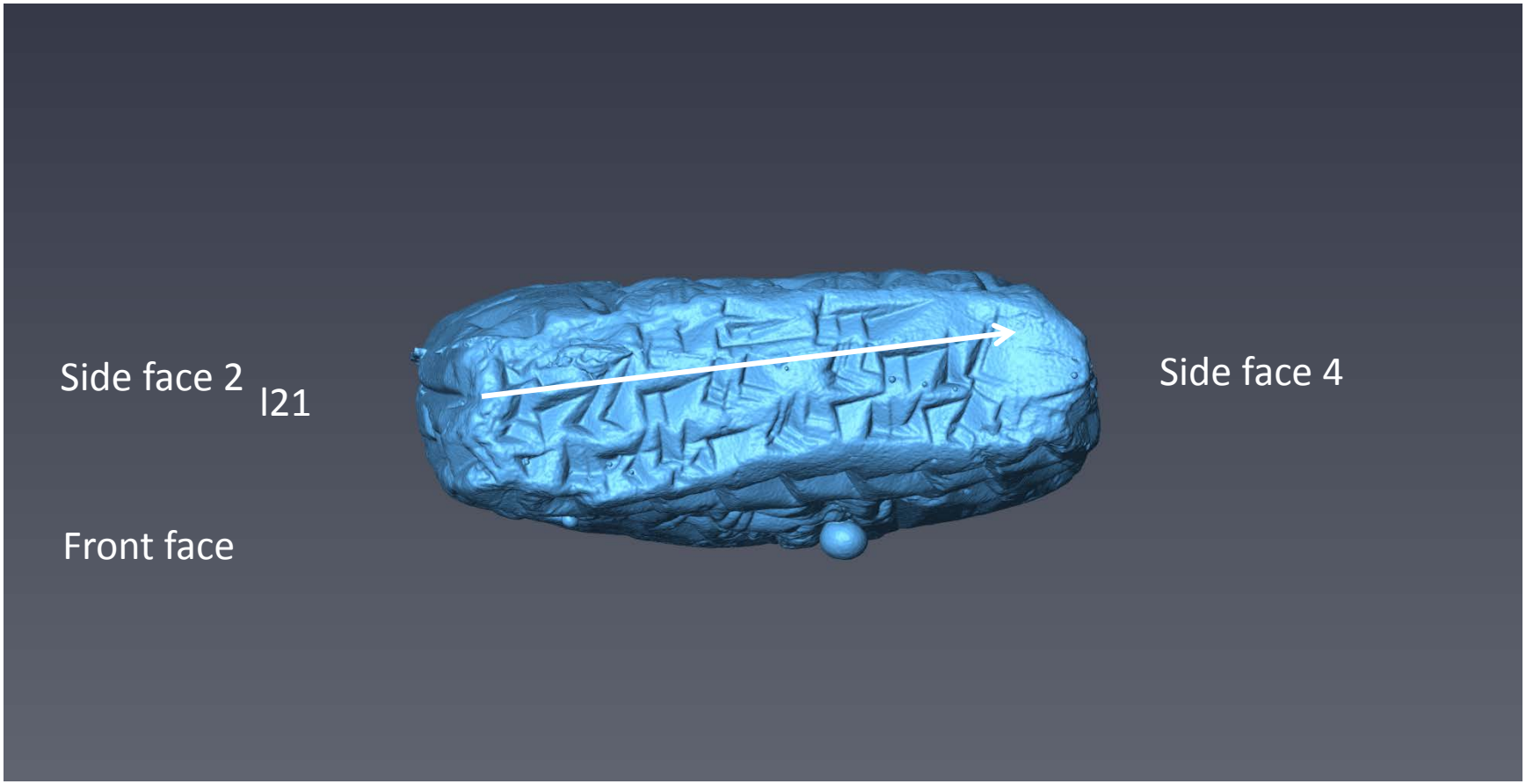
Translation process



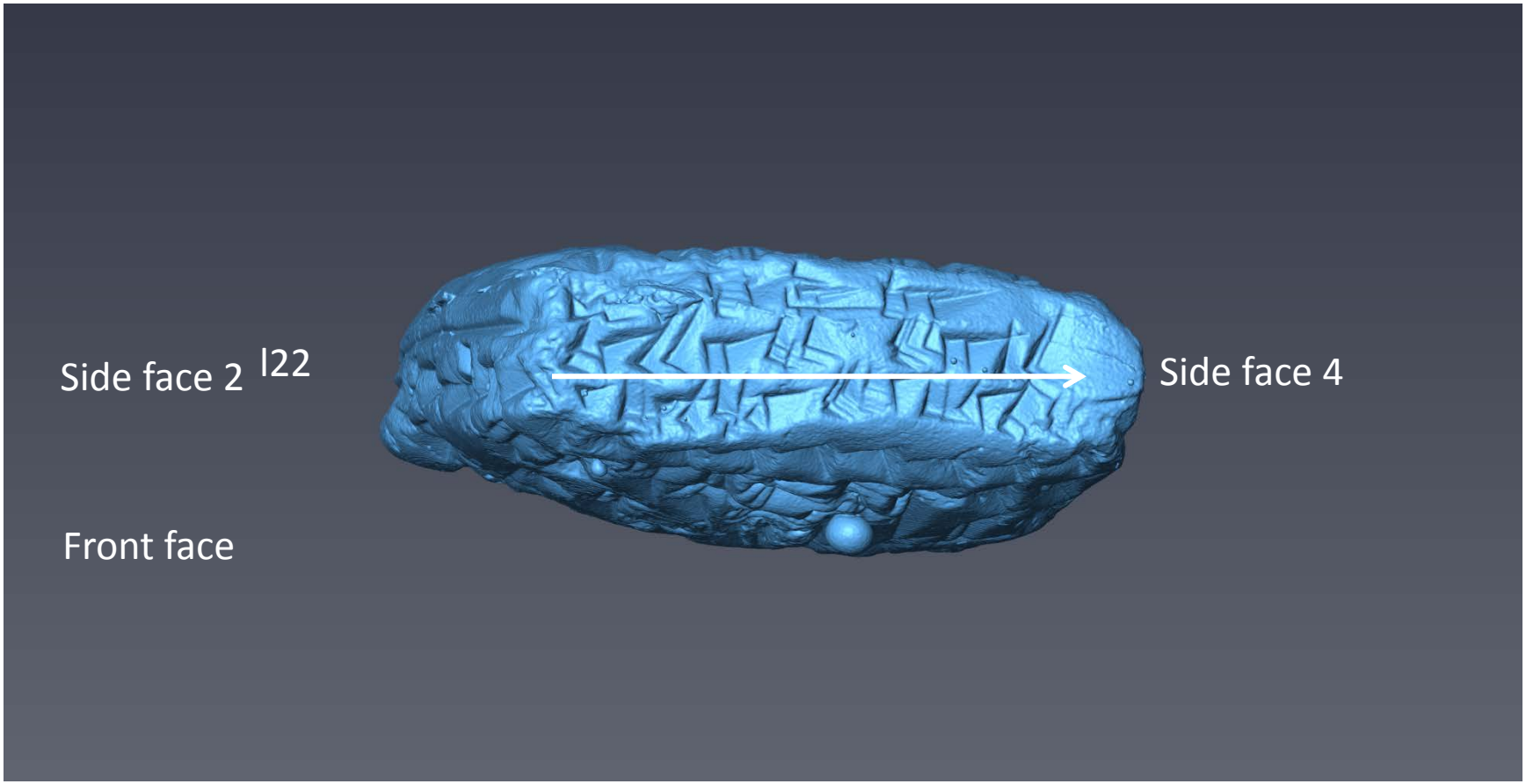
Translation process



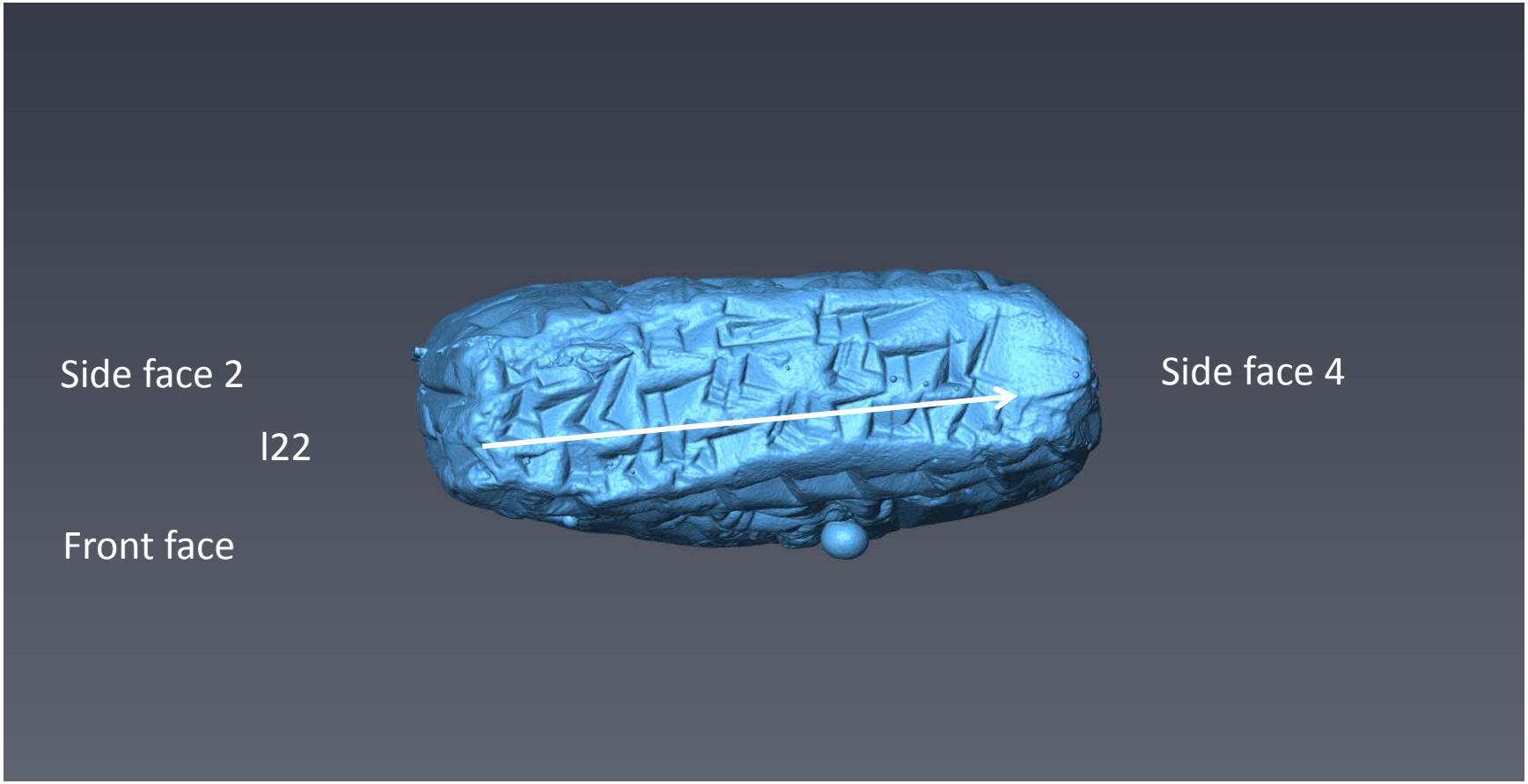
Translation process



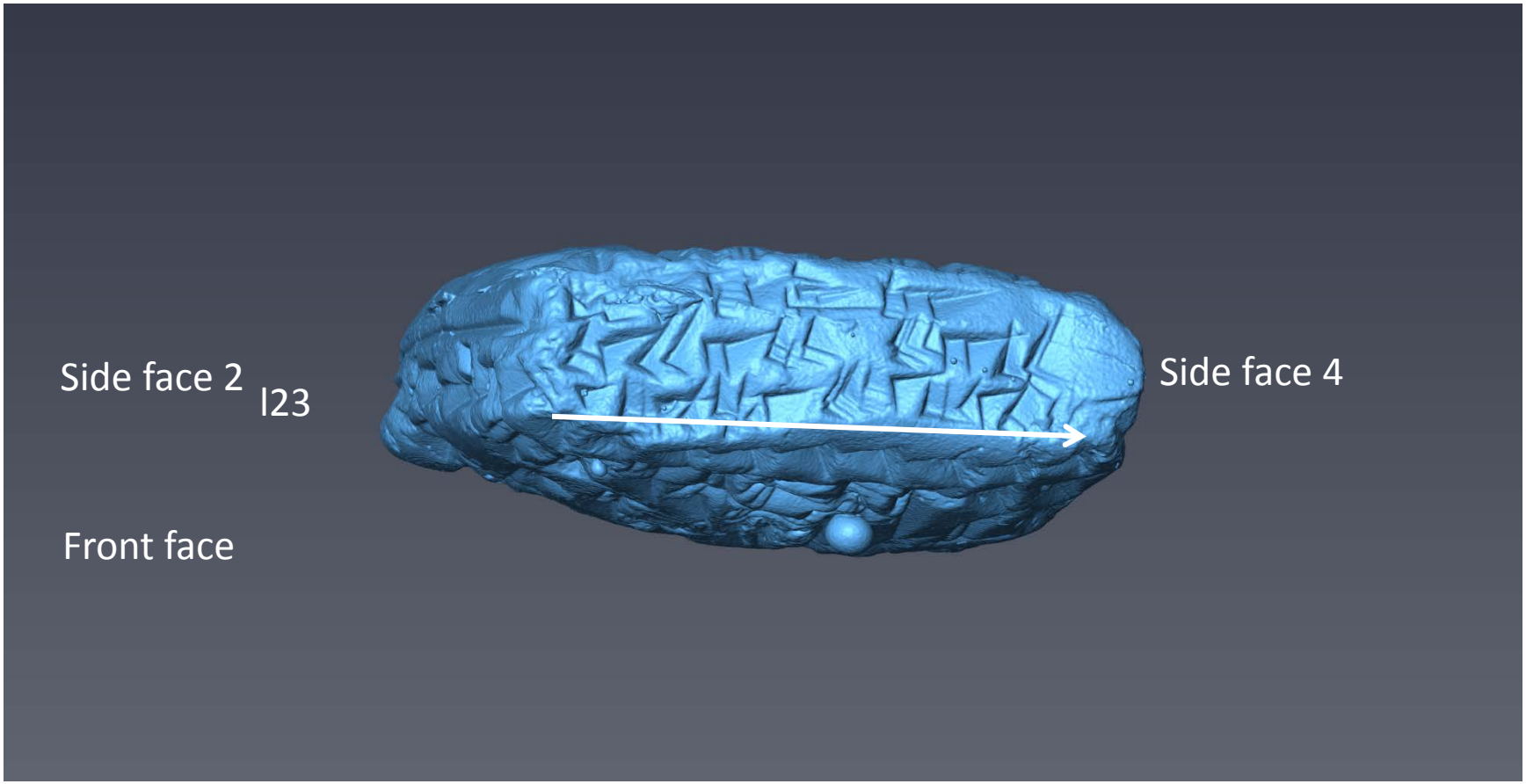
Translation process



Translation process

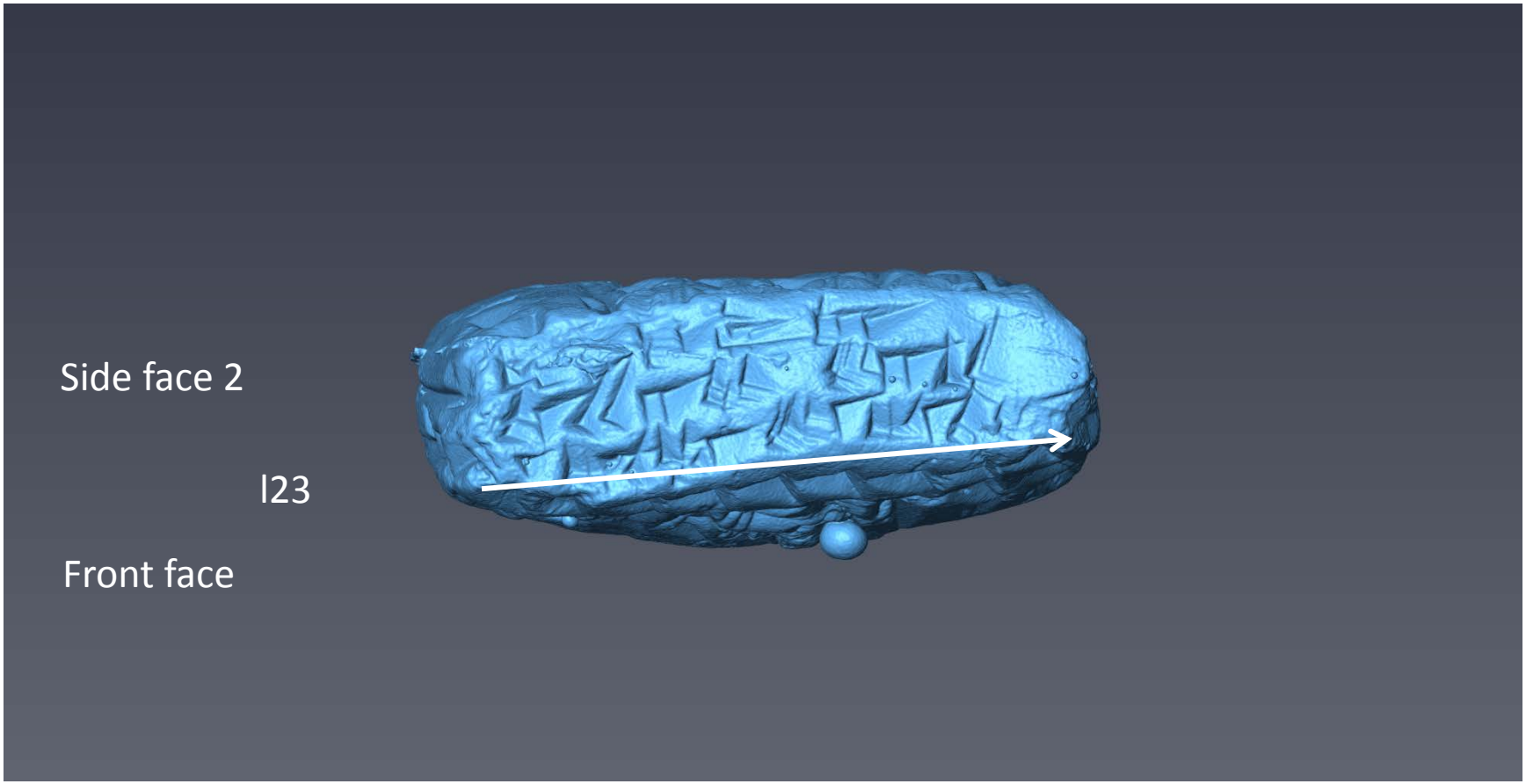


Translation process



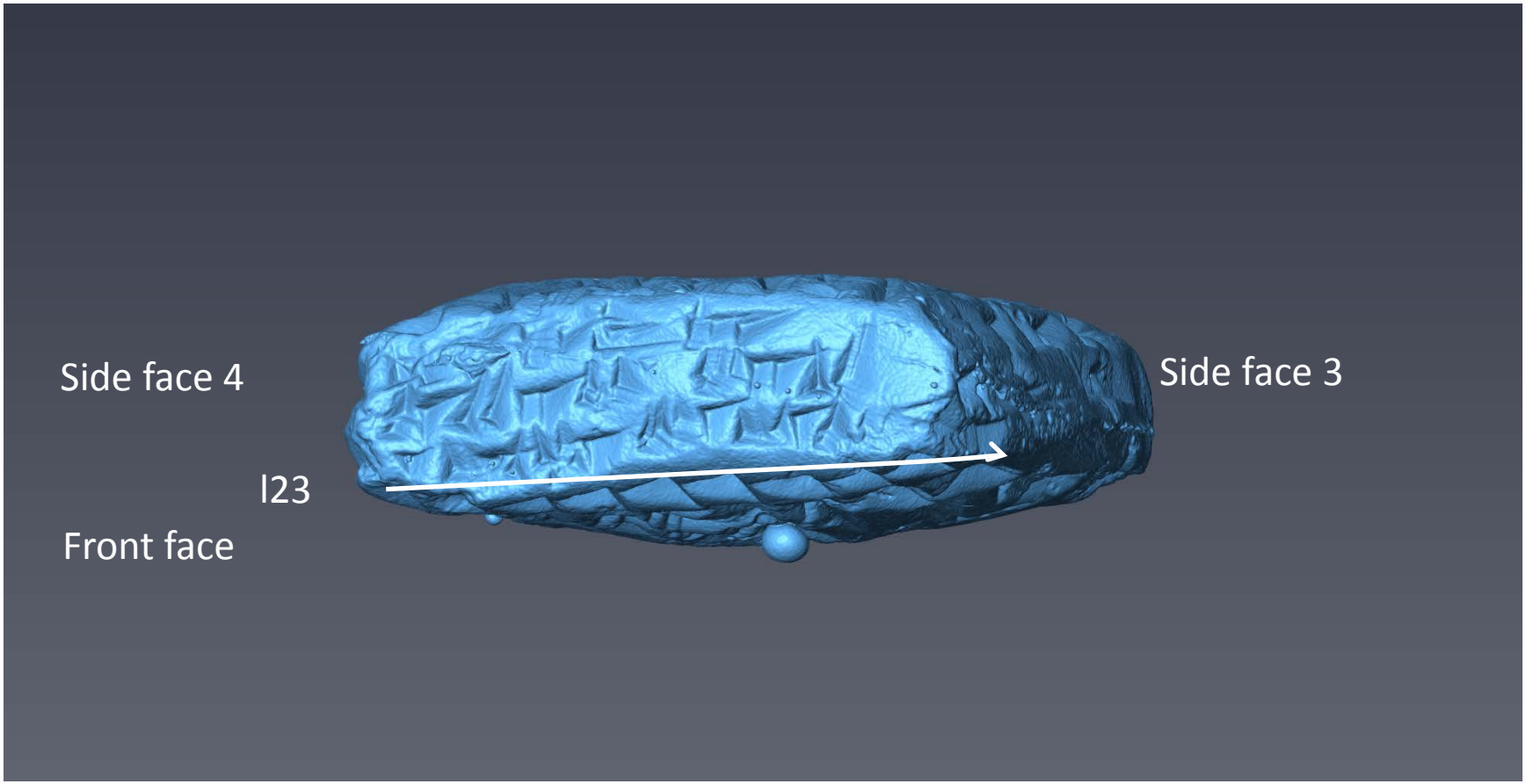
Note that the last characters of the last line of Side face 4 (l23) are placed on the adjacent face!

Translation process



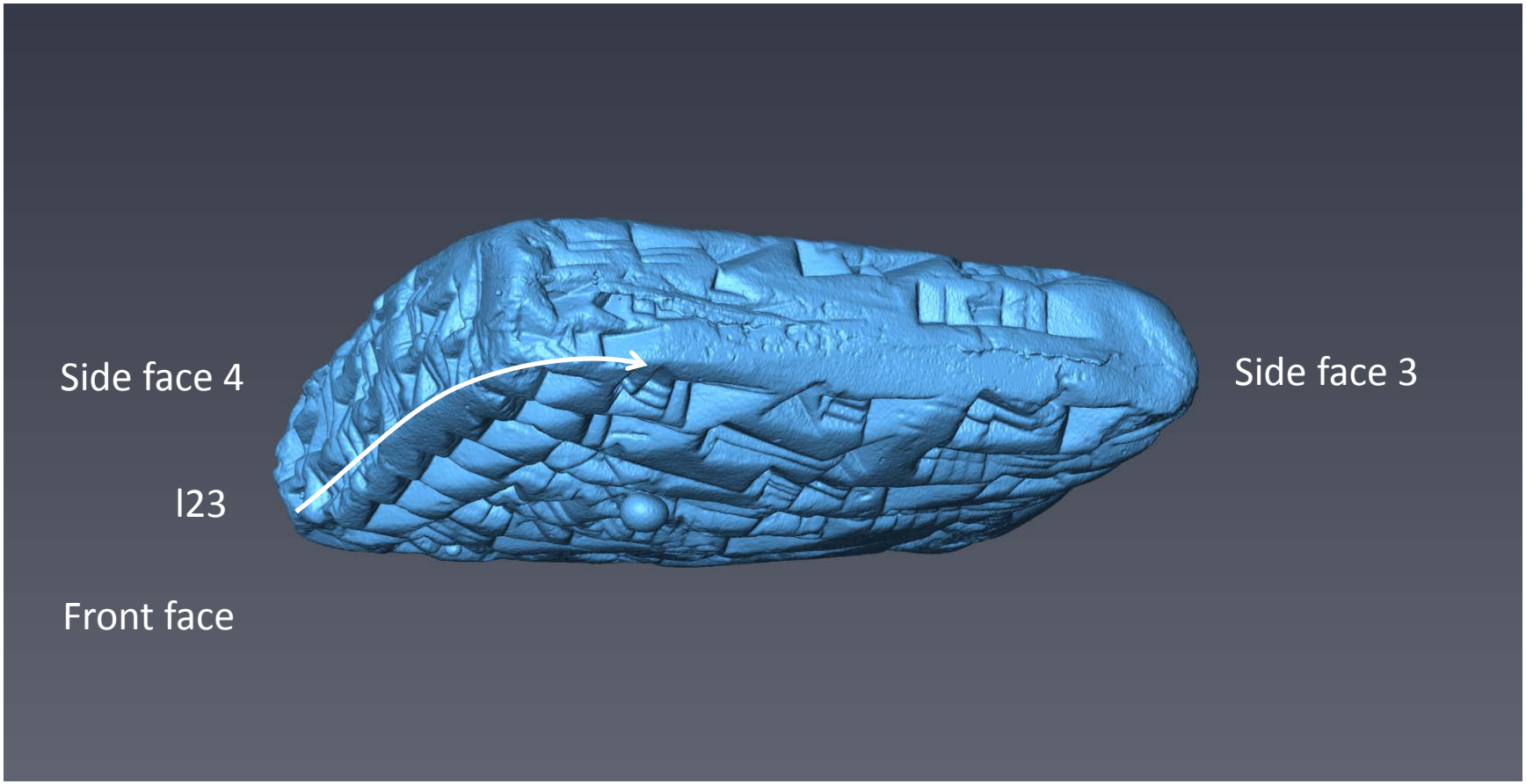
Note that the last characters of the last line of Side face 4 (l23) are placed on the adjacent face!

Translation process



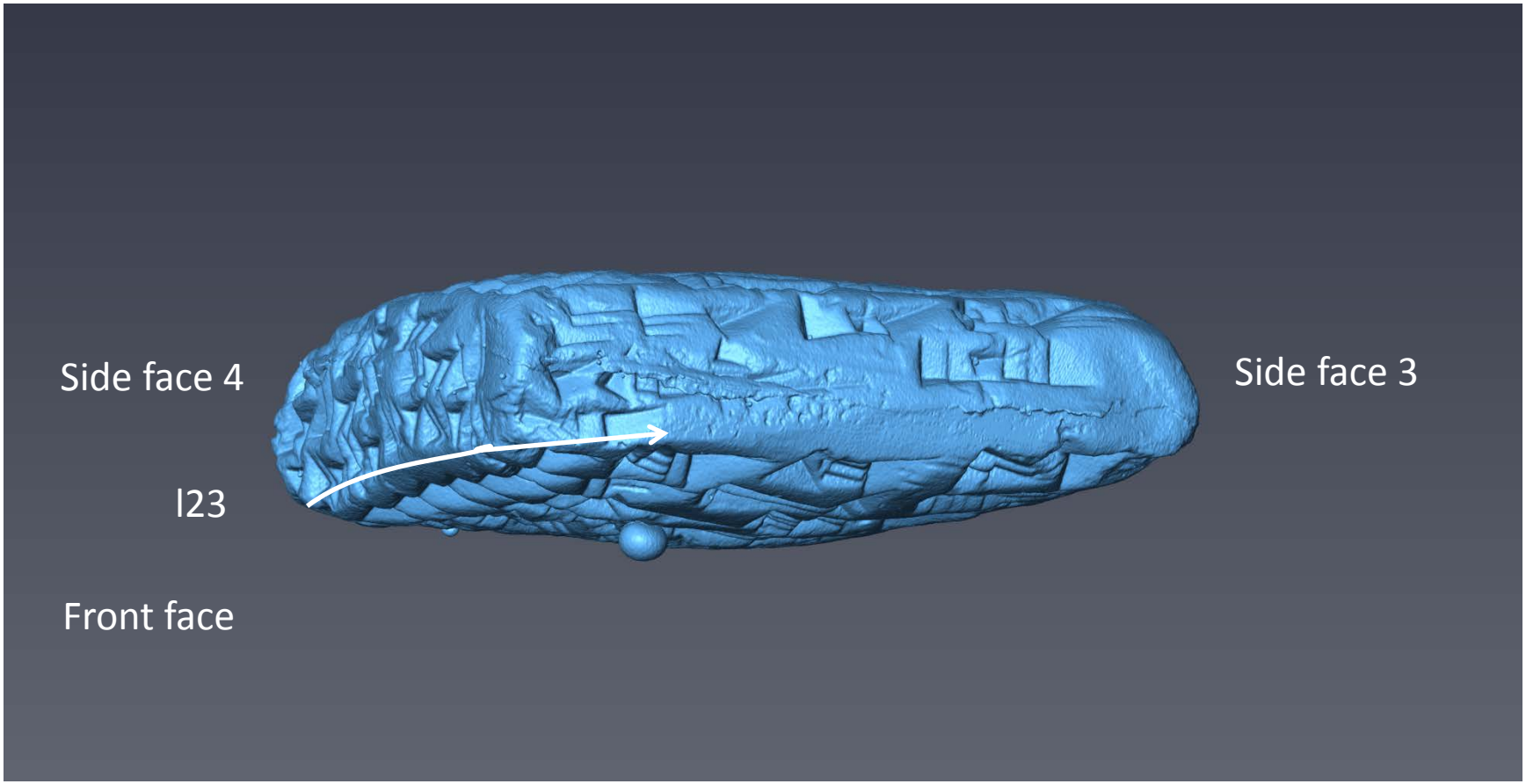
Note that the last characters of the last line of Side face 4 (l23) are placed on the adjacent face (Side face 3)!

Translation process



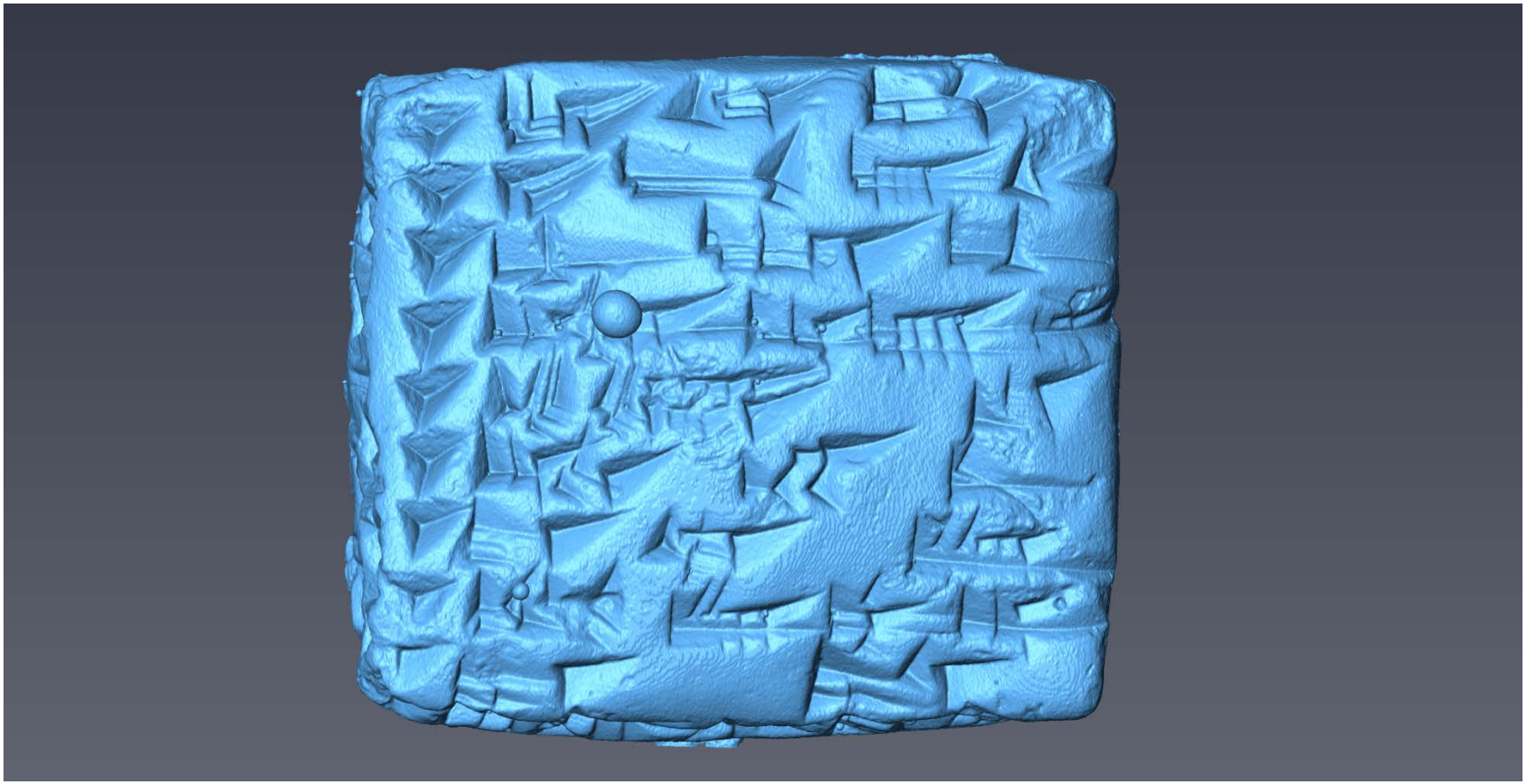
Note that the last characters of the last line of Side face 4 (l23) are placed on the adjacent face (Side face 3)!

Translation process



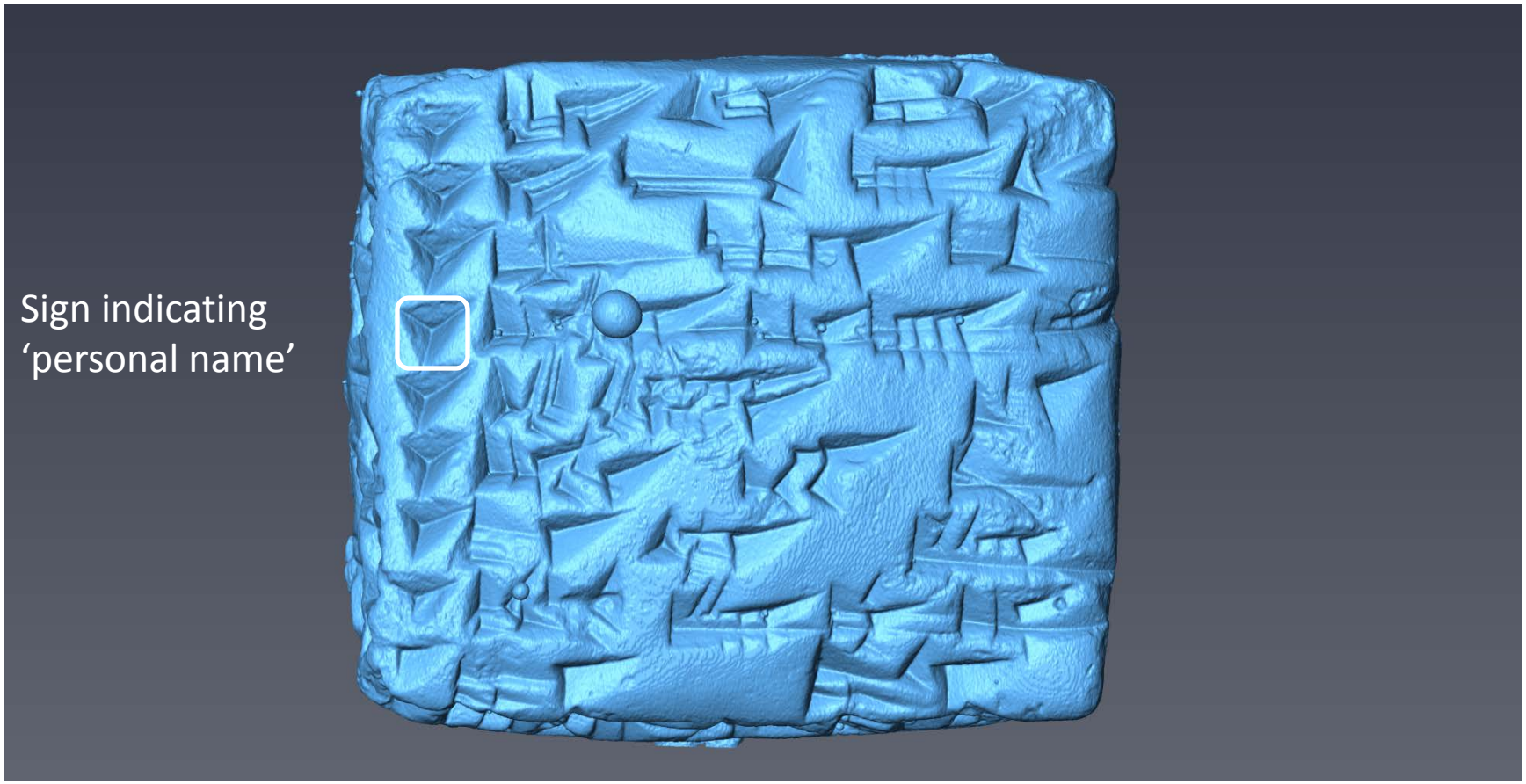
And the last characters interfere with the text of that face (Side face 3)!

Translation process



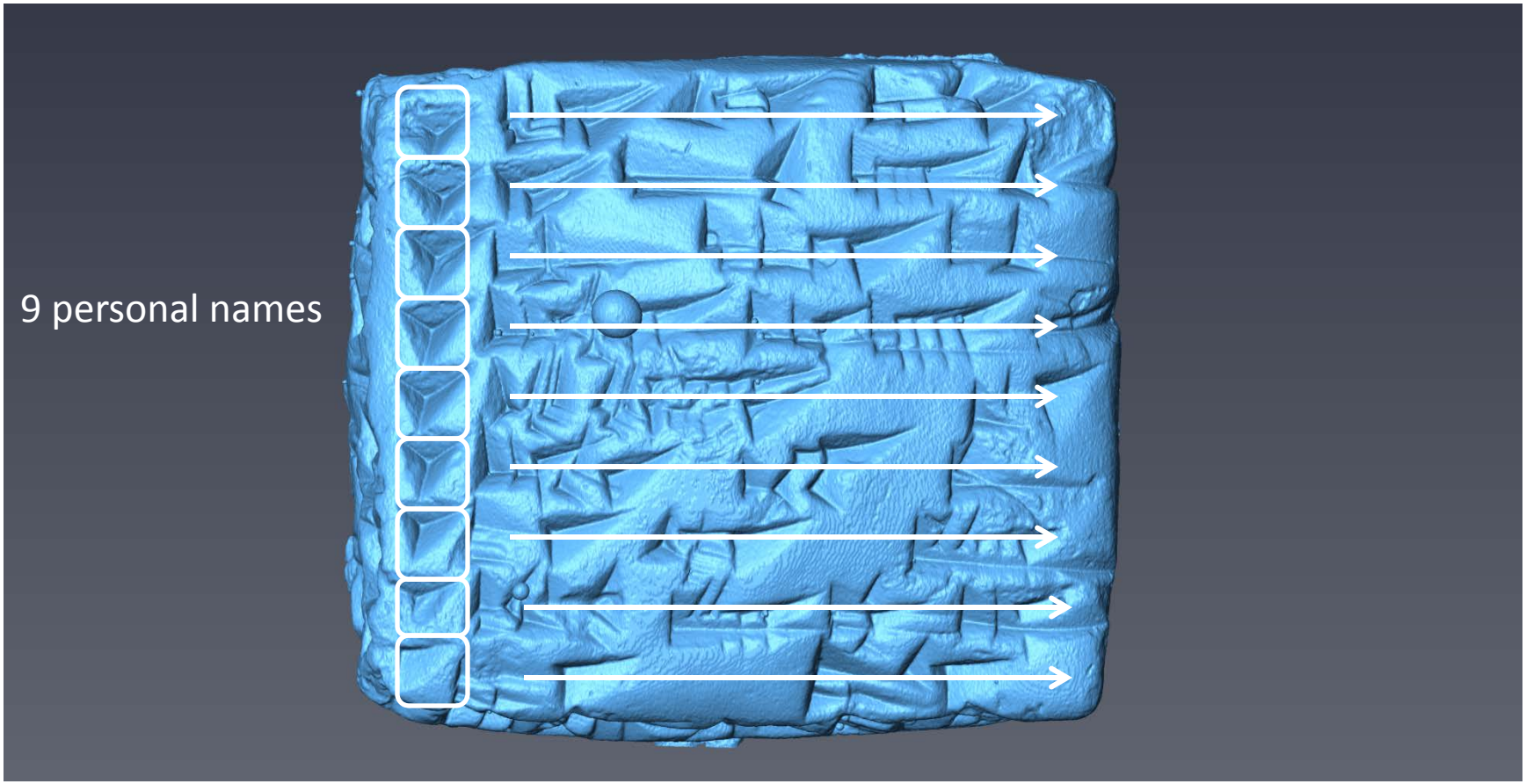
Basics of cuneiform writing

Translation process



Basics of cuneiform writing
Sign indicating ‘personal name’

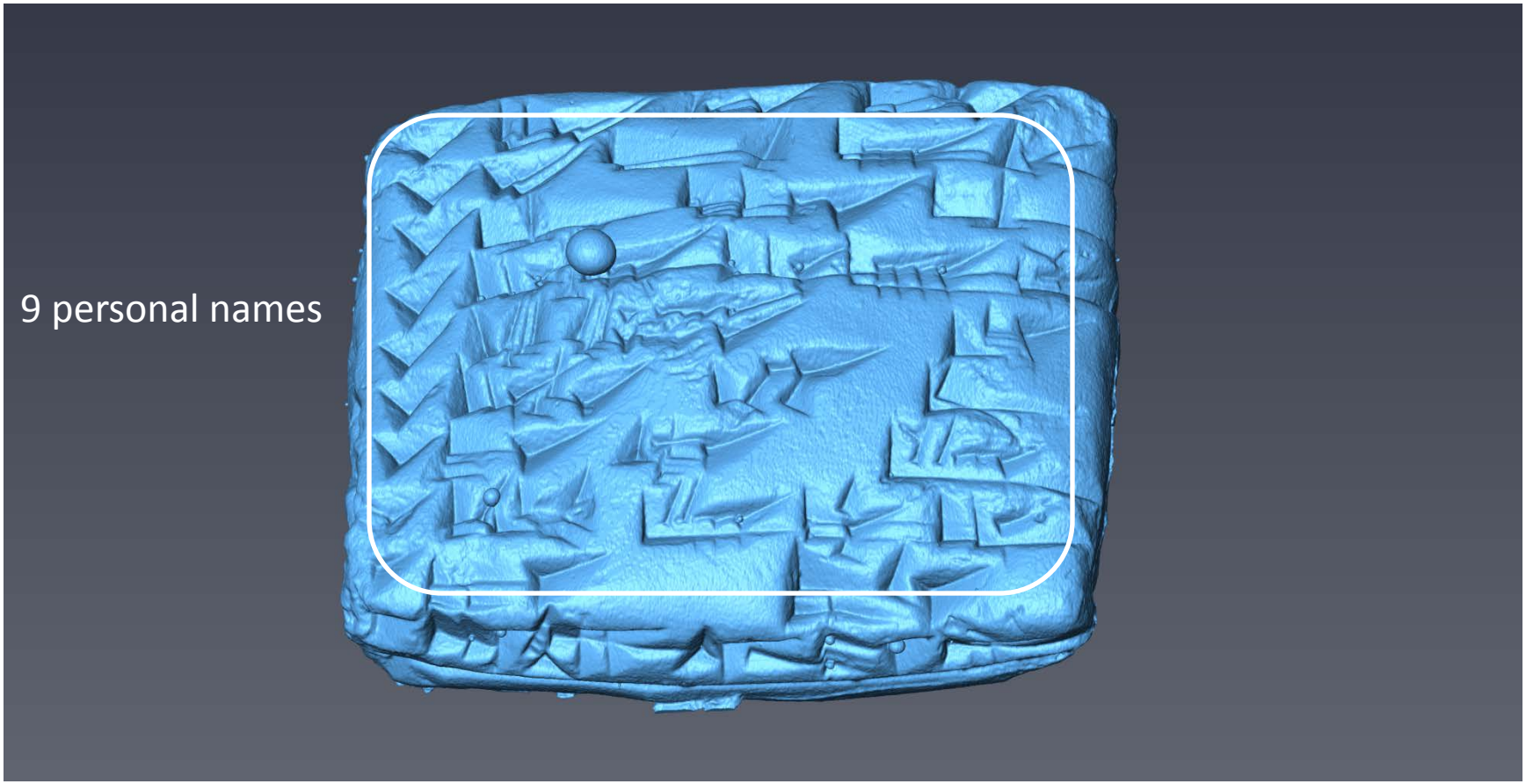
Translation process



Basics of cuneiform writing

Sign indicating ‘personal name’

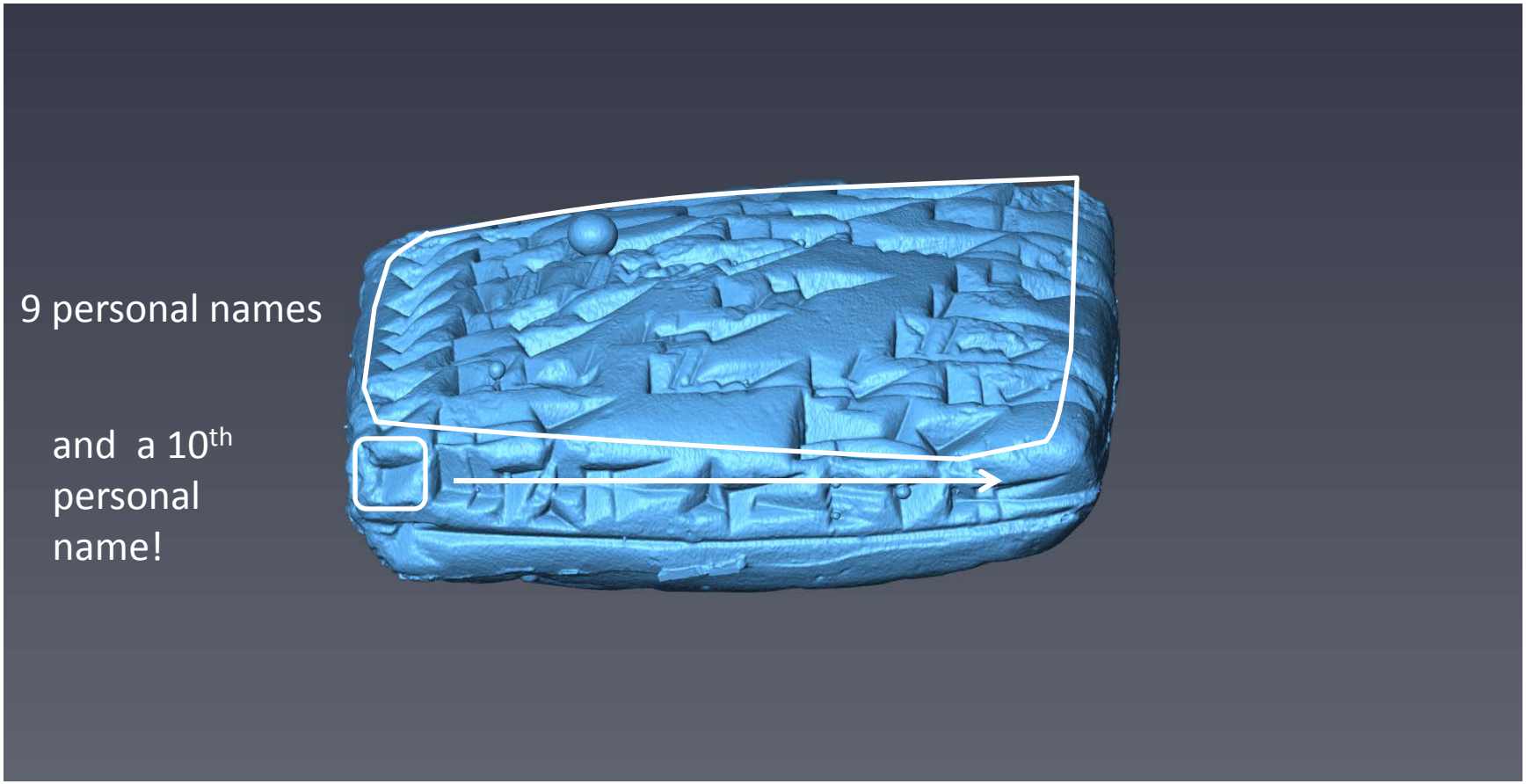
Translation process



Basics of cuneiform writing

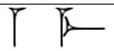
Sign indicating personal name

Translation process



Basics of cuneiform writing
Sign indicating ‘personal name’

Translation process

	1 or 60		9 or 540
	2 or 120		10
	3 or 180		20
	4 or 240		50
	5 or 300		70
	6 or 360		100 (1 x 100)
	7 or 420		300 (3 x 100)
	8 or 480		600

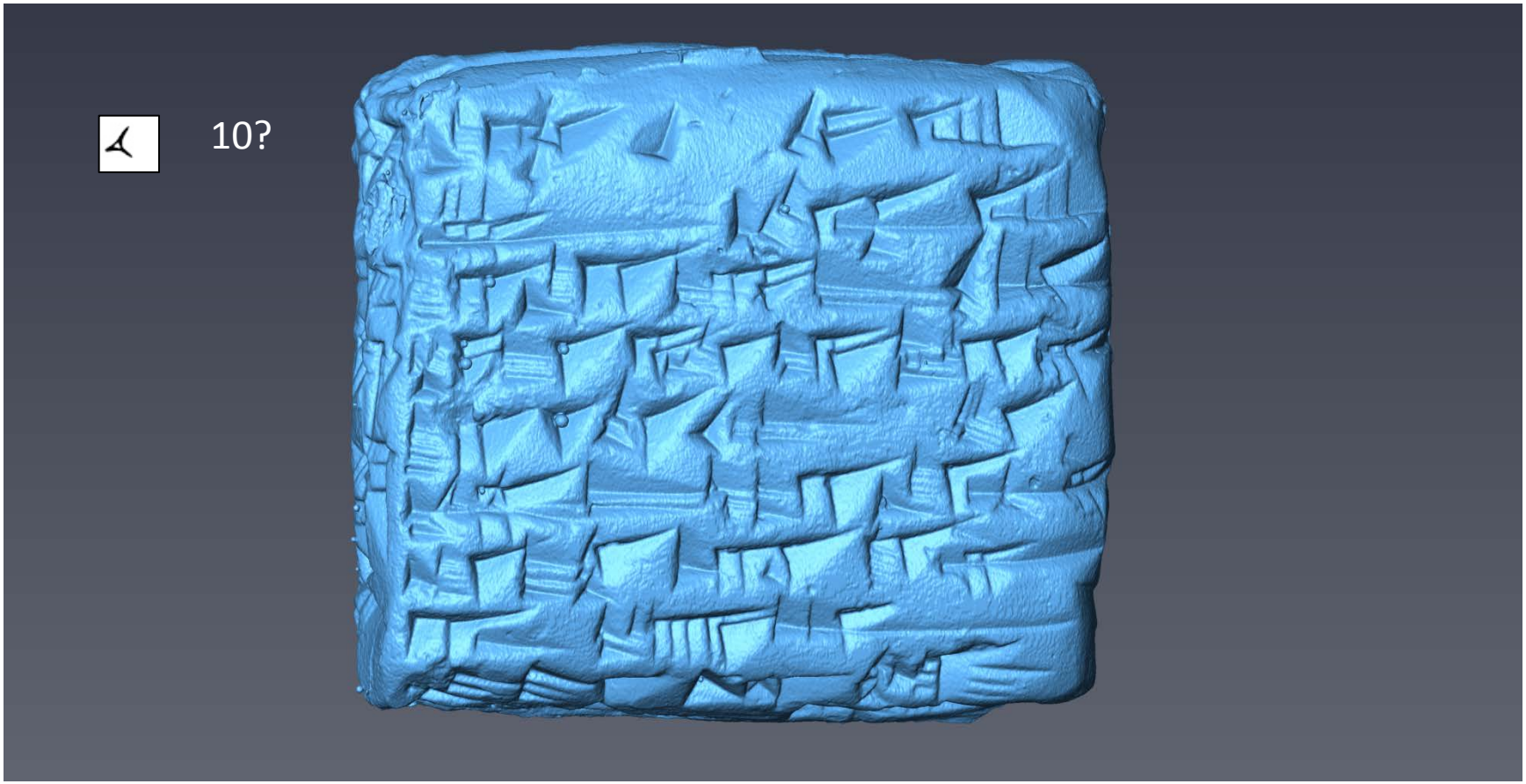
Basics of cuneiform writing
Cuneiform numbers

Translation process

10 and 100?

Basics of cuneiform writing
Cuneiform numbers 1 and 100

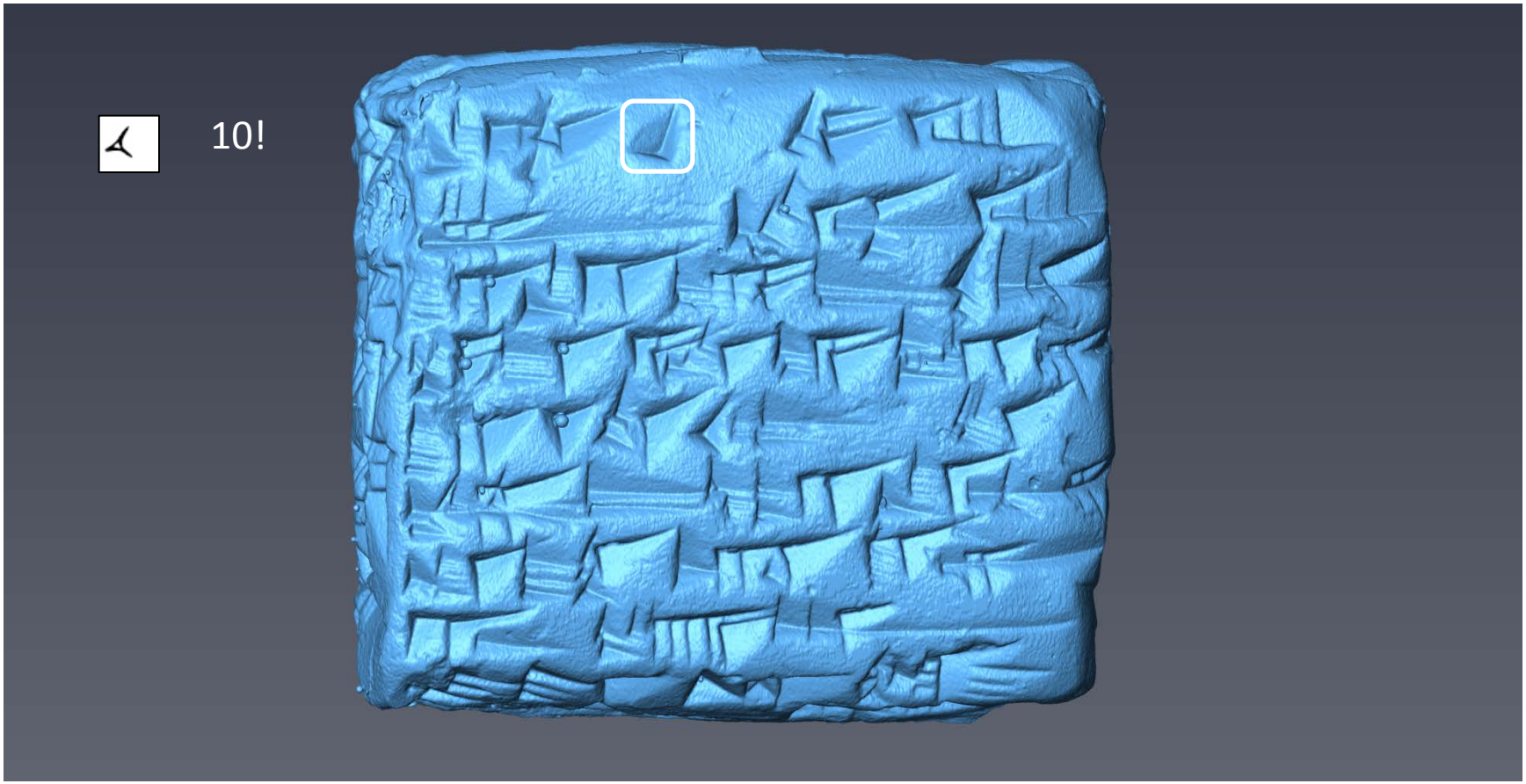
Translation process



Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

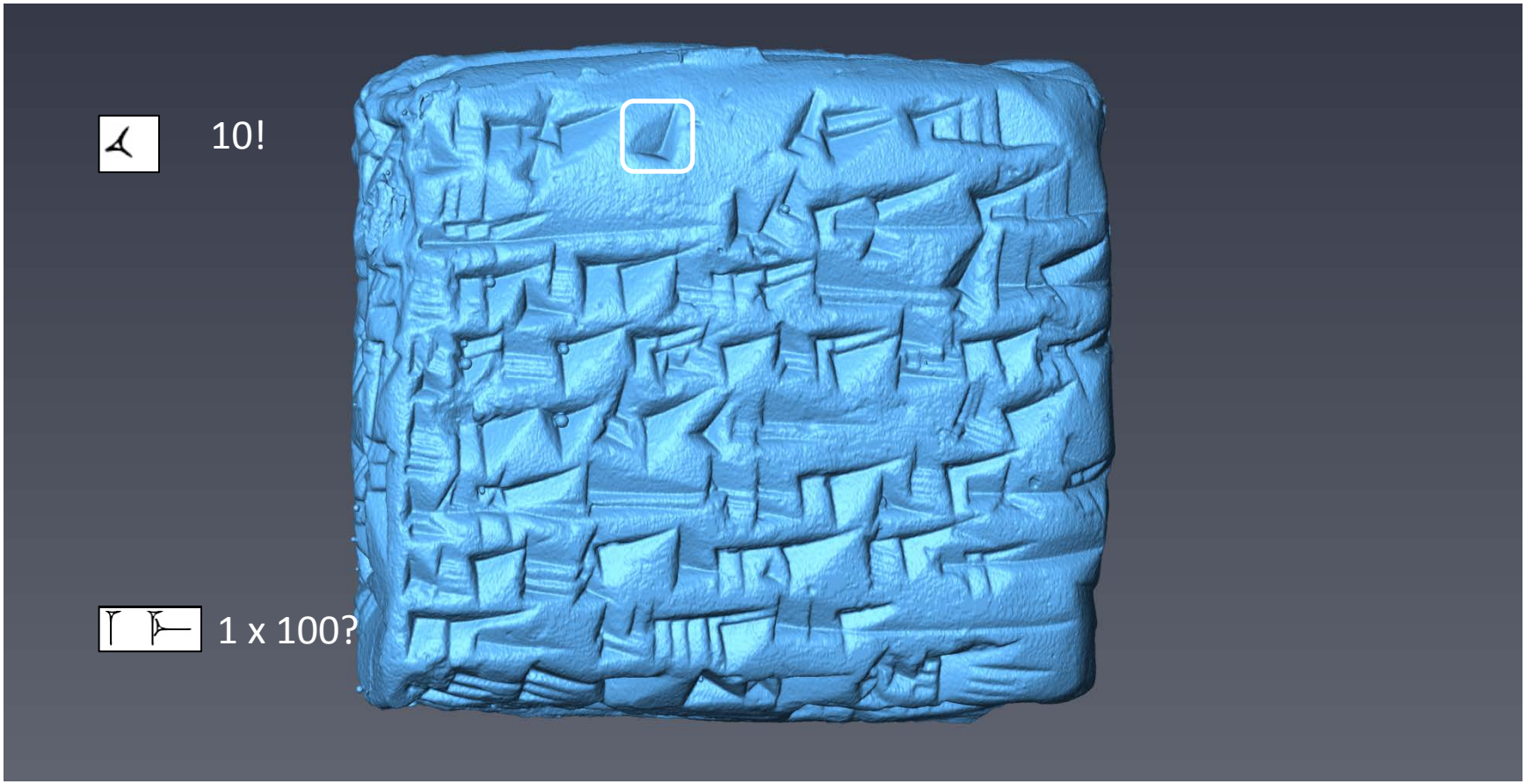
Translation process



Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

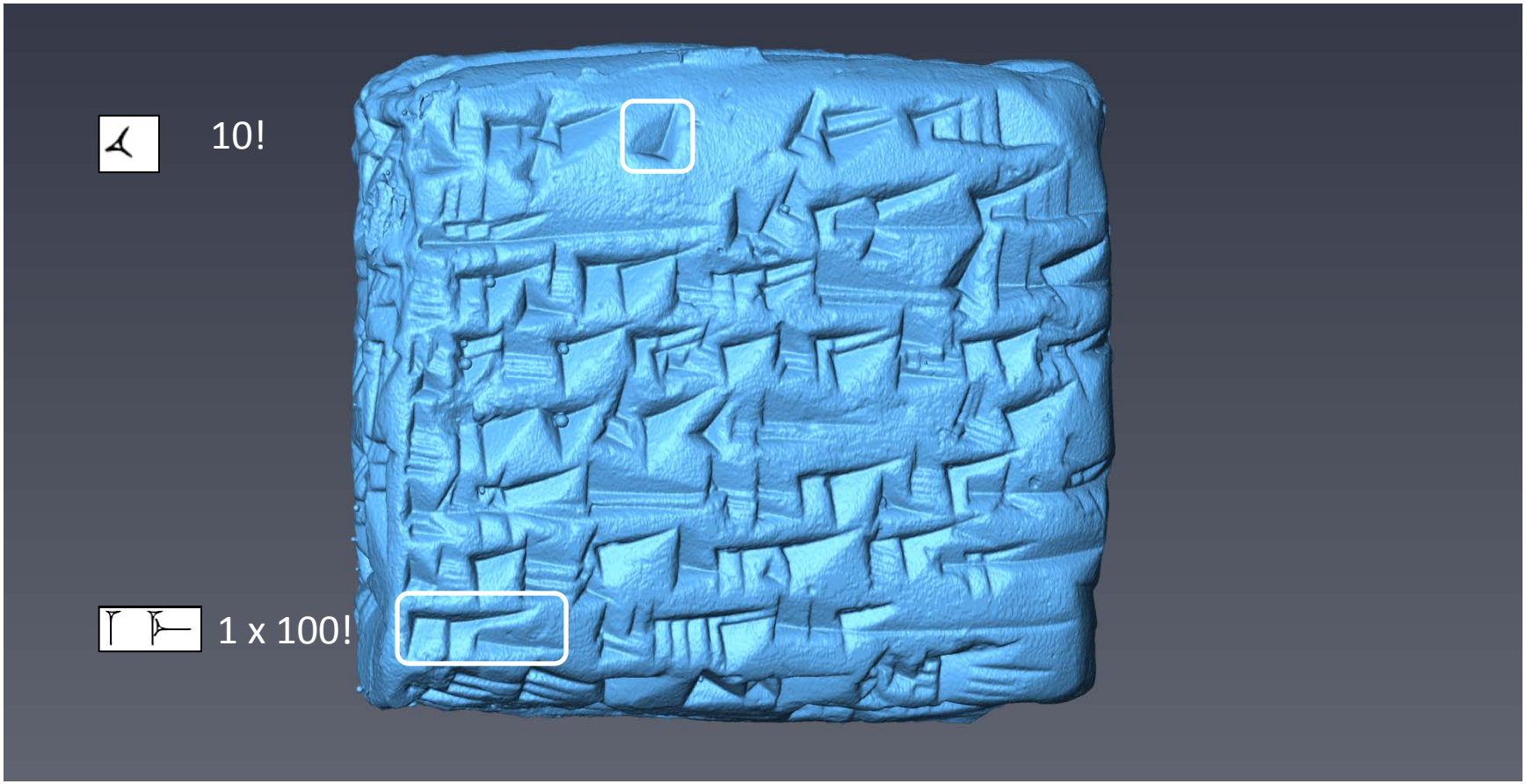
Translation process



Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

Translation process

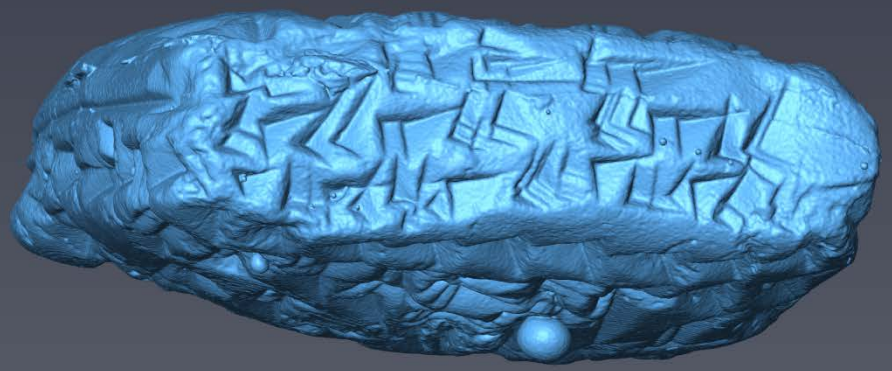


Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

Translation process

and 22?



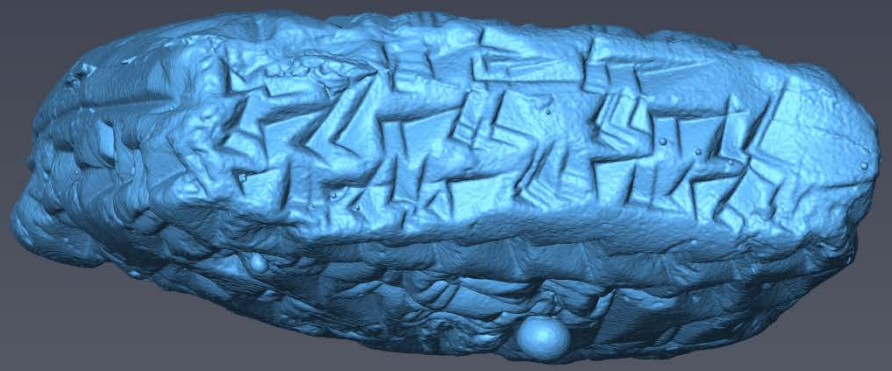
Basics of cuneiform writing
Cuneiform numbers 1, 100 and 22

Translation process

22 =

2 x 10 

2 x 1 



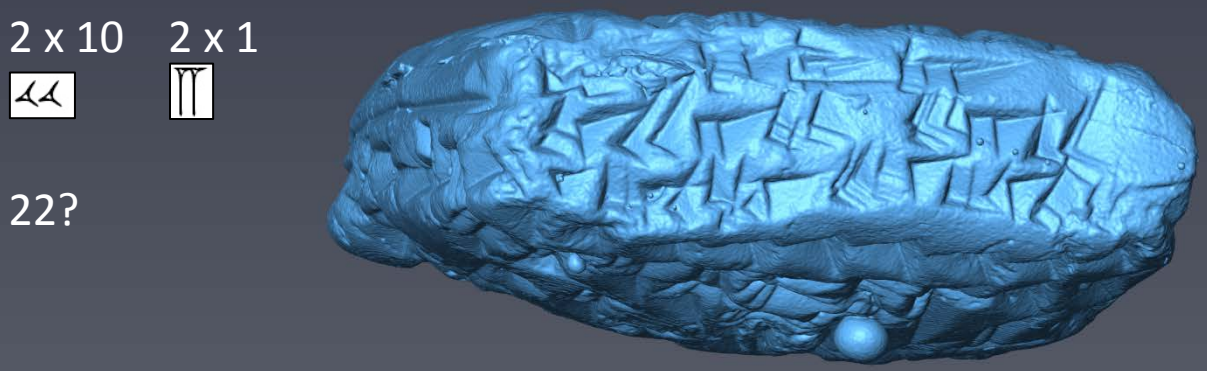
Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

Translation process

22 =

2 x 10 2 x 1



22?

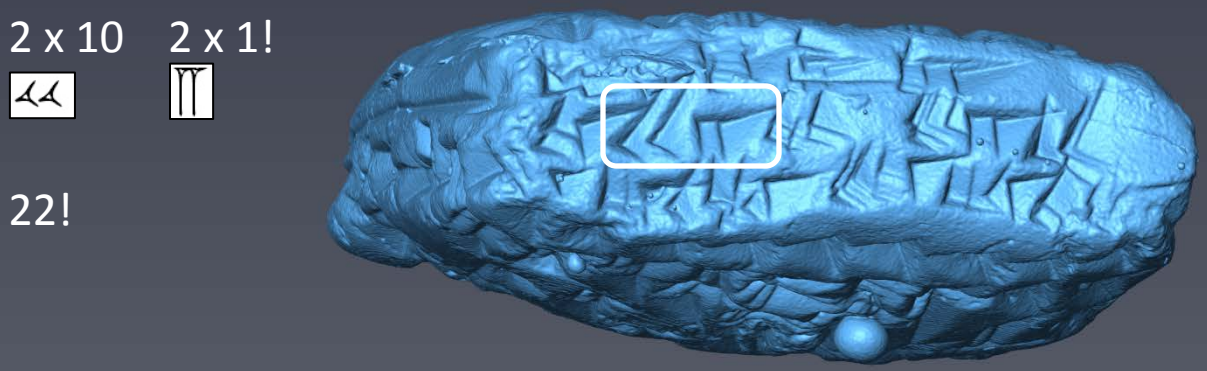
Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

Translation process

22 =

2 x 10 2 x 1!

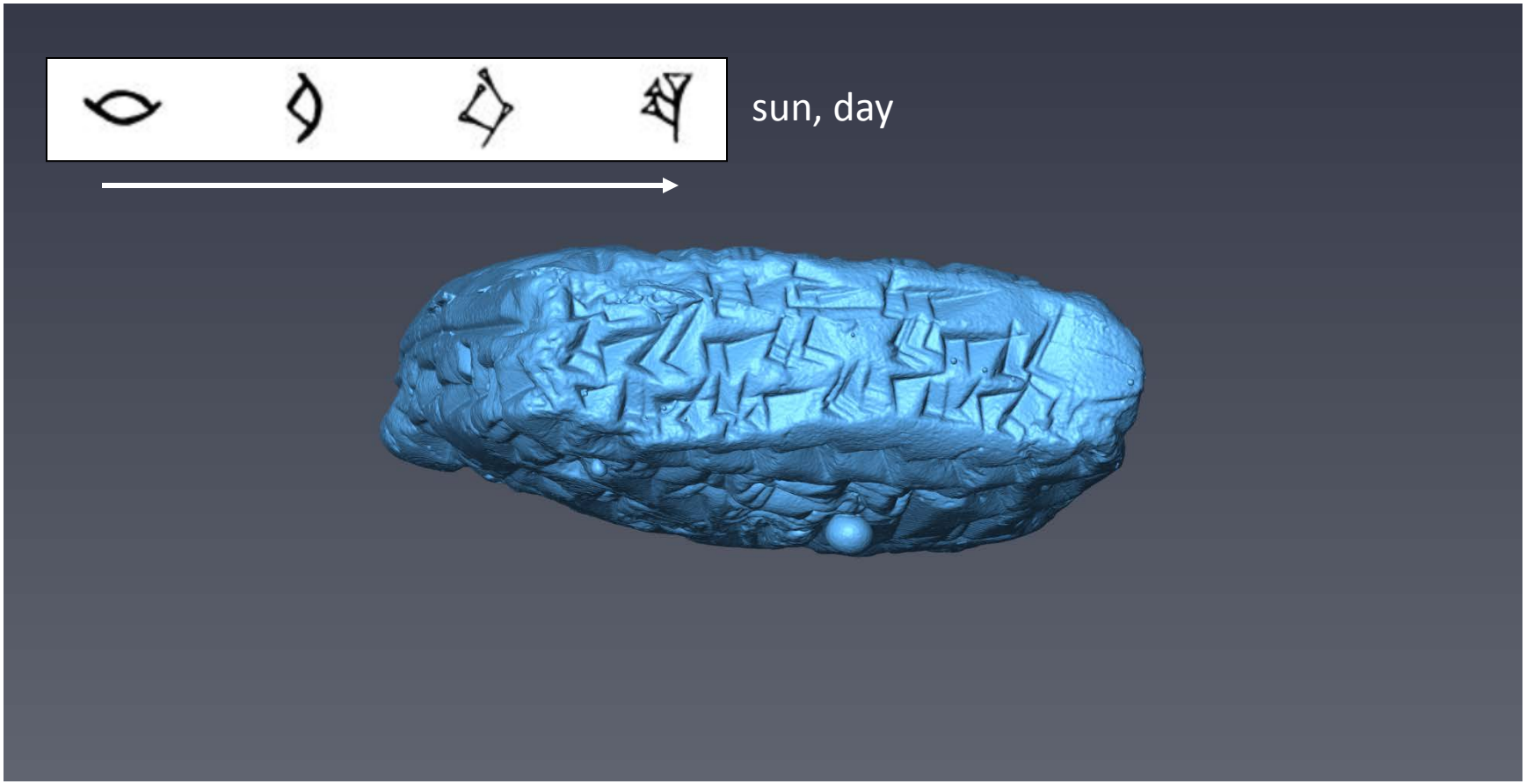


22!

Basics of cuneiform writing

Cuneiform numbers 1, 100 and 22

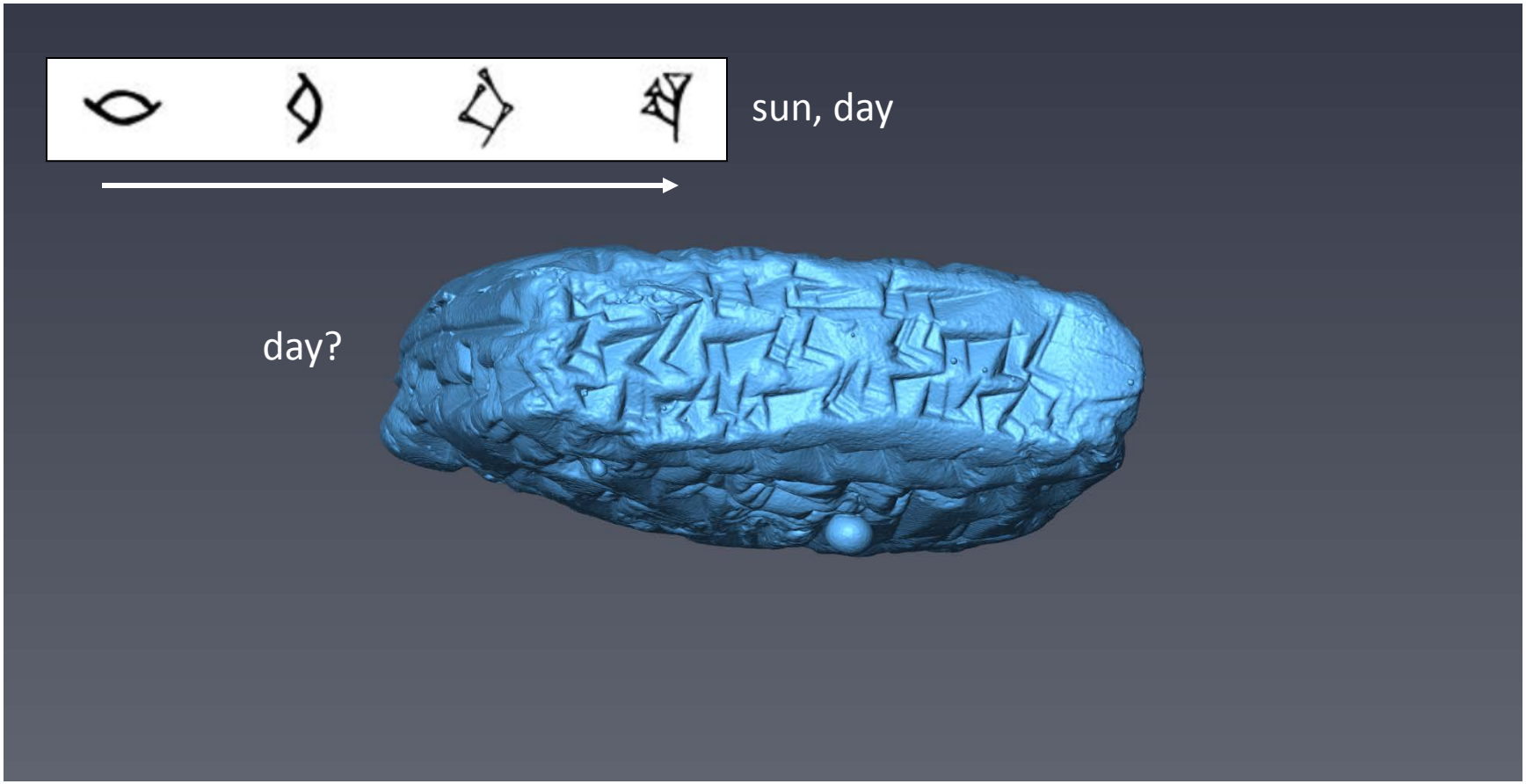
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘day’

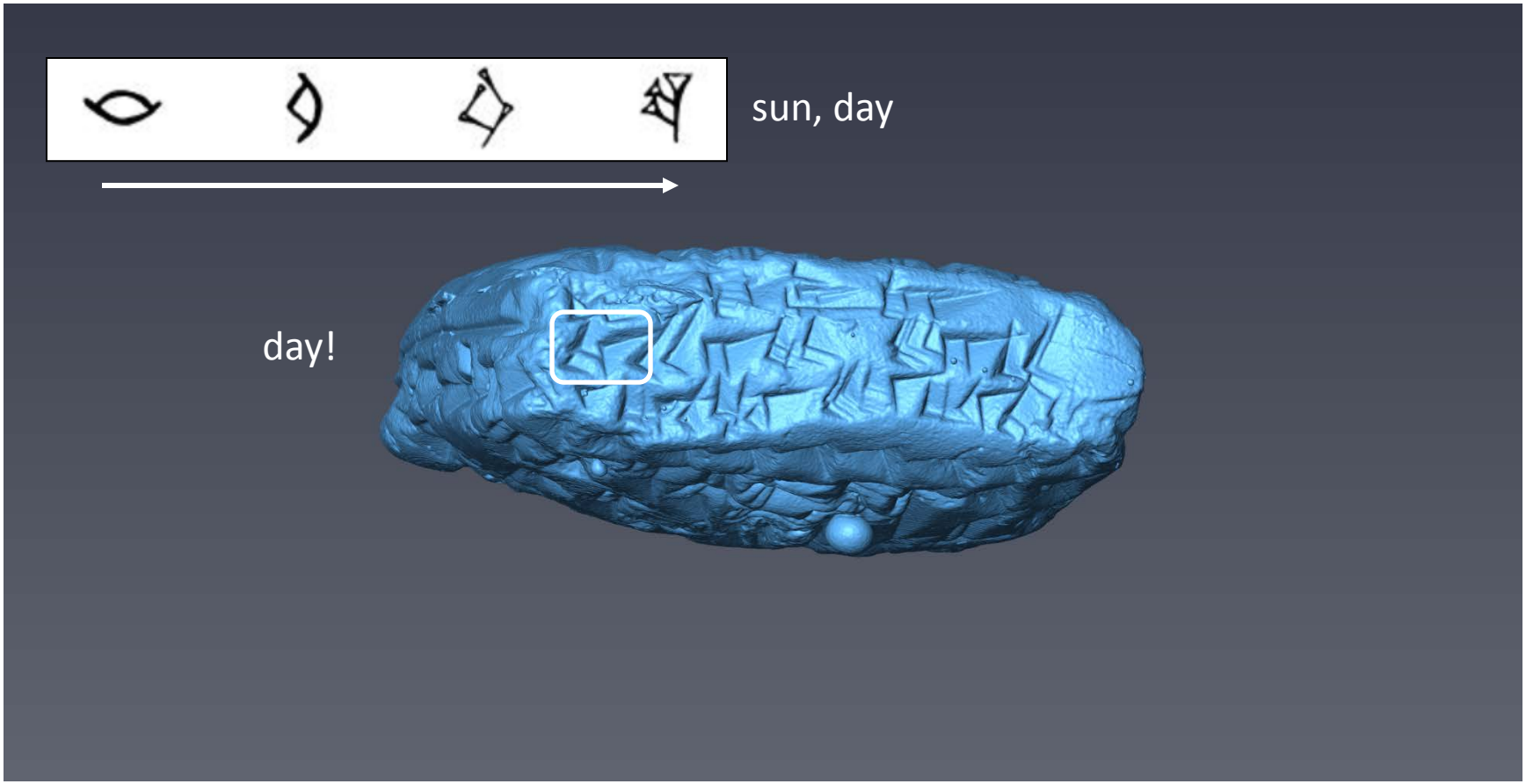
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘day’

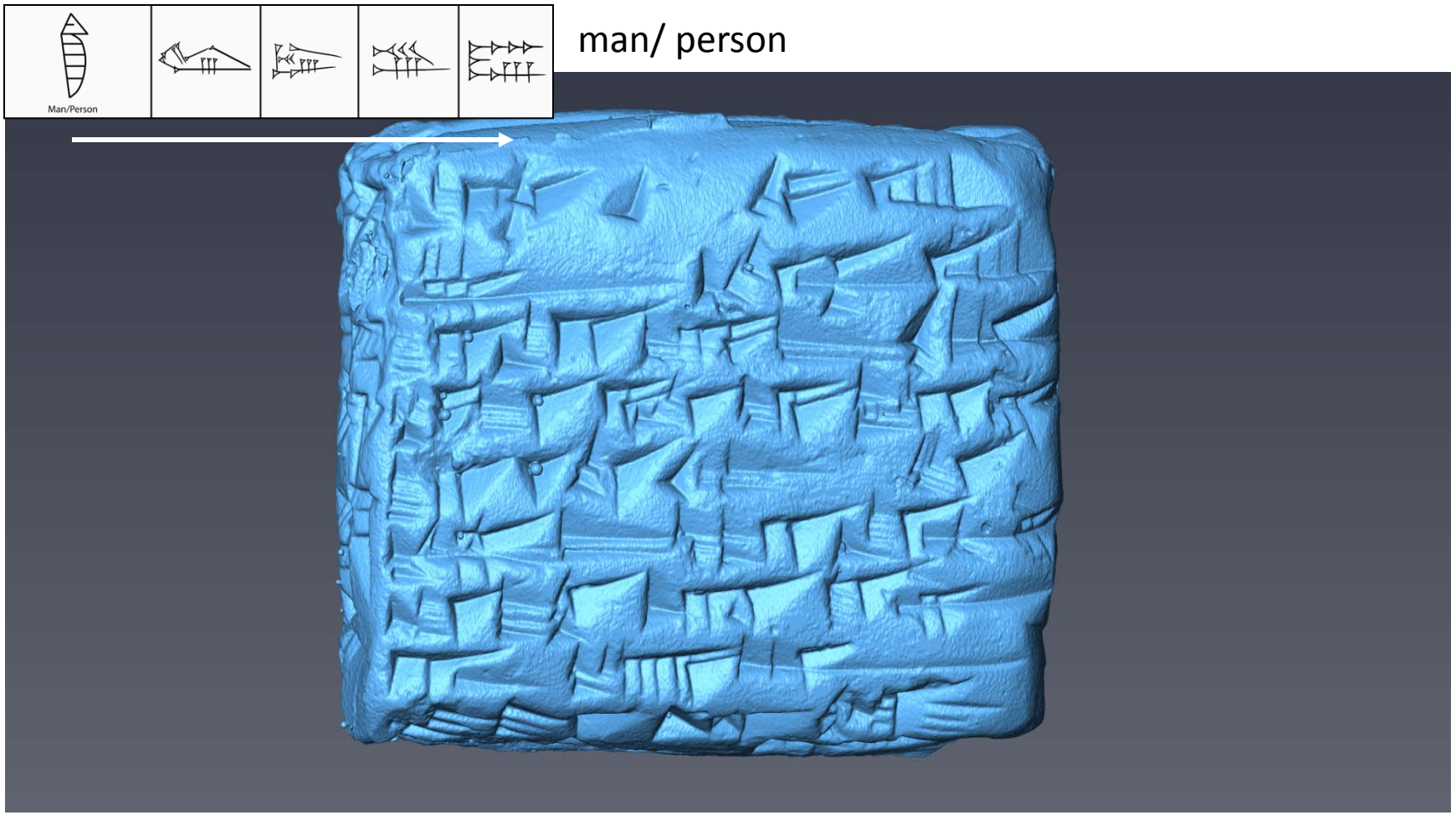
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘day’

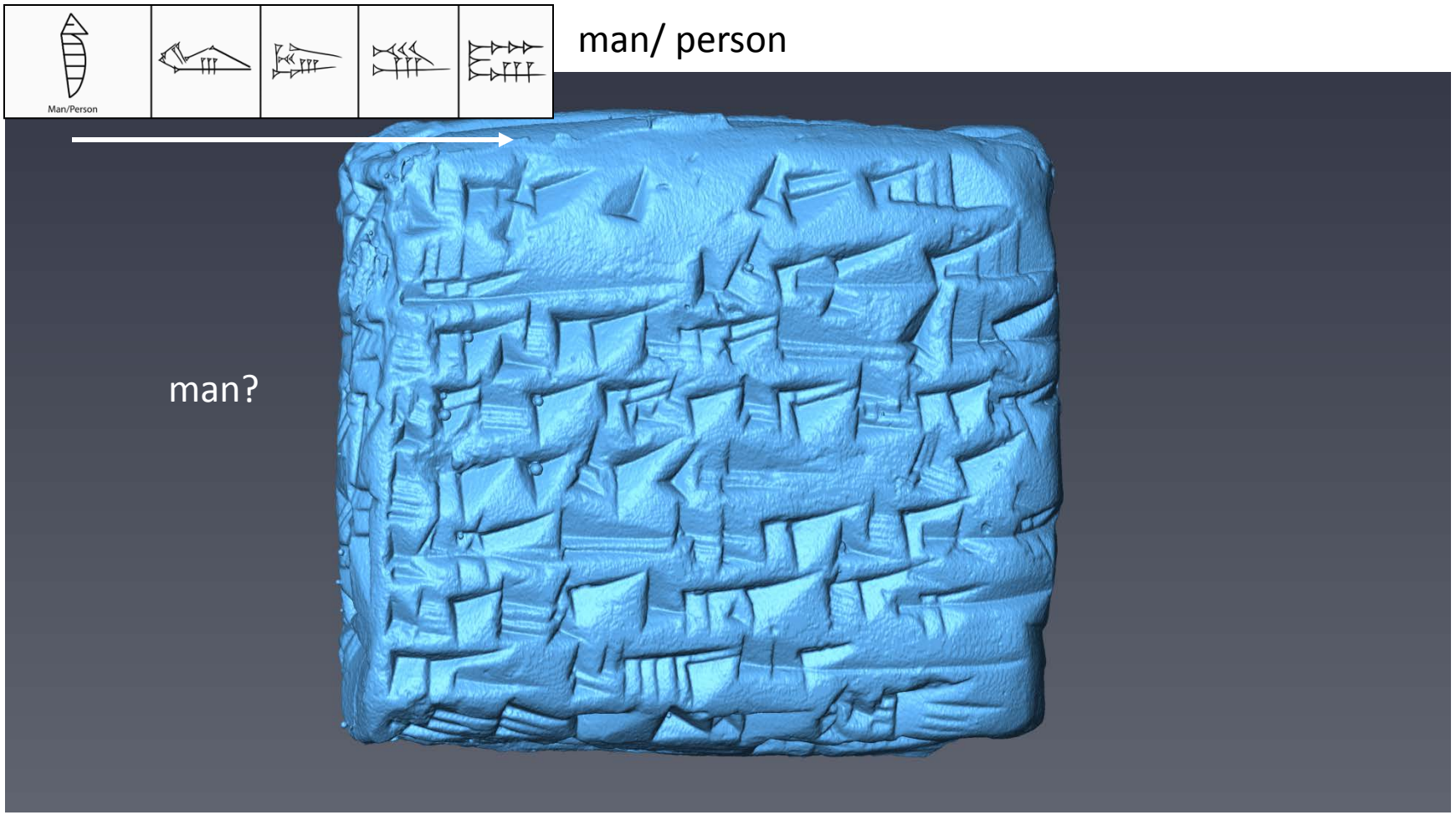
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘man’

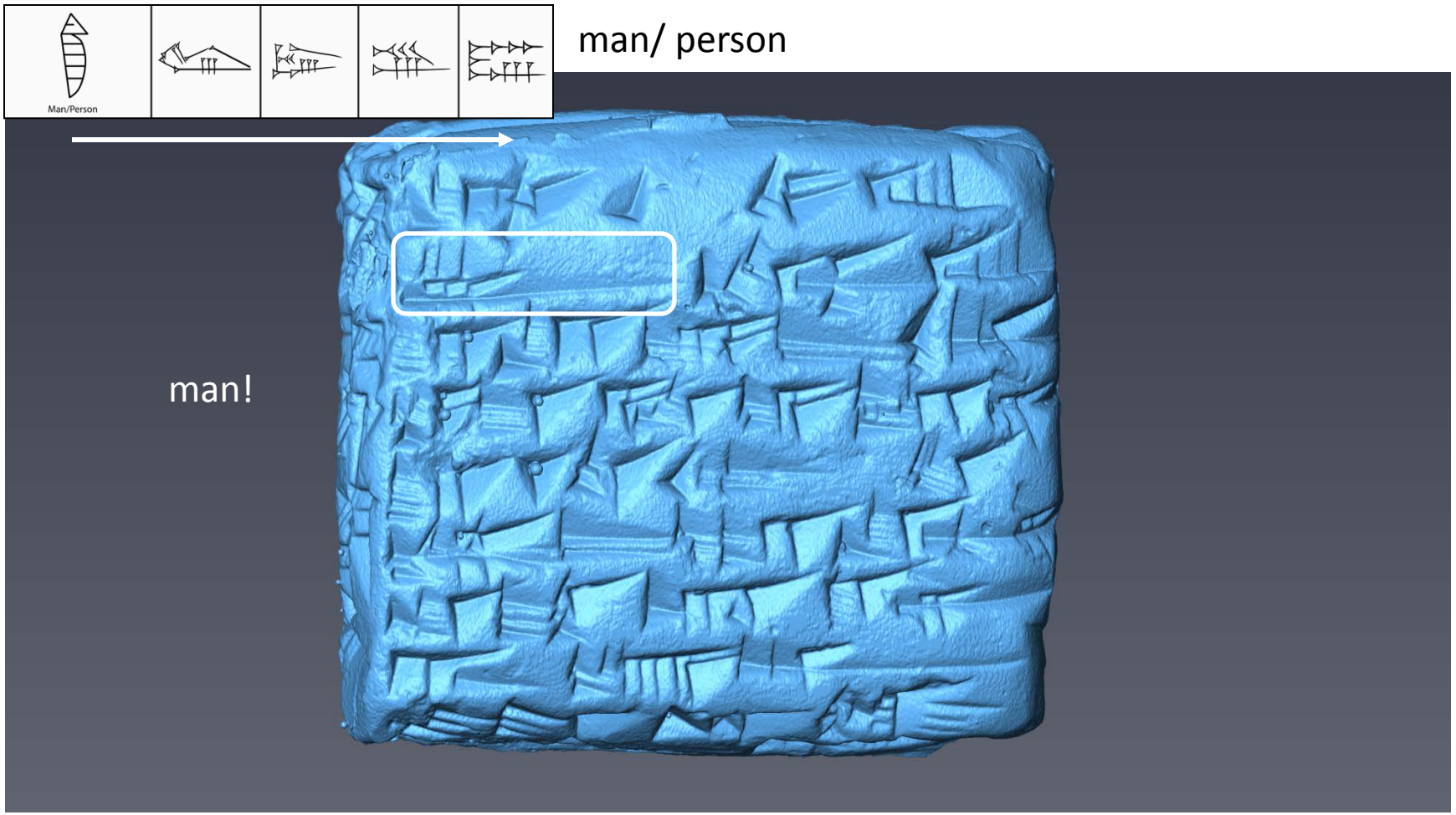
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘man’

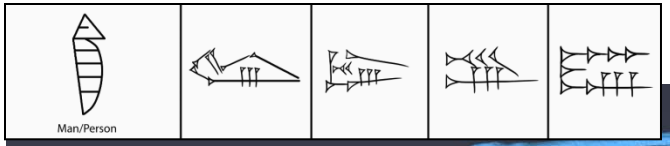
Translation process



Basics of cuneiform writing

Sign development over ca. 3500 years- example : ‘man’

Translation process



man/ person

man

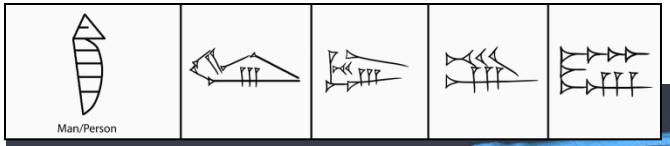
The signs evolved constantly over the years and every scribe had their own handwriting as well!

The most important thing was that the general shape of the sign was correct!

Basics of cuneiform writing

Sign development over ca. 3500 years- example: ‘man’

Translation process



man/ person

man

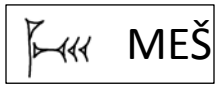
The sign for man on Tablet T98-34 is a simplified version of charater shown left.

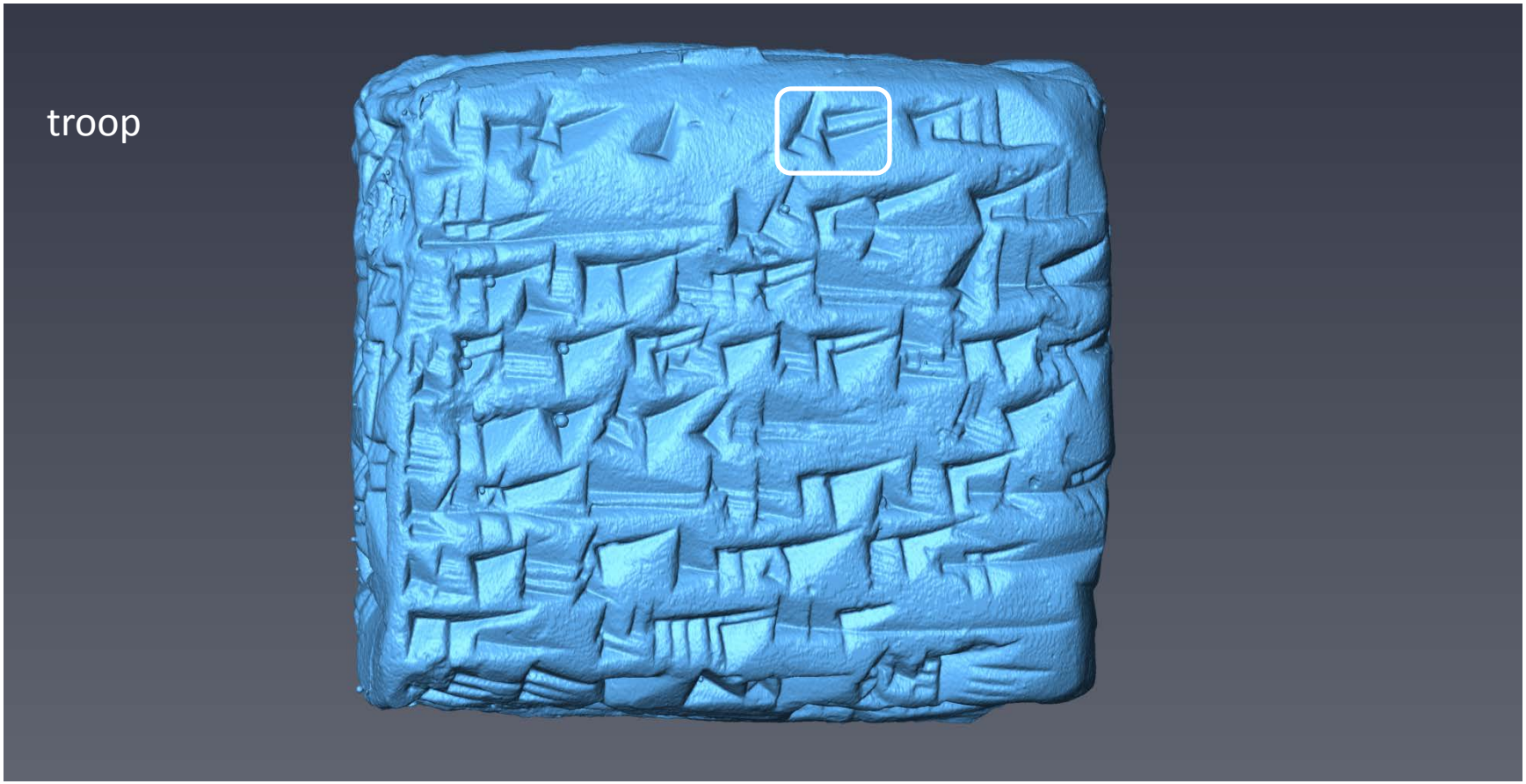
It is still the same sign!

Basics of cuneiform writing

Sign development over ca. 5500 years- example: ‘man’

Translation process

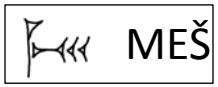
 MEŠ Plural of living being



Basics of cuneiform writing

Syntax: plural of living being- example: plural of ‘troop’

Translation process

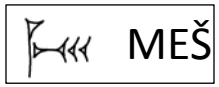

MEŠ Plural of living being

troop
+
plural of
living being
=
troops

Basics of cuneiform writing

Syntax: plural of living being- example : plural of ‘troop’

Translation process

 MEŠ Plural of living being

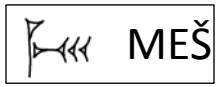
troop
+
plural of
living being
=
troops

The sign for plural on tablet T98-34 is slightly different!
The scribe probably wrote quickly!

Basics of cuneiform writing

Syntax: plural of living being- example : plural of troop

Basics of cuneiform writing
Syntax: plural of living being

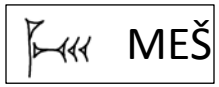

MEŠ Plural of living being

troop
+
plural of
living being
=
troops

Another living
being in plural?

Basics of cuneiform writing
Syntax: plural of living being- another example

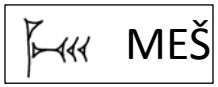
Basics of cuneiform writing
Syntax: plural of living being


MEŠ Plural of living being

troop
+
plural of
living being
=
troops

Another living
being in plural!

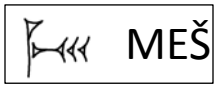
Basics of cuneiform writing
Syntax: plural of living being


MEŠ Plural of living being

troop
+
plural of
living being
=
troops

Another living being in plural: shepherd!

Basics of cuneiform writing
Syntax: plural of living being


MEŠ Plural of living being

troop
+
plural of
living being
=
troops

Another living being in plural: shepherd!

Line 12 specifies that the “10 troops” from line 11 are shepherds!

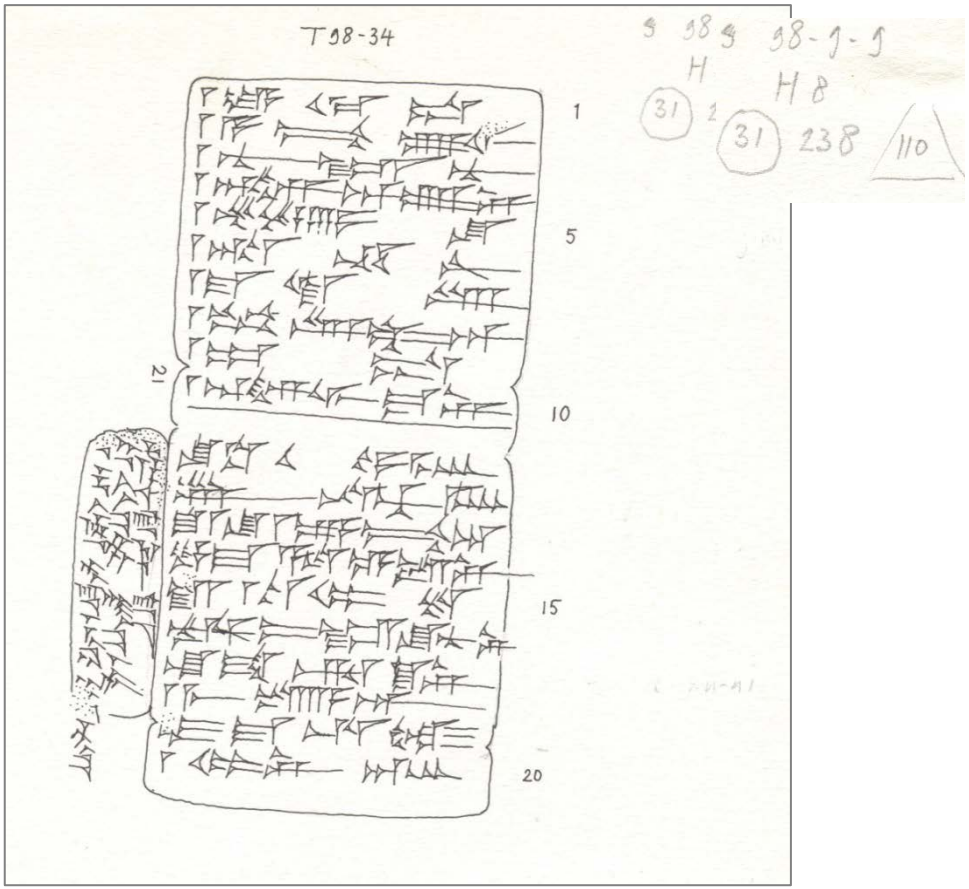
Translation process

Because

- the signs evolved constantly over the past 3500 years!
- the signs varied from place to place and
- every scribe had their own hand writing
  - Small / Large
  - Sloppy / Neat and tiddy,

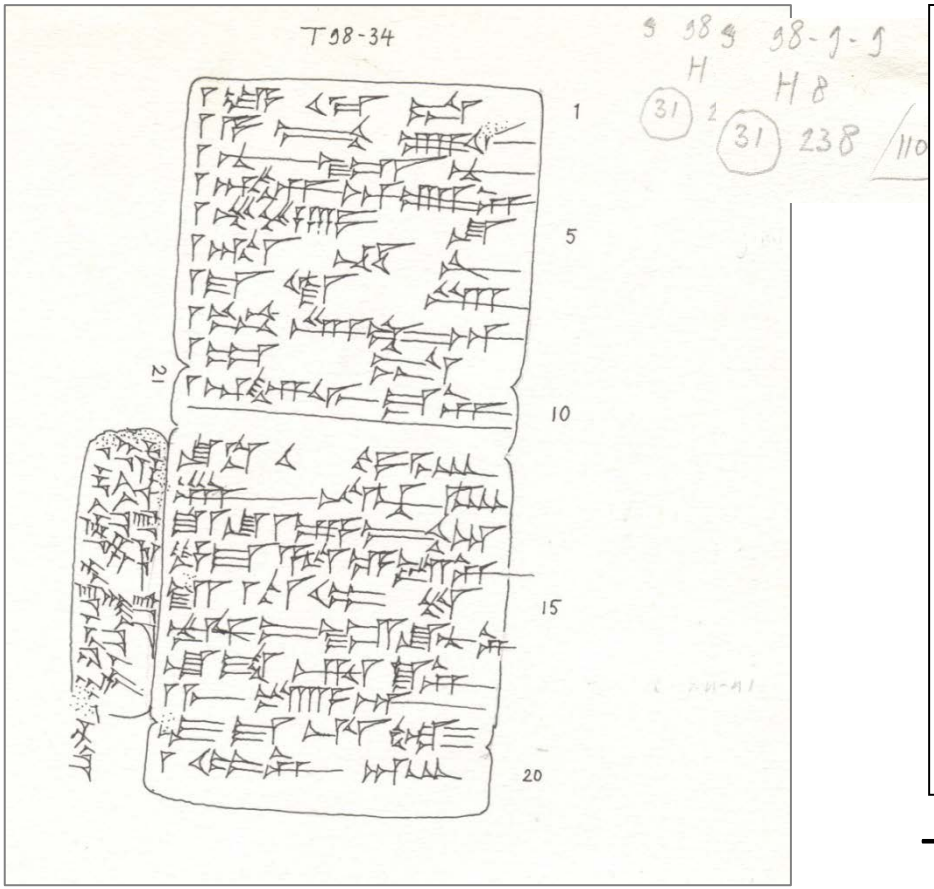
there is a need to re-examine previous decipherment(s) and re-translation(s)!

Translation process



Manual decipherment
by Frans Wiggermann (VU Amsterdam)

Translation process



Manual decipherment by Frans Wiggermann (VU Amsterdam)

T 98-34

1	^{1}*ia-di-du*	Yadidu
	^{1}*a-bi-šam-ši*	Abi-shamshi
	^{1}*nu-ra-nu*	Nuranu
	^{1d}IM-DINGIR-*ú-ni*	Adad-iluni
5	^{1}*mu-ter-šu*	Mutershu
	^{1d}UTU-EN-PAP	Shamash-bel-ibni
	^{1} *ma-ki-ru*	Makiru
	^{1}*qu-ru-ub*-DINGIR	Qurub-ili
	^{1}*ab-du*	Abdu
L.E.10	^{1d}IM-*ši-ma-ni*	Adad-shimmanni
R.	ŠU.NIGIN$_2$ 10 ERIN$_2$.MEŠ	Total : 10 troops,
	LÚ NA.GADA.MEŠ	shepherds,
	ša ŠU ^{1}*kal-bi*-DINGIR	that are under the authority of Kalbi-ili.
	šúm-ma a-na e-da-ni	If, on the (agreed) time,
15	*ša* ^{1}*tam-mi-te*	when Tammitte
	il-tap-ra-šu-nu-ni	had sent them
	la it-tal-ku-ni	they have not returned here,
	1 ME.TA.AM$_3$	100 times, each one of them,
U.E.	*i-ma-ḫu-ṣu*	he will flog.
20	^{1}*ṣíl-lí-*^{d}30	Tsilli-Sîn.
Le.E.	ITI *ku-zal-lu*	Month XI (Jan.-Feb.)
	U$_4$.22.KAM *li-mu*	day 22, limmu year
	^{1d}*Ištar-tu-bal-li-su*	Ishtar-tuballissu

Transcription in Latin letters and translation by Rients de Boer (Nino and VU Amsterdam)

Translation process

Text interpretation by Frans Wiggermann:

Apparently there are problems in the north of Ili-pada's realm of which Tammitte, the Assyrian governor wanted to stay exactly informed; hostile Muski or Kaska tribes, for example, who try to cross the Euphrates.

The use of shepherds as spies has one major disadvantage, namely that they do not show up when you expect them…

Tammitte promises shepherds in his service a hundred strokes when they miss their annual appointment - rather futile when they are not there!

Source: Wiggermann, F.A.M. 2010. Wein, Weiss und Gesang in een Midden-Assyrische nederzetting aan de Balikh, Phoenix 56/1-2, 17-57.

The animated story of T98-34, the clay tablet born again and again

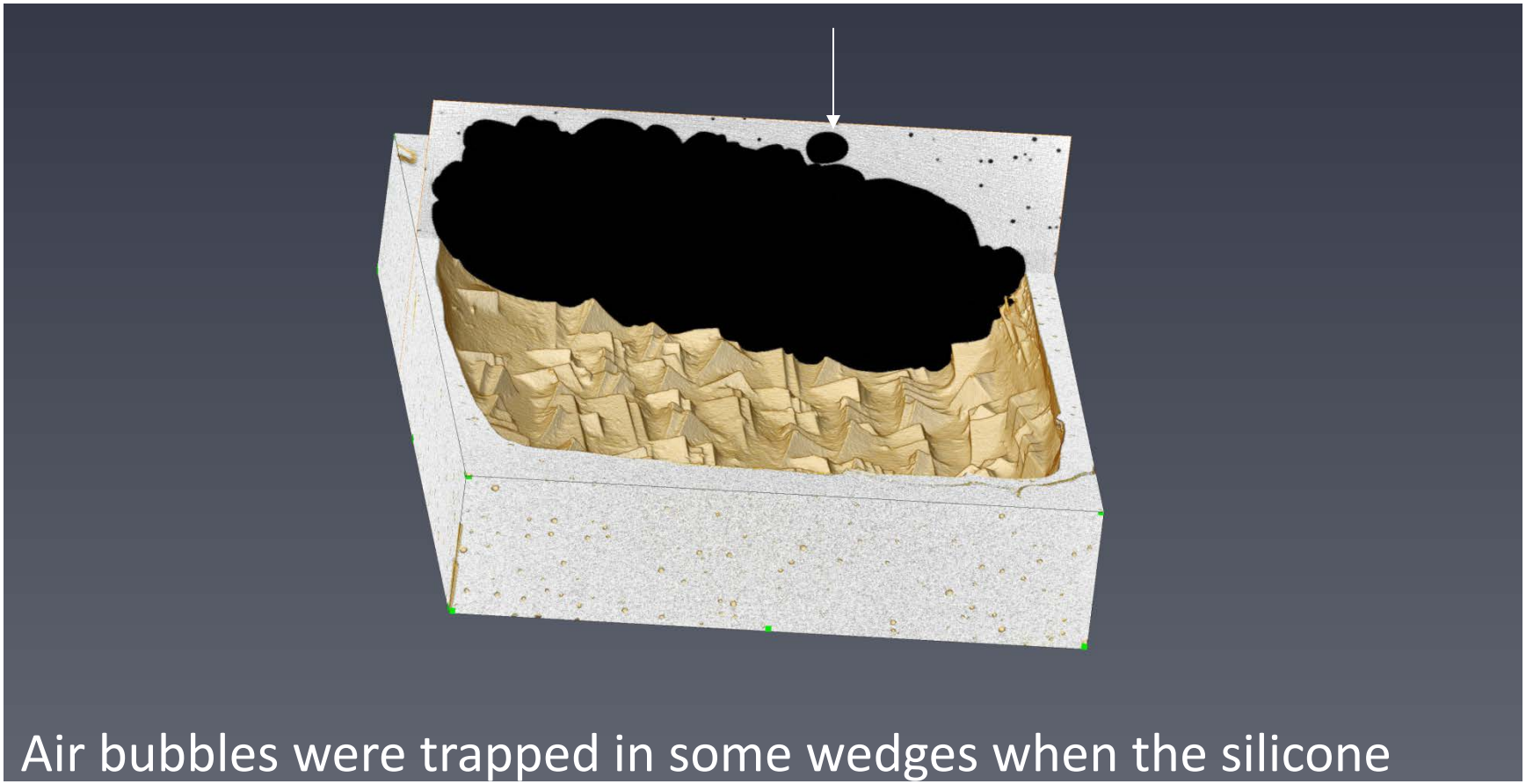
1. From recovery in Tell Sabi Abyad to loss in Raqqa
   - with silicone rubber casting
2. Digital preservation techniques
   - X-ray µ-CT scanner, close range light scanner, and portable light dome
3. From manual decipherment to translation and interpretation
   - Starting from basics of cuneiform writing
4. **Digital processing**
   - **imperfection removal, digital decipherment and automatic character recognition**
5. 3D printing
6. Conclusion
7. Acknowledgements

Digital processing

The digital models can be plugged into **GIGAMESH**, a suite of smart algorithms developed by **Hubert Mara at Heidelberg University, Germany** for:

- Cleaning of the imperfections in the moulds
- Digital decipherment
- Automatic character recognition

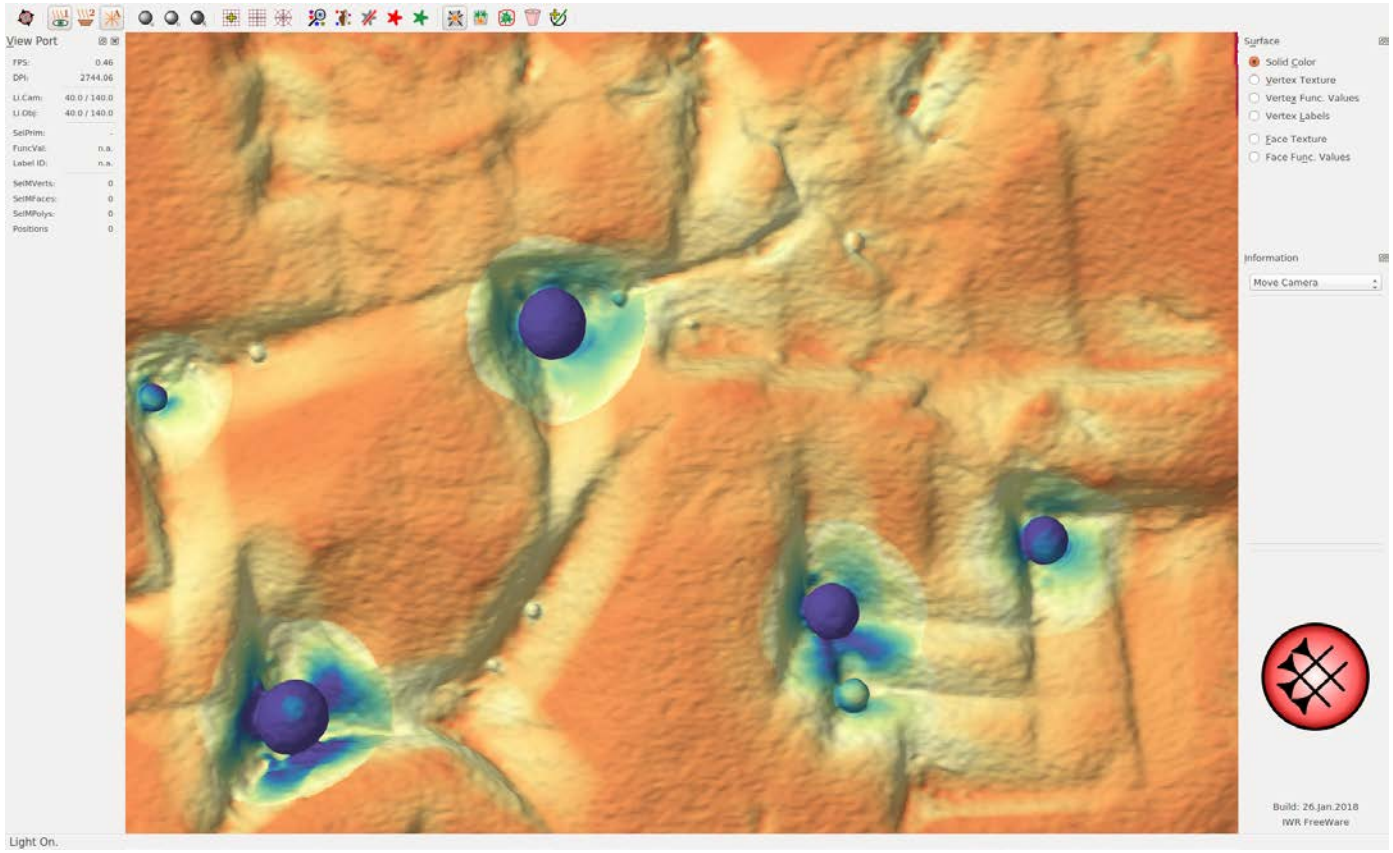
Digital processing



Air bubbles were trapped in some wedges when the silicone rubber cast were made.

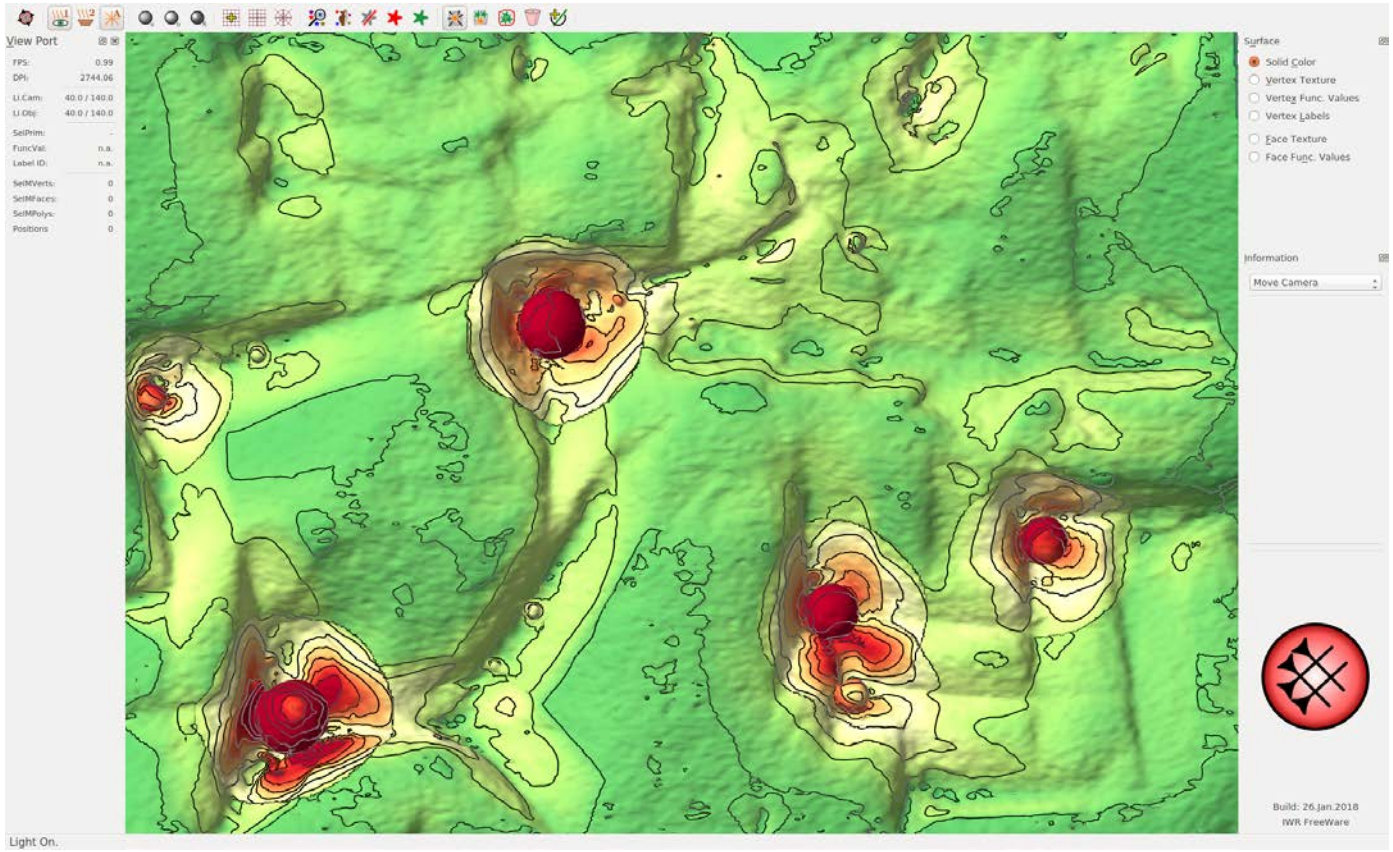
Bubbles can be automatically detected and cut!

Digital processing



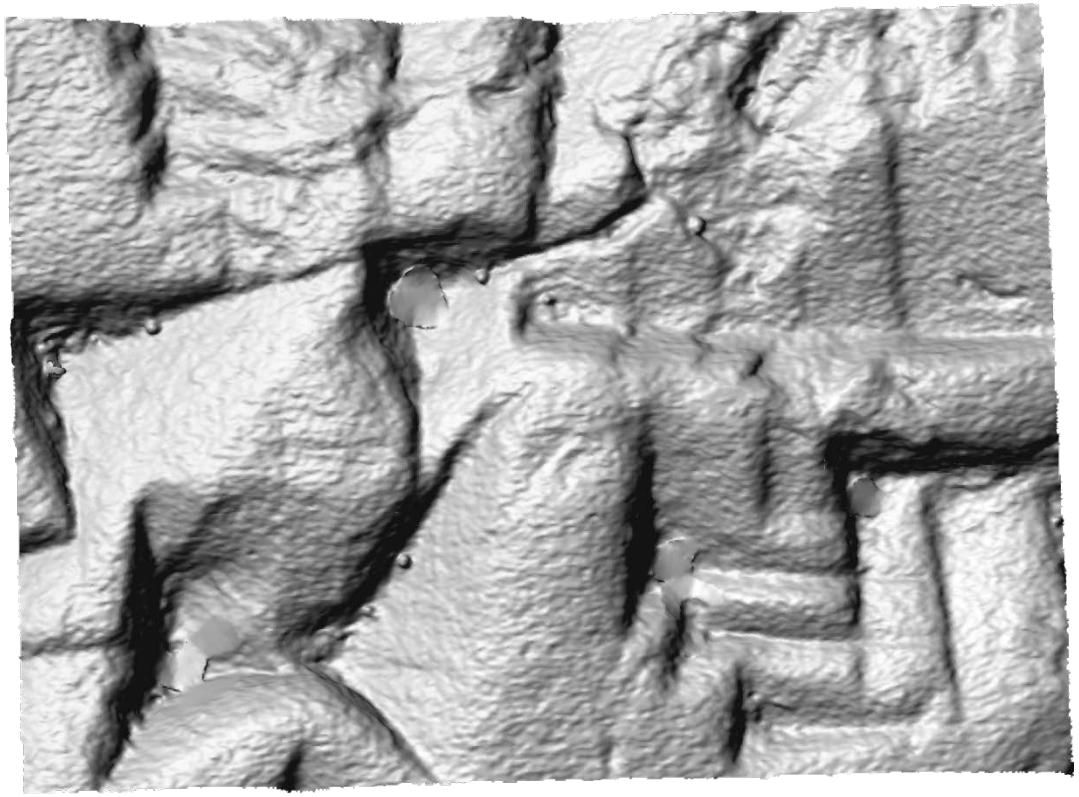
Bubbles cleaning process- Automatic detection of bubbles

Digital processing



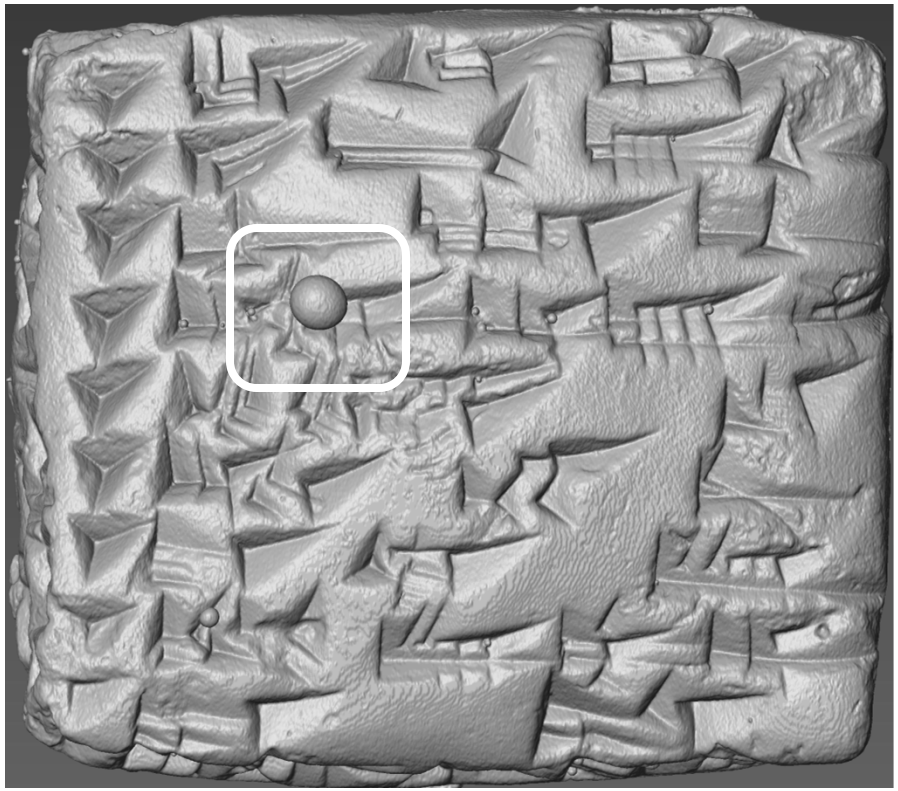
Bubbles cleaning process- Automatic detection of bubbles

Digital processing



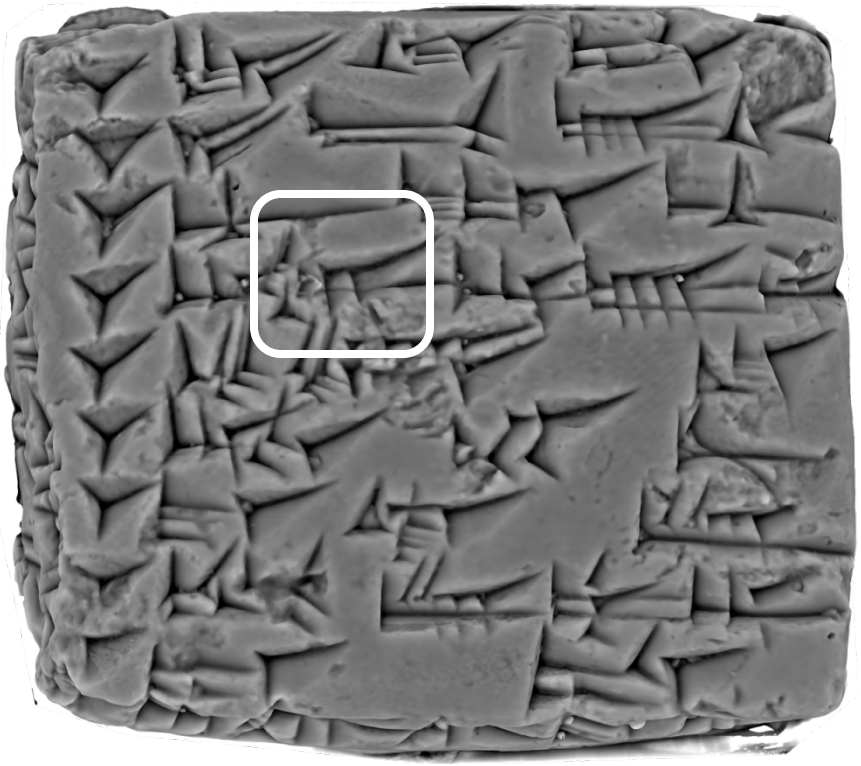
Bubbles cleaning process- Automatic cutting of bubbles

Digital processing



T98-34 before bubble removal

Digital processing



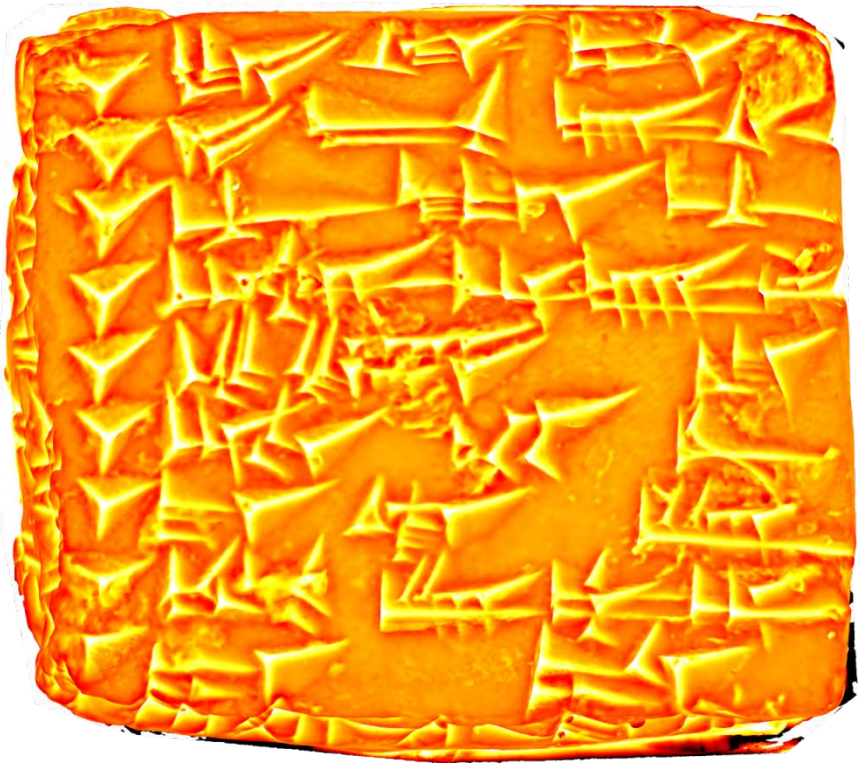
T98-34 after bubble removal

Digital decipherment

Manual decipherment is time consuming: about 4 hours for T98-34!

Digital decipherment can help!

Digital decipherment



Digital decipherment at Heidelberg U
measuring the curvature mapping, using the distance from virtual smooth envelope wrapping the tablet to the tablet itself

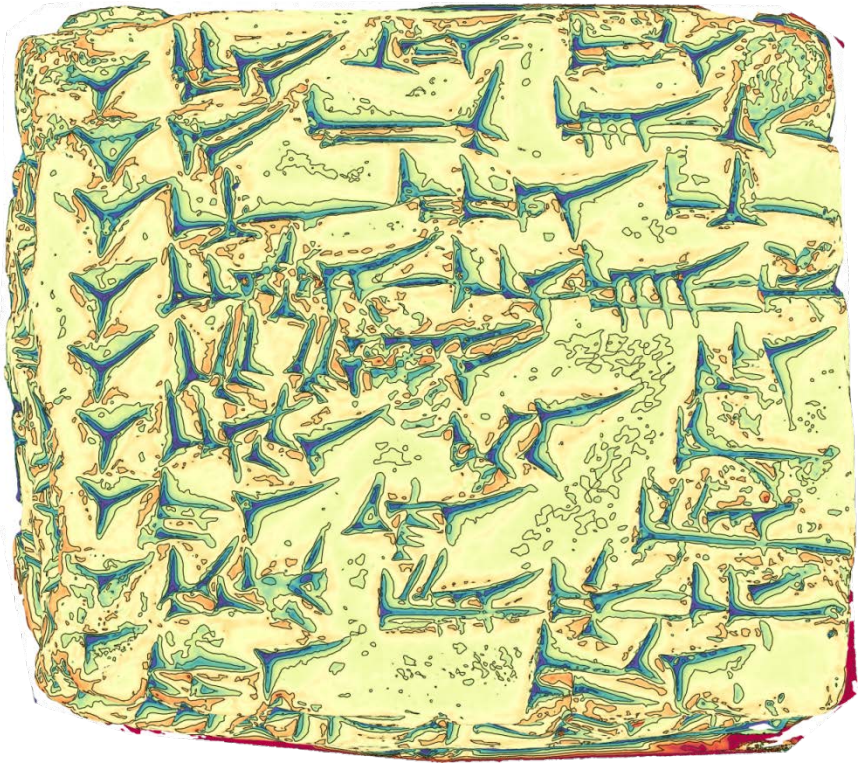
Digital decipherment

Digital decipherment at Heidelberg U
measuring the curvature mapping, using the distance from virtual smooth envelope wrapping the tablet to the tablet itself

Digital decipherment

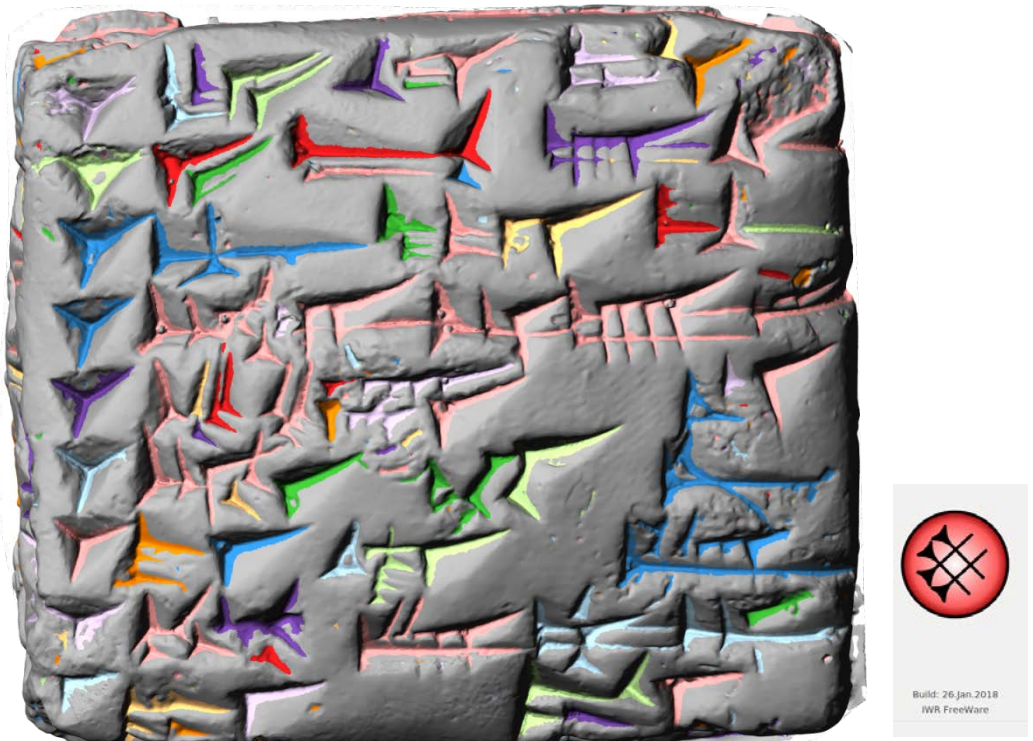
Digital decipherment at Heidelberg U
measuring the curvature mapping, using the distance from virtual smooth envelope wrapping the tablet to the tablet itself

Digital decipherment



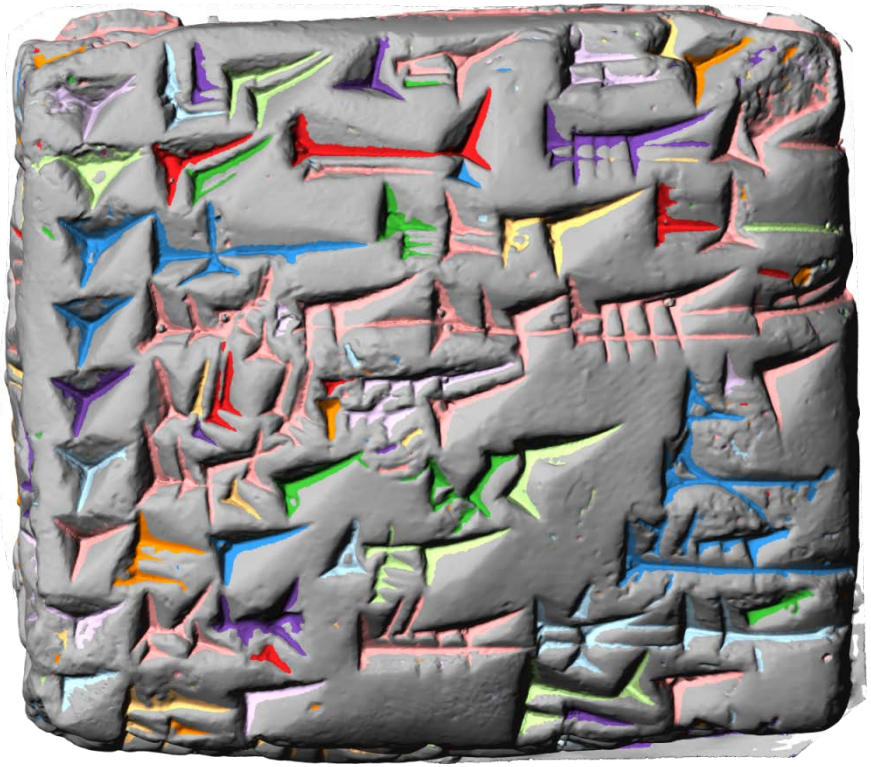
Digital decipherment at Heidelberg U
Relief extraction

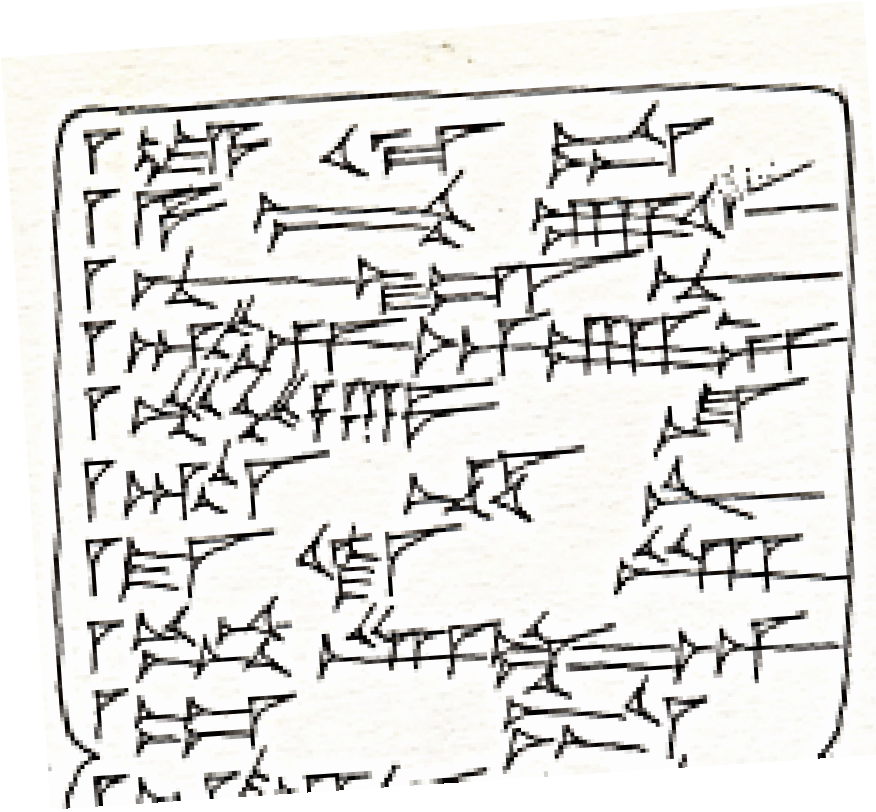
Digital decipherment



Digital decipherment at Heidelberg U
Character separation

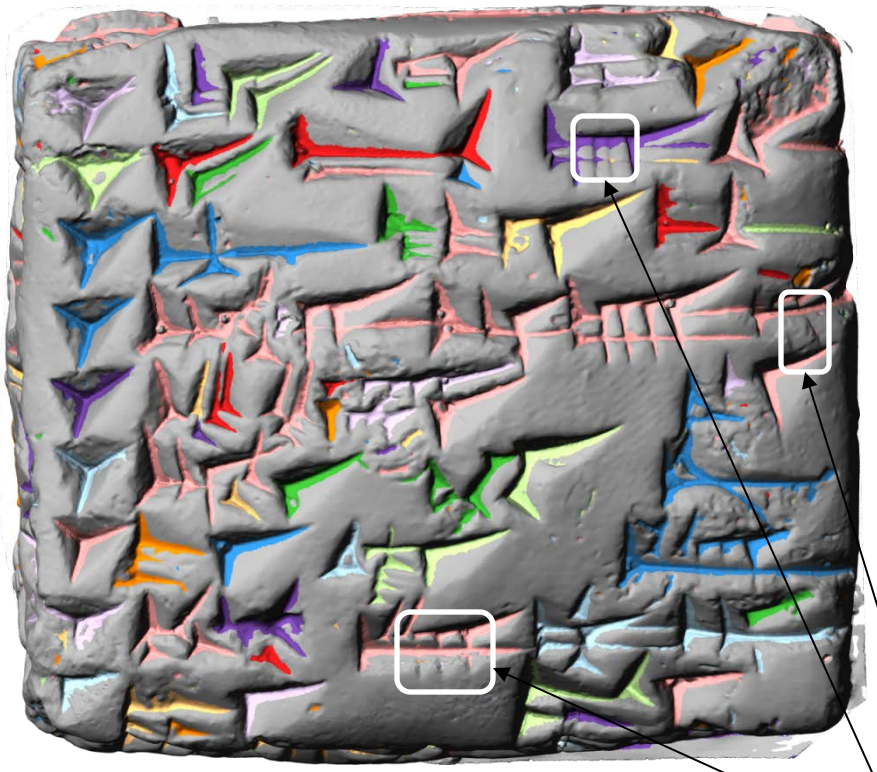
Digital decipherment

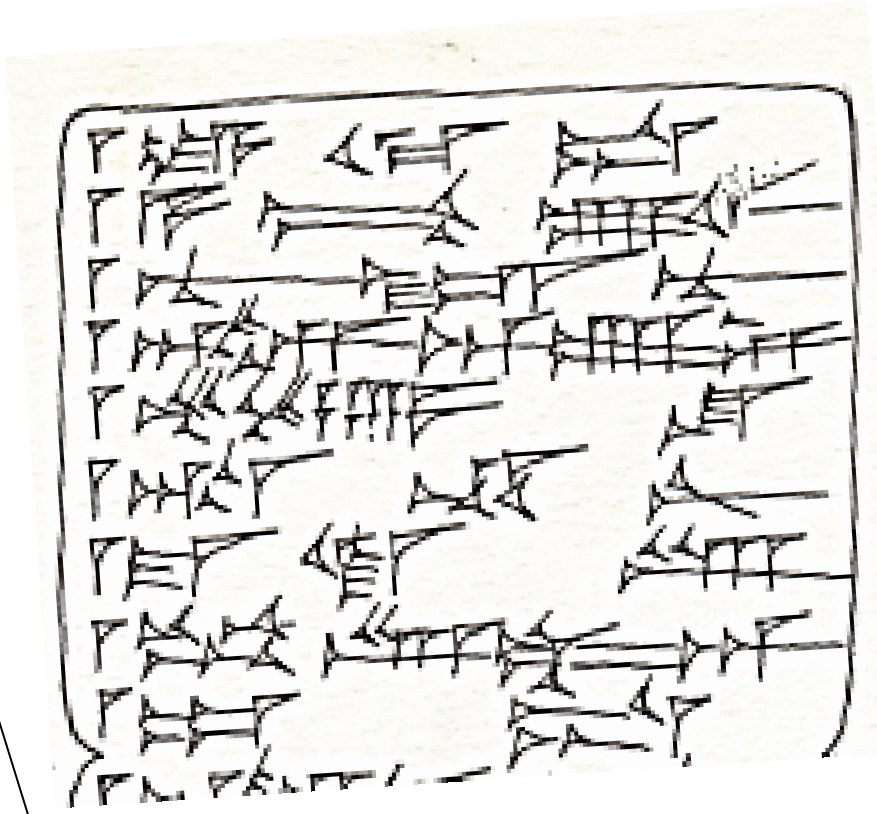




Digital decipherment versus manual decipherment

Digital decipherment

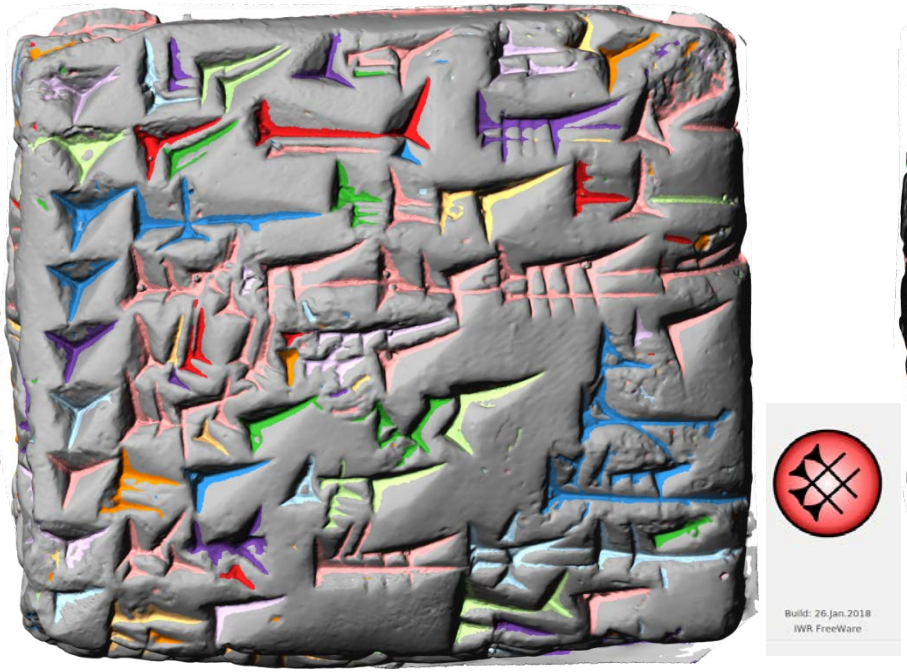




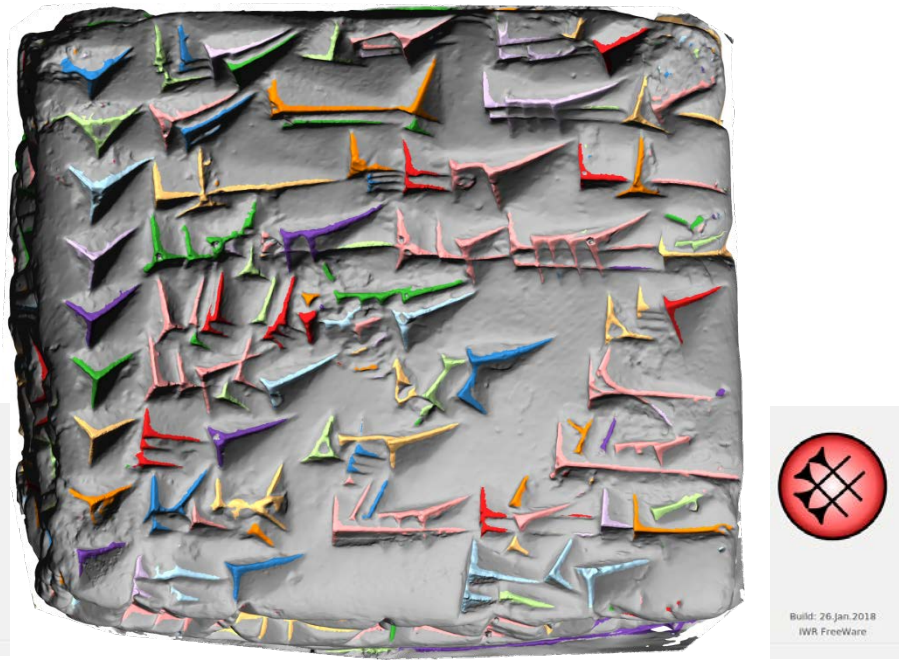
Very few imperfections!

Digital decipherment is almost perfect!

Digital decipherment



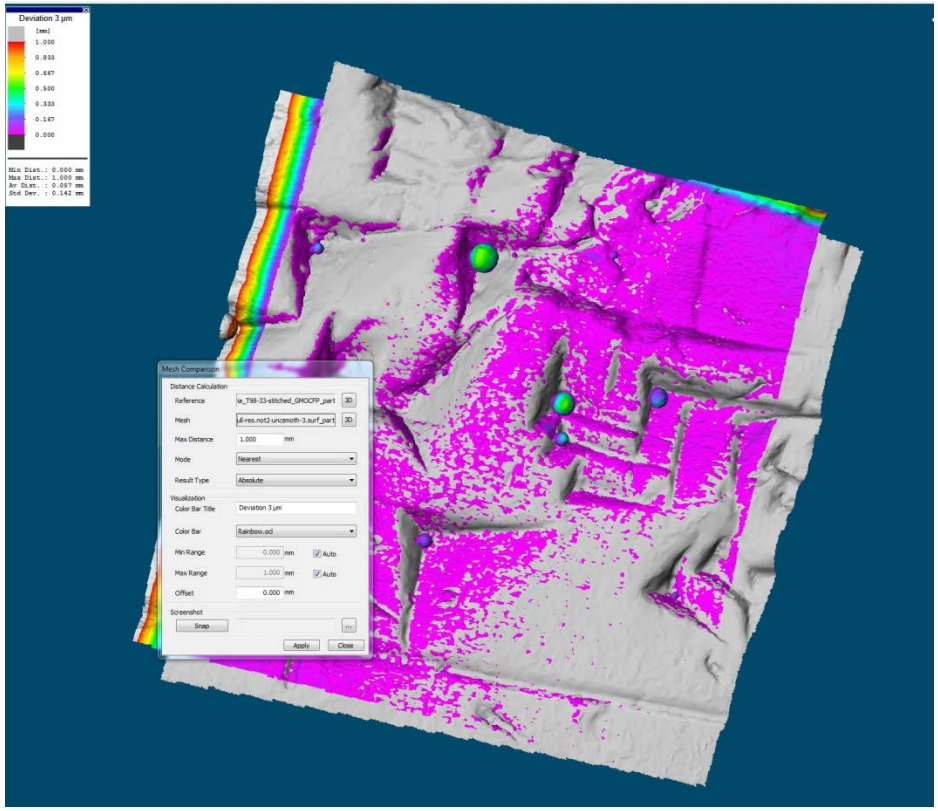
Close range High resolution Light scanner



µ-CT scanner

And this for both types of scans!

Digital decipherment

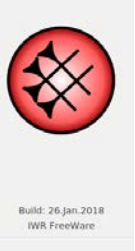


To be expected since the difference between both meshes after self alignment is below 30 µm [away from bubbles!].

Digital decipherment

total 10 men

etc…



And soon at Heidelberg U: automatic character recognition!

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2. Digital preservation techniques
   - X-ray µ-CT scanner, close range light scanner, and portable light dome
3. From manual decipherment to translation and interpretation
   - Starting from basics of cuneiform writing
4. Digital processing
   - imperfection removal, digital decipherment and automatic character recognition
5. **3D printing**
6. Conclusion
7. Acknowledgements

3D printing

The tablet has been printed with two types of 3D printing technologies: **material jetting** and **stereolithography**.

3D printing

The colored models have been printed with **material jetting**. For this process droplets of materials are selectively deposited and cured with UV light.

3D printing

The black and white models have been printed with **stereolithography**. This 3D printing process uses a liquid photopolymer that is selectively cured by a laser.

3D printing

For both systems, one print of Tablet 98-34 lasts about **5 hours**. Luckily batch printing of 4 tablets together is possible!

3D printing

- High resolution printer required to avoid loss of tiny details
- Various materials: resin, ceramics, …
  - Ceramics has to be baked and shrinks during baking. Mesh compensation is needed!
  - No direct 3D printing in REAL chocolate!
- Various colours
  - Avoid white, prefer blue, black, or grey for better legibility.
- Various textures depending on finish
  - Prefer mate to glossy finish for legibility.
  - Avoid cleaning of material jetting prints in a caustic bath of sodium hydroxide and sodium metasilicate.
- Possible magnification/ reduction

3D printing

Attractive and legible models despite a few imperfections:

- Tablet in ceramics will shrink and even crack during baking!
- Layering visible on side faces of tablet made using material jetting.
- Contact points between model and scaffolding visible on 2 tablet faces.

3D printing

The 3D printed models are displayed at the National Museum of Antiquities.

3D printing

Visitors can hold them in their hand for a better connection to the Assyrian heritage.

3D printing

They are often surprised by the amount of information that was communicated on such a small piece of clay!

The animated story of T98-34, the clay tablet born again and again

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The animated story of T98-34, the clay tablet born again and again

- Starting from moulds rather than tablets complicates the digitalisation and digital processing.
- Nevertheless, faithful digital and physical replicas of T98-34 have been produced.

Multiple users of the digital models and physical replicas

- Assyriologists and their students from the Netherlands and elsewhere for re-translation and re-interpretation.
- Musea to augment public engagement with Assyrian cultural heritage.
- Charity organisations- Sales of chocolate replicas to raise funds for refugee students in the Netherlands.
- Future generations as long as continuity in digital data archiving is warrantied.

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Scanning for Syria
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Scanning for Syria
Project partners

Four Dutch partners contributed to the digital preservation of clay tablets lost in Raqqa during the Syrian Civil War:

- two universities:
  - Delft University of Technology and
  - Leiden University,
- one knowledge centre, the Leiden-Erasmus-Delft Centre for Global Heritage and Development and
- one museum, The National Museum of Antiquities, in Leiden

Scanning for Syria
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