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Copying from Wooden Originals? Investigating the Materiality and Rationale for Holes in the Tablets from the Library of Ashurbanipal

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Abstract This study investigates the material characteristics and potential functions of the holes found on Neo-Assyrian cuneiform tablets from the Library of Ashurbanipal. Often referred to as 'firing holes', their exact purpose has remained speculative in scholarship. By analyzing a sample of tablets with colophons, this research explores the size, shape, and distribution of these holes on the surface. We suggest that different tools were used to create holes of varying sizes, with larger holes typically found on the edges and smaller ones on the tablet's surface. The study proposes that these holes may have been added after the writing process and could represent a visual echo of holes present on wooden writing boards, which were possibly used as templates for the clay tablets. This hypothesis opens new avenues for understanding the interplay between different writing media in Assyrian scribal practices and raises questions about the production processes of the tablets in the Library of Ashurbanipal.

Keywords Firing holes. Library of Ashurbanipal. Layout. Materiality. Writing boards.

1 Introduction

The presence of the so-called 'firing holes' on the surface of some cuneiform tablets is a well-known feature of texts, especially of those from Assyria dating to the first millennium BCE. Although the existence of such holes has been noted from the early days of Assyriology, their exact features have never been accurately examined. A detailed analysis of their physical characteristics (such as shape, size, number) together with their positioning (patterns and location on the surface), and their relationship with the general layout of the tablets (paragraphs, dividing lines, etc.) is however necessary in order to address the question of what their function (or functions) were, as well as the relationship between the holes, the written texts and the materiality connected to the very making of cuneiform tablets.[1]

The authors wish to thank Nicholas Gill for correcting the English of this paper; Jon Taylor and Sophie Cohen read a preliminary draft, offering useful suggestions: any shortcomings and the ideas expressed remain our own responsibility.

1 See Corò, Ermidoro 2020, 311-18.

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For the first time, this article offers a set of data obtained from the examination of a corpus of Neo-Assyrian cuneiform tablets pertaining to the so-called Library of Ashurbanipal, currently held in the British Museum.[2] The survey of the material revealed that more than 500 tablets and fragments from this collection display holes on their surface.[3] For the purpose of the present study, we have focused on a selection of these texts, i.e. those with a colophon,[4] and taken into consideration only tablets with round holes.[5] Approximately 400 tablets with colophons have clearly visible holes; among them, ca 150 specimens are so well preserved that a distributional analysis can be carried out.

2 Methodological Concerns: To Join or not to Join?

The joining of tablets, as is well-known, is an essential step in the process of reconstruction of the Library, for a better understanding of its nature, the rationale of its make-up and more in general for the proper appreciation of its extent. As Irving Finkel pointed out, the total number of "tablets, pieces, and fragments from Nineveh is conventionally put at about 31,000 items"; however, already in February 2016, more than six thousand physical joins had already been made between the extant pieces, and many indirect joins established.[6]

This figure has substantially increased in the past twelve years, although many more joins still await to be identified.[7] Important as joining undoubtedly is, it is worth noting that many of the observations that follow on the material characteristics of the holes are based on the most fragmentary and broken tablets in the collection, because they allowed us to inspect the hole's materiality from within, and to capture details that are otherwise impossible to discern from fully preserved tablets.[8]

The size of the holes and the traces left by the tool used to impress them deep into the clay can easily be observed and measured in a good number of cases and enable us to discuss specific characteristics of the pricking technology, which cannot be ascertained by looking at complete tablets.

The sample we have selected for this part of the analysis is thus made up of tablets whose only common feature, apart from belonging to the Library's collection, is represented by their housing of holes and being substantially broken, so as to display the hole's sections.[9] No coherence is to be expected in

2 The idea for this article stems from the project *The King's Librarians at Work. Applying Machine Learning and Computer Vision to the Study of Scribal Marks on Cuneiform Tablets* (acronym LIBER), which has been carried out at Ca' Foscari University of Venice in partnership with the Center for Cultural Heritage and Technology of the Italian Institute for Technology in Venice and the Ashurbanipal Library Project of the British Museum in 2020-22. The project was funded under the SPIN-2 Measure of the Ca' Foscari University Venice. For more details see Corò, Ermidoro 2020. Further research that brought to its development into written form, and in particular the connection between the hole's pattern and the layout of tablets (see below) is part of a wider study of the formats and layout of the Ashurbanipal Library texts which is being carried out by the Ca' Foscari University Venice (under the responsibility of Paola Corò) in the framework of the project *Exploring Scribal Minds. The Structural and Visual Organization of Knowledge in Mesopotamian Archives and Libraries* (PI E. Devecchi, Università degli Studi di Torino). The project received funding from the European Union Next-GenerationEU - National Recovery and Resilience Plan (NRRP) – MISSION 4 COMPONENT 2, INVESTIMENT 1.1 Fondo per il Programma Nazionale di Ricerca e Progetti di Rilevante Interesse Nazionale (PRIN) – CUP N. H53D23000390006.

3 We wish to thank Jon Taylor for providing us with a preliminary catalogue of tablets with holes in the BM collections, which formed the basis for our investigation. Numerous additions have been made to it over time.

4 This data have been collected as part of the LIBER project by Anna Baldon, in preparation for her MA thesis.

5 In the framework of the project LIBER, we have mapped all kinds of holes in addition to round ones, including triangular, square and almond-shaped. On holes see Panayotov 2016, and for a synthesis Taylor 2010, 15-17.

6 Fincke 2017; Finkel 2019, 369.

7 Thanks to the remarkable efforts of the main projects focusing on the Library of Ashurbanipal's materials (as, for example, the *electronic Babylonian Library* project based in Munich (henceforth: *eBL*, `https://www.ebl.lmu.de/`), whose results are regularly published in this journal as the "From the eBL Lab" section and the joint London and Munich *Reading the Library of Ashurbanipal* (henceforth: *RLAsb*, `https://oracc.museum.upenn.edu/asbp/rlasb/index.html`, focusing on colophons), as well as thanks to the reconstruction work carried out by the Assyriologists working on the Library texts: to quote but one example, Schwemer 2017, 43.

8 We at LIBER have thus – so to say – been working in the opposite direction to the joining process being carried out in the context of the *RLAsb* and *eBL* projects, sometimes running a race against time, to capture at least by means of photographs those details that will otherwise be forever lost. For the help received in this context, we wish to acknowledge here once again Jon Taylor's and the Department of the Middle East' staff assistance. Note also Panayotov's (2016) comment "Ironically, thanks to broken tablets we can see cross sections of the holes".

9 The preliminary selection was based on the photograph of the tablets, both in cases where specific details could be seen on the photographs and in all other cases where we suspected that details could be observed on the original, although they had not been captured by the existing photographs of the piece. Additional examples have been brought to our attention by Jon Taylor or emerged during working sessions in the Museum by Paola Corò. Team collaborators (especially Anna Baldon and Giorgia Mele) offered invaluable help to the sample's construction.

the tablets from the sample in terms of their content, shape, layout, size, genre, or whatever features other than their preserving the holes' sections.[10]

Additionally, even though holes may have different shapes (round, triangular, square, almond),[11] in this paper we will only deal with tablets housing round holes, as they are the best represented.

3 Holes

3.1 Size: Diameter

While shape is a notable characteristic of holes, and has been the main object of scholarly attention so far, their size conversely has generally gone unnoticed in previous studies.

The diameter of the holes extant on tablets from the Library varies to the extent that we can distinguish different groups of holes according to the average size of their diameter. Aiming at a classification system, we distinguish three types: the first is represented by holes whose diameter ranges from a min. of less than 1 mm to a max of 1.5 mm; we define them small holes. The second group includes holes whose diameter ranges from a min of 1.6 mm to a maximum size of 2.7 mm: these are what we call medium holes. Large holes, forming the third group, include those whose diameter ranges from a minimum size of 2.8 mm and larger. Among the larger ones, prevalent are those with an average size of 3 mm; the largest hole we have found so far in tablets from the Library reaches up to 4.1 mm.[12]

	Min	Max
Small	< 1 mm	1.5 mm
Medium	1.6 mm	2.7 mm
Large	2.8 mm	4.1 mm (or higher)

When considering a hole's diameter, one has to take into account the fact that measuring the diameter of the holes from the outside may sometimes be tricky: it is clear from the inspection of the traces of the holes left in the core of the tablet that the size of the hole's entry point (i.e. the hole's diameter itself, as we perceive it impressed on the surface of a tablet) is slightly different from what we can see from the traces left into the core of the tablet by the tool used to pierce it onto the clay. It is in fact clear that the tablet's drying process (as well as the baking process which the tablet may have undergone for conservation purposes, or the accidental baking caused by destruction fires in the past) may have shrunk the hole, to the effect that its diameter may appear slightly smaller from the outside than can be seen from the core (although the differences are minimal).[13] This warns us to be especially careful in dealing with the assumed 'regularity'/'irregularity' of the hole's shape, which (as is true for the general shape and size of a tablet) may have been affected by the drying/baking process as well as by other mechanical actions (as the twisting of the pricking tool, or the shape of the stopper).[14]

10 Examining the holes' materiality we also took into account some tablets not belonging to the Library collection, used as comparanda and to test further possible explorations of the topic in a comparative perspective. The data relating to this part is not included in this paper: it is however clear that the evolution of holes in time and their use is in fact a matter that deserves further investigation. This also confirms the significance of the LIBER project as a pilot, whose methodologies can be further extended to other corpora for a full investigation of holes in tablets from all periods (as envisaged in Corò, Ermidoro 2020).

11 See Panayotov 2016 and Taylor 2010, 15-17.

12 That the different size of the diameter is a remarkable feature of the holes, which one may also perceive at first sight, is clear from a preliminary database of tablets with holes that Jon Taylor kindly provided us for at the beginning of our research. There, holes were classified according to their size in three different groups (marked S, M, L): the average dimension of the different 'size groups' was however not further specified. In our own classification, we introduced ranges as a reference to distinguish the different types.

13 It is well known that the drying and baking processes affect clay causing shrinking, although to which extent is less clear. As Carmen Gütschow (personal communication) suggests: "The behavior of the clays depends on several factors: the composition of the clay minerals, the size of the clay particles, and thus the pore size in the clay mass. The quantity and size of the pores determine how much water they store. The amount of water used during processing must also be taken into account. Accordingly, the shrinkage of the clay mass can vary slightly when drying and later also when sintering the clay in the kiln". According to potter' instructions "All clays shrink during drying and again during firing. Depending on the type of clay, the shrinkage is 10-15%. The higher the firing temperature, the greater the shrinkage": `https://www.keramikbedarf.ch/michel/service/toepfern_anleitung.asp` (reference courtesy C. Gütschow). During firing, the shrinkage is related to the increase in temperature, a process that usually starts at around 800°-900°C: see Gütschow 2012, pls 31 and 36.

14 On traces of twisting and the impact twisting has on the shape of the holes, as well on the trace left by a possible 'stopper' (which is likely the so-called 'transversal bands' of the stylus: see Cammarosano, Weirauch 2021, 17 and 24, and the discussion below).

3.2 Size and Position

Especially interesting is the distribution of the holes on the tablet in relation to their size, a characteristic that is often not easy to appreciate on the photographs of the manuscripts. When tablets present both holes on the surface(s) (obverse/reverse) and on the edges, and the holes are not the same size, there is a clear trend for larger holes to occupy the edges, and for smaller ones to be located on the obverse/reverse. Reference to large and small is here unrelated to the classification given above and only refers to the relative size of the holes; as a matter of fact, we may have tablets housing only M-size holes, whose diameters are however different, and the same is true for tablets housing only L-size holes, or only S-size holes.

A case in point is K.2263+ **[fig. 1]**. The tablet has holes on all its surfaces, and they are all small according to our classification; however, the holes on the edges measure 1.5 mm, while those on the obverse and reverse are ca 1.12 mm large. The difference can only be noticed looking at the tablet in detail and is difficult to appreciate at first sight (or from the photograph).

In addition to tablets that house holes whose diameters range within the same size-group (e.g. all small holes, but with diameters not always measuring the same), we count numerous cases of tablets 'mixing' holes belonging to different size-groups. The pattern of distribution is the same as that observed so far: i.e. larger holes occupy the edges, while smaller ones are located on the obverse/reverse of the tablet. DT.222 **[fig. 2]** for example, features tiny holes with a diameter of only 1 mm on the obverse/reverse, while the holes housed on the edges are all on average 3 mm large.

Additionally, there is also evidence of holes of different sizes being located either on the obverse or on the reverse of the same tablet (no example is known to us of holes of different sizes being located on the edges of the same tablet, as in this position holes are usually consistently of the same size). This usually does not happen randomly, but in specific areas of the tablet, such as the intercolumnia and the colophon. Thus, for example, K.150 **[fig. 3]**, a Neo-Assyrian manuscript of *Šurpu* with many preserved holes, exhibits a clear distribution of small holes (ca 1.2-1.5 mm) on the obverse and reverse in the textual sections arranged in columns; on the same surfaces, in the marked intercolumnia separating columns 1 and 2 on the obverse, and columns 3 and 4 on the reverse, the holes are consistently M-size (reaching a diameter of about 2 mm); the edges house large holes of 3 mm.

A similar situation may be observed in K.2423+ **[fig. 4]**, which is also, to the best of our knowledge, the tablet that houses the biggest holes in the Library: those on the edges have a diameter of 4.1 mm.[15] As is clear already from the photograph, these holes are substantially larger than those on the obverse and reverse, that may be classified in the range of the M-size holes, and measure ca 2 mm. While still M-size, the holes in the intercolumnia, are slightly larger than the others on the same surface (that reach up to 2.3 mm), and the same applies to those in the colophon.

The size and shape suggests that holes located in different areas of the tablet could be produced with different tools. The possibility that a single conical (thus with two differently shaped ends) tool was used to produce both types must be ruled out in view of the fact that when holes of different size are housed on the same part of a tablet, and in particular on the obverse and reverse, the depth of the impression, which is limited by the tablet's thickness itself, is always the same. Since the impressions are usually only a little shorter than the tablets' thickness (which reaches on average 3 cm), it is impossible that a conical tool, whose section becomes larger moving from its pointed end to its upper part, produced holes of different sizes, but of the same length. To produce a hole with a larger diameter, one should have pressed the conical tool deeper into the clay, to reach the larger section of the tool itself, located upwards with respect to its pointed end. Also the possibility that the upper and lower ends, respectively, of the same tool were used for this purpose is to be discarded: in case the tool used is conical, its upper part would be larger than the other end. Using the upper end to make larger holes, would produce traces whose shape in the inner core of the tablet would appear specular to those produced using the thinner (pointed) end of the same tool; in other words, the triangular shaped traces would have the larger part (the 'base' of the triangle) located exactly on the opposite position with respect to the one that would be produced using the thinner (pointed) end of the same tool. But this is never the case in the examined sample. In addition, we have ample evidence (as we will see below) that besides conical (or partially conical) tools, straight ones were also used to produce the holes.[16]

15 Large holes occur frequently in the Astronomical Diaries; their investigation is the focus of a forthcoming article by the authors.

16 See Cammarosano 2014 on the shapes of the styli.

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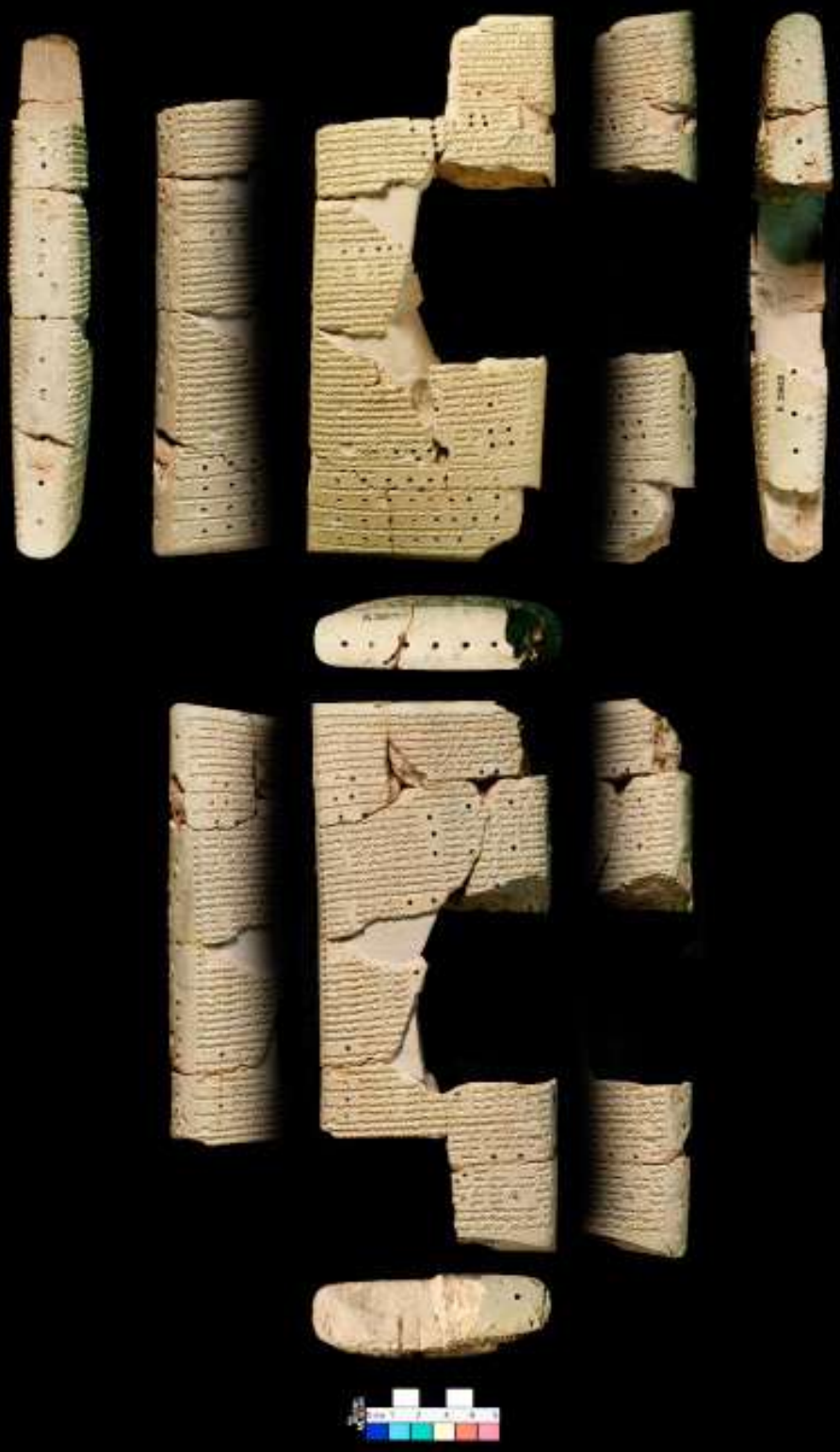

Figure 1 K.2263+. © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence)

Figure 2 DT.222. © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence

Figure 3 K. 150. © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence

Figure 4 K.2423+. © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence

3.3 Holes on the Edges

Given the preference for portrait orientation of scholarly tablets in this period, it comes as no surprise that mainly portrait-oriented tablets have holes.[17]

Tablets with holes on the edges feature a very regular schematization. Although their total number is not standard, the number of holes on corresponding edges is always consistent: those on the right edge equals those on the left edge; those on the upper edge is the same as those on the lower edge.[18] Their relative distance may vary, although slightly, also on the same edge. This rules out the possibility that their function was to host a tool used to grab them from the shelves, as this we might expect had to be rigid and universally usable. There is also a trend towards a consistent positioning of holes on corresponding edges. Our mapping of this feature is not yet concluded, so it is impossible to draw any further conclusions in this respect, yet.[19]

While we may find holes of different sizes (see above) on a single tablet, so that on the obverse and reverse we may have large and small holes at the same time or a tablet may have large holes on the edges and small and/or medium ones on the obverse/reverse, the holes on the edges of a single tablet are always all the same size.

The number of holes hosted on corresponding edges is variable. Judging from fully or sufficiently preserved specimens, they can have a minimum of five on the short (upper and lower) edges, while on the long (left and right) edges, the number of holes reaches as many as nineteen.

4 Distribution Patterns

As we have seen above, holes are distributed throughout on the surface of tablets, where they can appear on the obverse, on the reverse, and on the edges. Mapping the distribution pattern of the holes on the different parts of a tablet in the Library collection is a complicated issue, especially due to the general state of preservation of the manuscripts, which are often fragmentary.[20]

Doing this in the framework of our project, we verified the hole's presence and their distribution on a sample consisting of 1112 tablets, in Neo-Assyrian script, all with colophons.[21] Of them, less than 500 do not bear holes at all. 260 are too fragmentarily preserved to be able to determine if they had holes at all in any of their parts; for approximately 400 remaining tablets, however, we could map the presence of holes in different positions, though with different degrees of reliability.

In particular, ca 150 are sufficiently well preserved for us to establish if they had or lacked holes, and, in case they did, where they were located. Conventionally, we call them 'clearly preserved tablets', in reference to the actual visibility of holes (often only some of them) on the mapped parts of the relevant

17 So far K.3983 is the only sufficiently well-preserved tablet for us to be able to say is landscape oriented with holes.

18 A single exception to this rule was known to us on the basis of the photographs. Inspection of the original (P. Corò, May 2023) revealed that the presumed missing holes belong to a modern restoration of K.4426+, only artificially recreating the original shape of the lower edge (and omitting the holes, that it is conceivable were originally present). The information provided in Corò, Ermidoro 2020, 313, has therefore to be corrected. Another example of a possible exception is K.258+. Looking at the photograph of the piece, it would seem that this is also a tablet featuring holes on one edge and not on the other. This is however due to a photograph's mistake; the right edge of the tablet photographed as part of K.258+ belongs to K.261 (not to K.258+): `https://www.ebl.lmu.de/fragmentarium/K.258`.

19 A consistency in the location of the holes on corresponding edges may be simply due to the fact that the two edges are the same size and the holes tend to be prinked at similar, though not perfectly regular, distances. It must also be noted that the irregular distance between the holes could be related to the curvature of the edge. This point needs further investigation, after taking into consideration all the measurements: the size of the holes, their relative distance, their total number on the specific edges, the size of the tablets where they are housed and their curvature. Such investigations are being carried in the framework of our ongoing project and will be included in the final publication of its results. For the time being, it is worth noting that if holes on opposite edges were located consistently in the same positions, this would raise the question of whether a special tool was used to prink them. If this were the case we shall expect it to be quite flexible, and more similar to a tool to calculate the distance between the holes than anything rigid that was applied to the sides of the tablets, otherwise we should expect tablets to house holes always equally distant.

20 For an overview of the Library, see Reade 2000 and Finkel 2019. For the fragments' significance for its reconstruction, see also Reade 2022. A numerically limited list of scholarly tablets with colophons found in Nineveh whose eighth and width are fully preserved, is provided in the Appendix of Schnitzlein, Taylor in this volume and gives an idea of the volume of fragmentary tablets versus well preserved ones.

21 Part of this data (446 tablets) was originally collected by Anna Baldon in the framework of the LIBER project and included in her MA dissertation. The test sample has since then been expanded in the framework of the project *Exploring Scribal Minds* and is being continuously updated.

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tablets, but with no aim at indicating the actual state of preservation of the manuscripts themselves.[22]

On more than 200, the presence of holes on the different parts could only be mapped sparsely: we call them 'variously uncertain' as they reflect the situation of tablets that may, for example, have holes on the obverse but it is unclear whether they had them at the same time on the reverse and/or on the edges and tablets that have holes on the reverse, but we do not know whether they had them at the same time on the obverse and/or on the edges.

Of these, a particular group is especially interesting, and we take the opportunity to discuss it in more detail here. We in fact included amongst the 'variously uncertain' twenty-one tablets that we know for certain had holes on the edges but for which the contemporaneous presence of holes on the obverse and/or on the reverse is uncertain. In detail, seven tablets have holes on the edges and on the obverse, but their presence on the reverse is unclear, six have holes on the edges, have no holes on the obverse but their presence on the reverse is uncertain and eight have holes on the edges but their presence on both the obverse and reverse is unclear. This last group is noteworthy, since, as one can see from the table **[table 1]**, there is no evidence among the clearly preserved tablets in our sample of a single manuscript featuring holes on the edges only.

The emerging holes' distribution pattern for our sample is summarized as follows:

Table 1 Distribution of the holes in tablets with colophons

Holes location	Nr of tablets
Unmappable or without holes	
No holes	468
Impossible to map (due to the state of preservation)	260
Sub-total	**728**
'Clearly' preserved tablets	
Holes on obverse, reverse and edges	120
Holes on obverse and reverse only	18
Holes on obverse only	5
Holes on reverse only	4
Sub-total	**147**
Variously uncertain	
Sub-total	234
Total	**1112**

When clearly preserved tablets have holes on the edges, they also contain holes on both the obverse and reverse or at least on one of the two main surfaces. It is thus plausible that in those eight cases examined above of tablets with holes on the edges but for which it is impossible to determine if they had holes also on another of the main surfaces, this was actually the case (i.e. they had holes somewhere else as well). Conversely, the six that have holes on the edges, and appear to lack them on the obverse, in all likelihood originally had them on the reverse (although no longer visible to us due to their state of preservation).

A clear set of rules emerges from the examination of the distributional pattern of the holes on tablets with colophons (and it is conceivably applicable to any tablets with holes):[23]

1. tablets with holes represent only a small fraction of tablets with colophons in the Library;
2. there is a trend for tablets with holes to have them on all of their surfaces, more so than on single parts (of the tablet);
3. tablets that have holes only in specific parts of the tablet may have them located on the obverse and reverse only, only on the obverse or only on the reverse, on the obverse and edges or on the reverse and on the edges;
4. we have no evidence so far of tablets with holes on the edges only, which suggests that the application of holes to the edges of a tablet in isolation was either not admitted for some reason or, as we believe to be case, neither functional, nor meaningful;

22 We include here also tablets that may have visible holes on only one of two corresponding edges, as we have no single example among the well-preserved tablets, of specimens that are exceptions to this rule.

23 We have not completed the full mapping of the Library yet, so the results presented here must be considered preliminary and need refinement until the process is fully completed.

5. when a tablet has holes on the edges, their number is consistent on the corresponding edges (left/right and upper/lower);
6. as far as we can judge from tablets on which all the surfaces may be sufficiently inspected, when a tablet has holes on the edges, they appear on all four.

As our sample consists exclusively of tablets with colophons, we conclude from the above that there is no straightforward relationship between the application of holes and the presence of colophons on tablets: in other words, tablets with colophons do not necessarily bear holes. On the other hand, when tablets with holes feature them also in the colophon section, different patterns and distributional schemes can be observed.[24]

5 Holes and Text

Holes occur on single-column tablets as well as on multi-column ones, with a slight preference for the single column type over the multi-columns in our sample.

Not all the tablets with holes are regular and well-formed, nor the holes are consistently regularly distributed and spaced out on their surface. Particularly interesting are examples of holes that clearly interfere with either the written text by at least partially overlapping signs already written on the tablet, or with the layout markers, i.e. the horizontal and vertical lines used to mark paragraphs and specific areas of the written text.[25] An illustrative example is provided by K.51 **[fig. 5]**: the preserved part of the obverse of this tablet, which is subdivided into at least three columns, contains numerous holes, some of which overlap the vertical and horizontal lines used to mark columns and sections, and in a couple of cases also overlap the 'long tail' of some signs.

Figure 5 K51, Obverse (detail). © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence

24 See Baldon, Corò, in preparation, for details.

25 These details are the focus of the project mentioned above (see fn. 2 above).

Holes also overlap a few signs in K.55,[26] whose layout substantially differs from that of K.51: the tablet is written in the Neo-Babylonian script. K.2235+ **[fig. 6]**, in Neo-Assyrian script, has holes crisscrossing the vertical column dividers, as well as, though not systematically, the long tails of some signs[27] (the same holds true, for example, in K.150).[28]

Figure 6 K2235+, obverse. © The Trustees of the British Museum.

Although the rationale for this procedure escapes us, these examples bear witness to the fact that the holes on the obverse and reverse could be added to the tablet after writing (both text and layout) was completed, ruling out the possibility that they served to host implements used to draw lines or other elements functional to the writing process.[29]

On the other hand, it is also clear from the sample that the holes on the surface of tablets could be used to 'visualize' additional layout features, replacing missing markers, such as columns dividers and played a role in shaping the physical organization of the text in the absence of visible elements (especially vertical lines). In K.2427+ **[fig. 7]**, a vertical sequence of holes is used to mark an otherwise physically unmarked separation, roughly corresponding to a vertical line column marker characterizing

26 https://www.ebl.lmu.de/fragmentarium/K.55.

27 The complete repertoire of the manuscripts that have holes overlapping signs, parts of signs and layout markers will be published separately, as part of the results of the project mentioned in the previous footnote. To mention only a few examples, holes overlapping sign tails and vertical lines can also be observed in K.2597+; for holes overlapping sign tails, but not layout markers, see K.150.

28 https://www.ebl.lmu.de/fragmentarium/K.150.

29 This confirms our previous observation in this regard. See Corò, Ermidoro 2020, 310. For a new hypothesis on their function, see below.

Figure 7 K.2427+. © The Trustees of the British Museum. Shared under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0) licence

the single column text written on the tablet.[30] Smaller series of holes vertically aligned as to resemble a column division, as the one made up of four of them, not all perfectly aligned, visible on the obverse of the tablet between the third and fourth horizontal lines are also attested.

The reason for their use emerges from the comparison with other similar tablets: in K.2414+, K.2423+; K.2445+; K.2454+ and K.2597+ (to quote only a few), holes appear to be used as markers for 'tabulations', subdividing into smaller, otherwise unmarked, sub-columns a particular section of text. They take the shape of holes aligned as vertical (unmarked) columns when the relevant text sections are aligned with one another; conversely, they may appear as random or isolated holes when the text section they separate is right-aligned or left-aligned with respect to other following (or preceding) sub-columns (see the schematization in fig. 8 = K.2414+) **[fig. 8]**.

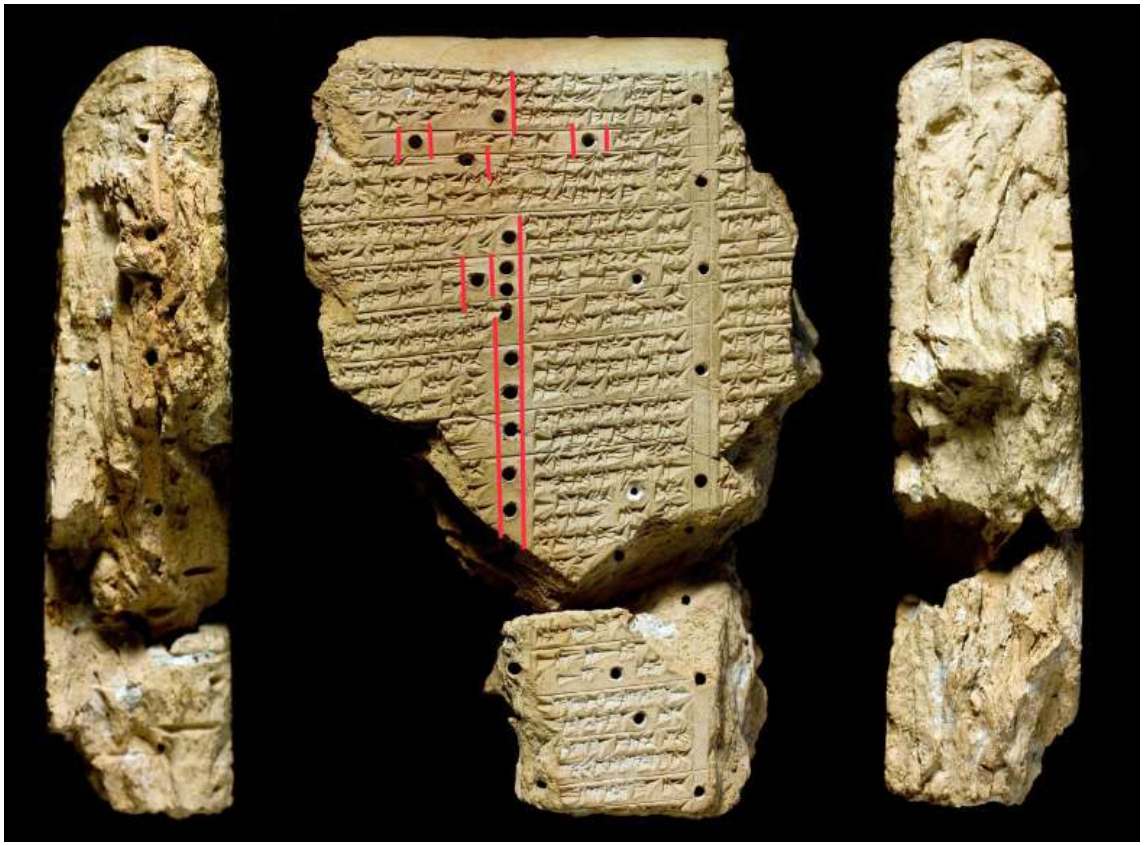

Figure 8 Schematization of the use of holes to mark tabulations in K.2414+.

30 K.2427+ is a single-column tablet, where the scribe only used horizontal lines to mark different sections of text: the text on the obverse is clearly divided into two columns, whose division is not marked by a vertical line, but visualized by means of holes vertically placed on top of one another, as if they replaced the vertical straight divider.

6 Holes and Writing Boards: A New Hypothesis

As noted above, what remains to be explained, and complicates the overall interpretation of the function of the holes (especially those on the obverse and reverse of a tablet) is the fact that they were applied to the tablet after the writing process was completed,[31] and thus were not used for the fabrication of the tablets themselves. If holes used as tabulation markers did not have a function related to the arrangement of the text on the tablet, but at the same time appear connected to the design of its layout, the reason for their use must be sought either in the future use of the tablet, or ought to be connected to the process that led to the realisation of the tablet and its text. We think of realisation here in particular with respect to the originals from which the tablet and its corresponding text was copied.

An intriguing hypothesis is that the holes represent the visible link between the two prevalent writing media in the Library of Ashurbanipal: clay tablets and wooden writing boards.[32]

Writing boards, typically composed of wood or ivory, consisted of a single leaf or of multiple leaves tied together by means of hinges to form diptychs (two leaves), triptychs (three leaves) or polypthics (multiple leaves). These boards usually feature a recessed surface, were covered by a wax paste, made of a special admixture, and were inscribed using a special stylus.

The coexistence of clay tablets and wooden writing boards in the Ancient Near East is attested since the third millennium BCE, all throughout the second and first millennia BCE.[33] Writing boards were used in administrative contexts, as well as media for literary texts, and their importance alongside clay tablets in the Library has often been emphasized in scholarship.[34] Nevertheless, with rare exceptions, we have no surviving examples of inscribed writing boards from Assyria.[35]

31 There may be isolated cases where this is not the case, as in K.2414+, where the hole on the sixth paragraph of the obverse is partially obliterated by the last sign preceding it, which had been written after the hole was made. However, as this sign is quite squeezed into the space next to the previous one, it may have been a later addition. This is not inconceivable, especially because we have evidence in the same tablet, on the top left paragraph, of an inserted short line, written in a smaller font compared to the previous and following ones, which looks like an addition to the main text. The signs that form this short line, represent a variant for a word, in the main text, written exactly on top of it; differently from the two lines between which it is inserted, this smaller font line does not have a corresponding set of signs or short line on the right.

32 We are currently working on a combined examination of all the characteristics (related to the materiality, layout and content of these tablets) to test and verify this hypothesis, the results of which will be the subject of a forthcoming article. A different suggestion has been proposed by S. Wisnom at the Rencontre in Helsinki. We unfortunately did not have access to the paper prior to its publication, which, according to the author, is due soon. On the application of holes to Babylonian tablets in the first millennium BCE, see Young in this volume.

33 On writing boards, see the comprehensive articles by Cammarosano et al. 2019 and Cammarosano, Weirauch 2021. A recent summary of the use of writing boards in the Near East is provided by Zimmermann 2023, 208-26, also listing literature that appeared after Cammarosano et al. 2019. See also Schnitzlein 2023, 151-9. For their use in the third millennium BCE, see Molina, Steinkeller 2023 and Maiocchi 2024.

34 The total number of writing boards listed in the fragmentary inventories of confiscated tablets and writing-boards that arrived in Nineveh in 648 BC is estimated at 300 by Parpola (1983, 4); the figure is more cautiously reduced to 140 by Fincke (2004, 58). According to Postgate, the absence of large multicolumn tablets from the Nineveh collection is due to the fact that long cuneiform texts were preferentially written on writing boards: Postgate 1986, 22.

35 Examples include the ivory board from Nimrud and Assur. For recent overviews of the wooden boards from the Near East, see Cammarosano et al. 2019 and Cammarosano, Weirauch 2021, both with previous literature.

Figure 9
BM 131952: ivory writing board from Nimrud.

Although first invented in the Ancient Near East, wax boards were extensively used in the Greek and Roman periods, throughout the Middle Ages, and in Early Modern Europe. Extant examples come primarily from Hellenistic Egypt and Roman Britain because their respective climates lend themselves to the preservation of perishable materials, but numerous medieval exemplars are also available.[36]

The Assyrian ivory writing boards from Nimrud are likely to have represented more a paradigmatic/exemplary specimen than the type of ordinary boards used in the Library and/or in the administration; thus, to get an idea of the shape or form of the ordinary ones, we must look for possible comparanda in the extant tablets from these diverse areas and periods.[37] Among them, some of the medieval ones look especially intriguing and one in particular captured our attention because of its exhibiting holes.[38] The document to which we refer is a wax tablet, with preserved writing, belonging to the monastic accounts from Cîteaux and is part of the collection of the Archive of the Cote d'Or (Dijon). It dates to 1321-1325 CE. **[fig. 10]**.[39]

36 For a general overview, see Cammarosano et al. 2019, 123-4. On the wooden boards in the Greek and Roman world, see especially Degni 1998. An introduction to writing boards from antiquity to the modern era is found in Lalou 1992. A list of the Medieval writing boards known as of 1989 is provided in Lalou 1989.

37 It seems likely that ordinary writing boards were made of wood (not ivory), as implied by the determinative used for their name; they may have looked like the walnut boards recovered in Nimrud, and currently housed in the British Museum. While they are very fragmentary, at least two of the three pieces were larger than the ivory ones from the same location, but one was smaller (Wiseman 1955, 4, with fn. 22). Paola Corò could inspect the originals in the British Museum in March 2024, but measurements and other details could not be taken, due to their very fragile conditions. Nothing is known about the script they could have housed, how it was drafted nor on their layout: however, they apparently preserve traces of wax (Jon Taylor, personal communication). For the Nimrud writing boards, see Wiseman 1955 and Howard 1955. We wish to thank Enrica Inversi from the Department of the Middle East of the British Museum for her kind assistance during the inspection.

38 The similarity between the holes on writing boards from the Middle Ages and those on clay tablets was noticed by Paola Corò during Marc Smith's presentation at the international workshop *On the Trail of the Neverending Manuscript. Comparative Perspectives on Rewritable Media* organized by Michele Cammarosano in Naples. We wish to thank here Marc Smith for kindly answering all questions about the holes' presence on the reverse of manuscript 11 H 1154, although holes were not the focus of his presentation. Many fruitful discussions on this topic followed during the dinner and we wish to thank here also Thomas Wosniak (Tübingen) for his many clarifications and the interest he showed on the topic of holes on clay tablets. For many fruitful conversations and bibliographic suggestions, we also wish to thank Paola Degni and Paolo Eleuteri (Ca' Foscari University of Venice).

39 We refer here to the reverse of manuscript 11 H 1154 (Arch. dép. Côte d'Or, 11 H 1154, f. 8HJ verso). For an image, see Lalou 2010, 233. See also `https://www.nakala.fr/11280/8843caec`. The wax tablets of the Cîteaux abbey, belonging to the departmental archives of the Côte d'Or, are available online in Flipbook format at the following address: `http://documents.cbma-project.eu/flipbook/citeauxAD21_11H1165_tablettes/tablettes.html`.

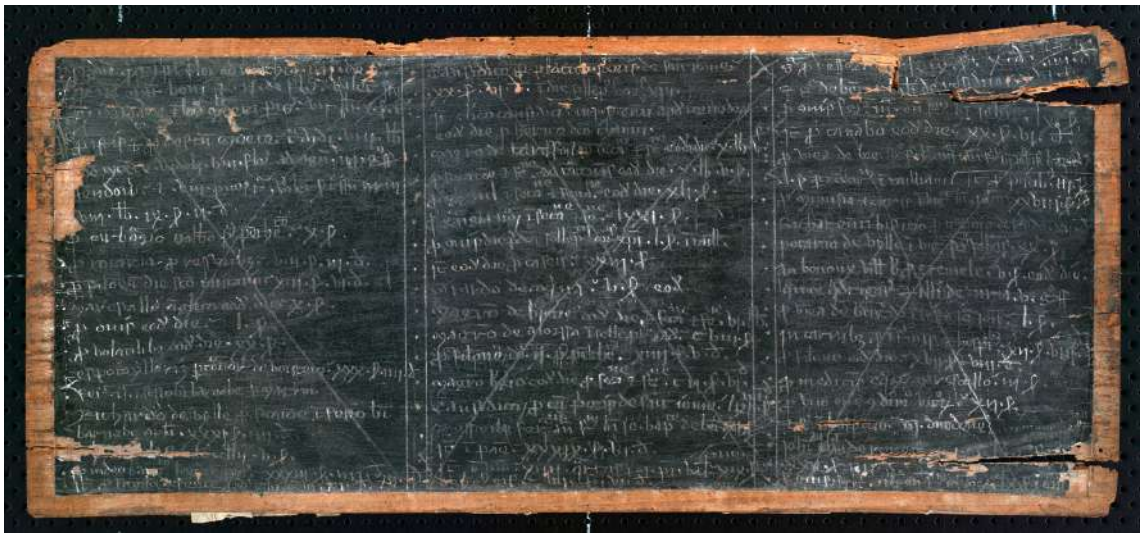

Figure 10 Wax tablet from Cîteaux (© Archive of the Cote d'Or (Dijon))

The wooden tablet is landscape oriented and has the text organized in three columns and separated from one another by two intercolumnia, each marked by two single parallel vertical lines. In the intercolumnia, small holes are arranged in vertical lines, marked at almost regular distances. The holes in the intercolumnia of the tablet from Cîteaux remind us of similar holes on clay tablets, also marked in the intercolumnia of those tablets whose layout is organized in columns. Although there is no 1:1 correspondence between the written lines and the holes, in the case of the boards from Cîteaux it is suggested that the holes are the traces left by the pegs used to hold strings that served to prepare the guidelines for writing and layout, similarly to what is known about the perforations that appear on parchments manuscripts.[40] As analogous holes in the intercolumnia of clay tablets are apparently not connected to the written lines, it seems unlikely that their function was the same.

In the case of the medieval boards, similar pegs were also added to the wooden frame. Round holes of various kinds are also found on wooden tablets from different areas and periods; in this case, it is well-known that holes located on the wooden frame, usually quite large and drilled, were used to bind together different leaves of diptychs and polyptychs.[41] A manuscript of the Greek text of Isocrates from Roman Egypt show holes in 'isolated' and unpredictable position at the tail of the board, which were added to accommodate the inserted leaf to the format of a pre-existing (different size) set of eight leaves.[42]

As we have ample evidence that clay tablets could be copied from originals on wooden boards,[43] it is tempting to see the holes as the imitation of the ones originally on the wooden manuscript. This would explain why they are apparently not functional to the writing process, could overlap writing and were added to the tablet after writing it. It may also explain why the holes are not consistently present on tablets. If the holes are imitations, it is also easier to explain their different sizes, distribution and patterns on clay. These specifications probably had functions related to the material composition of the waxed wooden tablet, which the clay tablet did not necessarily imitate in full. It is possible, for exam-

40 Describing the volume, Lalou 2011, 187 specifies "La mise en page était préparée à l'avance. Il semble que lors de la réutilisation des tablettes les mêmes paragraphes étaient écrits aux mêmes endroits. On distingue des points dans certaines colonnes, qui correspondent au début des rubriques, qui rappellent les points de réglure dans les manuscrits sur parchemin. Des «accolades» relient parfois plusieurs lignes entre elles".

41 See, for example, the Coptic writing board now at the MET: `https://www.metmuseum.org/art/collection/search/473393`. Other examples from Roman Egypt belong to the collection of the Leiden Papyrological Institute (see Hoogendijk, van Minnen 1991, esp. plates XI-VX). See also the interesting details of the manufacture of the wooden boards from the Dakhleh Oasis in Egypt, some of which preserve the Greek text of three Cyprian Orations of Isocrates and others the so-called Farm Account Book (FAB): Sharpe 1992, 138-49.

42 Sharpe 1992, 144, Fig. 27.

43 For a recent synthesis on the use of *gabarû* in colophons from the first mill. BCE, see Zimmermann 2023, 65-73. See also Schnitzlein 2023, 139-40. A comprehensive re-evaluation of the evidence of the term, in connection to parchment and wooden boards, is the subject of a forthcoming article by P. Corò.

ple, that large boards were copied into smaller clay tablets, that retained the general layout of the original, while adapting it to the new size. In addition, this hypothesis could also explain why not all tablets have holes and why tablets that house a certain type of text may sometimes look like exact copies (including holes) of other tablets and sometimes not, as this would depend on the original from which it was copied. Far from detracting from the validity of mapping the holes on clay tablets, the fact that the holes on clay tablets could be a visual echo of those on the original writing boards may pave the way to a better understanding of the – for us so far – inaccessible world of Assyrian wooden boards. At the same time, if this hypothesis proves true, it would prompt numerous questions, and suggest future investigations on the relevance and significance of writing boards for the creation of the Library, on the scribal processes and expertise involved in the production of the tablets with (and without) holes, on the implication this had for the Library, and on the relationship between tablets copied from writing boards and not. As it is well known that holes were more widespread in Assyria than in Babylonia, another question that would need further investigation is what role writing boards played in the two areas, also in connection with the formation of the Library, and how do the colophons purporting that the texts are copied from originals on writing boards relate to the presence (or lack) of holes on the tablets. Besides holes, it is conceivable that specific layouts, especially those arranged in columns or tabulated, imitate those used on writing boards.[44]

7 Pricking Technology

As mentioned above, poorly preserved tablets that originally housed holes on their surfaces offer a mine of information on the technology of hole's pricking, as they allow us to inspect the inner core of the tablet where the traces of the hole's impression are extant. The length of the traces left by the piercing tool in the clay, as well as their shape, provide a lot of information on the hole's manufacture.

One important element emerging from this part of the analysis is the possibility of reconstructing, at least partially if not in full, the order of impression of the holes. In a few examples, the traces left by the impression of the holes into the edges and those from the surface (obverse and/or reverse) crisscross. From these examples, we know that:

- holes from the obverse were impressed before holes belonging to the right edge (see K.2235+);
- holes from the reverse were impressed before those on the upper edge (see Sm.1060);
- holes from the upper edge were impressed before holes from the left edge (see DT.286).

The preserved examples do not cover the full spectrum of possibilities, and this prevents us from a complete reconstruction of the whole process. In addition, they do not all belong to one and the same tablet, so even a partial reconstruction is hampered by the fact that, in view of the reconstruction, we assume that holes were produced using a fixed and stable order in all tablets (although in the absence of a clear evidence for it).

If the examined examples bear witness to a general trend, we can tentatively suggest that the holes on the obverse and reverse of a tablet were impressed before those on the edges.

As for those on the edges we may expect that, in light of their consistency, their impression followed a regular flow, enabling the person in charge of their pricking to produce corresponding holes on opposite edges. We may therefore tentatively posit that a lower/upper and left/right order could be used, in view of the fact that DT.286 shows that holes from the upper edge were impressed before those on the left edge.[45]

When examining the development of the pricking process, one additionally has to consider that when tablets have holes all of the same size we may expect that pricking was effected using the same tool, for which a regular and continuous flow in the process is reasonable to assume. With respect to holes

44 The idea may not be too far-fetched considering that a similar observation was made on the record of a court hearing from 126/127 AD documented on a papyrus from the Egyptian village of Tebtynis (P.Mil.Vogl. I 25). In reference to the particular layout of the document which consists of two short and narrowed juxtaposed columns, Dolganov notes: "This diptych-like layout is attested in a handful of judicial records from Roman Egypt, all dating to the first century CE, and may be a visual echo of Roman waxed tablets, the typical dimension of which (ca 12 × 16 cm) correspond to the size of the two columns" (Dolganov 2022, 42). All the questions mentioned above are the object of a forthcoming publication by P. Corò.

45 Interestingly, Wunsch (2000, 564) demonstrated that on sealed court records from the time of Nabonidus, and on land sale contracts from the same period, the judges and notaries respectively impressed their seals on the edges of the tablets in the order left-right-lower-upper, showing a flow similar to the one we posit here (i.e. developing by pairs of corresponding edges). This is, however, not always the case, as shown by Altavilla, Walker 2016, 22.

of different sizes, which were in all likelihood made with different tools (see below), the pricking process was discontinuous. This is especially true for tablets that have holes of different sizes on the obverse and/or reverse.

8 Depth of the Impressions: Different Traces, Different Tools?

Another interesting feature that can be observed in broken tablets which originally contained holes is the depth of the impression, that is, how deeply into the clay the tool used to produce the holes was impressed. When examining this characteristic, we have to be aware that the collected data on the length of the traces are only reliable when these are fully preserved but are unreliable or only partially reliable when the traces are not preserved in their entirety; thus, although many tablets provide the opportunity to see traces of the hole's impression into their inner core, the number of those that are fully preserved and allow us to draw conclusion in this respect is substantially reduced. In general, there is a logical and predictable distribution of longer traces for holes located on the edges, and shorter traces from holes housed on the obverse and reverse, corresponding to the different depths of the hole's impression. This is obviously related to the tablet's thickness, and in fact, we have no evidence, to the best of our knowledge, of even a single passing hole (i.e. of any "perforated" tablet), due to a mistake.[46]

The difference in size between the length of the traces from holes on the obverse/reverse and those from holes on the edges, however, is often significant. For example, K.2235+ shows traces of holes 5.4 cm long from the right edge, and traces from the obverse that are visibly shorter (reaching a max length of 2.1 cm). The same applies to the trace of a hole from the left edge of the same tablet, which is also the same size as the one from the right edge. The hole's entry point is not preserved but it can be safely measured because part of the trace is visible until its end in the inner core of the tablet. Similar configurations may be found on other tablets in the sample (like, for example, K.2263+ and K.3967+); additionally, one can notice that both short and long traces tend to be regular in size on the same tablet **[fig. 11]**.[47]

This data prompt a few questions: how did the hole maker produce such regular traces? From a practical point of view, in terms of manufacture, this must not have been that easy to facilitate if the person who made the holes did them freehand.[48]

Additionally, what is the rationale for piercing the holes from the edges deeper into the clay than those on the surfaces? Indeed, while it is clear that those upon the surface had to be shorter because of the limited thickness of the tablet, there is no apparent reason why the other traces had to be longer; in other words, why expend time and effort pressing the piercing tool more deeply into the clay than on the surface and producing longer traces, perhaps also avoiding the risk to spoil the surface? Moreover, the deeper the tool was impressed into the clay, the more difficult it is to be certain that one presses it to a specific point. Therefore, we would expect the length of longer traces to be less regular than the length of shorter traces, but the data we collected rules this out, as the traces usually have a consistent length. We wonder whether the fact that we have no evidence of mistakes, in addition to the observation that the collected evidence shows a tendency for regularity in the length of the impressions, indicate that a specialized tool was used to pierce these holes, one that had a special shape or a stopper/indicator of some kind, which eased the production of these impressions of regular length.

In light of the extant bronze styli from Hattusa, for example, or other similar writing implements used in the Roman and Medieval periods, it seems conceivable that the (or the series of) thin horizontal 'bands'(s) that characterize their length may be used as indicators or stoppers, easing the production of the regular impressions. Transversal bands might also have been the cause of the special shape of some holes, at the entry point: they can look like signs of twisting, but are, in our opinion, too marked and 'complete' to have been produced because of the twisting of the pricking tool.[49]

46 We are not considering here those tablets or amulets that had perforations (with the appearance of passing holes), whose function was completely different from that of the holes we are examining in this context.

47 Very long traces of holes from the edges are frequently attested. The longest we have mapped so far is on K.4087. See already Corò, Ermidoro 2020, 313.

48 Another question we want to investigate is the identity of the person who made the holes: was he the scribe or a different individual? And in case they were two different persons how did their activities intersect?

49 On the 'transversal' band of the styli depicted in Neo-Assyrian wall panels, see Cammarosano, Weirauch 2021, 16. In this context they also mention a passage from a late copy of a letter to king Ashurbanipal stating that styli had to be soaked in a kettle. The authors tentatively connect this to the groove and the use of an oily mixture for writing; we wonder if this passage could hint at the need to soak the stylus in some particular mixture to ease its impression on the tablet to produce the holes. This could

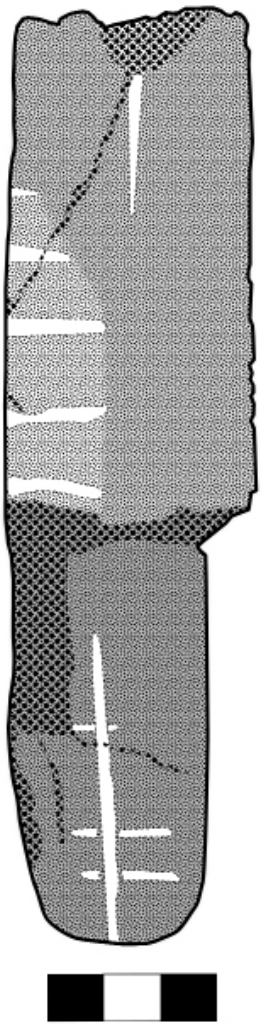

Figure 11 Detail of K.2235+. Drawing by Anna Baldon

Finally, the traces reveal various aspects about the tool's shape. This is not the place for a detailed discussion, but a few elements can be enumerated:

1. traces suggest that in many cases the tool used to produce the holes was only slightly conical. In both short and long traces, we see a quite straight initial part, which terminates into a more pointed extremity towards the end of the traces themselves;
2. against the idea that a conically shaped tool was responsible for holes of different hole sizes (the more it is pressed into the clay, the larger the hole becomes since a cone becomes larger the further it is impressed), the shape of the longer traces, especially compared to that of the shorter ones, suggests that different tools were used for holes of different sizes. Challenging as this may have been from the practical point of view, it seems the only plausible explanation in view of the available evidence. This would also explain why larger holes that we occasionally find on the surface of the tablet, for example in the intercolumnia, can be as large as those on the edges, although the tool used to make them was pressed into the clay only for a couple of centimetres as a maximum, compared to the others. The nature of these tools still escapes us. In the absence of extant specimens, should we, in view of the hypothesis on the nature of the holes we formulated above, look for them among the tools used to prepare the writing boards?

perhaps explain why the traces of the hole's impression are always so clear-cut. Unfortunately in the absence of further evidence, this remains a mere hypothesis.

9 Conclusion

Although the full mapping of holes on clay tablets is not yet complete, the evidence discussed in this paper has shed new light on many important details of the round holes, featured on manuscripts from the Nineveh collection with colophons.

Aspects of their materiality, such as the different sizes of their diameters, the length of the traces left by the impression of the tool used to make them (which we could measure in many instances when they were exposed in the inner core of the broken or fragmentary tablets to which they belonged), evidence of traces crisscrossing each other, which indicates the order of their impression, and the distribution patterns for holes of different sizes found on the same tablet (which reveals a trend for larger holes to be located in the intercolumnia and edges and for smaller ones to occupy the rest of the obverse and reverse, while holes on the edges consistently have the same size) all suggest that different tools were used for the production of holes of different sizes.

Although some crossing traces allowed us to attempt a partial reconstruction of the working flow implied in the pricking process, and though we could only offer hypotheses on the possible comparanda for a full investigation of such a complex matter, the analysis of the material characteristics of the holes raises important questions pertaining to the identity, professional skills, number and type(s) of professional(s) in charge of their production. Furthermore, the examination of the holes' main distribution patterns on the tablets' surfaces, and, especially, the relationship between the text (not only signs but also all kinds of layout markers: dividing lines, vertical divisions, etc.) and holes, reveals that in many instances holes were applied to tablets after the written text and the layout markers had been committed to clay. This laid the basis for a new hypothesis on their function: the idea that the holes may be the visual echo of originals on wooden boards. Should this be confirmed, it would open new avenues of research concerning the production chain of manuscripts that became part of the Library of Ashurbanipal. It would also enable further investigations into the mechanisms of its formation and construction, the significance of the texts it contains, the professionals involved at various levels in its management and the interoperability between different writing media.

Far from constituting the final stage in the research on the topic, our contribution aims to serve as the first step towards a series of further studies that aim to shed light on the multitude of questions and unresolved issues that still persist in the study of the Library. Future stages of our research will thus address pivotal topics such as the correlation between the materiality of holes and the contexts of the texts where they appear (i.e., the genres and sub-genres to which they belong), as well as their chronology and provenance when known. Further physical features of the holes, such as the presence of 'grids', i.e., groups of holes which are more or less precisely aligned in series, both vertically and horizontally, will be also taken into consideration to refine the analysis of the overall distributional patterns of the holes and their significance particularly in connection to the possibility that they may provide insights into the nature of the originals they represent.[50]

A diachronic analysis of the holes is also envisioned. Since it is already evident that the Middle Assyrian tablets with holes are relevant to the present study, and also those from Babylon may have connections to the data collected so far, a comprehensive understanding of the issue of the holes cannot disregard an analysis of their development over time.

50 At least two main "grid"-patterns can be singled out: small grids (made up of 4 to 9 holes in total) and large grids (formed by a minimum of 10-12 holes to as many as 50 holes). Grids appear in all types of texts: in those written continuously, as well as in those in columns and/or text boxes. Regular grids almost always coexist with isolated holes and/or with other irregular grids, made of a variable number of holes impressed next to the other but not aligned in a clearly recognizable format.

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