mc N° 15 2020

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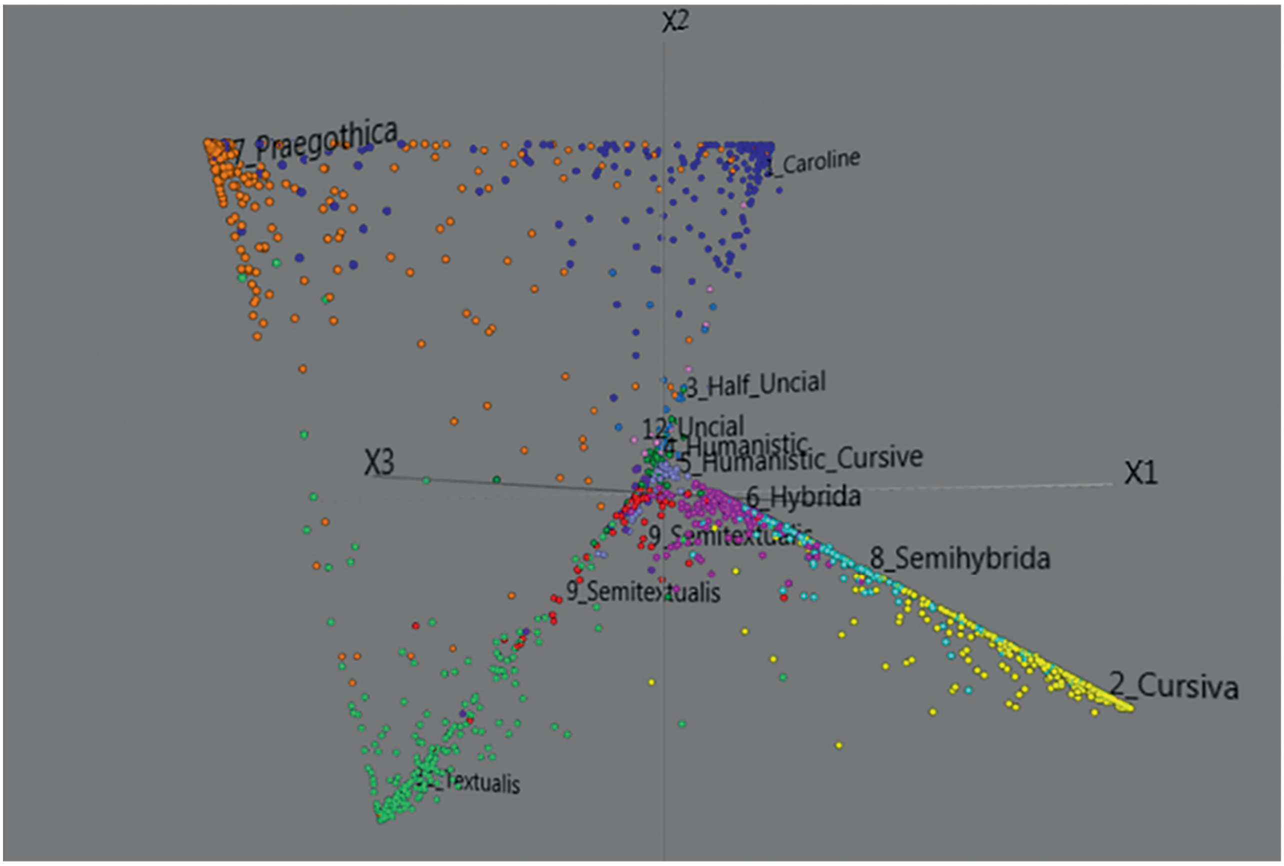

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Publishing Information

Natural Sciences, Technology and Informatics in Manuscript Analysis
Edited by Oliver Hahn, Volker Märgner, Ira Rabin, and H. Siegfried Stiehl

Proceedings of the third *International Conference on Natural Sciences and Technology in Manuscript Analysis* and the workshop *OpenX for Interdisciplinary Computational Manuscript Research* that took place at the University of Hamburg, Centre for the Study of Manuscript Cultures, on 12–14 June 2018.

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Layout
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Cover
Image of ICDAR2017 Tensmeyer's distance matrix (axes 2 and (1 and 3)), see article by Dominique Stutzmann, Christopher Tensmeyer and Vincent Christlein in this volume.

Translation and Copy-editing
Amper Translation Service, Carl Carter, Fürstenfeldbrück

Print
AZ Druck und Datentechnik GmbH, Kempten
Printed in Germany

ISSN 1867–9617

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Article

Inks Used to Write the Divine Name in a Thirteenth-Century Ashkenazic Torah Scroll: Erfurt 7 (Staatsbibliothek zu Berlin, Ms. or. fol. 1216)[1]

Nehemia Gordon, Olivier Bonnerot, and Ira Rabin | Ramat Gan, Berlin, Hamburg

Abstract

The scribe of 'Erfurt 7', a thirteenth-century Torah scroll now kept in Berlin, initially left blank spaces for the divine appellations *Elohim* (אלהים) and *YHWH Elohim* (יהוה אלהים), which were filled in during a second stage of writing. The appearance of the ink employed to write the appellations was significantly darker than that of the surrounding ink. X-ray fluorescence analysis (XRF) has shown that the light and dark brown inks had similar elemental compositions, but contained different ratios of iron to potassium, which could be explained by the use of different batches of ink. According to some medieval sources, the divine appellations were sometimes filled in during a second stage of writing in the presence of ten men from the Jewish community. In Erfurt 7, the two-stage procedure was only performed in the first 1.5 columns of the original sheets, suggesting it may have been part of a public ceremony inaugurating the writing of the divine names in the scroll. Erfurt 7 emerges from this study not only as a ritual object used for liturgy, but as a rallying point for the Jews of Erfurt to come together as a community to express their reverence for the written form of God's name. The divine name *YHWH* (יהוה) was written in a smaller script than the surrounding text on three replacement sheets using the same two-stage procedure. The ink used on the replacement sheets contained zinc, which is characteristic of other Erfurt manuscripts as well. This suggests that Erfurt was the place where the scroll was used, cherished and eventually repaired.

1. Background

Erfurt 7 is one of a cache of fifteen Hebrew manuscripts seized during a massacre of the Jewish community of Erfurt in March 1349. The manuscripts have been in non-Jewish custody ever since, so any Jewish scribal interventions must have pre-dated that event. Fourteen of these manuscripts are currently housed at the Staatsbibliothek zu Berlin (Berlin State Library), including four Torah scrolls designated Erfurt 6 (Ms. or. fol. 1215), Erfurt 7 (Ms. or. fol. 1216), Erfurt 8 (Ms. or. fol. 1217) and Erfurt 9 (Ms. or. fol. 1218). Jordan Penkower has dated Erfurt 7 to the thirteenth century and Erfurt 6, Erfurt 8 and Erfurt 9 to the fourteenth century (albeit with some reservations in the case of Erfurt 8).[2]

2. Scribal features of Erfurt 7 (Ms. or. fol. 1216)

Erfurt 7 consists of fifty sheets of parchment with three columns per sheet. Efraim Caspi discovered that it matches the manuscript Munich, Bayerische Staatsbibliothek, Cod. hebr. 212, which may have served as its *tiqqun soferim*, the codex from which the scroll was copied.[3] The scroll contains sixty lines per column, while the codex contains thirty lines per page, so each column in the scroll corresponds to two pages in the codex. All but six columns in the scroll begin with a word that starts with the letter *vav* at the beginning of a verse (see below). Out of the one hundred and forty-four columns in Erfurt 7 (including nine columns from replaced sheets, which are mentioned below), a hundred and thirty-seven begin with the same word as the corresponding verso

[1] This article is based on a chapter of Nehemia Gordon's doctoral thesis, the research for which was conducted at the Bible Department at Bar-Ilan University, Israel and carried out under the supervision of Prof. Yosef Ofer. The X-ray fluorescence (XRF) tests, data treatment and statistical analysis described here were carried out by Dr Olivier Bonnerot under the supervision of Prof. Ira Rabin. We would like to express our warmest thanks to the staff of the Staatsbibliothek zu Berlin, in particular Petra Figeac, Christoph Rauch and Melitta Multani, for their assistance throughout the analysis of the scroll. This research was partly funded by the German Research Foundation (DFG) in conjunction with the Federal Excellence Strategy and the Cluster of Excellence EXC 2176, 'Understanding Written Artefacts: Material, Interaction and Transmission in Manuscript Cultures', project no. 390893796. It was partly carried out at the Centre for the Study of Manuscript Cultures (CSMC) at the University of Hamburg.

[2] Penkower 2014, 118–119.

[3] Caspi 2014, 234–236.

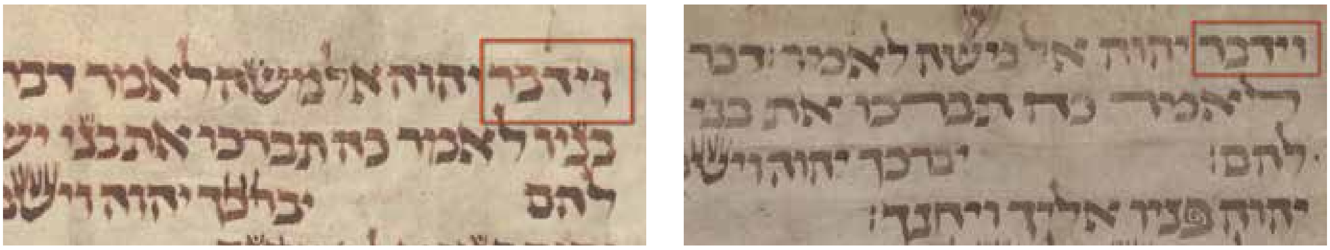

Fig. 1: Comparison of Erfurt 7 (sheet 33, col. 2 [col.98]), left image, with the corresponding verso page of Cod. hebr. 212 (fol. 98v), right image. Both begin with the same word, וידבר, the first word in Num. 6:32. The correspondence of the layout between the scroll and the codex applies to the beginning of columns/ verso pages, but not to individual lines.

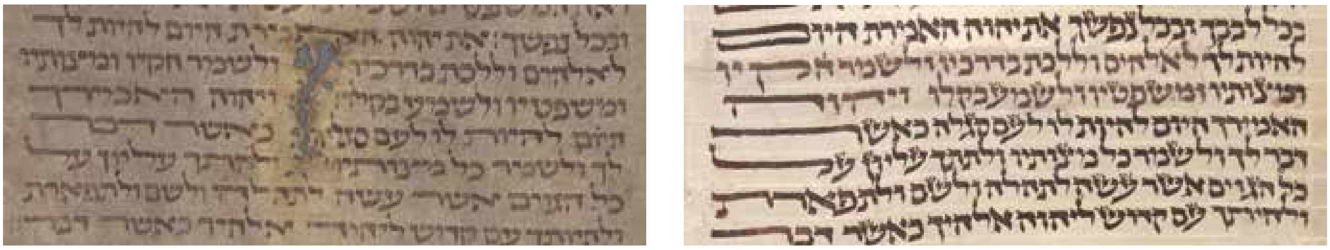

Fig. 2: The scribe of Cod. hebr. 212 (left) made moderate use of dilating (stretching) letters at the end of fol. 143r to begin the next page with the word ויצו, the first word in Deut. 27:1. This word begins with a *vav* in accordance with the practice of *vave ha-ʿamudim*. The scribe of the scroll Erfurt 7 (right), made extensive use of dilating letters at the end of the corresponding column (sheet 48, col. 1 [col. 142]) in order to begin the next column with the same word. Cod. hebr. 212 had to be written around a tear in the parchment, which was sewn up before the codex was written (the thread or sinews have been removed or fallen out since then). As there was no tear in Erfurt 7, the scribe had to dilate more letters than the scribe of Cod. hebr. 212 to begin the next column with the same word.

page of Cod. hebr. 212, six columns differ from Cod. hebr. 212 by one verse, and one column differs by four verses. For example, Erfurt 7, sheet 34, col. 2 [col. 98] and Cod. hebr. 212, fol. 98v both begin with the word וידבר ('And he spoke'), the first word in Num. 6:32 (see Fig. 1).[4] Erfurt 7 may have been copied directly from Cod. hebr. 212, from another scroll that was copied from Cod. hebr. 212 or the two manuscripts may actually derive from a common source.

The custom of beginning each column of a Torah scroll with the letter *vav* was commented on by the German legal scholar Rabbi Meʾir bar Jekuthiel ha-Kohen in the late thirteenth century (*c*.1260–1298):

> That which some of the ignoramus scribes have a custom to do – to start each column with a *vav*, which they call *vave ha-ʿamudim* – appears to be absolutely forbidden.[5]

The phrase *vave ha-ʿamudim* is a pun that can mean both '[the letters] *vav* in the columns [in a scroll]' and 'hooks of the pillars'. The latter meaning is used to describe an architectural feature of the Tabernacle in the Book of Exodus (27:10, 11; 38:10, 11, 12, 17). The architectural meaning in relation to the Tabernacle was cited in the Babylonian Talmud as an explanation of the name of the letter *vav* and the reason for its shape. The resemblance of the letter *vav* to a hook atop a pillar was deemed proof that the Torah was originally written in the so-called Assyrian script (the script used in Talmudic times, the Middle Ages and today) rather than Palaeo-Hebrew script.[6] This Talmudic reference may have led to the custom of writing Torah scrolls with *vavs* at the head of each column as an allusion to the script in which the Torah was supposedly written.

According to a *responsum* written by Meʾir bar Jekuthiel's teacher, Rabbi Meʾir of Rothenburg (*c*.1215–1293), known as Maharam, the scribal practice of *vave ha-ʿamudim* 'is not from the Torah or a rabbinical enactment, but rather there was a specific scribe, Rabbi Leontin of Mühlhausen, who

[4] The numbers in square brackets throughout this study refer to the overall column number from the beginning of the scroll [col. 1] to the end [col. 150].

[5] Meʾir bar Jekuthiel ha-Kohen, *Haggahot Maimuniyyot*, 1524, 56r (*Hilkhot Tefillin u-Mezuzah ve-Sefer Torah* § 7:7). On *vave ha-ʿamudim*, also see Penkower 2019, 136–138; Penkower 2020, 44.

[6] Babylonian Talmud, *Sanhedrin* 22a.

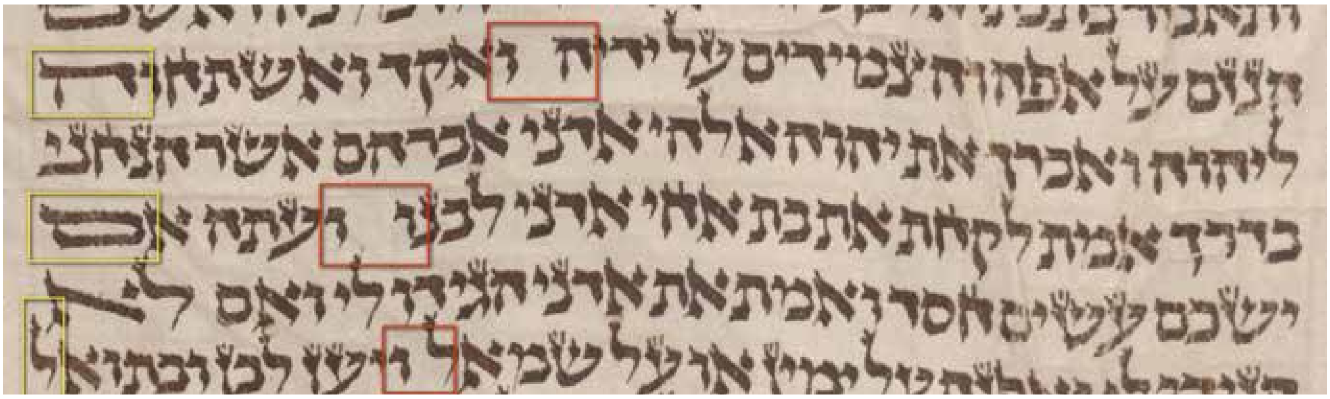

Fig. 3: Dilation and contraction of letters to justify the left margin (yellow). Spaces between verses (red). Erfurt 7, sheet 6, col. 1 [col. 16].

was showing off his skill'.[7] Both Meʾir bar Jekuthiel and Maharam forbade the use of *vave ha-ʿamudim* because it often required scribes to contract or dilate letters in order to begin a column with a specific word. These rabbis viewed dilation and contraction of letters as distorting the legally mandated shapes of the letter. Scribes would generally dilate or contract letters towards the end of a column when they realised they were going to reach the designated word for the beginning of the next column too early or too late, respectively (Fig. 2).

The objections of these thirteenth-century German rabbis notwithstanding, *vave ha-ʿamudim* are found in Erfurt 7 and two other thirteenth-century Ashkenazic Torah scrolls: Washington D.C., Museum of the Bible, SCR.4820 and Jerusalem, National Library of Israel, 34° 8421.[8] Contrary to Maharam's claim that the technique was invented by a twelfth- or thirteenth-century scribe in Germany, the scribal custom of *vave ha-ʿamudim* can already be found in an Oriental Torah scroll from *c*.1000 designated St Petersburg, Russian National Library, Parchment Scroll 3. The left-hand margin of each column in Erfurt 7 was justified by dilating and contracting letters near the end of the line, irrespective of any *vave ha-ʿamudim* (see Fig. 3).

Medieval Torah scrolls were generally written without any punctuation. However, some scribes used spaces to separate verses. According to Rabbi Isaac of Corbeil (d. 1280), '[a scribe must leave] the size of a small word between one verse and the next'.[9] Erfurt 7 usually followed this practice, separating verses with spaces that tended to be larger than those that separated words, as Fig. 3 shows.

Another scribal custom involved beginning six columns with specific words, the first letters of which form the acronym בי"ה שמ"ו (*beyah shemo*), 'in Yah, His name'. [10] This custom goes back to at least the eleventh century, with some variation regarding which words were chosen to represent the letters *yod, shin and mem*. The six letters that form the acronym in Erfurt 7 are the *bet* of בראשית in Gen. 1:1 (sheet 1, col. 1 [col. 1]), the *yod* of יודוך in Gen. 49:8 (sheet 13, col. 1 [col. 37], the *he* of הבאים in Exod. 14:28 (sheet 17, col. 1 [col. 49]), the *shin* of שפטים in Deut. 16:18 (sheet 46, col. 1 [col. 136]), the *mem* of מוצא in Deut. 23:24 (sheet 47, col. 3 [col. 141]) and the *vav* of ואעידה in Deut. 31:28 (sheet 50, col. 1 [col. 148]). The beginning of these six columns in Erfurt 7 matches the corresponding verso pages in Cod. hebr. 212 (fols 1v, 37v, 49v, 136v, 141v and 148v). According to the tradition followed by Cod. hebr. 212 and Erfurt 7, the words chosen to represent *yod*, *he* and *vav* are not at the beginning of verses. Virtually all Torah scrolls written since the thirteenth century incorporate the scribal custom of *beyah shemo*, while *vave ha-ʿamudim* was widespread, but not universal.

Erfurt 7 contains tagin, that is, decorative or mystical 'crowns' on many of the letters. There are two types of crowns in this manuscript. The first type consists of three small strokes added to the tops of the seven letters *shin*, *ʿayin*, *ṭet*, *nun*, *zayin*, *gimel* and *ṣadi*, which form the acronym *shaʿaṭnez geṣ*. This first type of crown also adorns the letter *ḥet*. The second type consists of larger lines added

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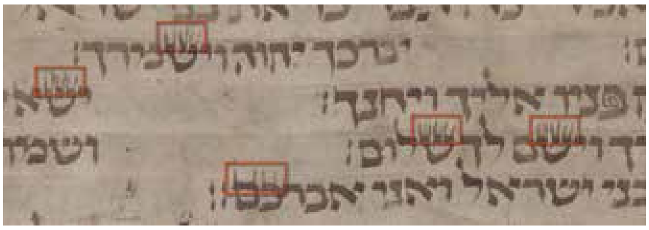
[7] Maharam's *responsum* was published in Meʾir ben Barukh of Rothenburg, *Teshuvot Pesaqim u-Minhagim*, ed. Kahana 1959/1960, vol. 2, 150 (§ 158). According to Israel Ta-Shema, the *responsum* was actually written by Maharam's teacher rather than Maharam himself, see Ta-Shema 1977, 24.

[8] Penkower 2019, 137.

[9] Isaac of Corbeil, *ʿAmude Ha-Golah*, 1556, 58a (§ 155); Strauss 2012.

[10] On the scribal practice of *beyah shemo*, see *ʿAdat Devorim*, ed. Baer and Strack 1879, § 66; Menaḥem ben Solomon ha-Meiʾri, *Qiryat Sefer*, ed. Hershler 1956, 53 (§ 2.3); Yedidyah Norzi, *Minḥat Shai*, ed. Betzer and Ofer 2005, 59 (Gen. 1:1), 151 (Gen. 49:8), 180 (Exod. 14:28), 251 (Lev. 16:8), 312–313 (Num. 24:5), 352 (Deut. 12:28), 364 (Deut. 23:24), 375 (Deut. 31:28); Caspi 2014, 235; Penkower 2019, 135–138.

a



b

Fig. 4a: Two types of crowns in Erfurt 7 (sheet 33, col. 2 [col. 98]). Small crowns (yellow) adorn the letters *shin*, *ʿayin*, *ṭet*, *nun*, *zayin*, *gimel* and *ṣadi*, known by the acronym *shaʿaṭnez geṣ*, as well as *ḥet*. Large crowns (red) adorn specific instances of specific letters, largely based on Cod. hebr. 212 or a common source. Fig. 4b: Large crowns (red) on specific instances of specific letters in Cod. hebr. 212 (fol. 98$^{\text{v}}$). The small crowns on the letters *shin*, *ʿayin*, *ṭet*, *nun*, *zayin*, *gimel*, *ṣadi* and *ḥet* are absent.

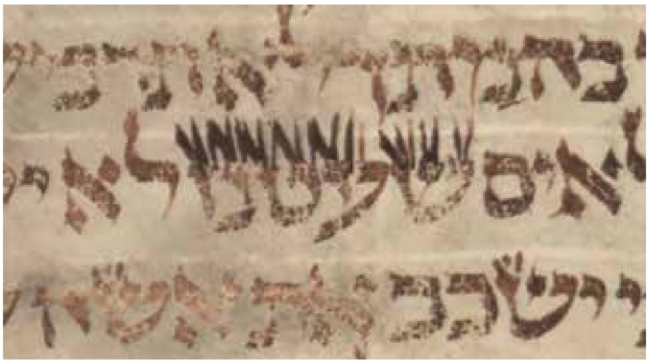


Fig. 5: Crowns added to Erfurt 7 by a later scribe stand out against the background of the original ink, which has been worn away.

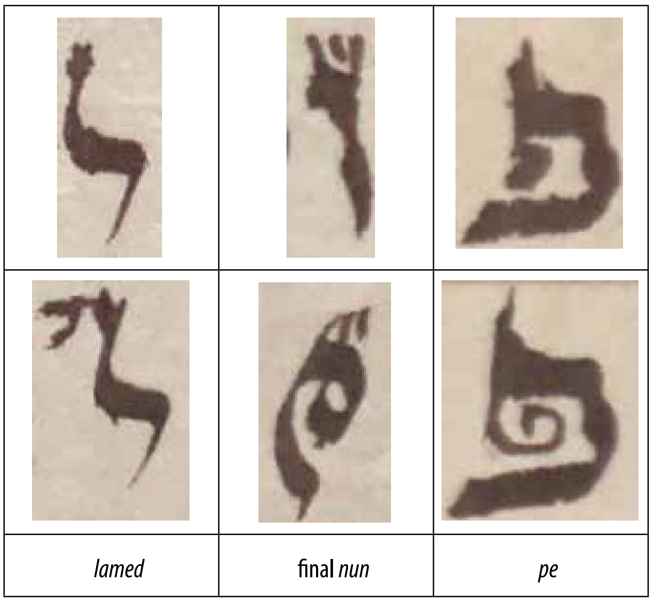


Fig. 6: Examples of regular letters (top) and 'strange letters' (bottom) in Erfurt 7.

to the tops of specific letters of specific words, largely based on Cod. hebr. 212 (Fig. 4).[11] The small crowns are withheld when the large crowns are placed on the *sha῾aṭnez geṣ* letters or *ḥet*, suggesting that the large crowns may have been added before the small crowns (or at the same time).

Some crowns were added by a later scribe. This is particularly obvious when the ink of the original scribe has flaked off, but the ink of the later scribe who added the crowns is well preserved. A clear example of this can be found in Lev. 19:19 (sheet 28, col. 3 [col. 84]), which contains the word שעטנז (an obscure term that refers to a mixture of wool and linen). This word was given special attention because it is the first part of the phrase *sha῾aṭnez geṣ*, the acronym formed from the seven letters normally marked with the first type of crown mentioned above. The later scribe marked this word with the second type of crown (Fig. 5), which is consistent with the corresponding passage in Cod. hebr. 212 (fol. 85$^{\text{r}}$).

Some of the letters were decorated with special paratextual features known as *otiyot meshunot* (literally, 'strange letters'), which may have had a mystical significance (Fig. 6).[12]

[11] Cf. Michaels, 2020, 6–7.

[12] Caspi and Veintrob 2011; Olszowy-Schlanger, 2019, 124–134; Michaels 2020, 1–20.

Various corrections were made in Erfurt 7 to resolve some common scribal errors, with most erasures carried out by abrasion, that is, scratching the ink off the parchment with a sharp implement. These sorts of corrections were done by both the original scribe and later scribes. For example, in Lev. 23:16 (sheet 29, col. 3 [87]) a second hand abraded over half a line and wrote the correction in a different type of ink than that used by the original scribe (see Fig. 7). Most of the correction is written over the abrasion, with the exception of the last three letters, which were written over an unused section of parchment. Corrections in different hands and different inks are apparent throughout Erfurt 7 (see Fig. 8).

One of the most common types of scribal errors is the confusion of graphically similar words, especially when a rare word is confused with a common one. Such an error occurred in Erfurt 7 in Num. 30:4 (sheet 39, col. 3 [col. 117]), where the scribe initially wrote the common word בנערה ('with the girl') instead of the relatively rare word

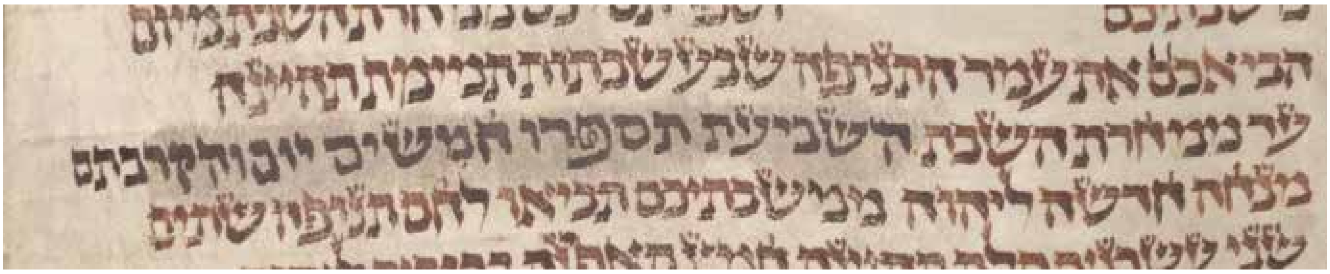
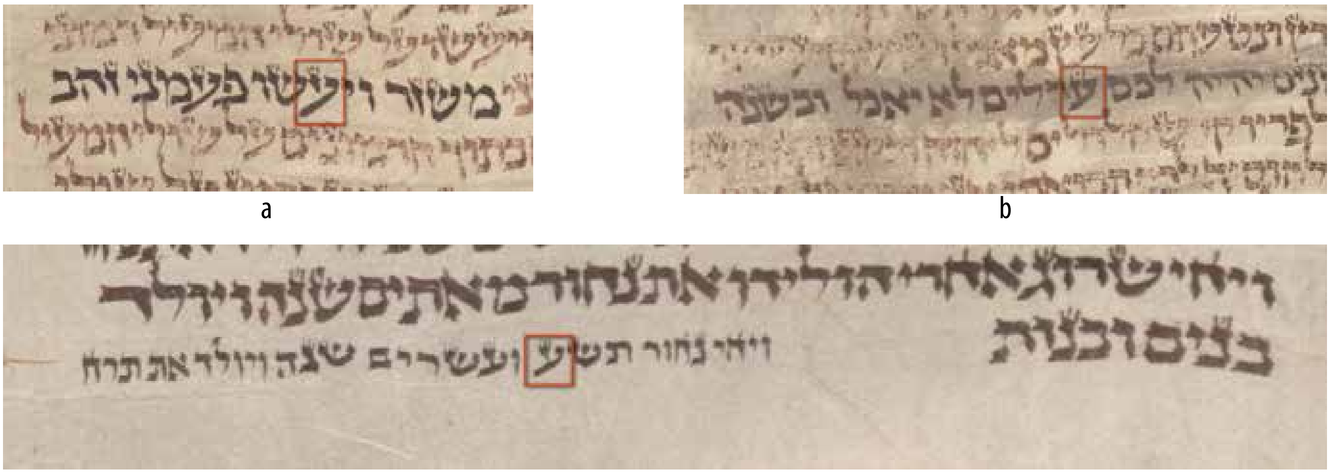


Fig. 7: Signs of abrasion using a sharp instrument to erase text in Lev. 23:16 (sheet 29, col. 3 [87]).



a b

c

Fig. 8: Corrections made in Erfurt 7 by three different scribes, as evident from the appearance of the inks and the forms of the letters. The letter ʿ*ayin* has a different form for each of the three scribes (see the red box). Correction (a) was probably done by the original scribe of Erfurt 7 using a different batch of ink than for the main text on the sheet (sheet 23, col. 2 [col. 68]). Correction (b) was written by a second scribe over an erased section of text (sheet 28, col. 3 [col. 84]). Correction (c) was done by a third scribe who supplied a missing verse that was accidentally omitted due to *homoioarkton*, that is, two passages with similar beginnings (sheet 3, col. 1 [col. 7]).

בנעריה ('in her youth') (Fig. 9). While the two words have quite different pronunciations (*ban-naʿarah* vs. *bi-neʿureha*), vowel points are not written in a Torah scroll, making these graphically similar words easy to confuse. The original scribe apparently caught the error as he was writing, and stopped before completing the left leg of the *he*. It seems he then left a blank space and continued writing the next word while he waited for the ink to dry. This is consistent with the instructions of Rabbi Menaḥem ben Solomon ha-Meʾiri (1249–1315), who said that '[a scribe] should not wipe away wet ink because the blackness of the ink is very pronounced and remains [on the sheet], which is not [very] elegant…'.[13] Once the ink dried, the scribe of Erfurt 7 resolved the error in Num. 30:4 by first abrading the stunted left leg of the *he* with a sharp instrument. Next, he added a horizontal stroke to the remnants of the *he*, turning it into the required *resh* (technically it looks more like a *dalet*, but the scribe was satisfied). Finally, the scribe added the missing *yod* and another *he* in the blank space he had left earlier.

Fig. 9: A scribal error fixed by the original scribe using abrasion. The scribe originally wrote בנערה ('with the girl') instead of the graphically similar בנעריה ('in her youth').

Sometimes the abraded text is still clearly legible. For example, in Gen. 18:19 (sheet 4, col. 2 [col. 11]) the scribe originally wrote ושמרו את דרך ('and they will keep the way') with an extraneous instance of the direct-object marker את. A

[13] Menaḥem ben Solomon ha-Meʾiri, *Qiryat Sefer*, ed. Hershler 1956, 53 (§ 2.3).

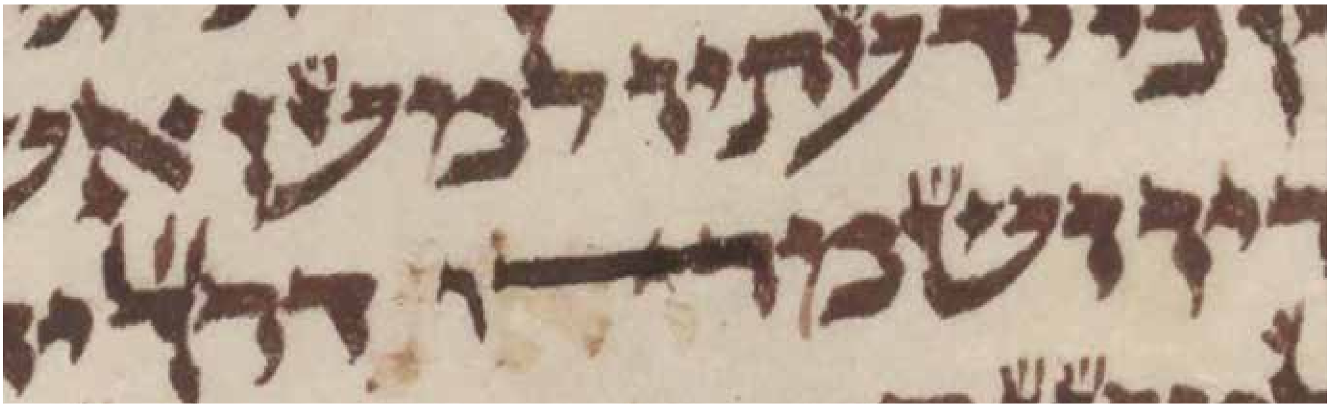
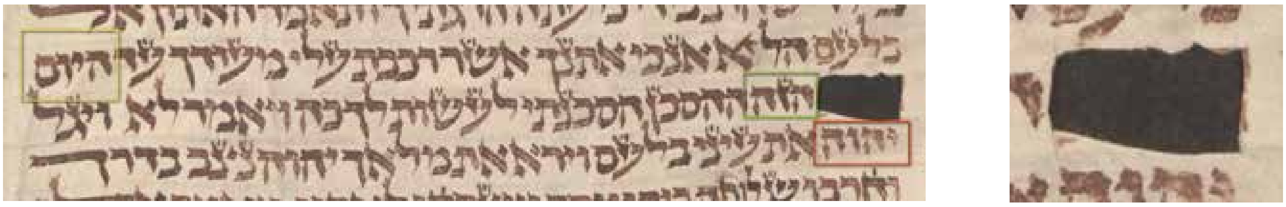


Fig. 10: The word את (a directobject marker) erased by abrasion is still clearly visible, as is the bottom portion of an erased *vav*.



a b

Fig. 11: Erfurt 7, sheet 37, col. 3 [col. 111]. a: the scribal error of *parablepsis* occurred when the scribe finished a line of text (see the yellow box at the far left) and looked back at his source. Instead of reading and copying the word הזה ('this'; marked by a green box), his eye jumped to the next line where he read the graphically similar *Tetragrammaton* יהוה (marked by a red box here). This caused him to initially skip an entire line of text. The scribe immediately realised his mistake, however, and copied the correct word הזה following the wrongly placed instance of the *Tetragrammaton*. Due to rabbinical strictures on erasing the *Tetragrammaton*, the scribe surrounded the erroneous word with an ink rectangle and later it was excised from the parchment. b: a close-up of the hole left from excising the *Tetragrammaton*.

Fig. 12: Cod. hebr. 212, fol. 111^{v}, detail showing the graphically similar words הזה ('this') in Num. 22:30 and יהוה (God's name) in Num. 22:31 on the next line.

later corrector erased the word את, although remnants of the letters are still clearly legible (Fig. 10). To remove the empty space left by the erased word, the corrector first erased the descending line of the *vav* (damage done to the parchment by the abrasion is still visible). Next, he added a horizontal line through the roof of the *resh* and the remaining top of the *vav*. Finally, he rewrote the *vav* following his dilated *resh*.

Another common type of scribal error is *parablepsis*, that is, when a scribe's eye jumps from one section of text to another as he is looking back and forth between his source and the text he is writing. The result is the scribe skipping a section of text. In Erfurt 7, this happened in Num. 22:30 (sheet 37, col. 3 [col. 111]; see Fig. 11) when the scribe's eye jumped from the word הזה ('this') on one line to the *Tetragrammaton* – a Greek term for the four-letter name of God – יהוה on the next line (Num. 22:31). In Cod. hebr. 212 (fol. 111^{v}) the words הזה and יהוה are graphically similar (Fig. 12). The scribe of Erfurt 7 must have realised his mistake immediately because he copied the correct word הזה on an unused section of parchment, immediately afterwards. Rabbinic strictures deemed it sacrilegious to deface the *Tetragrammaton* by abrading it.[14] To solve this problem, the scribe initially surrounded the divine name with an ink rectangle, traces of which are still visible. In

[14] Gordon 2020.

a b c d e

Fig. 13: The scribe of Erfurt 7 worked around pre-existing holes in the parchment, usually leaving ample space before and after the hole. a: A pre-existing hole in the parchment that was sewn up (sheet 3, col. 1 [col. 7]). The word בנו (Gen. 11:5) is squeezed in on the third line, to the right of the stitches. b: A tear that was sewn up with an adjacent hole (sheet 12, col. 3 [col. 36]). c: The scribe contracted the letters *tav* (ת) and *he* (ה) of the word ועתה (Gen. 50:5) on the second line to fit them in to the right of the tear (sheet 13, col. 1 [col. 37]). d: Sheet 30, col. 3 [col. 90]. e: Sheet 36, col. 1 [col. 106].

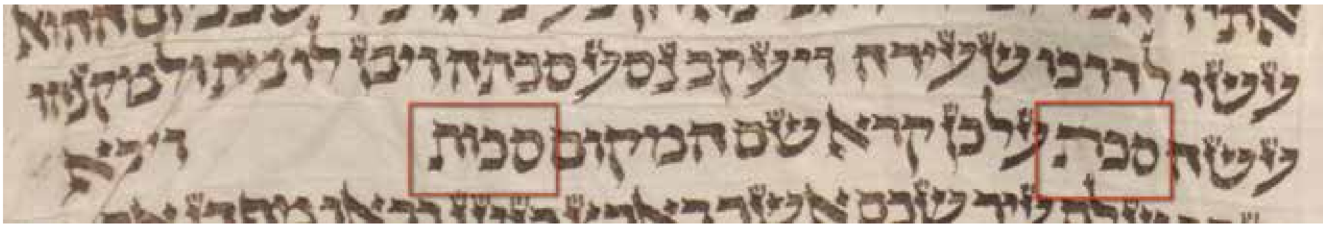


Fig. 14: The word *sukkot* spelt *plene* with a *vav* – סכות (left) – and in a 'defective' form without a *vav* – סכת (right) – in the same verse (Gen. 33:17; sheet 8, col. 3 [col. 24]).

a later phase, the original scribe or a different one excised the divine name, that is, he cut it out of the parchment using a razor or sharp knife, leaving behind a rectangular hole. In Erfurt 7, excision was used to remove twenty-two erroneous instances of the *Tetragrammaton* or another divine appellation, leaving a rectangular hole in the parchment in each case.[15] In some cases, the original scribe worked around pre-existing holes in the parchment as well as tears in it that were sewn up (Fig. 13).[16]

In terms of its typology, Erfurt 7 exhibits Ashkenazic characteristics that distinguish it from the standard Tiberian version of the Masoretic Text in numerous ways.[17] The Tiberian text was transmitted and standardised in Tiberias over a period of several centuries, culminating in the Aleppo Codex around the year 925. The influence of the Aleppo Codex gradually spread throughout the Jewish world over the course of several centuries, resulting in the 'correction', or rather standardisation, of Bible codices and Torah scrolls. One area of this standardisation was matters of *plene* and defective orthography. The four Hebrew letters *alef* (א), *he* (ה), *vav* (ו) and *yod* (י) can be used to indicate the presence of a vowel, in which case they are referred to as *ʾimot qeriʾah*, translated by the Latin term *matres lectionis* ('mothers of pronunciation'). When a word was written with a *mater lectionis* (sing.), it was called *male*, translated by the Latin term *plene* ('full'); when it lacked a mater lectionis, it was called *ḥaser* ('defective'). Biblical Hebrew did not have uniform orthography when it came to *matres lectionis*, so the same word could be written in a *plene* way or a 'defective' one without changing the meaning. Take the word *sukkot* ('booths' or 'name of a town'), for example, which is written as סכות (with a *vav*) in a *plene* way and as סכת (without a *vav*) in a defective way in Gen. 33:17 (Fig. 14).

The Tiberian scribes developed an intricate system to fix the precise orthography of every word in the Bible, including the use of *matres lectionis*, for every instance of every word. Erfurt 7 contains numerous corrections of *plene* and defective orthography that bring it in line with the standard Tiberian text. Changing a word from *plene* to defective spelling usually involved erasing an extraneous *vav* or *yod* as

[15] Sheet 14, col. 2 [col. 41], sheet 17, col. 2 [col. 50], sheet 27, col. 3 [col. 81] *bis*, sheet 29, col. 1 [col. 85], sheet 29, col. 3 [col. 87], sheet 32, col. 3 [col. 96], sheet 33, col. 1 [col. 97] *bis*, sheet 35, col. 1 [col. 103], sheet 37, col. 1 [col. 111], sheet 39, col. 2 [col. 116], sheet 41, col. 3 [col. 123], sheet 42, col. 1 [col. 125] *bis*, sheet 43, col. 1 [col. 127], sheet 43, col. 2 [col. 128], sheet 43, col. 3 [col. 129], sheet 44, col. 1 [col. 130], sheet 44, col. 3 [col. 132], sheet 45, col. 3 [col. 135] and sheet 50, col. 1 [col. 148].

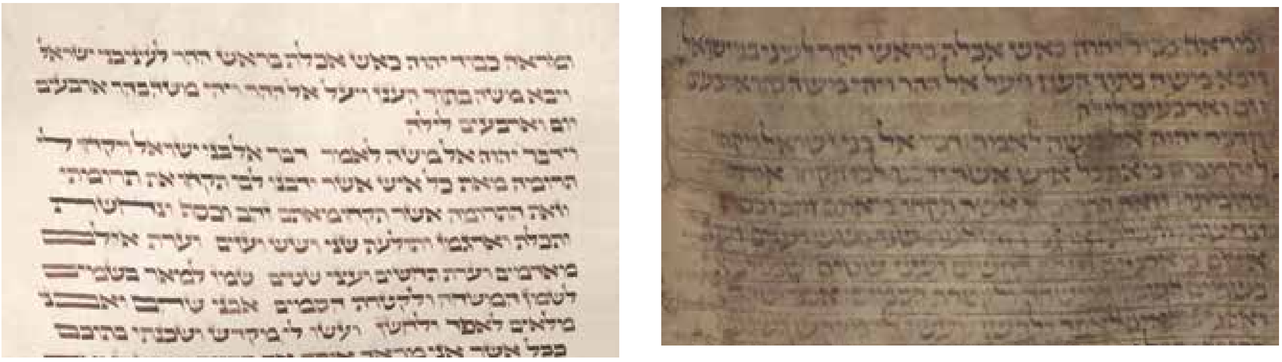
[16] See cols 36, 65, 90 and 106, for example.

[17] Penkower 2015, 124–128.

a b

Fig. 15: Corrections of orthography in Erfurt 7. a: The *plene* התולעת was changed to the defective התלעת in Deut. 29:39 (sheet 48, col. 3 [col. 144]). b: The defective אלים was changed to the *plene* אילים in Num. 23:1 (sheet 38, col. 1 [col. 112]).

Fig. 16: The letters *he* (right) and *vav* (left) added by a later scribe as supralinear corrections, that is, above the line, in Deut. 26:12 using a different ink than the original scribe's (sheet 48, col. 1 [col. 142]).



a b

Fig. 17: A replacement sheet in Erfurt 7 (sheet 19, col. 2 [col. 56]), a, compared with the corresponding verso page of Cod. hebr. 212 (fol. 56v), b. The correspondance between the two manuscripts' layout applies to the beginning of columns and usually to paragraph spacing, but not to individual lines. The replacement sheets may have been copied from the original sheets of Erfurt 7, which were presumably damaged or worn out at the time, or directly from the codex.

well as part of an adjacent letter. The partially erased adjacent letter was then dilated to cover up the erased *vav* or *yod*. For example, in Deut. 29:39 the scribe originally wrote the *plene* התולעת ('the worm') contrary to the standard Tiberian text, which has the defective התלעת. The corrector erased the extra *vav* (traces of which are still visible) as well as part of the adjacent *lamed* (ל). He then dilated the *lamed* to cover up the missing *vav* (Fig. 15a). Changing a word from defective to *plene* involved the opposite process, that is, erasing part of a letter to make room for a missing *vav* or *yod*. The partially erased letter would then be rewritten in a contracted form (as in Fig. 15a). In Num. 23:1, for example, the scribe wrote the defective word אלים ('rams') contrary to the standard Tiberian text, which has the *plene* form אילים. A later corrector, using a different ink than the original scribe's, erased part of the *lamed* and then rewrote it in a contracted way. He then added a small *yod* between the *alef* and contracted *lamed*.

Occasionally, a later scribe would add missing letters supralinearly, that is, above the line. For example, in Deut. 26:12 a later scribe using a different ink than the original scribe's added the letter *he* to the word ונתתה ('and you will give') and the letter *vav* to וליתום ('and to the orphan') (Fig. 16). The *he* was a *mater lectionis*, so its addition did not change the meaning. However, the *vav* in וליתום functioned as a conjunction with the meaning 'and'. The first of these corrections brings Erfurt 7 in line with the standard Tiberian text, whereas the second is actually contrary to it. This means there was a scribe in thirteenth- or fourteenth-century Germany with a manuscript that he believed to be authoritative and that he used to correct Erfurt 7, but this manuscript did not conform with the standard Tiberian text in every detail. The conjunction *vav* added by the later scribe is found as a textual variant in several other Ashkenazic manuscripts, which confirms this

a b

Fig. 18: The scribe of the replacement sheets dilated the final lines of sheet 19, col. 1 [col. 55], shown in snippet (a), in order to begin the following column with the word ומראה in Exod. 24:7 (Fig. 17). The corresponding section of Cod. hebr. 212 (fol. 56r) – snippet (b) – has no significantly dilated letters in it even though it also begins the next column with the same word as the replacement sheet in Erfurt 7. This is due to the horizontal density of the handwriting added by the scribe who wrote the replacement sheets.

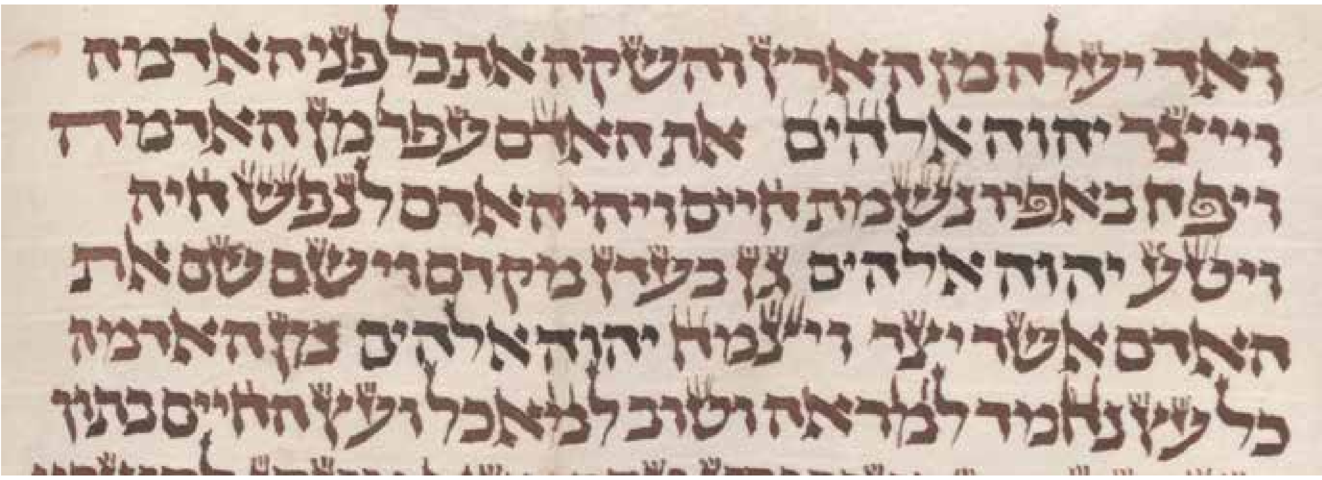


Fig. 19: Erfurt 7, sheet 1, col. 2 [col. 2], detail with divine appellations (יהוה אלהים) in dark brown ink on lines two, four and five, surrounded by non-sacred words in lighter ink. The 0.5 cm blank space to the left of יהוה אלהים (Gen. 2:7) on the second line is due to the scribe's overestimation of how much space he would need to fill in the divine appellations in the second stage of writing.

was a version known in medieval Germany, even though it is contrary to the standard Tiberian text.[18]

Three of the fifty sheets (19, 20 and 26) of Erfurt 7 were replaced in the late thirteenth or early fourteenth century.[19] They are roughly the same size and have the same layout as the original sheets, with three columns and sixty lines per column, and each column beginning with the letter *vav* at the beginning of a verse. Every column starts with exactly the same words as the corresponding verso page in Cod. hebr. 212, suggesting that they have the same column layout as the sheets they replaced. For example, Erfurt 7, sheet 19, column 2 (col. 56) and Cod. hebr. 212, fol. 56v both begin with the word ומראה ('and the appearance'), the first word in Exod. 24:17 (Fig. 17). The handwriting of the scribe who produced the replacement sheets was horizontally denser than the handwriting of the scribe who wrote the original sheets. This obliged him to dilate letters extensively in order to begin each column with the same word as in the original sheets; two letters alone (*tav* [ת] in מתוך and *he* [ה] in הענן) take up about seventy-five per cent of the last line of sheet 19, col. 1 [col. 55], for example (see Fig. 18a). The script and overall appearance of the replacement sheets closely resemble those of Erfurt 6 and Erfurt 8, which indicates they were produced in the same region and period and perhaps even by the same school of scribes.

3. Procedure for writing divine appellations

A Jewish custom among medieval scribes involved leaving blank spaces for divine appellations, which were filled in during a second stage of writing. This procedure has parallels in the Second Temple period and is still followed today by some scribes. According to certain medieval rabbis such as David ben Solomon ibn Abi Zimra (*c*.1479–1573), it only applied to the *Tetragrammaton YHWH*, which was considered the unique name of God. Other rabbis, such as

[18] See Kennicott, vol. 1, 417.

[19] Caspi 2014, 234–236.

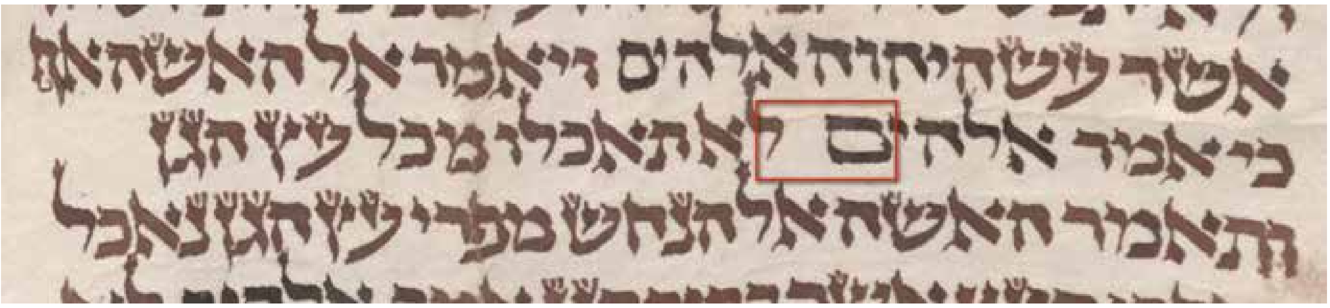
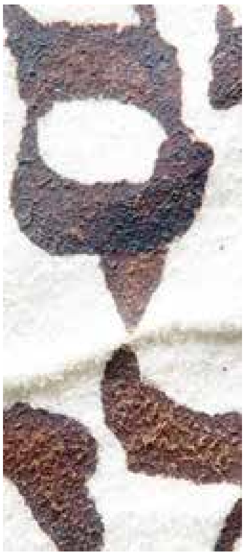


Fig. 20: The scribe misjudged how much space he would need to fill in the divine appellation *Elohim* (sheet 1, col. 2 [col. 2]). To fix this, he dilated the final *mem*, but an extra 0.5 cm of space still remained anyway. This sort of space in the middle of a line normally indicates a separation between verses in Erfurt 7. However, in this case, it is in the middle of a verse.



a

b

Fig. 21: The dark brown ink of divine appellations superimposed on lighter brown ink from the line below (a: sheet 1, col. 1 [col. 1]; b: sheet 1, col. 2 [col. 2]). This could only have happened if the divine appellations were written after the text on the line below. Photographed at about 20x in visible light. Contrast enhanced.

Joseph Caro (1488–1575), applied it to all divine appellations that are not allowed to be erased according to rabbinical law, such as *YHWH*, *Adonai* ('Lord') and *Elohim* ('God').[20]

In the Middle Ages, three reasons were given for following this practice. First, divine appellations had to be written with specific intent, hence a distracted scribe might delay writing them until he could concentrate on them properly. Second, divine appellations could only be written by a scribe following his immersion in a *mikveh* (ritual bath), and so the scribe might delay writing them until he had done this. Third, there was a custom to write divine appellations in the presence of ten adult Jewish men (or according to one version, ten saintly Jewish men), hence the scribe might delay writing them until he could muster the required audience.[21]

In Erfurt 7, the scribe left blank spaces for the divine appellations *Elohim* (אלהים) and *YHWH Elohim* (יהוה אלהים) throughout Gen. 1:1–3:5, corresponding to the first 1.5 columns of the first sheet.[22] The same scribe then filled them in himself (judging from the script) during a second stage of writing. The inseparable preposition *kaf* (כ) in כאלהים (Gen. 3:5) was also written during this second stage. The ink used to write these divine appellations is a darker shade of brown than that of the surrounding text (see Fig. 19).

[20] See Gordon 2020, 14, n. 23; Gordon forthcoming.

[21] Gordon forthcoming.

[22] *Elohim* and *YHWH Elohim* are the only divine appellations in this section of the biblical text.

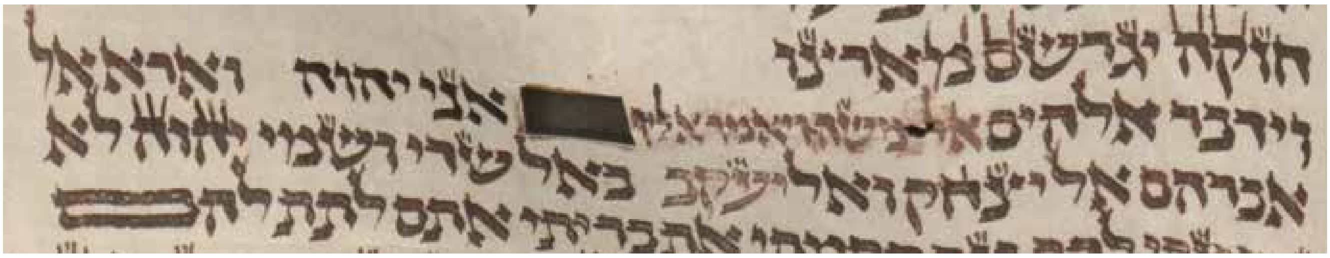
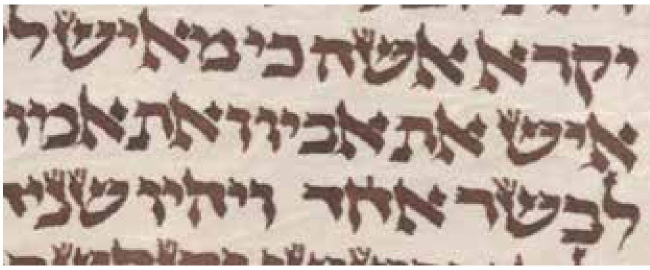
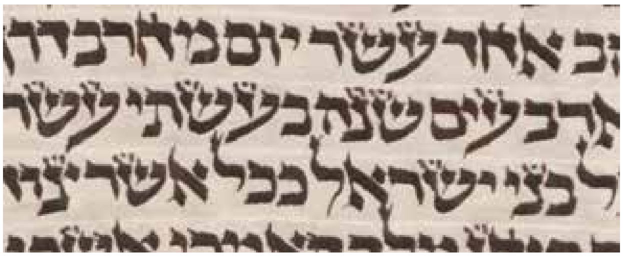


Fig. 22: An erroneous instance of the *Tetragrammaton* יהוה (*YHWH*) was surrounded by an ink rectangle and later excised. It was replaced with אני יהוה ('I am *YHWH*') on an unused section of parchment, proving the *Tetragrammaton* was written at the same time as the rest of the text in Exod. 6:2.



a



b

Fig. 23: Two shades of brown ink used by the original scribe of Erfurt 7; a: light brown (sheet 1, col. 2 [col. 2]), b: dark brown (sheet 41, col. 2 [col. 122]. The two inks were probably black originally.

In some instances, the spacing around the divine appellation is awkward, indicating that the scribe wrongly estimated how much space would be required to fill in the name in the second stage of writing; יהוה אלהים in Gen. 2:7 is followed by about 0.5 cm of blank space, for example (Fig. 19, line 2). Similarly, אלהים in Gen. 3:1 is followed by 0.5 cm of blank space and the final *mem* (ם) has been dilated to about 0.75 cm (Fig. 20). To put this into perspective, the blank space between words in this scroll is usually about 0.1 cm wide, the space between verses is about 0.5 cm wide and the final *mem* is about 0.5 cm wide.

Further evidence of the two-stage procedure can be found in places where some of the ink used for a divine appellation on one line is superimposed on the ink of a word on the line below it. In sheet 1, col. 1 [col. 1], line 20 (Gen. 1:14), the dark brown ink of the base of the final *mem* of אלהים ('God') is superimposed on the lighter ink of the mast of the second *lamed* in הלילה ('the night') on line 21 (Fig. 21a). This could only have happened if אלהים on line 20 was written after הלילה on line 21. Similarly, in sheet 1, col. 2 [col. 2], line 20 (Gen. 2:19), some of the dark brown ink used for the left leg of the first *he* of יהוה (*YHWH*) is superimposed on the lighter ink used for the mast of the *lamed* of כל ('all') on line 21 (Fig. 21b). Again, this could only have happened if יהוה on line 20 was written after כל on line 21.

The divine appellations, which begin in Gen. 3:8 (sheet 1, col. 2 [col. 2], line 45), were written at the same time as the rest of the text, as is evident from the correction of scribal errors. In Exod. 6:2, for example (sheet 14, col. 2 [col. 41]), the scribe initially made a mistake that needed erasing and a portion of the verse had to be rewritten. It was not permissible to abrade the *Tetragrammaton*, so the scribe invalidated it by drawing a rectangle around it in ink. In a later phase, the original scribe or a later one excised the *Tetragrammaton*, leaving a hole in the parchment, although traces of the ink rectangle are still visible (Fig. 22).[23] The correction אני יהוה ('I am *YHWH*') was written by the original scribe directly after the hole on a clean, unabraded section of parchment, followed by a space between the verses. Had the scribe skipped writing the divine appellations and only filled them in later, it would not have been possible to write the correction אני יהוה on a clean section of parchment immediately after the erroneous instance of the *Tetragrammaton*. This space would have been filled with the following words (וארא אל), which the scribe would have needed to erase by abrasion. Such an

[23] Gordon 2020, 124, n. 139.

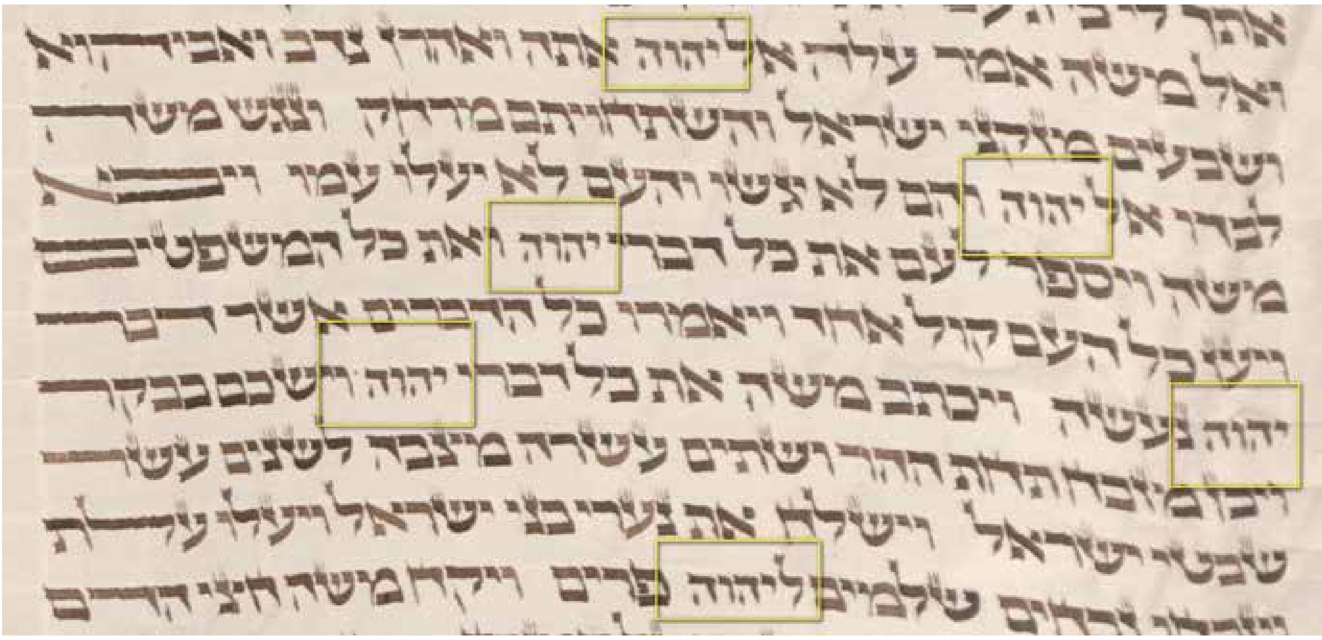


Fig. 24: Divine appellations filled in during a second phase of writing in a replacement sheet in Erfurt 7 (sheet 19, col. 1 [55]). The appellations here are slightly smaller than the surrounding text.

erasure would have left obvious marks, though, which is actually the case earlier on the same line of sheet 14, col. 2 [col. 41] where the words אל משה ויאמר אליו are written over an abrasion.[24]

The reason for only performing the two-stage procedure in the first 1.5 columns (of the original sheets) may have been hinted at by Rabbi Judah ben Samuel he-Ḥasid of Regensburg (*c*.1150–1217):

> Some say [the scribe] was required to write [the divine name] in the presence of many people to warn [him] to write it with proper intent.[25]

Thus it is possible that the scribe of Erfurt 7 performed the second stage of this procedure in the presence of members of the Jewish community of Erfurt as a way of reminding both himself and the community of the profound sanctity of the written form of the divine name. It would have been impractical to maintain a large gathering of community members for the time it took to add all the divine appellations required in a scroll, of course. Hence, the first 1.5 columns may have been chosen as a way of 'inaugurating' the writing of the divine name in a public ceremony.

The dark brown shade of ink used to write the divine appellations in the first 1.5 columns of the first sheet (Gen. 1:1–3:5) has the same colour and appearance as the ink used to write entire sheets elsewhere in the scroll (such as sheets 2, 3 and 38–44; see Fig. 23b). Similarly, the light brown shade of ink used to write the 'non-sacred' words (that is, anything other than the divine appellations) in the first 1.5 columns also has the same colour and appearance as the ink used to write whole sheets (like sheets 5, 14, 17 and 21–25; see Fig. 23a). All the inks were probably black when fresh and turned different shades of brown over time; the degradation of the Fe complex into the soluble constituents $Fe^{2}+$ and gallic acid is known to cause brown discolouration in iron-gall inks.[26]

The divine name יהוה (*YHWH*) was inserted into blank spaces in the three replacement sheets (19, 20 and 26), sometimes in a smaller script than the surrounding text. It does not seem that the scribe miscalculated the space needed for the *Tetragrammaton* as it was sometimes written in a smaller script than the surrounding text even when there was

[24] Similarly, in Num. 12:14, the scribe initially neglected to insert an open *parashah* (a space between sections). To remedy this, he erased the verse by abrading it, with the exception of the *Tetragrammaton*, which he excised, leaving a rectangular hole. The corrected verse was then written on the following line on a clean, unabraded section of the sheet. In Deut. 4:2, the scribe initially wrote the *Tetragrammaton*, excised it and then wrote the correction immediately after the rectangular hole on a clean, unabraded section of the parchment. The fact that these corrections were written on clean, unused parts of the respective sheets indicates that the scribe caught the errors as he was writing. This means he must have been writing the *Tetragrammaton* at the same time as the rest of the words in these sections.

[25] *Sefer Hasidim*, ed. Wistinetzki 1924, 420 (§ 1762).

[26] Krekel 1999; Rabin et al. 2012.

ample room (Fig. 24). The appearance of the script suggests the divine name was added by a second scribe. It is possible that the main text was produced by an apprentice whose master filled in the *Tetragrammaton*. The inseparable preposition *lamed* (ל) was written in the second stage, often being dilated to fill in the blank space. The two-stage procedure was not followed for other divine appellations such as אלהים ('God') that appear in the three replacement sheets. The scribe(s) of the replacement sheets treated the *Tetragrammaton* with more sanctity than other divine appellations, whereas the original scribe treated all the divine appellations with equal sanctity.

The primary aim of this material analysis was to determine the relationship between the divine appellations (DN) in the first 1.5 columns (Gen. 1:1–3:5) of the original sheets (OS) and the surrounding non-sacred words (NS). Initially, it was hypothesised that the difference in shade between the dark brown (DK) divine appellations (OS.DK.DN) and the surrounding light brown (LT) non-sacred words (OS.LT.NS) occurred because of different elemental compositions and possibly even different types of ink, viz. carbon ink and iron-gall ink. A secondary aim was to compare the divine appellations written in light brown ink (OS.LT.DN) after Gen. 3:8 with the surrounding non-sacred words written in what appears to be the same light brown ink used for non-sacred words in the first 1.5 columns (OS.LT.NS). It was assumed that these two subcategories of ink (OS.LT.DN, OS.LT.NS) would have identical characteristics.

Some sheets used a dark brown ink (OS.DK) of the same colour and appearance as that used for the divine appellations in the first 1.5 columns. Similarly, other whole sheets used a light brown ink (OS.LT) of the same colour and appearance as that used for non-sacred words in the first 1.5 columns. To complete the picture of the original sheets, we proposed exploring the relationships between these two main shades of ink used throughout the scroll (OS.DK, OS.LT), the corrections performed by various hands (OS.CR) and the crowns added to the letters (OS.CW).

What the relationship was between the divine appellations (RS.DN) and the surrounding non-sacred words (RS.NS) was a key question regarding the replacement sheets (RS). Another question concerned the relationship between the inks used for the replacement sheets and the different inks used to write the original sheets (OS.LT, OS.DK, OS.CR, OS CW), along with their connection to other manuscripts in the Erfurt collection, especially scrolls that appear to be similar from a palaeographical perspective, such as Erfurt 6 and Erfurt 8.

4. Experiment

Testing was conducted using ultraviolet-visible-near-infrared (UV-vis-NIR) reflectography followed by X-ray fluorescence analysis (XRF) to determine the relationship between the inks used for the main text written in the first stage and the divine appellations written in the second stage in the original sheets and the three replacements. This two-step procedure, which has now been used successfully by BAM for more than a decade, allows a reliable, non-destructive and non-invasive investigation of inks.[27]

4.1 UV-vis-NIR reflectography

Carbon-based, plant and iron-gall inks belong to different typological classes of black ink. Soot ink is a fine dispersion of carbon pigments in a water-soluble binding agent, whereas plant-based ink consists of a solution of tannin extracts and a binding agent. Iron-gall ink combines water-soluble components (iron sulphate and tannin extract from gall nuts) with insoluble black material that evolves when the components undergo a chemical reaction. Each ink class has distinct optical properties: the colour of soot ink/carbon ink is independent of the wavelength between 300 and 1700 nm; iron-gall ink gradually loses its opacity towards long wavelengths (that is, 750–1400 nm) and becomes transparent at 1400 nm, whereas plant ink is already transparent at ~750 nm.[28] We used a portable microscope (a Dinolite AD4113T-I2V USB) with illumination from the ultraviolet (UV, 395 nm), visible (VIS) and near-infrared (NIR, 940 nm) regions of the electromagnetic spectrum and magnifications of x50 to x200 to determine the ink type and tannin distribution.

4.2 X-ray fluorescence (XRF)

Elemental analysis by X-ray emission techniques relies on the study of characteristic patterns of X-ray emissions from atoms irradiated with high-energy X-rays or electrons: X-ray fluorescence (XRF) and energy-dispersive X-ray spectroscopy (EDX) respectively. When the external excitation beam interacts with an atom within the sample, an electron is ejected from the atom's inner shell, creating a vacancy. In the next step, another electron from an outer

[27] Hahn et al. 2004, Rabin et al. 2012, Cohen et al. 2017, and Rabin 2017.

[28] Mrusek, Fuchs and Oltrogge 1995.

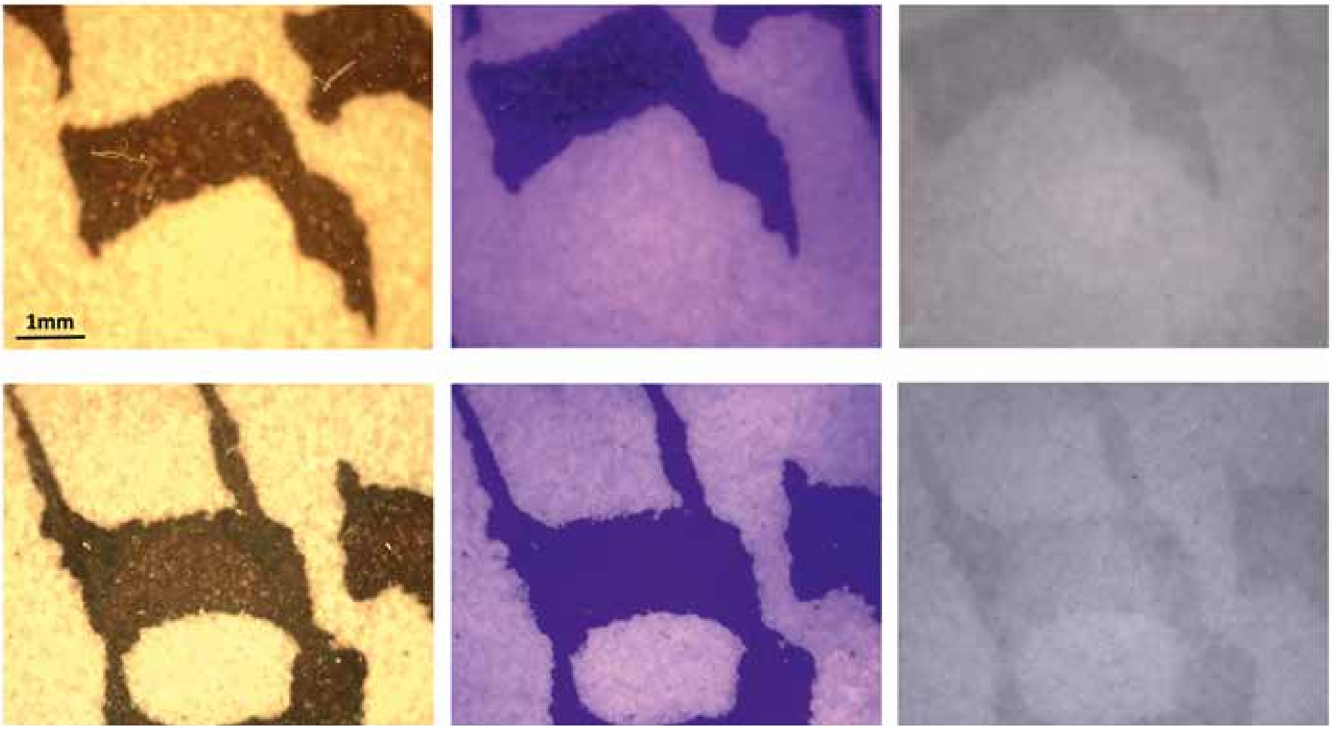


Fig. 25: Details of spots from sheet 1, col. 1, line 20 corresponding to the roof of the *resh* (ר) of ויאמר (top row) belonging to the OS.LT.NS category and the roof of the final *mem* (ם) of אלהים (bottom row) belonging to the OS.DK.DN category under visible light (left), UV light (395 nm, middle) and near-infrared light (940 nm, right) at x50 magnification. The top ink corresponds to the lighter shade of brown observed and the bottom one to the darker shade of brown. Both inks appear to have faded, but are still visible at 940 nm, which indicates that they are of the iron-gall type. The slightly yellow hue under visible light is an artifact of the LED lamps used.

shell fills the vacancy, emitting X-rays in the process. The energy of the emitted X-ray fluorescence is characteristic of a certain element, whereas the signal intensity (and a number of other factors) is related to the amount of the element in the volume sampled. It is worth noting that each technique has its limits in terms of applicability and different penetration depths. Excitation by electrons (in the case of X-ray spectroscopy, EDX), which is conventionally used in electron microscopy, is limited to the study of surfaces (but capable of detecting lightweight elements), whereas excitation by X-rays (XRF) has greater penetration power. However, conventional portable instruments are limited to detecting elements where $Z > 11$, that is, elements heavier than sodium.

The X-ray fluorescence (XRF) technique is commonly used for analysing the elemental composition of various objects concerned with cultural heritage. More specifically, earlier studies of carbon and iron-gall inks conducted by BAM and the Centre for the Study of Manuscript Cultures resulted in a database of possible metallic contaminants being created. In the case of iron-gall ink, the most common source of iron necessary to form the iron-gallate complex responsible for the black colour of the ink is vitriol, which contains different metallic contaminants (such as manganese, copper and zinc) in different quantities. An analysis of these contaminants allows researchers to compare and discriminate between different inks.

Due to time and place limitations, the X-ray analysis we performed was done *in situ* at the Staatsbibliothek using ELIO, a portable micro-XRF spectrometer from Bruker-XGLab with a 4W low-power rhodium tube, a 25 mm^2 large-area silicon drift detector (SDD) and an interaction spot of 1 mm. All of our measurements were conducted under the following experimental conditions: a spot analysis of 120 seconds and excitation parameters of 40 kV and 80 µA.

4.3 X-ray fluorescence (XRF) data treatment

After measurement, the spectra were processed with Spectra (ARTAX) software from Bruker to identify the elements and determine their net peak intensities. The contribution of the support was then subtracted. The thickness of ink can vary considerably, depending on the spot analysed, so making a direct comparison of net peak intensities can lead to incorrect interpretations. To compare iron-gall inks successfully, we used iron as a standardisation parameter for all the other inorganic components to be quantified, that is, the intensities due to the contaminants were normalised to that of iron, following the semi-quantitative adaptation of the method described by Hahn, Malzer, Kanngießer and Beckhoff (2004; see note 27 above).

Finally, to determine whether the differences observed between several groupings of data were statistically significant, Welch's t-test was performed (an adaptation of Student's t-test to compare the means of two independent groups without requiring the variances to be the same).[29] In Welch's test, which is similar to Student's t-test, but not used as often, the null hypothesis that two groups of data have equal means is tested. Unlike Student's t-test, the two tested groups can have different variance values. A t-value is computed, which depends on the difference between the two means and the standard deviations, and then compared with a table of values depending on the degree of freedom of the dataset.[30] If the computed t-value is bigger than the tabulated critical t-value for a given significance level α, then the null hypothesis can be rejected and the probability that the means are statistically different is $(1-\alpha/2)*100\%$.

The degree of freedom is approximated by the following formula,[31] where σ_A and σ_B are the standard variations of samples in groups A and B respectively and n_A and n_B are the number of samples in groups A and B respectively (the result is then rounded up or down to the closest integer):

$$df = \frac{\left(\frac{\sigma_A^2}{n_A}+\frac{\sigma_B^2}{n_B}\right)^2}{\frac{\sigma_A^4}{n_A^2(n_B-1)}+\frac{\sigma_B^4}{n_B^2(n_A-1)}}.$$

The t-value is calculated as follows, where μA and μB are the mean values of sample groups A and B respectively, σ_A and σ_B are the standard variations of samples in groups A and B respectively and n_A and n_B are the number of samples in groups A and B respectively:

$$t = \frac{|\mu_A-\mu_B|}{\sqrt{\frac{\sigma_A^2}{n_A}+\frac{\sigma_B^2}{n_B}}}.$$

5. Results

All of the inks investigated via reflectography, both the light brown (OS.LT) and dark brown (OS.DK) ones from the original sheets and the inks on the replacement sheets (RS), were found to be of the iron-gall type. When illuminated by near-infrared light, the iron-gall ink faded, remaining slightly visible, as seen in Figure 25 (right). In contrast, carbon ink would have remained unfaded under near-infrared light. No carbon ink was detected anywhere in the scroll.

Following the reflectographic survey, we conducted XRF measurements to determine the elemental composition and relative intensities of the inks. To that end, 35 spots in the ink were examined and 11 spots were analysed on the parchment support so that the contribution of the parchment could be subtracted.

The original aim of the investigation was to compare eight subcategories of inks based on their appearance and function within the text. These subcategories distinguished between the two primary inks used throughout the original sheets (OS), specifically light brown ink (LT) and dark brown ink (DK). They also differentiated between divine appellations (DN), non-sacred words (NS), corrections (CR) and crowns (CW). Additionally, two subcategories were delineated in the replacement sheets (RS), namely divine appellations (DN) and non-sacred words (NS). The result was six subcategories in the original sheets (OS.LT.DN, OS.LT.NS, OS.DK.DN, OS.DK.NS, OS.CR and OS.CW) and two subcategories in the replacement sheets (RS.DN and RS.NS). However, limitations in terms of time, place and equipment prevented us from collecting enough XRF data points to be able to draw any reliable conclusions about all the subcategories. As a result, the statistical analysis had to employ broader categories based on the visual appearance of the ink (OS.LT, OS.DK, RS) as representative of some of the most important subcategories. The difference between the inks used in the original sheets and replacements was obvious. Although inks from the original sheets did not contain any copper or zinc (or only had traces of them), the inks from the replacement sheets all exhibited traces of copper and high counts for zinc, as Figure 26 shows.

As for the two shades of ink observed in the original sheets, OS.LT and OS.DK, the distinction is less obvious since both shades contain the same elements and the spectra look similar at first glance. Counts for iron, potassium and calcium vary from one spot to another, but cannot be directly correlated with differences in the appearance of the inks. However, the two groups are clearly

[29] Welch 1951. The variance is the average of the squared differences from the mean, and the standard deviation is the square root of the variance.

[30] Otto 2017, 32.

[31] Otto 2017, 35.

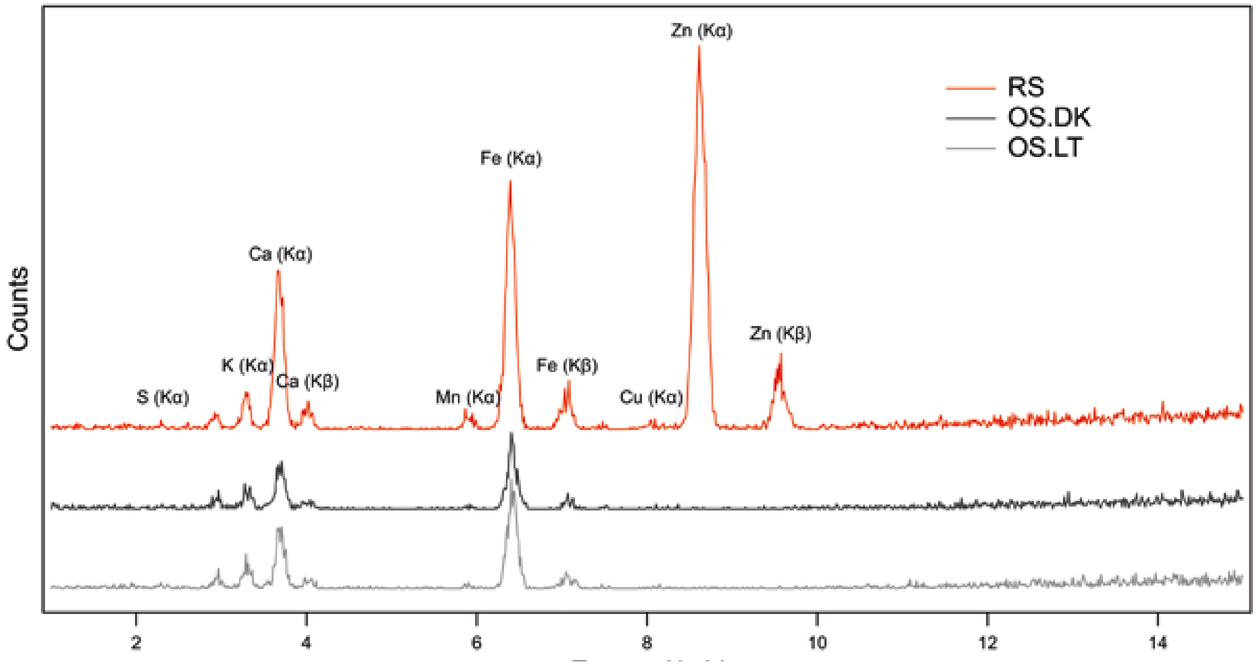


Fig. 26: XRF spectra of ink from OS.LT (sheet 1, column 1, line 20, roof of *resh* from ויאמר, bottom), OS.DK (sheet 1, column 1, line 20, roof of final *mem* from אלהים, middle) and RS (sheet 19, column 1, line 41, *yod* from דברי, top). In addition to the elements indicated, a peak at 2.96 keV corresponds to the Kα of argon (Ar), which was detected because the analysis was performed in open air. This element is not relevant to our study.

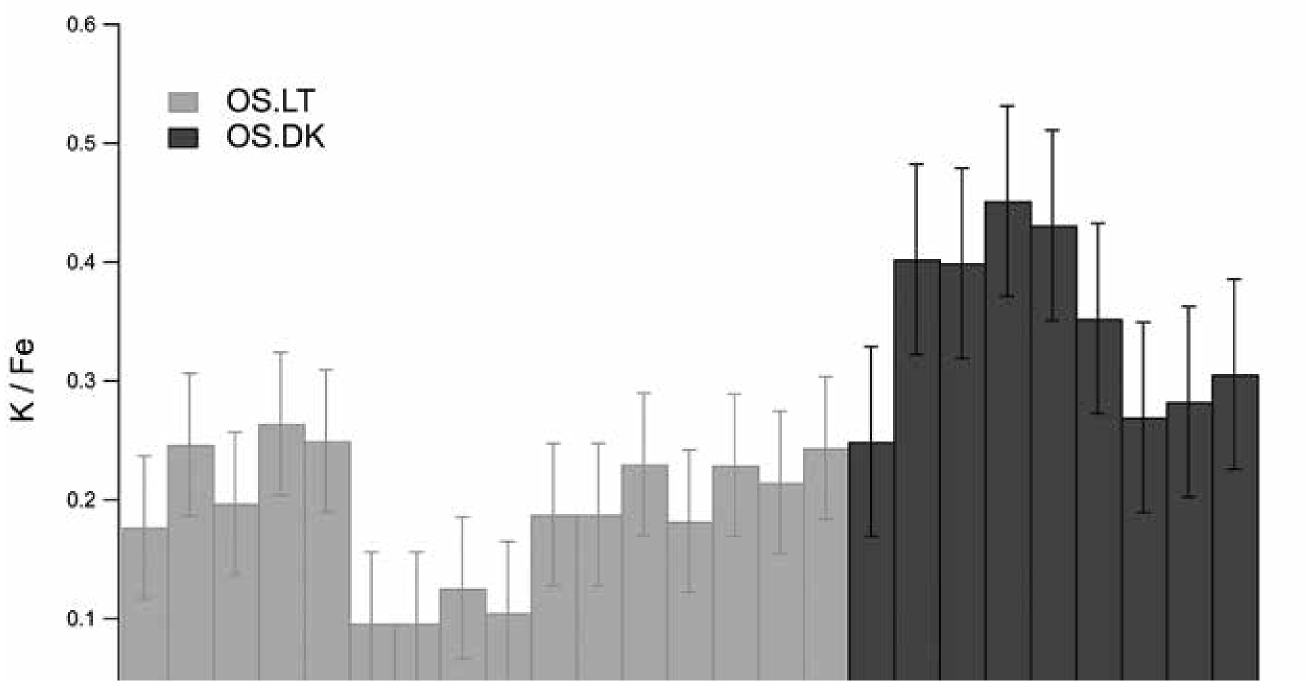


Fig. 27: Comparison of K/Fe for both shades of ink observed on the original sheets.

distinguished from the potassium normalised to iron (Fig. 27). Inks with the lighter shade have a lower potassium-to-iron ratio, with an average value of 0.19 (a standard deviation of 0.06), whereas inks with the darker shade have an average K/Fe value of 0.35 (a standard deviation of 0.08). Table 1 below shows the list of ink spots analysed and summarises the XRF results:

To determine whether the difference between the K/Fe mean value of OS.LT and OS.DK data was statistically significant, Welch's t-test was performed. The t-value is well above the critical threshold of the 0.5 per-cent significance level (Table 2). Therefore, the probability that the means are statistically different is 99%. We tentatively attribute the two shades of ink from the original sheets to different writing sessions for which the scribe prepared different batches of ink with different ratios of potassium to iron.

6. Discussion

Iron-gall ink was used throughout the scroll, both on the original sheets and the replacement ones, whereas there was no sign of any carbon ink. This finding is a significant one because there are discussions in rabbinic literature about the permissibility and desirability of adding vitriol (*calcanthum*) to ink (for example, in the *c*. third-century minor tractate *Sefer Torah* 1:5, the *c*. eighth-century minor tractate *Soferim* 1:6 and the twelfth-century *Mishneh Torah* of Maimonides (*Tefillin, Mezuzah and the Torah Scroll* 1:4).[32]

The primary question in this study was what the relationship was between the ink used for the divine appellations in Gen. 1:1–3:5 (the first 1.5 columns) and what was used for the surrounding text. It was clear from visual observations that the two inks were consistently of different shades, indicating that they were probably employed during two separate writing sessions. Unfortunately, limitations in time, place and equipment prevented us from collecting enough XRF data points in Gen. 1:1–3:5 to be able to arrive at unequivocal conclusions about the inks in this section. However, some tentative conclusions can be reached by regarding the two shades of ink used throughout the original sheets (OS.DK and OS.LT) as representative of the visually similar darker and lighter inks used to write the divine appellations and non-sacred words in Gen. 1:1–3:5 respectively (OS.DK.DN and OS.LT.NS). Based on this approach, it can be cautiously concluded that the two shades of ink have the same basic elemental composition and correspond to different batches of ink with different ratios of potassium to iron. The two inks having the same elemental composition is consistent with the divine appellations having been added by the same scribe who wrote the non-sacred words, which appears to be the case on palaeographical grounds.

Another question we answered concerned the relationship between the three replacement sheets (19, 20 and 26) and the original ones. Although the ink on the original sheets did not contain any copper or zinc (or just traces of the elements), the ink from the replacement sheets is characterised by traces of copper and high zinc counts. Such a high signal for zinc may be characteristic of Erfurt as high zinc counts were already found in previous investigations of Erfurt 1 (Staatsbibliothek zu Berlin, Or. fol. 1210-1211)[33] and more recently in a number of manuscripts produced or annotated in Erfurt.[34] Finally, it is highly significant that the three replacement sheets in Erfurt 7 not only closely resemble Erfurt 6 from a palaeographical perspective, but also have the same zinc-rich ink. The latter finding strongly supports the attribution of the replacement sheets to the Erfurt area.

7. Conclusions

This survey was conducted with limitations in terms of time, location and equipment. More specifically, the tests were limited to a two-day period at the facility of the Staatsbibliothek zu Berlin. The examinations required a small portable XRF spectrometer with an interaction spot of 1 mm. In view of these confines, there was only enough time to analyse forty-six 1 mm spots (thirty-five in ink and eleven in the background parchment). Despite our data set being so limited, some important results were obtained:

1. The two shades of ink used throughout the scroll contain the same chemical composition of iron-gall ink.
2. It was tentatively confirmed that the first 1.5 columns of the scroll were written in two stages.
3. A relationship was shown to exist between the zinc-rich ink used for the replacement sheets and other Hebrew manuscripts and Latin annotations from the Erfurt collection.

These results give us a glimpse into the life of the Jews of Erfurt who gathered as a community to inaugurate the writing of the divine names in the Torah scroll, which would serve them in public liturgy for about a century. It seems that the scroll was also repaired using three replacement sheets in this very same community.

These conclusions notwithstanding, some of the textual and paratextual elements could not be reliably analysed. These included ‘crowns’ and other paratextual features for which the

[32] Higger 1930, 22; *Masekhet Soferim*, ed. Higger 1937, 99–100; Maimonides, *Mishneh Torah*, ed. Qafih 2007, vol. 2, 309. For the English translation, see Higger 1930, 9–10.

[33] Hahn et al. 2008.

[34] BAM performed an experimental analysis of the inks used in these manuscripts in 2014, followed by a more detailed investigation of inks from Erfurt 2 in 2019. The results of both experiments are discussed in Martini et al. forthcoming a, and in Martini et al. forthcoming b.

Table 1: Ink spots analysed, with the corresponding category/subcategory, sheet (Sh), column (C), line (L), overall column number (#), word, letter and counts for the elements of interest (after subtracting the parchment's contribution, arbitrary units): sulphur (S), potassium (K), calcium (Ca), manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn). Counts for potassium normalised to iron are also indicated.

Category	Sh	C	#	L	Word	Letter	S	K	Ca	Mn	Fe	Cu	Zn	K/Fe
OS.LT.NS[1]	1	1	1	20	ויאמר	roof of *resh*	11	123	177	17	656	0	0	0.19
OS.DK.DN[2]	1	1	1	20	אלהים	roof of final *mem*	9	101	73	11	375	0	0	0.27
OS.LT.NS	1	1	1	21	הלילה	roof of second *lamed*	10	98	100	17	523	0	0	0.19
OS.LT.NS	1	1	1	54	ויברך	roof of *bet*	20	131	160	22	570	0	0	0.23
OS.DK.DN	1	1	1	54	אלהים	roof of *he*	14	191	105	21	676	0	0	0.28
OS.LT.NS	1	1	1	54	את	foot of *tav*	23	113	143	18	621	0	0	0.18
OS.LT.NS	1	1	1	55	מכל	roof of *lamed*	24	119	79	19	555	0	0	0.21
OS.DK.DN	1	2	2	40	כאלהים	roof of *kaf*	0	334	181	23	1093	0	0	0.31
OS.LT.NS	1	2	2	41	למאכל	roof of first *lamed*	0	189	188	12	776	0	0	0.24
OS.LT[3]	1	2	2	52	ויאמר	roof of resh	5	70	0	0	396	0	0	0.18
OS.LT	1	2	2	52	אלהים	roof of *lamed*	21	160	36	7	650	0	0	0.25
OS.LT	1	2	2	52	אל	oblique line of *alef*	10	111	36	5	564	0	0	0.20
OS.LT	1	2	2	54	ויאמר	roof of *resh*	13	137	22	26	519	0	0	0.26
OS.LT	1	2	2	54	יהוה	roof of first *he*	14	130	0	13	521	0	0	0.25
OS.LT	1	2	41	40	אלהים	roof of *he*	29	143	409	20	1492	0	0	0.10
OS.CR[4]	14	2	41	40	ויאמר	oblique line of *alef*	16	111	425	39	1315	0	0	0.08
OS.DK[5]	14	2	41	40	יהוה	roof of first *he*	19	282	143	18	1133	0	0	0.25
OS.LT	14	2	41	40	וארא	top of *vav*	29	143	409	20	1492	0	0	0.10
OS.LT	14	2	53	36	וגנב	base of *bet*	20	200	166	29	1593	0	0	0.13
RS[6]	18	1	55	41	דברי	*yod*	0	167	362	83	1658	44	3152	0.10
RS	19	1	55	41	יהוה	*yod*	7	122	161	79	1111	82	2863	0.11

[1] OS.LT.NS: light ink from original sheets corresponding to non-sacred words.
[2] OS.DK.DN: dark ink from original sheets corresponding to divine appellations.
[3] OS.LT: other light ink from original sheets.
[4] OS.CR: ink of corrections from original sheets.
[5] OS.DK: other dark ink from original sheets.
[6] RS: ink from replacement sheets (19, 20, 26).

Category	Sh	C	#	L	Word	Letter	S	K	Ca	Mn	Fe	Cu	Zn	K/Fe
RS	19	2	77	53	אני	*yod*	24	150	45	87	1349	96	3349	0.11
RS	26	2	77	53	יהוה	*yod*	27	167	14	116	1624	132	3848	0.10
OS.CW[7]	26	3	83	36	שעטנז	crowns	0	129	81	18	544	2	0	0.24
OS.LT	28	3	83	36	כלאים	oblique line of *alef*	9	136	151	3	1296	0	0	0.10
OS.CR	28	3	83	43	לכם	roof of *kaf*	23	128	1505	55	1470	19	31	0.09
OS.CR	28	3	83	42	להטיבך	roof of *he*	25	89	1624	30	532	4	5	0.17
OS.DK	43	3	129	55	דבר	roof of *resh*	8	214	189	14	532	0	0	0.40
OS.DK	43	3	129	55	יהוה	roof of first *he*	1	158	146	11	396	0	0	0.40
OS.CR	43	3	129	55	אלהיך	erasure line	2	19	0	0	76	0	0	0.25
OS.DK	43	3	129	55	אלהיך	leg of final *kaf*	0	102	0	6	226	0	0	0.45
OS.DK	43	3	129	55	לך	roof of final *kaf*	3	187	145	3	434	0	0	0.43
OS.CW	43	3	129	56	לפניך	right crown of *nun*	4	25	49	6	57	0	0	0.44
OS.DK	43	3	129	56	לפניך	base of *nun*	1	111	65	7	315	0	0	0.35

[7] OS.CW: ink of crowns from original sheets.

inked area is smaller than the interaction-spot size of the micro-XRF spectrometer (1 mm). Furthermore, additional tests are warranted with analysis of more samples from each subcategory of ink in the scroll. This could be accomplished by using an XRF imaging spectrometer that has an adjustable interaction spot ranging from 50 to 650 µm and would allow whole columns of the scroll to be imaged. This would provide us with better statistics as well as readily available information from spatial maps of the elements' distribution. Future tests using this approach would complement the preliminary results presented in this article. The following studies could be performed in this manner:

1. A definitive comparison of the dark brown and light brown inks used to write the divine appellations and the main text respectively in Gen. 1:1–3:5 (the first 1.5 columns) without recourse to a comparison with other sections of the scroll.

2. Investigating the relationship between the divine appellations in the replacement sheets and the surrounding text, which our visual observations indicate were written in two stages.

3. Examining what relationship corrections in the original sheets (written in different scribal hands) have to each other, to the main text of the original sheets and to the text on the replacement sheets.

4. Examining the relationship between the main text and the 'crowns'; the latter were clearly added to the letters, but it is unclear whether the original scribe or a later one made these additions.

5. Looking at how crowns that were added later are related to the original crowns and other corrections.

Analysis with an XRF imaging spectrometer of the aforementioned type would give us an unprecedented glimpse of the life of a medieval Ashkenazic Torah scroll and the Jewish community that once produced it, cherished it, maintained it and revised it.

Table 2: Comparison of K/Fe for the two shades of ink observed on the original sheets.

	OS.LT	OS.DK
Number of spots analysed (n)	16	9
Average K/Fe (μ)	0.19	0.35
K/Fe standard deviation (σ)	0.06	0.08
Degree of freedom from Welch's t-test (df)	$df = \frac{\left(\frac{\sigma_{OS.LT}^2}{n_{OS.LT}} + \frac{\sigma_{OS.DK}^2}{n_{OS.DK}}\right)^2}{\frac{\sigma_{OS.LT}^4}{n_{OS.LT}^2(n_{OS.DK}-1)} + \frac{\sigma_{OS.DK}^4}{n_{OS.DK}^2(n_{OS.LT}-1)}} \approx 22$	
t-value from Welch's t-test	$t = \frac{\lvert\mu_{OS.LT} - \mu_{OS.DK}\rvert}{\sqrt{\frac{\sigma_{OS.LT}^2}{n_{OS.LT}} + \frac{\sigma_{OS.DK}^2}{n_{OS.DK}}}} = 17.6$	
Critical t-value for a significance level α of 0.02	2.508	

REFERENCES

ʿAdat Devorim (1879), in Seligman Baer and Hermann Leberecht Strack (eds.), *Die Dikduke ha-Teamim des Ahron ben Moscheh ben Ascher und andere alte grammatisch-masorethische Lehrstücke zur Feststellung eines richtigen Textes der hebräischen Bibel*, Leipzig: Fernau.

Caspi, Efraim (2014), 'Burnt *Gevil* on the Sabbath of New Moon: Concerning the Torah Scrolls in the Erfurt Collection', *Yerushatenu*, 7: 231–249 (in Hebrew).

—— and Mordechai Veintrob (2011), 'Concerning the Date of Sefer Tagin', *Yerushatenu*, 5: 300–310 (in Hebrew).

Cohen, Zina, Judith Olszowy-Schlanger, Oliver Hahn and Ira Rabin (2017), 'Composition Analysis of Writing Materials in Geniza Fragments', in Irina Wandrey (ed.), *Jewish Manuscript Cultures*, Berlin: De Gruyter, 323–337.

Gordon, Nehemia (2020), 'Blotting Out the Name: Scribal Methods of Erasing the *Tetragrammaton* in Medieval Hebrew Bible Manuscripts', *Textus*, 29: 8–43, 111–155.

—— (forthcoming), 'Scribal Procedures for Writing the *Tetragrammaton* in Medieval Hebrew Bible Manuscripts', *Journal of Jewish Studies*.

Hahn, Oliver, Wolfgang Malzer, Birgitt Kanngießer and Burkhard Beckhoff (2004), 'Characterization of Iron-Gall Inks in Historical Manuscripts and Music Compositions Using X-ray Fluorescence Spectrometry', *X-ray Spectrometry*, 33: 234–239.

——, Timo Wolff, Hartmut-Ortwin Feistel, Ira Rabin and Malachi Beit-Arié (2008), 'The Erfurt Hebrew Giant Bible and the Experimental XRF Analysis of Ink and Plummet Composition', *Gazette du livre médiéval*, 51: 16–29.

Higger, Michael (ed. and trans.) (1930), *Seven Minor Treatises*, New York: Bloch.

—— (ed.) (1937), *Masekhet Soferim*, New York: Debe Rabanan.

Isaac of Corbeil (1556), *ʿAmude ha-Golah*, Cremona: Vincenzo Conti.

Kennicott, Benjamin (1776–1780), *Vetus Testamentum Hebraicum cum Variis Lectionibus*, 2 vols, Oxford: Clarendon.

Krekel, Christoph (1999), 'The Chemistry of Historical Iron Gall Inks', *International Journal of Forensic Document Examiners*, 5: 54–58.

Maimonides, Moses, *Mishneh Torah*, ed. by Yosef Qafih (2001–2007), 25 vols, 4th edn, Jerusalem: Machon Mishnat ha-Rambam.

Martini, Annett, Zina Cohen, Olivier Bonnerot, Oliver Hahn, and Ira Rabin (forthcoming a), 'New Perspectives on the Hebrew Manuscripts from the Erfurt Collection on Grounds of Experimental XRF Ink Analysis'.

——, Olivier Bonnerot, Grzegorz Nehring, Zina Cohen, and Ira Rabin (forthcoming b), 'The Genesis and Reception of the Bible Codex Ms. or. fol. 1212 in the Light of Ink Analysis'.

Meʾir ben Barukh of Rothenburg, *Teshuvot Pesaqim u-Minhagim*, ed. by Isaac Zeʾev Kahana (1957–1977), 4 vols, Jerusalem: Mosad ha-Rav Kook.

Meʾir ha-Kohen of Rothenburg (1524), *Haggahot Maimuniyyot*, Venice: Bragadini.

Menaḥem ben Solomon ha-Meʾiri, *Qiryat Sefer: ʿal Hilkhot Sefer Torah, Tefillin u-Mezuzah*, ed. by Moshe Hershler (1956), Jerusalem: Hamasorah.

Michaels, Marc (2020), *Sefer Tagin Fragments from the Cairo Genizah*, Leiden: Brill.

Mrusek, Ralf, Robert Fuchs and Doris Oltrogge (1995), 'Spektrale Fenster zur Vergangenheit. Ein neues Reflektographieverfahren zur Untersuchung von Buchmalerei und historischem Schriftgut', *The Science of Nature*, 82/2: 68–79.

Olszowy-Schlanger, Judith (2019), 'The Making of the Bologna Scroll: Palaeography and Scribal Traditions', in Mauro Perani (ed.), *The Ancient Sefer Torah of Bologna: Features and History*, Leiden: Brill, 107–134.

Otto, Matthias (2017), *Statistics and Computer Application in Analytical Chemistry*, 3rd edn, Weinheim: Wiley-VCH Verlag GmbH & Co.

Penkower, Jordan (2014), 'The Ashkenazi Pentateuch Tradition as Reflected in the Erfurt Hebrew Bible Codices and Torah Scrolls' in Frank Bussert, Sarah Laubenstein and Maria Stürzebecher (eds), *Zu Bild und Text im jüdisch-christlichen Kontext im Mittelalter* (Erfurter Schriften zur jüdischen Geschichte, vol. 3), Jena: Bussert & Stadeler, 118–141.

—— (2019), 'The 12th–13th Century Torah Scroll in Bologna: How It Differs from Contemporary Scrolls' in Mauro Perani (ed.), *The Ancient Sefer Torah of Bologna: Features and History*, Leiden: Brill, 135–166.

—— (2020), 'Graphic Fillers and Marginal Corrections in the Bologna Torah Scroll' in Yitzhak Berger and Chaim Milikowsky (eds), '*In the Dwelling of a Sage Lie Precious Treasures*': *Essays in Jewish Studies in Honor of Shnayer Z. Leiman*, New York: Yeshiva University Press, 33–49.

Rabin, Ira, Roman Schütz, Anka Kohl, Timo Wolff, Roald Tagle, Simone Pentzien, Oliver Hahn, and Stephen Emmel (2012), 'Identification and Classification of Historical Writing Inks in Spectroscopy: A Methodological Overview', *Comparative Oriental Manuscript Studies Newsletter*, 3: 26–30.

—— (2017), 'Building a Bridge from the Dead Sea Scrolls to Mediaeval Hebrew Manuscripts', in Irina Wandrey (ed.), *Jewish Manuscript Cultures*, Berlin: De Gruyter, 309–322.

Strauss, Abraham (2012), 'Space between Verses in Writing Torah Scrolls, Tefillin and Mezuzahs', *Yerushatenu*, 6: 207–222 (in Hebrew).

Ta-Shema, Israel (1977), 'Towards a Characterisation of 14th-century German Rabbinic Literature', *Alei Sefer*, 4: 20–41 (in Hebrew).

Welch, Bernard Lewis (1951), 'On the Comparison of Several Mean Values: An Alternative Approach', *Biometrika*, 38: 330–336.

Wistinetzki, Jehuda (ed.) (1924), *Yehuda he-Ḥasid, Sefer hasidim = Das Buch der Frommen nach der Rezension in Cod. de Rossi No. 1133*, mit einer Einleitung von Jakob Freimann, Frankfurt: Wahrmann.

Yedidyah Norzi, *Minḥat Shai*, ed. by Zvi Betzer and Yosef Ofer (2005), Jerusalem: World Union of Jewish Studies.

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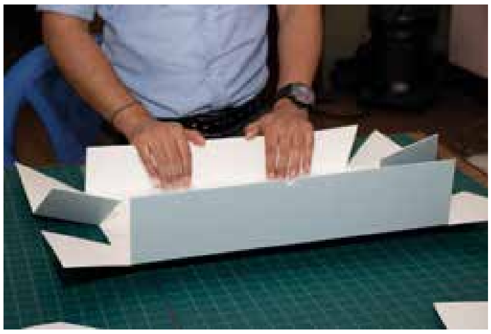

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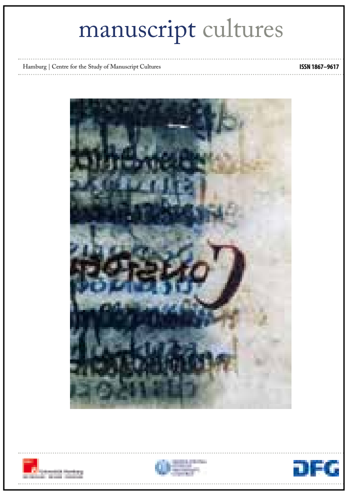

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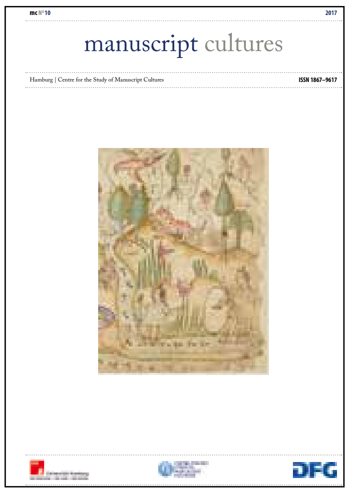

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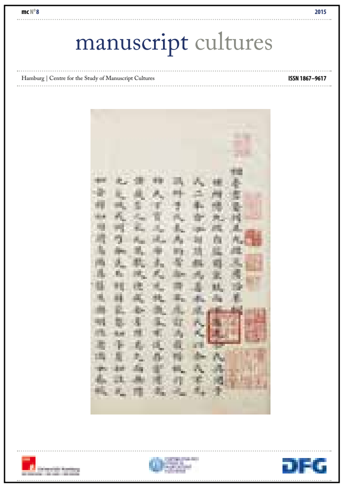

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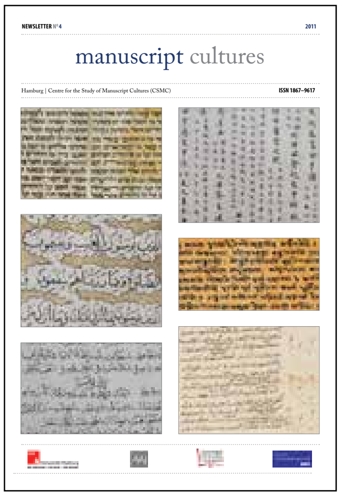

Studies in Manuscript Cultures (SMC)

Ed. by Michael Friedrich, Harunaga Isaacson, and Jörg B. Quenzer

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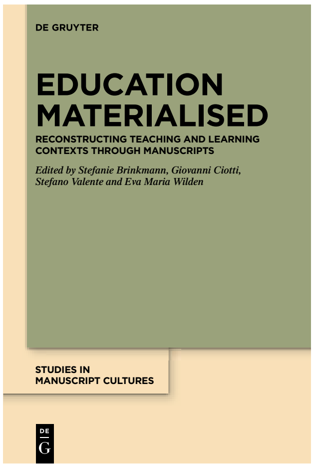
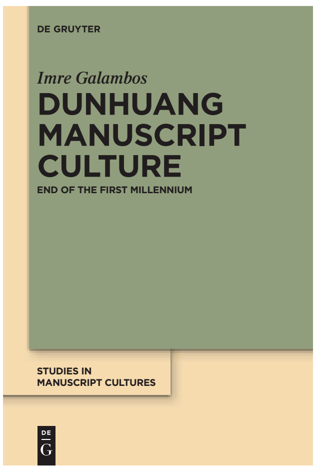
Forthcoming



23 – *Education Materialised: Reconstructing Teaching and Learning Contexts through Manuscripts,* edited by Stefanie Brinkmann, Giovanni Ciotti, Stefano Valente and Eva Maria Wilden

Manuscripts have played a crucial role in the educational practices of virtually all cultures that have a history of using them. As learning and teaching tools, manuscripts become primary witnesses for reconstructing and studying didactic and research activities and methodologies from elementary levels to the most advanced.
The present volume investigates the relation between manuscripts and educational practices focusing on four particular research topics: educational settings: teachers, students and their manuscripts; organising knowledge: syllabi; exegetical practices: annotations; modifying tradition: adaptations.
The volume offers a number of case studies stretching across geophysical boundaries from Western Europe to South-East Asia, with a time span ranging from the second millennium BCE to the twentieth century CE.

New release



22 – *Dunhuang Manuscript Culture: End of the First Millennium*, by Imre Galambos

Dunhuang Manuscript Culture explores the world of Chinese manuscripts from ninth–tenth century Dunhuang, an oasis city along the network of pre-modern routes known today collectively as the Silk Roads. The manuscripts have been discovered in 1900 in a sealed-off side-chamber of a Buddhist cave temple, where they had lain undisturbed for for almost nine hundred years. The discovery comprised tens of thousands of texts, written in over twenty different languages and scripts, including Chinese, Tibetan, Old Uighur, Khotanese, Sogdian and Sanskrit. This study centres around four groups of manuscripts from the mid-ninth to the late tenth centuries, a period when the region was an independent kingdom ruled by local families. The central argument is that the manuscripts attest to the unique cultural diversity of the region during this period, exhibiting – alongside obvious Chinese elements – the heavy influence of Central Asian cultures. As a result, it was much less ‘Chinese’ than commonly portrayed in modern scholarship. The book makes a contribution to the study of cultural and linguistic interaction along the Silk Roads.

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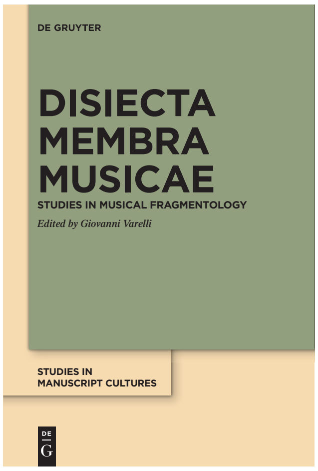
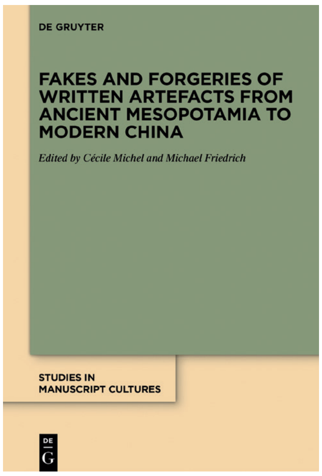


21 – *Disiecta Membra Musicae: Studies in Musical Fragmentology*, edited by Giovanni Varelli

Although fragments from music manuscripts have occupied a place of considerable importance since the very early days of modern musicology, a collective, up-to-date, and comprehensive discussion of the various techniques and approaches for their study was lacking. On-line resources have also become increasingly crucial for the identification, study, and textual/musical reconstruction of fragmentary sources. *Disiecta Membra Musicae. Studies in Musical Fragmentology* aims at reviewing the state of the art in the study of medieval music fragments in Europe, the variety of methodologies for studying the repertory and its transmission, musical palaeography, codicology, liturgy, historical and cultural contexts, etc. This collection of essays provides an opportunity to reflect also on broader issues, such as the role of fragments in last century's musicology, how fragmentary material shaped our conception of the written transmission of early European music, and how new fragments are being discovered in the digital age. Known fragments and new technology, new discoveries and traditional methodology alternate in this collection of essays, whose topics range from plainchant to *ars nova* and fifteenth- to sixteenth-century polyphony.

New release



20 – *Fakes and Forgeries of Written Artefacts from Ancient Mesopotamia to Modern China*, edited by Cécile Michel and Michael Friedrich

Fakes and forgeries are objects of fascination. This volume contains a serie of thirteen articles devoted to fakes and forgeries of written artefacts from th beginnings of writing in Mesopotamia to modern China. The studies empha sise the subtle distinctions conveyed by an established vocabulary relating t the reproduction of ancient artefacts and production of artefacts claiming t be ancient: from copies, replicas and imitations to fakes and forgeries. Fake are often a response to a demand from the public or scholarly milieu, or eve both. The motives behind their production may be economic, political, reli gious or personal – aspiring to fame or simply playing a joke. Fakes may be revealed by combining the study of their contents, codicological, epigraphi and palaeographic analyses, and scientific investigations. However, certain fa mous unsolved cases still continue to defy technology today, no matter hov advanced it is. Nowadays, one can find fakes in museums and private collec tions alike; they abound on the antique market, mixed with real artefacts tha have often been looted. The scientific community's attitude to such objects calls for ethical reflection.

ISSN 1867–9617

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