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Did Johannes Gutenberg invent the hand mould?
Conclusions drawn from microscopic type comparisons of early prints[1]

Of course, it is assumed Johannes Gutenberg (around 1397-1468) invented the hand mould, which is a device used to produce several identical types of a character by casting fluid metal in a mould. Nevertheless, researchers of book and print history are confronted with publications questioning his developments every few years, which is usually accompanied by an extensive media coverage. However, in most cases these approaches are to be considered untrustworthy. But the starting point of my considerations concerning this question was a promising investigation of the well-respected bibliographer Paul Needham along the scientist Blaise Agüera y Arcas. They examined the types of the Latin *Bulla turchorum* (GW 591610N) by pope Calixtus III in Princeton printed about 1456 in Mainz[2] and they doubt that the hand mould was a development by Gutenberg.

Mechanized type examination in Princeton

Agüeras published the results of the study in a short essay in 2003.[3] He had recorded the pages of the *Bulla* photographically with a resolution of 1200 dpi and then converted the colour images into black and white images providing higher contrast. A threshold was set to filter out most of the image features that were considered to be irrelevant, irregularities caused by paper quality or inking for instance. The now simplified printed image, exempted from colour and three-dimensional traits, could serve for a mechanized type comparison through a software developed by Agüera. Due to the variety of type forms only the type »i« was inspected – at least in the publication. The number of different type groups was assessed to be so large, that a system of matrices and hand mould could not be

1 This is a short version of my German publication: Christoph Reske: Hat Johannes Gutenberg das Gießinstrument erfunden? Mikroskopischer Typenvergleich an frühen Drucken, in: Gutenberg-Jahrbuch 90 (2015), pp. 44-63, as an offer for readers of other mother tongues. All figures were taken by the Author.

2 Paper, Princeton, Scheide Library Sign. S2.4 (ISTC ic00060000). http://arks.princeton.edu/ark:/88435/0v8380652 [2 December 2020].

3 Blaise Agüera y Arcas: Temporary Matrices and Elemental Punches in Gutenberg's DK type, in: Kristian Jensen (Ed.): Incunabula and their readers. Printing, Selling, and using Books in the Fifteenth Century. London 2003, pp. 1-12. Phase One PowerPhase: 4 × 5" camera back, scan area: 6000 × 8400 px, 12-bit colour depth. Based on the type area of the latin *Bulla* of 10 × 16.5 cm Agüera y Arcas calculated a resolution of about 500 px / cm (= about 1200 dpi [meant is ppi]).

assumed, as this system generates virtually identical types. The paper does not exactly show, in what way the researchers and the software determined a meaningful number of groups, but it must have been at least dozens different. A possible explanation would be, according to Agüera, that the types were produced from individual punches, actually not using a permanent but a lost mould, known from sand casting. This means the mould was destroyed after the casting and had to be produced over and over again. The approach as well as the results of the study were very interesting but left open many methodological questions unanswered. They were the occasion for the own type comparisons presented here.

Written and material evidence

Physical examinations suggest themselves, as our main problem is, that there are no equipment or written sources dating from that early period of book printing in the 1450s or 1460s of which we could derive technical explanations from.[4]

As to when can we assume the existence of a hand mould, which we regard the nucleus of Gutenbergs inventions? Until the recent past, hand moulds have been used to produce lead types. Its earliest written record dates not earlier than the year 1477. It was described in a latin written lawsuit of the German printer Stephan Arndes (around 1450-1519) in Perugia, who made a device to produce types for the printing of books.[5] From the same year dates an entry in the account book of the Ripoli printing office in Florence, in which costs for »uno gittino«, hence a »hand mould« are recorded.[6] Thus it

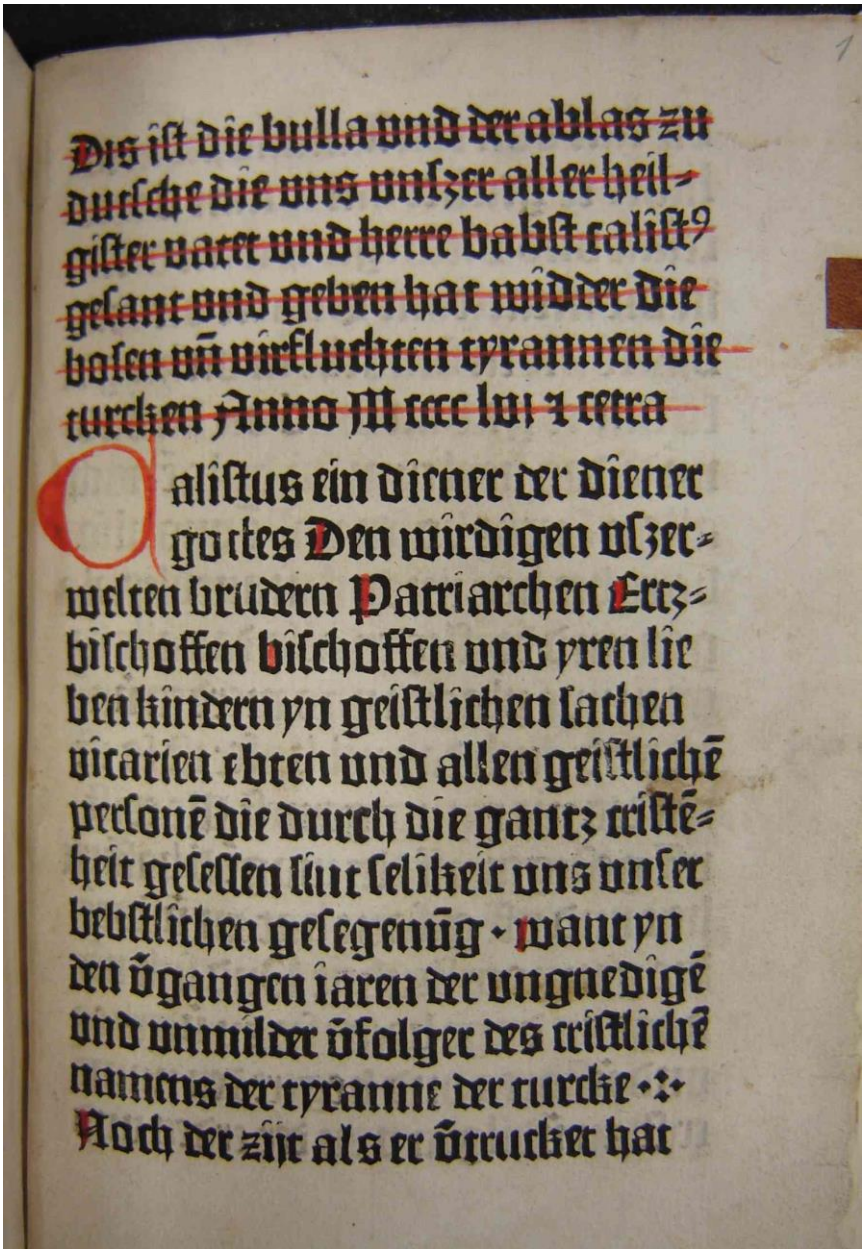
4 The type printed in the Pelplin Gutenberg Bible (GW 4201; ISTC ib00526000) on fol. 46r is too unspecific. Illustration by Paul Schwenke: Untersuchungen zur Geschichte des ersten Buchdrucks. Festschrift zur Gutenbergfeier. Berlin 1900, p. 25. The earliest known significant imprint is found in Petrus Damacenus: *Liber de laudibus ac festis gloriosae Virginis*, fol. b4v (GW M32213; ISTC ip0046800), printed in Cologne about 1475 by Nikolaus Götz, copy of the Cambridge University Library (Sign. Inc.3.A.4.9.[525]) shown at: James Mosley: Fallen and Threaded Type«, in: Typefoundry. Documents for the History of Type and Letterforms, blog, posted at 22 June 2007 at http://typefoundry.blogspot.co.uk/2007/06/fallen-and-threaded-types.html [2 December 2020]. The earliest types can be found only for the late 15th century. Maurice Audin: Types du XV° siècle, in: Gutenberg-Jahrbuch 29 (1954), pp. 84-100. A wider discussion of sources, especially the role of Peter Schöffer d. Ä, is mentioned in the German essay (see note 1).

5 »[L]aboravit, fecit, et composuit unum instrumentum aptum ad jactandum litteras ad imprimendum libros«, after Konrad Haebler: Handbuch der Inkunabelkunde. Leipzig 1925, p. 85. An »instrument« is also found in the lapel issued at 26 February 1468 of Konrad Humery, who received from the Archbishop of Mainz »etliche Forme[n] / buchstaben / Instrume[n]t. geczauwe vnd anders zu de[m] truckwerg gehore[n] / daz Johan[n] gutenb[er]g nach syme tode gelaiszen hait / Vnd min gewest vnd noch ist« from the estate of Gutenberg. Hitherto, a copy was known, the original was found in Würzburg in 2016. See a figure in Stephan Füssel: Vorwort des Herausgebers, in: Gutenberg-Jahrbuch 91 (2016), p. 6.

6 Entry from March 1477 there was a hand mould like a galley (»telaio«) equivalent to 1 lira. And on 12 May 1477 matrices (»le madri della lettera anticha«) and also in Mai 1477 punches (»uno puntello«) and

is very probable that in the mid of the 1470s hand moulds for the production of types existed.

But as there are no written sources for the very early period of printing, the main attention should be focused on the prints themselves, as Needham and Agüera did rightly.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namens der tyranne der turcke ·⁘
Noch der zijt als er ōtrucket hat

fig. 1: *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

already on 20 December 1476 a ladle for casting types (»ramaiolino per gittare lettere«). See Melissa Conway: The Diario of the Printing Press of San Jacopo die Ripoli 1476-1484. Commentary and Transcription. Florenz 1999 (Storia della tipografia e del commercio librario IV), p. 318, p. 102 (fol. 5r), p. 319, p. 106 (fol. 6r), p. 323, p. 104 (fol. 6r), p. 324, p. 94 (fol. 2r). On 17 October 1471, the casting of »writing material« was mentioned in a contract between Thomas Ferrandus and Andreas Belfortis and Statius de Francia. See Konrad Haebler: Schriftguss und Schriftenhandel in der Frühdruckzeit, in: Zentralblatt für Bibliothekswesen 41 (1924), pp. 81-104, p. 84, quoting Luigi Napoleone Cav. Cittadella: La stampa in Ferrara. Roma 1873, pp. 11-12.

Factors influencing the appearance of printing types

Considering which method is suitable to compare the objects, one should be aware of the fact that what we see is only a coloured impression of a non-existing printing forme. In figure 1 is shown fol. 1r from the German *Bulla turchorum* of pope Calixtus III (GW5916), printed in June 1456 in Mainz, now in Berlin.[7] From this, the letters »ken« in the 6th line are increased in approximately twenty-fold in figure 2, to show, that these impressions are subject to a range of influences that directly effect the visible typeface: namely the production of types, the composing, the inking, the substrate to be printed and finally the printing process.

fig. 2: Detail »ken« of line 6, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

Producing the types, thus during the creation of the punch, the matrix and the type, flaws could occur at any stage of the production and determine the appearance of the printing type. Looking at the punch, mistakes could happen while carving, filing, or punching the typeface on top of the metal pin. A significant potential for errors existed when the steel was hardened. Pierre Simon Fournier le Jeune (1712-68) referred to this in his *Manuel Typographique* from 1764.[8] Was the punch hardened poorly it was too soft to strike it into metal and had to be recutted.[9] Matrices produced from these punches and types casted

7 4°, 14 leaves [a13], 19 lines, 210 x 140 mm, paper, Staatsbibliothek zu Berlin – PK, 8° Inc 1512.20 (ISTC ic00060100), http://digital.staatsbibliothek-berlin.de/werkansicht/?PPN=PPN739821091&PHYSID=PHYS_0005 [2 December 2020].

8 Pierre Simon Fournier le Jeune: Manuel Typographique. Paris 1764, pp. 63-67. See also Otto Hupp: Gutenbergs erste Drucke. Ein weiterer Beitrag zur Geschichte der ältesten Druckwerke. München, Regensburg 1902, p. 74.

9 Stan Nelson was able to demonstrate through practical experiments that with a modern steel punch only about 20 good strikes can be performed as Stephen Pratt points out, who could make 50 good types at his own practical experiments with brass punches stroked into lead matrices (the lead-tin-antimony alloy has

from these matrices looked different from the original ones. And contrariwise, was the punch not reheated in the right way it became too brittle and could break during its further use.

When striking the punch into the matrix it was important to keep the punch straight and to get it deep enough into the metal. Occurring deviations had to be justified, which was also necessary because metal was displaced when the punch was hammered into the matrix. That is, the matrix was ground until it conformed to the other matrices in size and shape.[10] Even impure metal for the matrix could lead to flaws when it was hammered by a punch.[11]

Finally, defects could occur when the types were casted in the hand mould, because of encased air bubbles for instance.[12] Not to be underestimated was the risk of burned matrix metal, which arose when a matrix was used extensively, while the alloy used was too soft, for example.[13] This would make the types wear down quickly so that they had to be casted more often.[14]

Above all, problems were caused, if, for instance, the body was not neatly rid of the casting fin – to justify the line and to close the printing forme is difficult then. It was also delicate, if the types were not filed to the appropriate height-to-paper after they had been casted, and the jets had been snapped off. Minimal differences in height-to-paper already caused massive problems with inking and printing. Higher types hinder neighbouring, lower types, from obtaining enough printing ink. This was highlighted 1793 by Ernst Wilhelm Gottlob Kircher (1758-1830) in his *Printer's Manual* with a print sample.[15]

Lastly one has to consider the subsequent grinding of types until the recent past. Reducing

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a lower melting point than pure lead). See Stephen Pratt: The myth of identical types: a study of printing variations from handcast Gutenberg type, in: Journal of the Printing Historical Society N. S. 6 (2003), pp. 7-17, p. 10, p. 15. I thank Richard Lawrence for his kind advice on the practical experiments of Pratt. The use of copper punches stroked into lead matrices is reported in: Proef van Letteren, Welke gegooten worden in de Nieuwe Haerlemsche Lettergietery van J. Enschedé. [Haarlem] 1768, fol. C4v-D1r.

10 Wherein the width of the matrix had to take into account the width of the character. See Fournier (see note 8), pp. 76-78.

11 Hupp: Gutenbergs erste Drucke (see note 8), p. 74.

12 Practical tests have shown that 10-25% of the types cast with a hand mould are useless. Particular problems in casting caused »i«, since the air during the pouring of the metal font could not easily escape through the narrow opening of the hand mould. See Pratt: Myth of identical types (see note 9), p. 11 and pp. 16-17.

13 Hupp: Gutenberg (see note 8), p. 74, see also Pratt: Myth of identical types (see note 9), p. 10.

14 For material analyses of type alloy in the 16th century see Daniel Berger et al.: Noten für den Reformator? Zur Untersuchung der Drucktypen aus dem Wittenberger Franziskanerkloster und ihr Zusammenhang mit dem Musikaliendruck der Reformationszeit. Halle/Saale 2014.

15 E[rnst] Wilh[elm] Kircher: Anweisung in der Buchdruckerkunst so viel davon das Drucken betrifft. Braunschweig 1793, print example no. 2.

the width, and thus affecting the type face, types could be adjusted, which made a visible difference among finished types although they were casted from the same matrix.[16]
The second aspect is the **composition of the printing forme** by the compositor. When setting the individual types together with spaces the length of the lines can vary a little if they are not justified carefully. In that case the close up of the forme leads to instability: the types wobble. This wobbling results in an inaccurately printed typeface. To be seen in figure 3 is the recto page of the so-called *Sibyllenweissagung* (GW M41981), which arguably dates from about 1455 and is preserved in Mainz.[17]

fig. 3: *Sibyllenweissagung*, recto, GM Mainz, (© Author).

The visual effects are also due to a poor casting of the type as I have explained earlier. The phenomenon of one character above the other, which non-specialists tend to postulate to be incompatible with letterpress printing, is likewise based on a bad close up of the forme

16 Pratt presented by the usual method punches of the types of the Gutenberg bible (B42), stroke them into a matrix and cast types in a replica of the GI-48 hand mould of the Plantin-Moretus Museum, 10 types per matrix each. Those types showed »numerous variations« in their impressions. See Pratt. Myth of identical types (see note 9), pp. 15–17.

17 11 lines, 129-130 x 89-91 mm, paper, Gutenberg Museum in Mainz, Sign. Ink 100 (ISTC is00492500). In GW the *Sibyllenweissagung* is dated around 1452/53. For the date around 1455 and the text see Frieder Schanze: Wieder einmal das »Fragment vom Weltgericht«. Bemerkungen und Materialien zur »Sibyllenweissagung«, in: Gutenberg-Jahrbuch 75 (2000), pp. 42-63, with older literature.

or bad justification of the type. Figure 4 shows a microscopic detail from the *Sibyllen-weissagung* with the »r« of the word »werl[t]« in line 9 only taking the »l«s' ink.[18]

fig. 4: Detail »werl[t]« of line 9, *Sibyllenweissagung*, recto, GM Mainz, (© Author).

The third aspect is the **inking**. Which can be observed in the well-known woodcut of a printing office from Jost Amman in the *Ständebuch* from 1568 (VD16 S244), showing a printing press with the puller and the beater.[19] The inking has to be repeated after every single impression. Thus, the inking is specific for every copy. For this activity, a lot of practical knowledge was needed, and it is no wonder that inking with ink balls was extensively described in printer's manuals. Christian Gottlob Täubel († 1813) pointed out in 1810 that the printing forme had to be inked with steadily pressure from the bottom to the top and back again.[20] Occurrent problems were visualized once again by Kircher. If the inking was not uniform, parts of a type might be missing in the impression.[21] If too much ink was used, the stroke thickness of a typeface was influenced or a counter could clog.[22] This would be the case if the ink was not spreaded evenly on the ink ball.[23] Even the

18 This phenomenon is also seen in the German *Bulla* on fol. 1r: the »t« of the ligature »st« in the word »cristliche[n]« in line 17 taking the »l«s ink.

19 Eygentliche Beschreibung Aller Stände auf Erden. Frankfurt/Main 1568, fol. F3r: http://digital.slub-dresden.de/werkansicht/dlf/7451/49/0/ [2 December 2020].

20 Christian Gottlob Täubel: Neues theoretisch-praktisches Lehrbuch der Buchdruckerkunst für angehende Schriftsetzer und Drucker. Wien 1810, p. 9.
In September 1984, the ink of the sheet was examined with a cyclotron and discovered the similarly high lead and copper values as the Gutenberg bible (B42). See Peter Zahn: Gutenbergdrucke im Teilchen-beschleuniger. Papier- und Druckfarben-Analysen in Kalifornien, in: Bibliothek 12 (1988), no. 1 (Forschungsberichte), pp. 71-87, p. 84.
So far there has been no satisfactory explanation why the early printing inks have such a high metal content. In printer manuals of the 19th century, you will find the hint that inks dry more quickly if admixing them litharge, lead oxide and verdigris. See, for example Alexander Waldow: Illustrierte Encyklopädie der graphischen Künste und der verwandten Zweige. Leipzig 1884, pp. 796-797.

21 Kircher, Buchdruckerkunst (see note 15), print example no. 1.

22 Practical tests of Pratt with ink balls also yielded different impressions of typefaces, as appeared about six prints of »a«, the stroke thickness of the first impression was even wider and these rapidly decreased, whereas the counter clog successively. Pratt: Myth of identical types (see note 9), p. 11 and pp. 15-16.

23 Kircher: Buchdruckerkunst (see note 15), print example no. 6.

condition of the typefaces mattered, as Benjamin Krebs (1785-1858) pointed out in his *Printer's Manual* 1827: new typefaces require more ink than used typefaces, whereas worn out typefaces need more ink than new ones in turn.[24]

The fourth aspect regards the **printing substrate**.[25] Until the end of the 19th century, brittle rag paper with its rough surface needed moistening to ensure ink trapping. This step of procedure occupies a lot of space in printer's manuals, too. There is Joseph Jérôme François de la Lande (1732-1807) for instance, who pointed out in his *Art de faire le papier*, published 1761 in Paris, that strongly sized paper, like the writing paper used at the beginning of book printing, needs a particularly careful damping and the paste not only required greater printing pressure but also wore off the type to a greater extend.[26] Examples for the effects of bad moistening can be found in Kirchers' book, too: damp sheets increase the stroke thickness of a typeface.[27] When paper is moistened too little, the ink trapping is poor and only part of the printing forme leaves a mark.[28] This can also be observed when a sheet is dampened patchy. A partial impression of a type face can also be caused by impure paper.

The last aspect of influences on the appearance of types concerns the force applied in the **printing process**.[29] Figure 5 (next page) shows a detail of a not-levelled printing sheet from the book *Limburger Chronik*, printed 1826 in Herborn, kept at the University of Mainz. It depicts the massive three-dimensional deformation of the dampened and thus smooth paper caused by the printing process. If pressed too hard, the characters come out

24 [Benjamin Krebs]: Handbuch der Buchdruckerkunst. Frankfurt/Main 1827, p. 478.

25 Some explanations to parchment are given in the German essay (see note 1).

26 Joseph Jérôme François de la Lande: Art de faire le papier. Paris 1761. Cited the German translation from 1762: Schauplatz der Künste und Handwerke. Vol. 1. Translated by Johann Heinrich Gottlob von Justi. Berlin u. a. 1762, § 108 (p. 389), http://diglib.hab.de/drucke/oc-26-1b/start.htm?image=00413 [2 December 2020]. Säuberlich mentioned 1917 a strength wear of type required by the higher pressure forces on hard rough sized paper. Otto Säuberlich: Buchgewerbliches Hilfsbuch. 3. ed. Leipzig 1917, p. 103.

27 Kircher: Buchdruckerkunst (see note 15), print example no. 4.

28 Kircher: Buchdruckerkunst (see note 15), print example no. 5.

29 The printing press was until the late 18th century wooden and allowed only the pressure of a roughly DIN A3 large area. At the beginning folio printed sheets were printed page by page. A folio sheet had to be printed four times, with the respective deformation of the printing substrate. Only with the introduction of the two-pull press in the 1470s, are not folded folio sheet pages were printed in a two-part operation. See Lotte Hellinga: Press and Text in the First Decades of Printing, in: Lotte Hellinga: Texts in Transit. Manuscript to Proof and Print in the Fifteenth Century (Library of the Written Word 38/ The Handpress World 29), pp. 8-36 (first published in: Arnaldo Ganda et al (eds.): Libri tipografi, biblioteche: Ricerche storiche dedicate a Luigi Balsamo. Vol. 1. Florence 1997, pp. 1-23). Printing with a wooden press is described in the printer manuals in the beginning of the 19th century in comparison with metal presses as very powerful exhausting. See for instance Krebs: Buchdruckerkunst (see note 24), pp. 521-522.

more, if pressed too weak, the forme does not print out properly – parts of the typeface are missing.


Einleitung.

Die Lahn, die gleich einem Aequator das Herzogthum Nassau südlich und nördlich in zwei Hälften theilt, berühret in ihrem Laufe viele fruchtbare und malerisch schöne Gegenden, mehrere freundliche Städte ruhen an ihrem Ufer, zwei ausgezeichnete Gymnasien und zwei alte, ehrwürdige Universitäten haben an ihr ihren Sitz und auf ihren steilen Bergen trifft man viele Wohnun-

fig. 5: Detail, printing sheet, *Limburger Chronik*, Herborn 1826, Univ. Mainz, (© Author).

The force applied had to be customized to the appearance of the printing forme. Thus, solid setting needs more force than leaded setting.[30] An even print could only be achieved if all of the printing types were equally high. As Kircher reported, the reiteration was carried out while the sheet was still moist, the sheet being fixed in the tympan on damp waste, so that the printed image did not set-off.[31] If this was not done correctly, the first print could suffer.

Methodological approach to microscopic type comparisons

These explanations on the parameters influencing the appearance of a printed type face show, that one has to be very careful when interpreting observed phenomena on printing types. A 100 percent similarity is not as likely as it is generally assumed, even if types derive from the same mould. The multitude of possible influencing factors made me decide not to leave the judgement of what is similar to a mechanically working computer

30 Krebs: Buchdruckerkunst (see note 24), p. 478 and p. 486-490, where Krebs listed numerous problems occuring during the printing process.

31 Kircher: Buchdruckerkunst (see note 15), pp. 124-126.

software. The human eye is better at assessing whether too much ink is spread on a certain spot or if there was a little notch in the type.

Taking pictures of whole pages for detailed studies is challenging as printed pages are often uneven. For instance, the online accessible *Mainzer Psalter* from 1457 (GW M36179) now in Darmstadt shows massive deformation of the parchment.[32] Which optical effects would have these deformations, if one would want to compare types in detail? Therefore, it methodically makes sense to compare types of the early printed objects by means of a microscope. I used a USB-microscope with a two megapixel sensor that accomplishes a resolution of about 3800 dpi relative to its expanse.[33] The types were photographed together with a metric ruler as a reference in a multitude of some twenty-fold. The images where than manually projected one above the other using GIMP, an image processing software. To make sure the bottom character can be perceived, the image on top was given a 40 to 60 percent transparency.[34]

It is evident that it is not sensible to record types of a copy with several pages in that way. But looking at the question it is not necessary to consider such a huge amount of types. Different types from one matrix can only be assumed assuredly within every single page, as at this early stage of printing only one page was printed at a time.[35] According to the typographical circuit – of setting, printing, distributing and setting again – all subsequent pages might consist of reused types. Thus, there is a great probability to light upon identical types when projecting types one above the other. At this German *Bulla* for example, printed pages were distributed straight away in order to set the next page, as Paul Schwenke observed in 1911 on the basis of the immediate recurrence of defective types.[36] There was only little type material available. Therefore, the question implies that one data set comprises one page only.[37]

The starting point of this investigation was the study by Needham and Agüera, so the main

32 Psalterium cum canticis. Mainz: Fust and Schöffer, 1457 (ISTC ip01036000), ULB Darmstadt Inc V 7: http://tudigit.ulb.tu-darmstadt.de/show/inc-v-7/0004 [2 December 2020].

33 2 MP-USB-microscope Celestron, no. 44306: 1600 × 1200 pixel array. In relation of the coverage of 1.05 × 0.8 cm, result in a resolution of about 1600 × 1500 pixel / cm (= around 4000 × 3800 ppi).

34 Using GIMP 2.6 and 2.8 (www.gimp.org).

35 If printing in formes is used, that concerned of course all pages of a forme. For the single page printing and the one-pull press, see Hellinga: Press (see note 29).

36 Paul Schwenke: Die Türkenbulle Pabst [!] Calixtus III. Ein deutscher Druck von 1456 in der ersten Gutenbergtype. Berlin 1911 (Seltene Drucke der Königlichen Bibliothek zu Berlin. In Nachbildungen hrsg. unter Leitung von Paul Schwenke 1), p. 8.

37 If a data set corresponds to one side, this ensures that not the same types are analysed, but only those of a matrix. Higher accuracy can be achieved naturally when more records, so more pages would be analysed in each case in itself.

interest concerned the *Donat-Kalender-Type*, named DK type, they had analysed. According to the Haebler-Proctor method, it has a size of 85 mm for ten lines, which corresponds to the sizes of today's body of about 24 pt (pica point).[38] It can also be found in the German *Bulla*. All the types of the first page were recorded by means of the microscope which forms one data set. In addition to that, selected types of the subsequent pages were recorded for further checks. Aided by the GIMP software the respective types, one above the other, were projected afterwards.
The DK type can also be found in the *Sibyllenweissagung.* It involves a fragment of paper, printed on both sides. The recto page is given here. The individual types of the recto and the verso page were completely recorded, hence there are two data sets.

Comparisons of types casted with the hand mould

As a kind of reference for further examinations, it was necessary to determine the similarity of types that were definitely produced by means of the punch-matrix-hand-mould-system. Terminus post quem is as I mentioned before the year 1477. For this, the first five lines of the last paragraph of the right column from fol. e1r from the *Summa angelica de casibus conscientiae* by Angelus de Clavasio, printed in Nuremberg in 1488 (GW 1927), were recorded with a microscope (fig. 6).[39]

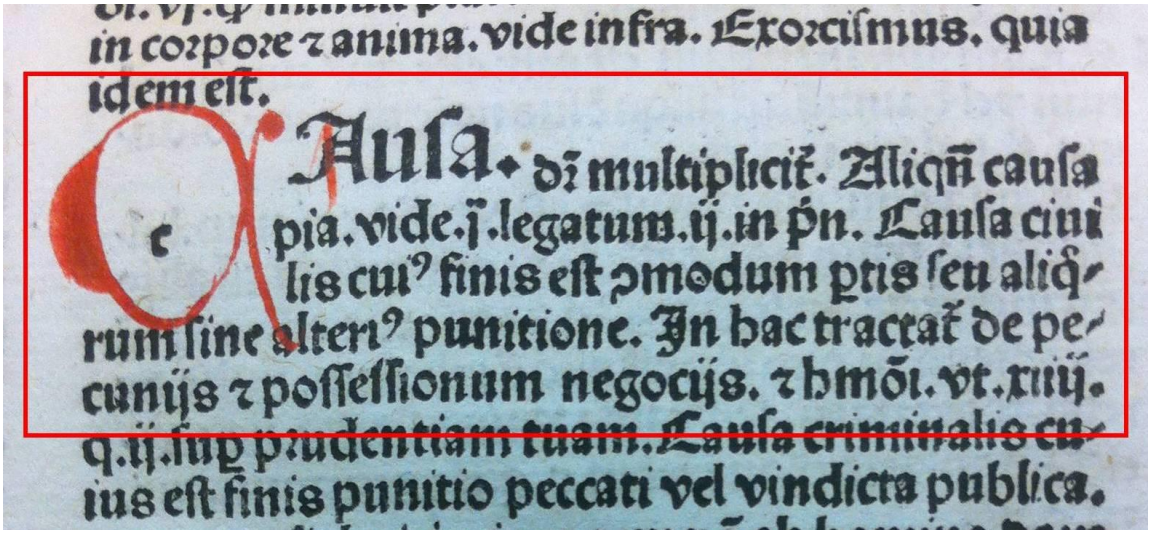

fig. 6: Detail, Angelus de Clavasio: *Summa angelica de casibus conscientiae*. Nürnberg 1488, fol. e1r (right column, last paragraph, 5 lines), UL Mainz, (© Author).

38 Type 1:164G, M61, Mainz, Offizin no. 1 (Johannes Gutenberg). http://tw.staatsbibliothek-berlin.de/queries/id.xql?id=ma06118 [2 December 2020].
39 Paper, University Library Mainz, Sign. 4° INC 2 (ISTC ia00717000). http://tudigit.ulb.tu-darmstadt.de/show/inc-iv-453/0051?sid=68206e2face10a9ac8f06cac08dfe400 [2 December 2020].

For the projection the lower case »a« of the Rotunda typeface was chosen.[40] The third »a« taken from the second line, was put on top of the first »a« from the first line and the transparency of the upper »a« had to be reduced to 50 percent so that the lower »a« shone through (fig. 7). In order to see these deviations more clearly in this paper, the respective upper character was dyed in red colour. Deviations at the top are visible. You can see that the »a« coincide to a great extent, at the top the lower »a« seems to be a little more distinct. This characteristic is even more evident in the next example (fig. 8).

fig. 7: Superimposition: 1st »a« of line 1 with 3rd »a« of line 2, ... *Summa* (see fig. 6), (©Author).

fig. 8: Superimposition: 1st »a« of line 1 with 2nd »a« of line 1, *Summa* (see fig. 6), (© Author).

The last »a« of the word »causa« in the first line shows a broadened stem – ink amassed here – a phenomenon observed frequently at the edge of columns during the hand-press period. The superimposed projection of this »a« inked in red and the »a« prior to that, shows a match for the part in dark red on the one hand, on the other it reveals that the parts in light red to the right jut out. And the lower »a« shines through in grey at the top and at the bottom, which means it is bigger than the upper red »a« there. Figure 9 shows the other »a« of this data set. One can see that the superimposed types match – but a complete congruence does not exist.

fig. 9: Superimposition (left to right): 1st »a« of line 1 with »a« of line 3; 1st »a« of line 1 with 2nd »a« of line 4; 1st »a« of line 1 with 4th »a« of line 4; 1st »a« of line 1 with 2nd »a« of line 2, *Summa angelica* ... (see fig. 6), (© Author).

40 Koberger type 17, 72 mm per 20 lines, equal to about 10 point. In use since 1487. http://tw.staatsbibliothek-berlin.de/queries/id.xql?id=ma02061 [2 December 2020].

It can be stated that a superimposed projection of those types definitely produced with a system of punch, matrix and a hand-mould, reveal a substantial similarity and nonetheless divergences at the edges.[41]

External effects on the same types

In order to point out external effects on the appearance of identical types it is sensible to analyse different copies of an edition at the same position. But this investigation focuses on the DK type, of which impressions only exist as unica, disregarding the later *36-line Bible* and a few fragments of *Donats.*[42] However, thanks to the typographical circuit external effects can be visualised: it is possible to make statements on the appearance of identical types when their recurrence is tracked over several pages. To make sure that it is really an identical type distinctive defects can help, which Schwenke had detected in the German *Bulla* already, for example a »g« with a gap in the right hand stem, which was used in the *Bulla* nine times.[43]

In figure 10-1/10-2 the defect »g« of fol. 4r is projected under that of fol. 10v, 8v, 2r and 10r. They match to a great extent, but the »g« did not print exactly alike.[44] Of a complete congruence of this type on different pages cannot be spoken.

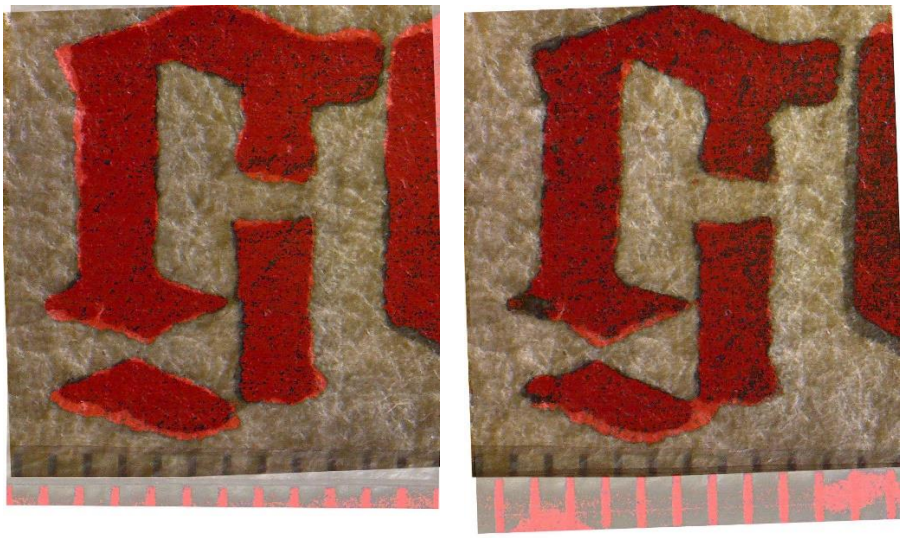

fig. 10-1: Superimposition (left to right): defect »g« of fol. 4r with defect »g« of fol. 10v, fol. 8v, *Bulla turchorum*, German, SB Berlin, (© Author).

41 A further example is mentioned in the German essay (see note 1).

42 37 prints recorded the ISTC (»Type of the 36-line Bible«), of which 27 are donats: one 26-line donat, fifteen 27-line donats, three 28-line donats, one 29-line donat and seven 30-line donats, are preserved in various libraries, but sometimes only as fragments. https://data.cerl.org/istc/_search [2 December 2020].

43 Schwenke: Bulla (see note 36), p. 8. A further example is mentioned in the German essay (see note 1).

44 In practical tests Pratt demonstrated how differently the imprints are from the same types. Pratt: Myth of identical types (see note 9), p. 17, fig. 5.

fig. 10-2: Superimposition (left to right): defect »g« of fol. 4r with defect »g« of fol. 2r, fol. 10r, *Bulla turchorum*, German, SB Berlin, (© Author).

For these both fields of the investigation can therefore be stated that prints are predominantly similar as well when their types were casted from the same matrix as when the types were identical, but the mentioned external factors considerably influence the appearance.

Microscopic type comparisons of the DK type

We can now focus on the question what can be said about the congruence of types within one printed page of the DK type. In the publication by Agüera from 2003 the use of the punch-matrix-hand-mould-system for that typeface was doubted. He substantiated the theory with the character »i« of the Latin *Bulla*. Therefore, in this investigation the »i« of the German *Bulla* were presented, too. Black letter typefaces of the early times depict two forms for some characters: a normal form and an abutting form, which was used after an »c«, »e«, »f«, »g«, »r«, »t« or »x« most of the times.[45] The normal form was used 29 times on fol. 1r of the *Bulla*. (fig. 11): four variants of that form can be differentiated, which can be seen here from left to right:

1. round i-bow, near to the body (third normal-»i«, first line);
2. bevelled i-bow to the left, near to the body (second normal-»i«, eighth line);
3. bevelled i-bow to the left, distant to the body (first normal-»i«, fourth line);
4. characteristic thorn to the left (first normal-»i«, tenth line). The fourth version

45 Schwenke: Bulla (see note 36), p. 3.

seems to be a damaged type on first sight, but it can be found several times on the same page, as can be seen on fol. 1v. This means the mould was faulty.[46]

fig. 11: Normal »i« (left to right): variant 1 (3rd normal »i« of line 1), variant 2 (2nd normal »i« of line 8), variant 3 (1st normal »i« of line 4), variant 4 (1st normal »i« of line 10), *Bulla*, fol.1r, SB Berlin, (©Author).

It follows an intensive comparison of several prints of each variant. In figure 12 the normal »i« of the first variant (third normal »i« from the first line, given in black) is superimposed with the normal »i« from line three, the third from line ten, the first from line thirteen and the second from line seventeen (each in red).

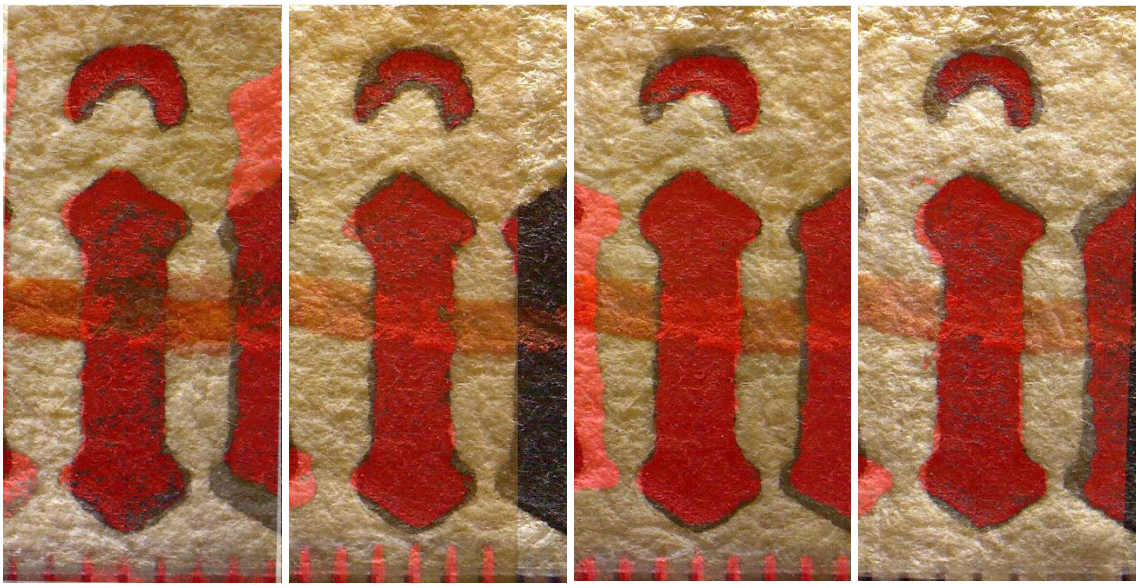

fig. 12: Superimposition (left to right): normal »i« variant 1 (3rd normal »i« of line 1) with that from line 3, with 3rd of line 10, with 1st of line 13, with 2nd of line 17, *Bulla*, German, fol. 1r, SB Berlin, (© Author).

46 On fol. 1v it is found for example in the second and seventh line. It could also used a second time on fol. 1r as a not very expressive forming »i« suggests from the thirteenth line.

In my opinion they match largely, there are only little differences at some edges. The same applies to the second variant of the normal »i« in figure 13 (second normal »i« from the eighth line, black) which is superimposed with the second from line seven, the first from line eleven, the first from line fifteen and the second from line eleven (each in red).

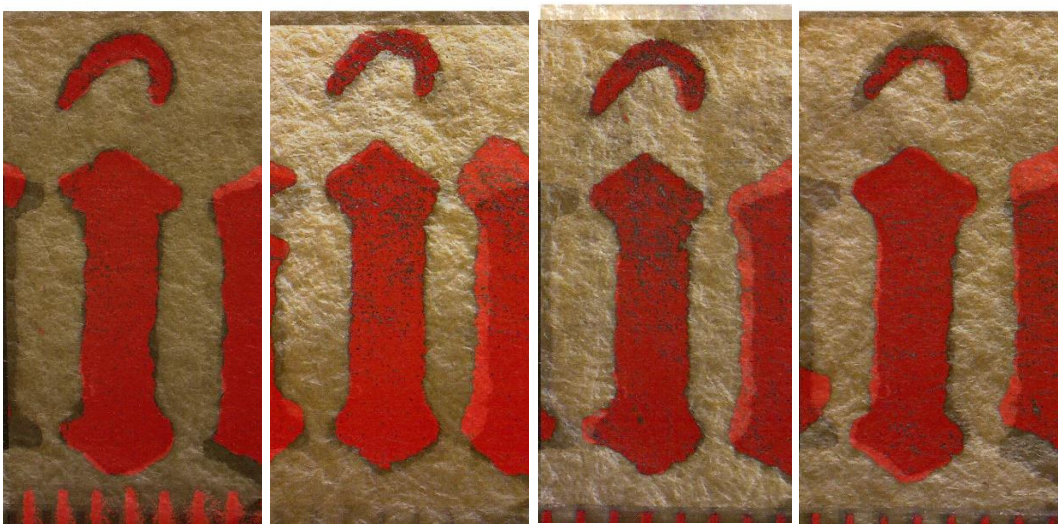

fig. 13: Superimposition (left to right): normal »i« variant 2 (2nd normal »i« of line 8) with 2nd of line 7, with 1st of line 11, with 1st of line 15, with 2nd of line 11, *Bulla*, German, fol. 1r, SB Berlin, (© Author).

In figure 14 you can see that the third variant of the normal »i« (first normal »i« of the fourth line, red) is identical to that of the second variant (second normal »i« of the eighth line, black), only the bevelled i-bow to the left is farther from the body: on the left the projection brought the bodies into conformity, on the right the projection brought the i-bows into conformity.

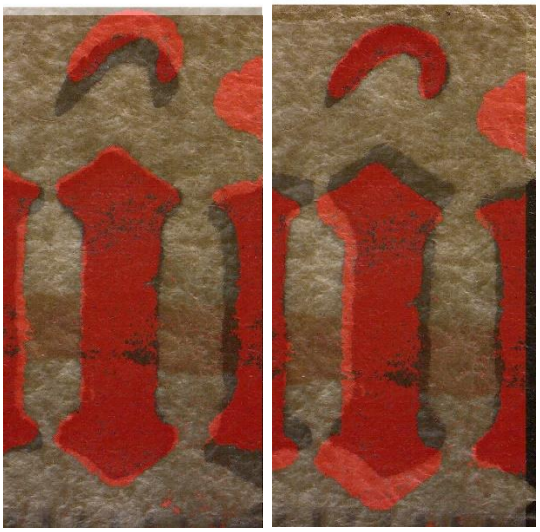

fig. 14: Superimposition: normal »i« variant 2 (2nd normal »i« of line 8) with variant 3 (1st normal »i« of line 4), bodies in conformity (left), conformity of i-bows (right), *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

The normal »i« from the third variant are broadly consistent, too (fig. 15): the first normal »i« from the fourth line (black) is superimposed with the second of the fourth line, the first of the fifth line, the first of the eighth line and the second of the first line (each in red). The rightmost seems to have not printed completely at the bottom left, it might have been damaged.

fig. 15: Superimposition (left to right): normal »i« variant 3 (1st normal »i« of line 4) with 2nd of line 4, with 1st of line 5, with 1st of line 8, with 2nd of line 1, *Bulla*, German, fol. 1r, SB Berlin, (© Author).

Like Schwenke identified, there are two variants of the abutting »i« (fig. 16):

1. the left variant from the second line has got a longer body that tapers to the top
2. the right variant can only be found once on the first page in line 9.

fig. 16: Abutting »i« variant 1 (left, of line 2), variant 2 (right, of line 9), *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

Whereas there are eleven types from the first variant of which figure 17 shows five in the superimposed projection: the abutting »i« from line two (black) is superimposed with that from line eleven, that from line seven, the first from line twelve and the second from line fourteen (each in red). One may speak of a substantial congruency.

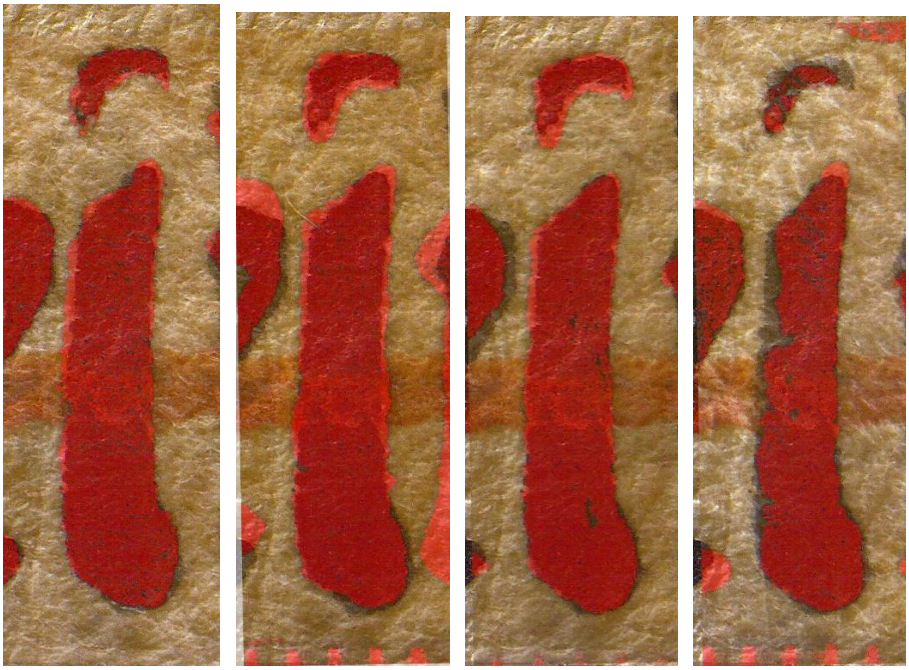

fig. 17: Superimposition (left to right): abutting »i« variant 1 of line 2 with that of line 11, with that of line 7, with the 1st of line 12, with the 2nd of line 14, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

Other characters of the *Bulla* show comparable results like the »i« I have chosen exemplarily. That is why I believe that there are several variants of a character, but it is a matter of a limited number of variants – in the case of the »i« there are only six, including the abutting forms. In contrast to Agüera I do not come to the conclusion that only very few types correspond to each other.

The same goes for the *Sibyllenweissagung*, a positively chaotic print with the DK type on first sight. The problem with external influences is evident when looking at the wobbling lines. In the *Sibyllenweissagung* only one variant can be differentiated for the normal »i« and the abutting »i« respectively.
Once again, I only show a few of the 26 normal »i« from recto. In figure 18 (next page) the second normal »i« from line two (black) is superimposed by the third from line six, the first from line seven, the first from line nine and that from line eleven (each in red).

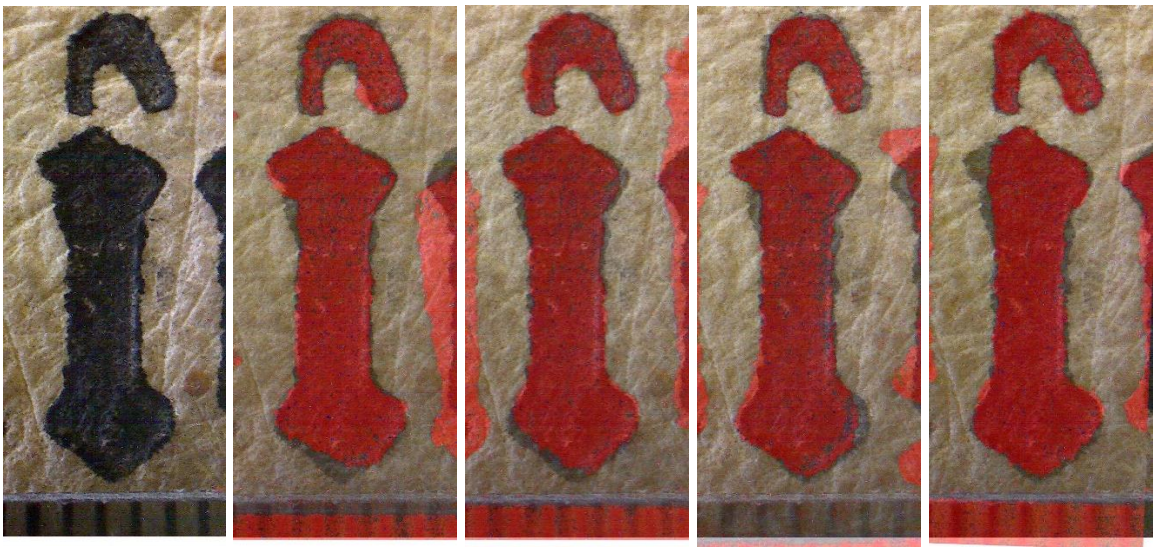

fig. 18: normal »i« (left); Superimposition (left to right): 2nd normal »i« of line 2 with 3rd of line 6, with 1st of line 7, with 1st of line 9, with that of line 11, *Sibyllenweissagung*, recto, GM Mainz, (© Author).

In figure 19 the second normal »i« from line two (black) is superimposed by the second from line four, the second from line six, the first from line eight and the first from line six (each in red). They match but do not seem to print properly at all times, as can be seen on the right.

fig. 19: Superimposition (left to right): 2nd normal »i« of line 2, with 2nd of line 4, with 2nd of line 6, with 1st of line 8, with 1st of line 6, *Sibyllenweissagung*, recto, GM Mainz, (© Author).

The body of the five abutting »i« in figure 20 (next page) seems to match almost entirely, too: the second abutting »i« from line five (black) is superimposed by that from line four, the first from line five, that from line six and that from line seven, but it is obvious there were problems at the upper end.

fig. 20: Abutting »i« (left); Superimposition (left to right): 2nd abutting »i« of line 5, with that of line 4, with 1st of line 5, with that of line 6, with that of line 7, *Sibyllenweissagung*, recto, GM Mainz, (© Author).

Even though the leaf of the *Sibyllenweissagung* is generally in a worse condition than the leaves of the *Bulla*, the projections reveal such a congruence that in my view nothing speaks against a production by means of the punch-matrix-hand-mould-system. Or, to put in another way: Compared to the objects shown before, that dated from a somewhat later time and were definitely produced with a hand mould, the differences observed have not increased.

Use of element punches?

Agüera concluded from his findings, that the typeface of the DK type could actually only have been composed from separate punch elements. The austere appearance of the Textura furthers this presumption. Therefore, I focus on conspicuous forms and potential assemblings now, too. In my comparisons I could not assign structures suggesting a composition of separate punch elements. However, a multiple use of punches could be detected.

In the *Sibyllenweissagung* the matrices for the first »n« of the third line and the second »u« of the eleventh line were made from the same punch for instance. Upturning the »n« by 180 degrees and dyed in red and projected on top of the »u« the similarity can already be seen (fig. 21, next page). If the same is carried out with the much more accurate print of the *Bulla* – the upturned red dyed third »n« of line twelve was projected on top of the third »u« of line five, there is a clear conformity (fig. 22, next page). With regard to the *Sibyllenweissagung* this emphasizes which effects external factors can have on the print image.

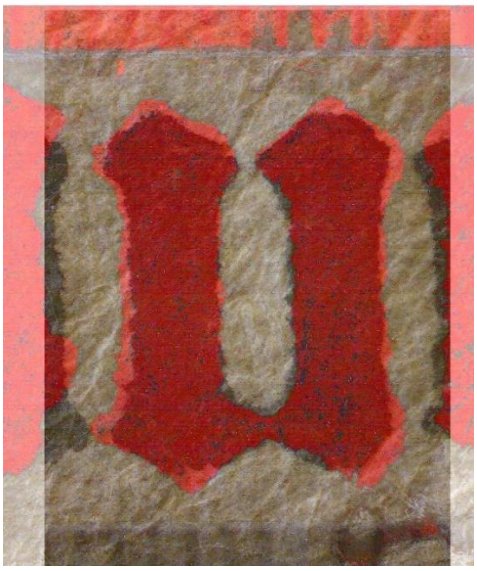

fig. 21: Superimposition: 2nd »u« of line 11 with 1st »n« (180° turned) of line 3, *Sibyllenweissagung*, recto, GM Mainz, (© Author).

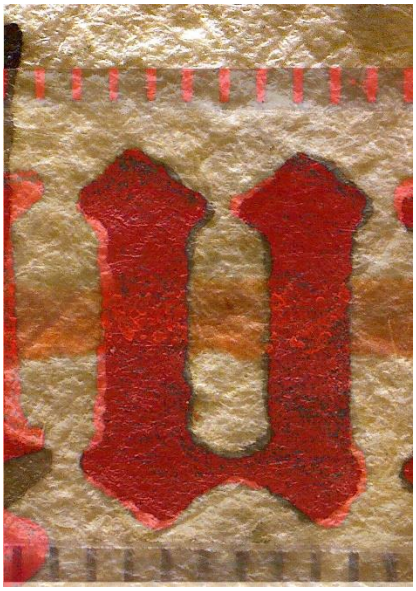

fig. 22: Superimposition: 3rd »u« of line 5 with 3rd »n« (180° turned) of line 12, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

With the aspect in mind that punches were used for different purposes, one pays attention to the »w« soon. On fol. 1r of the *Bulla* there are three largely congruent »w«, and one that lacks the thorn at the bottom left. The »w« seems to consist of two types. On top of the first part of the »w« from line four (black) the »i« without i-bow from line fifteen (red) is superimposed and on the rear portion the red-dyed »u« from line eight (fig. 23).

fig. 23: Superimposition: »w« of line 4, top on first part with »i« (without i-bow) of line 15, rear portion with »u« of line 8, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

This result is not uncommon, two punches were used in later times for the production of characters with accents. But what can also be observed is that there is no link between the

parts when the two punches were stamped at a time. The matrix had to be touched up with a graver for example.[47]

Thus, an additional use of punches is detectable, but to a small extent only. According to my investigations a systematical composition of characters from separate punches cannot be verified for the DK type, not to speak of a composition of elements of even smaller character parts.

Subsequent processing of types

But what has to be considered is that ready to use types were modified later if required, which could be exemplified by the »d«. There are thirteen of them on fol. 1r of the *Bulla*, which exhibits two thorns to the left from the left stem. In line eight there is another one, which lacks the thorns. In figure 24 the first »d« from line thirteen (black) is superimposed by the »d« from line eight (red). This »d« is apparently an abutting character, which could have been expected because it is preceded by an »r«. One might assume a punch different to that of the other »d« but the left stem of this »d« is peculiar straight. It looks as if it was smoothed. And as a matter of fact, the red line faded in, see figure 25, proves that the typefaces extend to the outermost edge of the body. This could be the case if the type was filed off later.

fig. 24: Superimposition: 1st »d« of line 13 with »d« (without thorns) of line 8, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

fig. 25: »rd« of line 8, *Bulla turchorum*, German, fol. 1r, SB Berlin, (© Author).

47 A second example is mentioned in the German essay (see note 1).

Conclusion

The *Bulla* and especially the *Sibyllenweissagung* are prints not easy to be analyzed. And in fact, the Donat-Kalender-Type used in these works shows more variants, as would be expected by our present ideas of economy and efficiency. During this paper I could only present a few examples. But the way in which the types of the DK type match in the *Bulla* and the *Sibyllenweissagung* let me come to the conclusion, that the phenomena observed are in compliance with the punch-matrix-hand-mould-system. The variants of different types remain within narrow limits.

We are dealing with an early stage of type production. One has to disengage from present-day's efficiency concepts. Experiments were carried out for sure. Improper handling could easily have made a punch unusable, it had to be reworked or even made entirely new. Overheating a matrix resulted in the production of a new one. Defects arose while a type was casted or finished as well.

All of this caused type variants in the system of punch, matrix and a hand mould, probably invented by Johannes Gutenberg after all.