

Digital methods for inscriptions on bronze: a case study on 3D modelling and stereomicroscopy

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Brigetio is one of the most important Roman settlements in Pannonia, consisting of a civil town, a canabae and a legionary fortress. Several hundreds of high-quality bronze objects came from here, which make Brigetio the most important site for Roman figural bronzes in Pannonia. However, the most important „world-famous” bronze object from Brigetio is not a figural one, but a large bronze tablet found in 1930 containing the law of Constantine the Great and Licinius. The genre of the inscription – *exemplum sacrarum litterarum* – is exceptionally rare and only a few similar bronze tablets are known from the Roman Empire, so it was quite striking when four fragments of a bronze tablet (right) was found in 2014 in the legionary fortress of Brigetio, just some meters away from the findspot of the above mentioned first inscription. The fragments – measuring a total of 3.5 kg – containing a previously unknown law issued by the emperor Philippus Arabs.

Several different techniques were used during the analysis of the tablet. We used a Breuckmann 3D industrial white light scanner for creating 3D models of the bronze fragments,

applying various textures on them to make the inscription easily readable. Changes of the lighting in the software also produced good results during the paleographical research. Stereomicroscopical images made by a Zeiss Discovery V8 helped us reconstructing the process of planning and engraving the text into the bronze material, and the shape of the tools used by the worker. These digital techniques also revealed the „biography” of the object: the name of Philippus Arabs was chiseled out from the tablet during its use, and traces of hammer strikes indicate that the four surviving fragments just avoided the recycling as scrap metal.



3D scan images of Fragment 1.

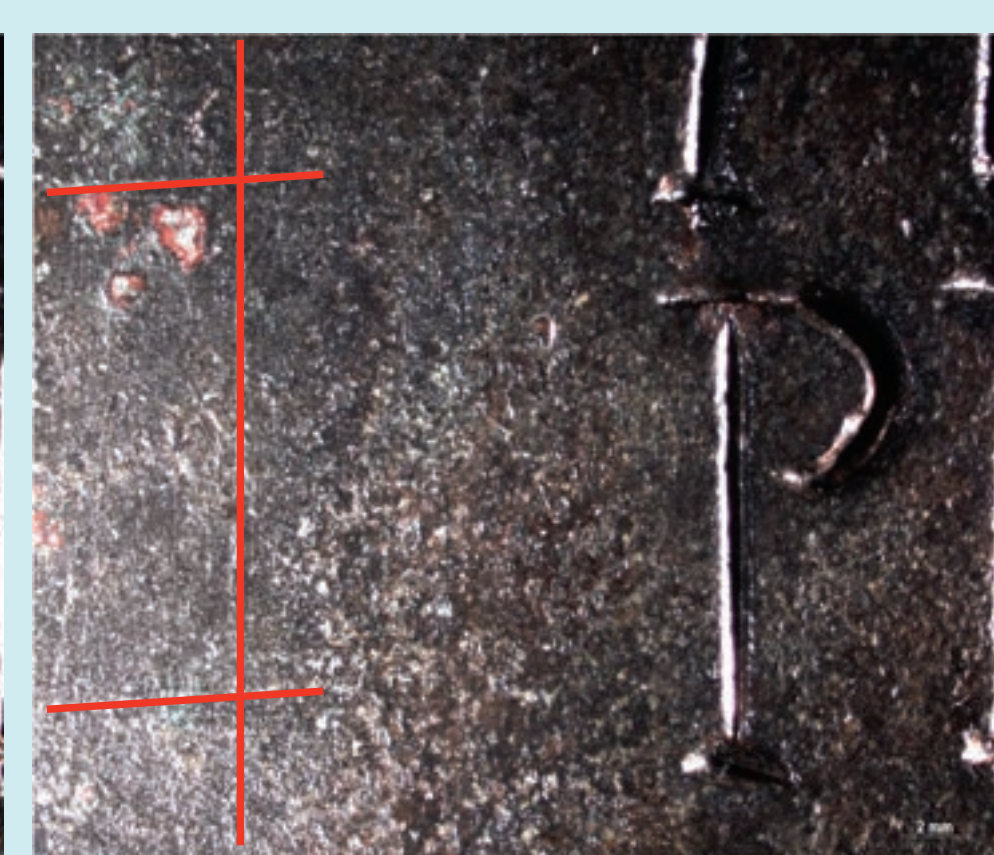
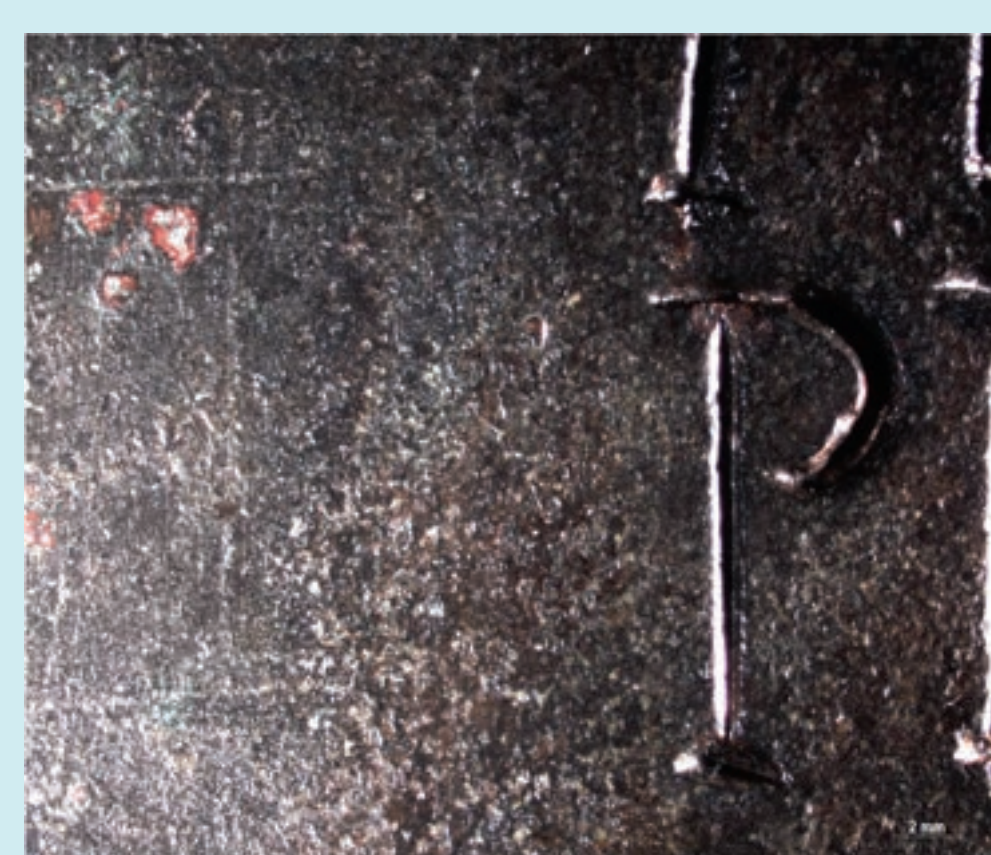
(Breuckmann 3d industrial white light scanner, FOV: 90 mm, X,Y resolution: 55 µm, Max. resolution (Z): 1 µm, Typical accuracy: +/- 9 µm)

High-resolution professional 3D scans were made of all fragments to create very detailed, accurate virtual models of the fragments, which can be observed even better than the original ones, without the need of touching the bronze itself.

Software generated (left) and a handmade drawing (right) of Fragment 4.



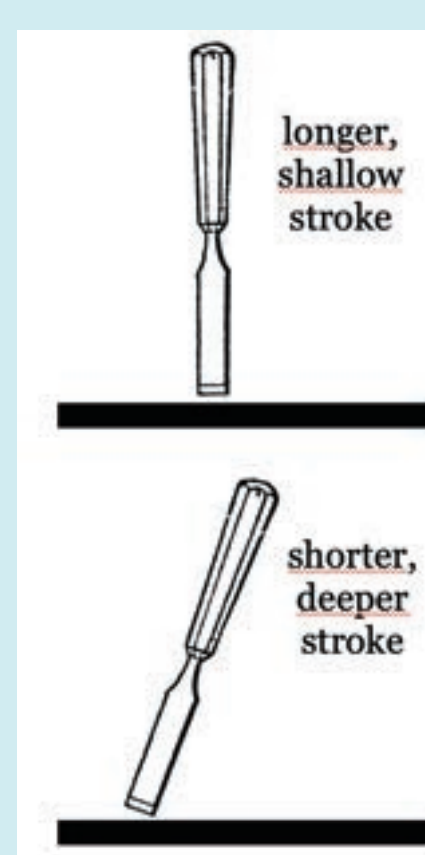
The fast, automatic drawing based on the 3D model has approximately the same level of accuracy as the very time consuming handmade version



Traces of the ordinatio on stereomicroscopic images

(Zeiss Discovery V8, Plan Apo S 0.63x FWD 81 mm, AxioCam Mrc 5, AxioVision LE 64)

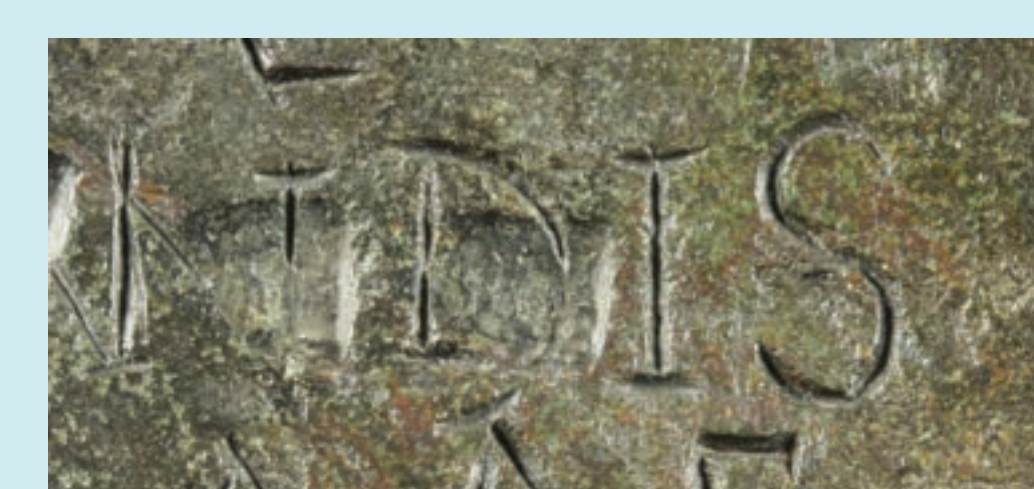
First, two vertical margins were drawn with a sharp, pointed tool, then the line heights were marked on the margins with small hatches, then the writing lines were drawn connecting the hatches between the two vertical margins.



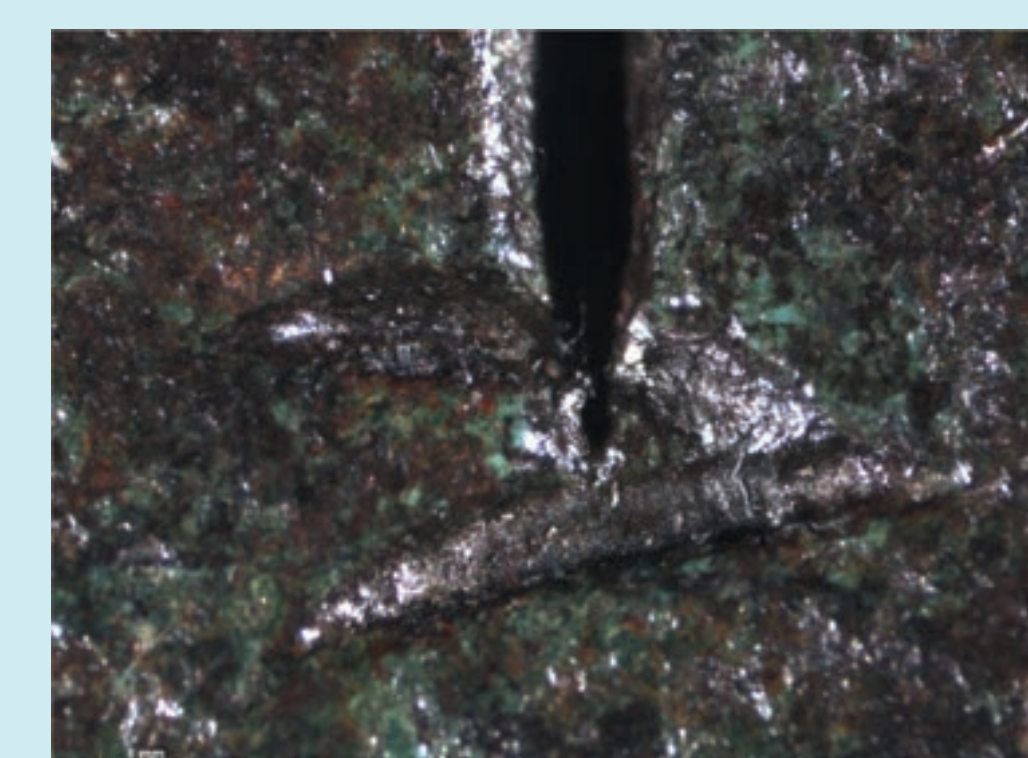
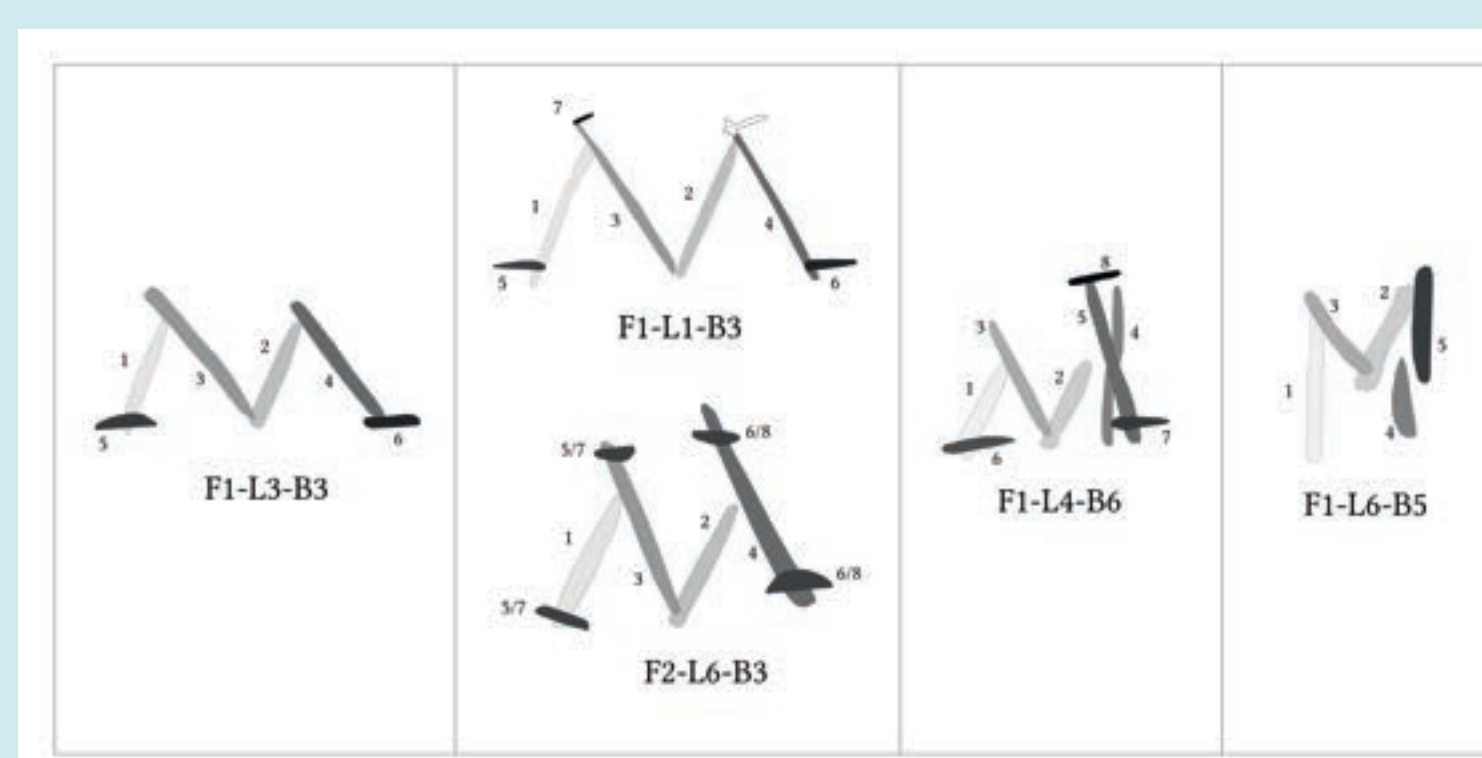
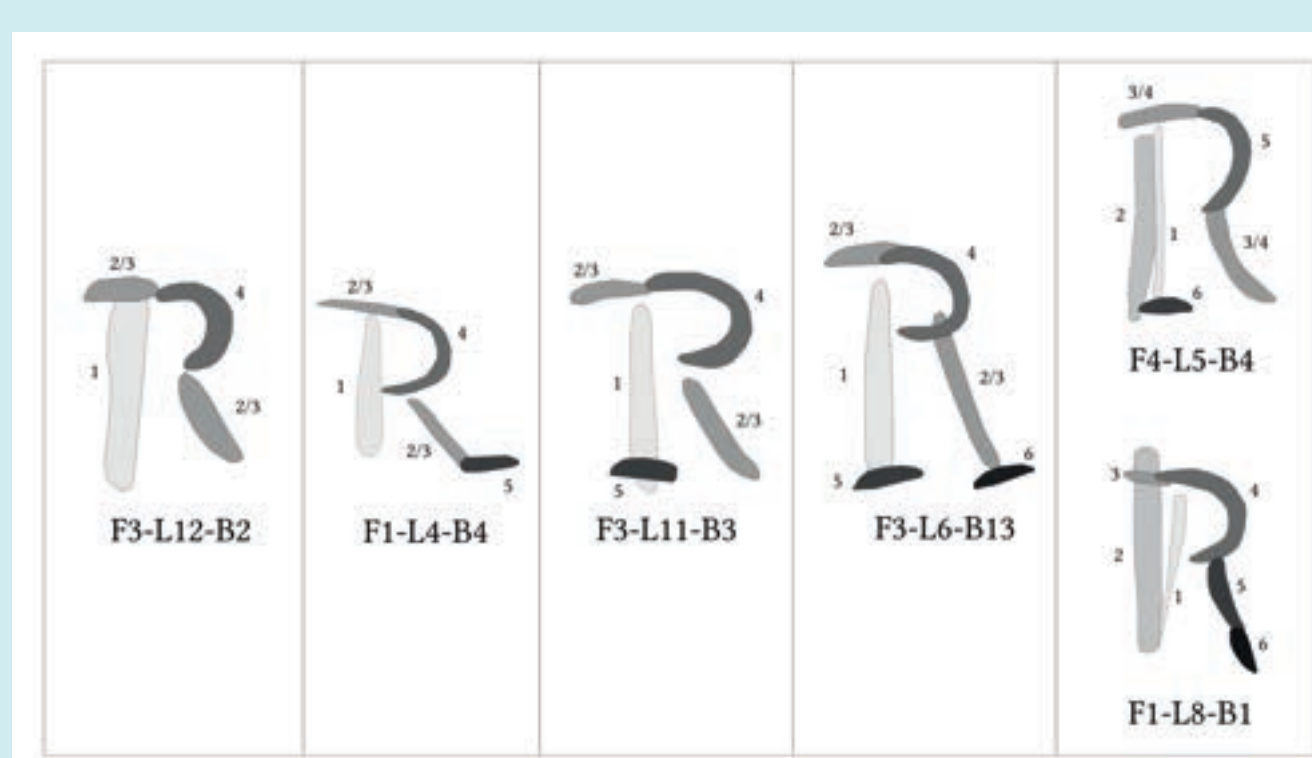
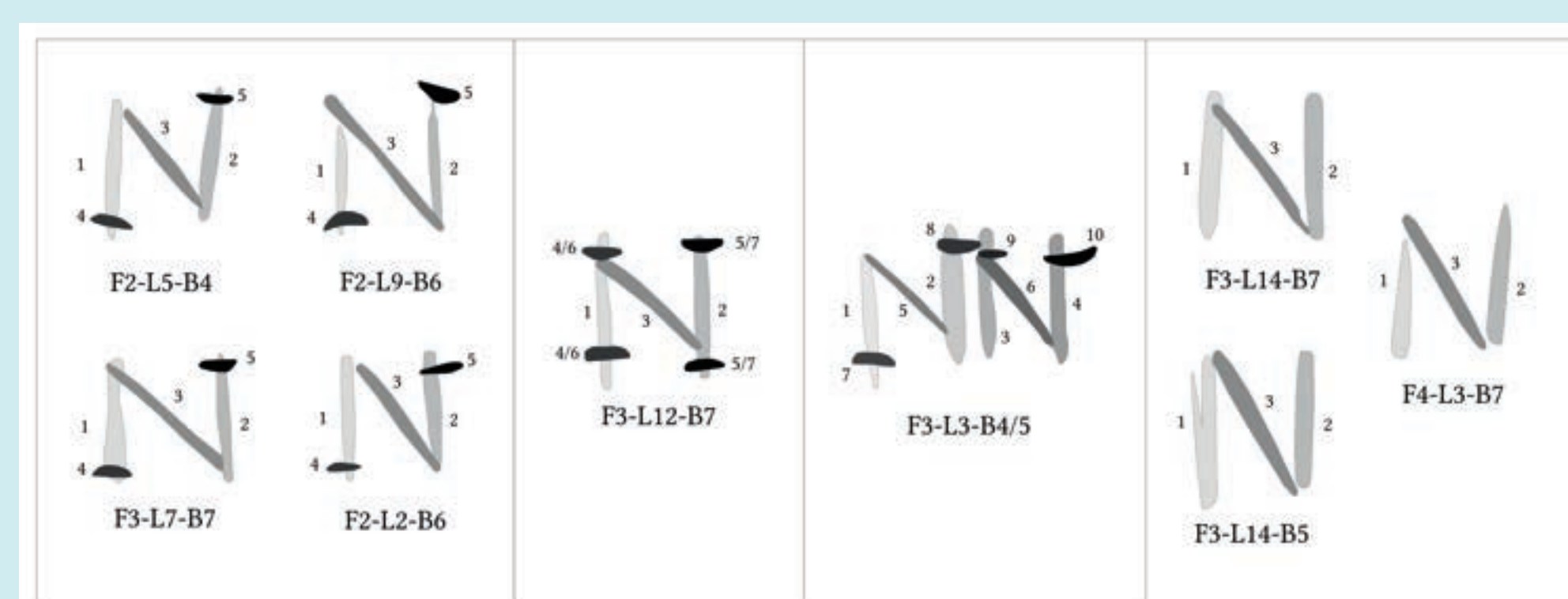
Using the chisel to make different strokes (left) and the color visualization of depth of incision on the 3D model of Fragment 4 (right).



The damnatio memoriae of Philippus Arabs on two of the fragments



Marks of hammer strikes on Fragment 1.



Observation on the paleography of different letters based on the stereomicroscopic images (left) and a corrected serif (right)

The maker of the tablet did not use letter-shaped tools, but engraved the letters with chisels of straight and curved end. The numbers are showing the order of creating a letter from small lines, which can be determined by the overlap of the lines. Always the straight lines were done after each other, then the curved line, to minimize the need of changing the tools.