

# Date, Materiality and Historical Significance of P.Köln Inv. 5941

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The paper presents the results of the radiocarbon dating and ink analysis of a leather fragment bearing an important liturgical text in Hebrew from the early centuries of the common era. The work initiated by the scholarly interest in the text stresses the importance of the date and materiality of the manuscripts and closes with an appeal to the curators of manuscript collections.

## **Introduction**

MS Cologne, Kölner Papyrussammlung, P. Köln inv. 5941<sup>1</sup> is a Hebrew leather fragment that became first known in 1983. Several dating hypotheses, from the very first centuries of the Common Era to the Early Islamic period, have been proposed on the basis of textual and palaeographic research.

Methods from natural sciences, mainly radiocarbon and ink analyses, have now for the first time been applied to the fragment, in order to try to narrow down the possible dating range.

In the following, after a short introduction on the historical background of P. Köln inv. 5941 (§ 1, by Hillel Newman) and a brief description of the codicological aspects (§ 2, by Sophie Breternitz), we present the details on the ink examination (§ 3, by Ira Rabin and Ivan Shevchuk) and radiocarbon dating (§ 4, by Elisabetta Boaretto), followed by the concluding remarks (§ 5).<sup>2</sup>

### **§ 1. P.Köln Inv. 5941 (Hillel I. Newman)**

In 1983, Felix Klein-Franke published a leather fragment,<sup>3</sup> reported to have originated in Oxyrhynchus, bearing a Hebrew text of nine lines. Klein-Franke dated it on palaeographical grounds ‘roughly to the period prior to the fifth century CE’ and interpreted it as a Hebrew lamentation bemoaning the fate the Jews in Egypt in the wake of their failed revolt under Trajan in 115–117 CE.<sup>4</sup> A closer reading of the text, however, reveals this interpretation to be un-

4 Klein-Franke’s transcription is generally reliable but must be corrected at several points. I would like to extend my thanks to Charikleia Armoni for providing me with high-reso-



Fig. 1. P.Köln Inv. 5941, photo courtesy of the Institut für Altertumskunde at the Universität zu Köln.

tenable.<sup>5</sup> I have proposed elsewhere that it must be read, on the contrary, as a thanksgiving prayer of a type familiar from the statutory Jewish liturgy of the first centuries of the Common Era.<sup>6</sup> The text is rich in significant liturgical and palaeographical details (including the singular use of Hebrew *nomina sacra*) and is all the more important considering the rarity of liturgical texts among the already limited number of extant Jewish manuscripts from the period in question.

In order to base my own analysis on sound chronological foundations, it was imperative to establish a reliable date for the manuscript. The most thorough palaeographical study of its script remains that of Edna Engel, who dated it in the range of the second to the fifth centuries CE.<sup>7</sup> On the other hand, Judith Olszowy-Schlanger has argued for a date in the early Islamic period.<sup>8</sup>

Given the uncertainty surrounding the chronology based solely on palaeography, I felt that material analysis could provide further valuable points of reference. With the kind cooperation of Charikleia Armoni, curator of the papyrus collection of the Institut für Altertumskunde at the Universität zu

lution photographs of the manuscript, taken in both visible and infrared light. I have also made use of tracings of the text made by the late Ada Yardeni.

- 5 Compare the reservations concerning the characterization of the text as a lament in Harding 1998, who nevertheless follows Klein-Franke's premise in taking it to refer specifically to the travails of Egyptian Jewry.
- 6 I first presented my analysis of the manuscript on 30 April 2015, at a symposium at the Hebrew University of Jerusalem in honor of Prof. Moshe David Herr. For a revised and expanded study: Newman forthcoming.
- 7 Engel 1990, I, 278–279; III, Table 14. Prior to the completion of the laboratory analysis of the manuscript, Dr Engel informed me in a personal communication of her inclination towards a date preceding the fifth century.
- 8 Olszowy-Schlanger 2017, 55, n. 21.

Köln, and under the supervision of Sophie Breternitz, it became possible to subject the fragment to radiocarbon dating and material analysis that are described in detail below. The manuscript was first conveyed to Ira Rabin for the multispectral analysis of its ink. Subsequently a small sample of leather was removed and sent to Elisabetta Boaretto for the purpose of  $^{14}\text{C}$  dating.<sup>9</sup>

§ 2. *P.Köln Inv. 5941: physical description (Sophie Breternitz)*

MS Cologne, Kölner Papyrussammlung, P. Köln inv. 5941 has been greatly disfigured by heat, and the resulting carbonization (see Fig. 1). The surviving fragment is a leather sheet, which is c. 230 mm wide and 85 mm high at the widest points. The thickness of the leather sheet is c.0.4 mm. The text is written on the hair side.

The writing area measures c.120 mm × 60 mm (width × height). The upper margin is of c.25 mm, the right margin is c.60 mm, and the surviving left margin c.50 mm (the left margin is significantly damaged and deformed). The layout may suggest that the fragment once constituted the upper part of a scroll sheet.

The main text is written in a single column of 9 lines. Ruling is visible at some points: four horizontal blind-point ruled lines are visible in the upper margin; three unevenly spaced vertical blind-point ruling lines are visible in the left margin. In addition, occasional remains of ruling of the writing area, produced in ink, are discernible between some of the lines. The text lines are spaced at c.5 mm, with the evenly written letters being 3 mm tall.

There are also seemingly random letters in both the right and the left margins (all of them are written upside down in the right margin, and most of them in the left margin). These scribbles were probably added later, as they use an ink different from the one of the main text (see the analysis below), yet possibly by the same hand as the main text. Only two letters (?) remain visible in the left margin to the naked eye, yet iron and copper map reveals several upside-down letters in the damaged part (see Fig. 2b). The upper left corner, containing a part of a letter (not clearly identifiable) has detached itself (see Fig. 2a).

The flesh side is uninscribed, which supports the suggestion that we are dealing here with the upper part of a scroll.

9 I gratefully acknowledge the support of the Halpern Center for the Study of Jewish Self-Perception, Bar-Ilan University, under the direction of Prof. Adiel Schremer, for funding the  $^{14}\text{C}$  test at the Weizmann Institute.

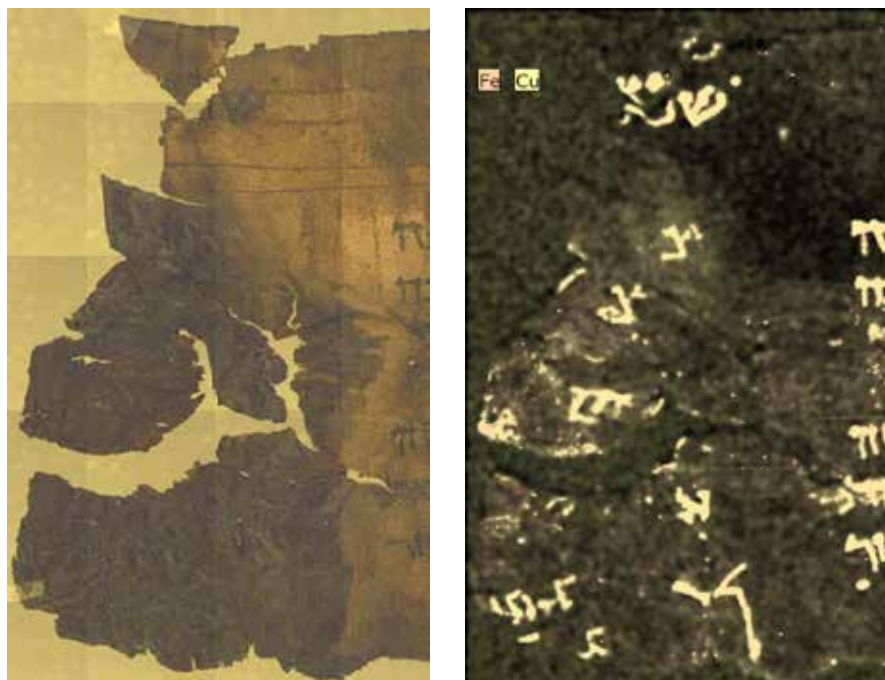


Fig. 2. The damaged left margin, with the carbonized part and the detached upper left corner; (a) white light and (b) XRF imaging with the scribbles revealed.

### § 3. *P.Köln Inv. 5941: material analysis* (Ira Rabin and Ivan Shevchuk)<sup>10</sup>

Research dedicated to the use of different inks in historical Hebrew manuscripts has been conducted in the Bundesanstalt für Materialforschung und -prüfung (BAM) for more than a decade.<sup>11</sup> Currently, we are focusing on the time scale of the transition from the carbon inks of Antiquity to the iron-gall inks of the Middle Ages. The first indications of the metal-containing inks appear in the early Hellenistic times but become more and more pronounced towards the Common era.<sup>12</sup> Initially, these new inks contain both carbon and metals and, most probably, represent a transition phase. Their importance though is reflected in the high number of the extant recipes as well as Talmudic and rab-

10 We gratefully acknowledge the funding support provided by the German Research Foundation (DFG) for the SFB 950 ‘Manuskriptkulturen in Asien, Afrika und Europa’ / Centre for the Study of Manuscript Cultures (CSMC), Universität Hamburg.

11 Rabin 2017.

12 Garlan 1974, 324; Zerdoun 1983, 91–92; Delange et al. 1990; Nir-El and Broshi 1996; Rabin et al. 2019; Bonnerot et al. 2020.

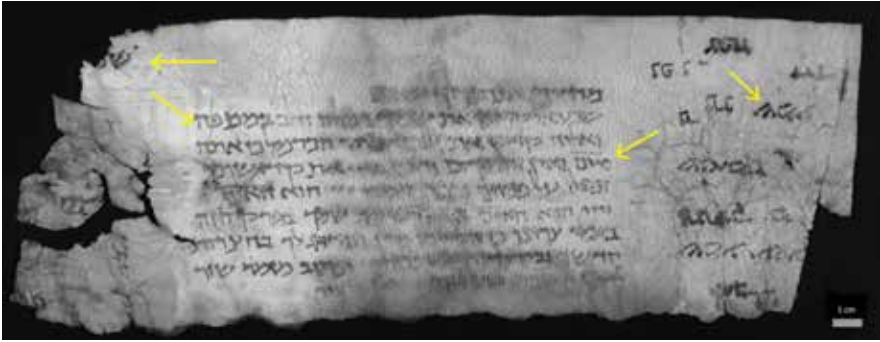


Fig.3. P. Koeln Inv. 5941 photographed at 940 nm and the protocol of the XRF measurements.

binic medieval discussions of the permissible ingredients.<sup>13</sup> In this respect, the Köln manuscript presents a milestone in the material studies since it has been carbon-dated to the fourth century CE, i.e. the ‘intermediate’ period of the Hebrew manuscripts. To study the ink composition, we have used reflectography in the short-wave infrared range (SWIR, 1510–1800 nm) of electromagnetic radiation necessary for the interference-free recognition of carbon and  $\mu$ -X ray fluorescence (XRF) imaging described in detail elsewhere.<sup>14</sup>

The protocol of the ink analysis used in this work consists of the initial screening in the near infrared region to determine the ink type. When ink becomes invisible at the wavelengths around 1000 nm or partially loses its opacity, one speaks of the plant and iron-gall inks, respectively. When the change of the opacity is not very pronounced or not observed, the ink under study could be made of carbon or carbon mixed with other ingredients. Our leather fragment presents such a case. We can see that the ink of the main text is well visible at 940 nm (Fig. 3). At the same time, the marginal scribbles appear much darker, tentatively suggesting that different inks might have been in use in the margins. Generally, opacity of the iron-gall ink depends strongly on the degree of its chemical degradation, which is usually quite heterogeneous. Therefore, the difference in opacity cannot be used as a valid factor for differentiating between the inks. To establish whether the inks contain carbon that would be responsible for the dark colour of the ink, we have used near-infrared photography (Fig. 4) in the wavelength range 1510–1800 nm, performed with Apollo Infrared Imaging System.<sup>15</sup> At wavelengths longer than 1500 nm

13 Rabin 2017, Colini et al. 2018; Cohen 2020, 69–71.

14 Rabin 2015. The measurements were conducted with the M6 (Bruker nano) instrument at 50 kV Rh tube, 50 $\mu$ m X-ray spot, 100ms dwell time and 50 $\mu$ m pixel size.

15 The regular SWIR sensing range (900–1800 nm) of the 128  $\times$  128 pixel scanning InGaS sensor of the Apollo IR imaging system was reduced by a LWP1510 long

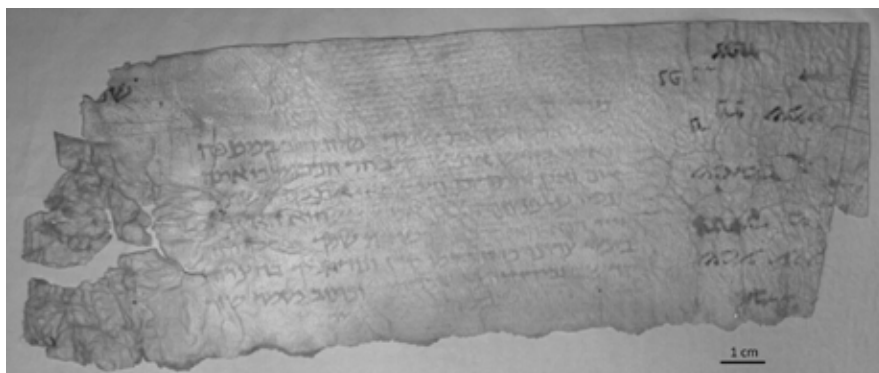


Fig. 4. NIR photograph of the P. Koeln Inv. 5941 at 1510-1800 nm.

carbon still absorbs light, while iron-gall ink is transparent. In Fig. 4 the main text and the text in the margins are still visible indicating the presence of carbon in all the inks. Yet, it is clear from the change of opacity between 940 and 1500 nm that the ink is not of pure carbon and must contain other ingredients, that is, mixed inks were used in this manuscript. Note that the upside-down words in the margins remained without a change, which most probably reflects a higher concentration of carbon in the ink composition.

Fig. 5 visualizes different element distributions from four areas indicated with arrows in the fragment image of the top row. The elemental distributions of iron (Fe), copper (Cu) and potassium (K) in the first, second and fourth columns of the Fig. 3, respectively, demonstrate the presence of these elements in the inks. In the case of the element chlorine (third column), the opposite is true: this element is present only in the leather; the ink layer absorbs the X-rays of chlorine, and therefore, the letter traced by the chlorine distribution appears as a negative image.

It is certain that the inks tested, i.e. both of the main text and of the margins, contain iron gall ink as a second ingredient. Moreover, we can say with a great certainty that vitriol<sup>16</sup> was used as a raw material for iron (Fe) because the ink contains also large amounts of copper (Cu) and smaller amounts of manganese (Mn) and zinc (Zn) as inorganic contaminants (see Fig. 6). Their

wave pass filter that blocks wavelengths shorter than 1510nm, limiting the operation range to 1510–1800nm. Two halogen lamps provided broad band illumination. We used the following settings: sensor to object distance of 80cm, the aperture of the lens was set to f11 and the acquisition time of 50ms per tile.

16 Vitriol is a mixture of hydrated metal sulphates; Karpenko & Norris 2002.

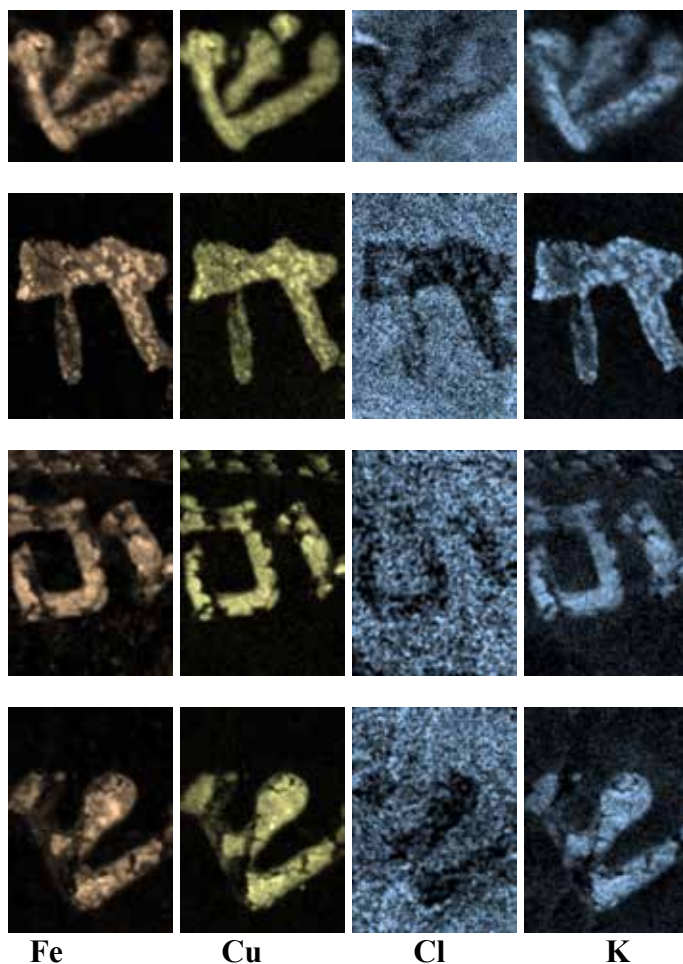


Fig. 5. Iron (Fe), copper (Cu), chlorine (Cl) and potassium (K) distributions corresponding to the four areas indicated in Fig. 3. From top to bottom: 'sin' from the left corner; 'het' from the second row; 'yod samek' from the fourth row; 'sin' from the right margin. Colour intensity correlates with the intensity of the signal.

presence is usually associated with vitriol, a common ingredient of the inks in the Middle Ages.<sup>17</sup>

To compare the composition of the iron-gall ink contribution to the main text with that of the left and right margins, we calculated the relative intensities of the inorganic contaminants in the inked areas (Fig. 6). For a better

<sup>17</sup> Zerdoun 1983.

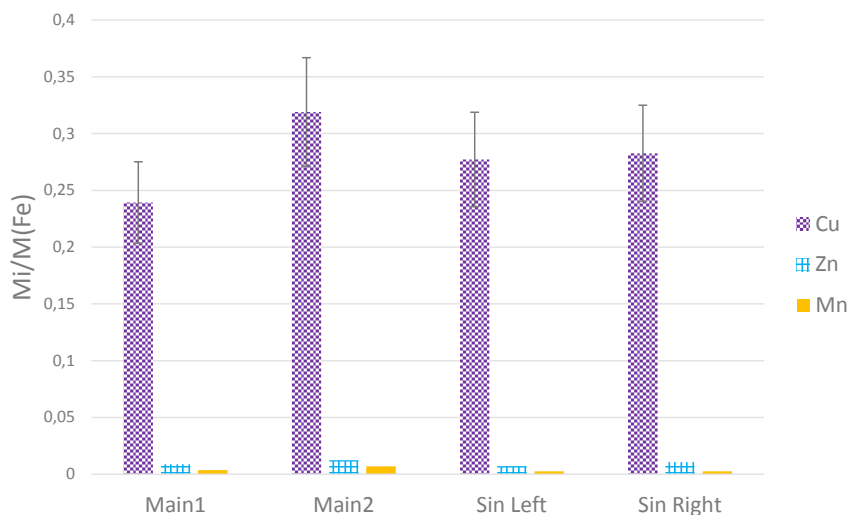


Fig. 6. Relative composition of the inks corresponding to the four areas shown in Fig. 1. Main1 and Main2 correspond to the ‘het’ and ‘yod samek’, respectively. Sin Left and Right correspond to the letter ‘sin’ in the left and right margins, respectively. Relative intensities of the inorganic contaminants manganese (Mn), copper (Cu), and zinc (Zn) were obtained by normalization to the intensity of iron (Fe).

comparison, one must consider the signal background due to the fact that all the elements detected in the inks were also found in varying quantities in the leather. This is in no way surprising, because iron is one of the most widely spread contaminants of the archeological items. In this specific case, the ink loss due to abrasion produced a smear that contaminated leather surface with the ink. In our evaluation of the relative ink composition, we took the elemental composition of the leather into account. Comparison of the inks in Fig. 6 demonstrates that we deal here either with the same iron-gall ink or at least, with an iron-gall ink based on the same vitriol.<sup>18</sup>

#### § 4. P.Köln Inv. 5941: radiocarbon dating (Elisabetta Boaretto)

A sample extracted from the upper left corner of P.Köln inv. 5941 was submitted to the pre-screening procedures at the D-REAMS radiocarbon laboratory (Weizmann Institute) following the preparation procedure published elsewhere.<sup>19</sup> In short, the integrity of the leather was first controlled by comparing

18 Relative intensities of the inorganic contaminants manganese (Mn), copper (Cu), and zinc (Zn) were obtained by normalization to the intensity of iron (Fe). See Rabin et al 2012.

19 Boaretto et al. 2009.



its Fourier Transform Infrared (FTIR) spectrum with that of the pure fresh collagen.<sup>20</sup> The sample was then purified using standard Acid-Base-Acid procedure that consists of three steps.<sup>21</sup> First, the sample was treated with 0.5 N HCl until any sign of mineral dissolution disappeared. Then it was washed with ultra-pure water to remove acidity (pH= 7). In the next step, the sample was cleaned with 0.1 N NaOH for 30 minutes and washed with ultra-pure water again to remove the base (pH= 7). A final acid treatment of 0.5 N HCl for 5 minutes was followed by washing to obtain pH=3. The integrity of the extracted collagen was then again examined using FTIR spectroscopy.

Purified sample was lyophilized for 24 hours, combusted with ~200 mg copper oxide (CuO) in vacuum sealed quartz tubes. Reduction to graphite of the produce CO<sub>2</sub> was obtained on iron (Fe) as a catalyst in the presence of hydrogen gas at 560 °C for 10 hours.<sup>22</sup> The resulting sample was analyzed by accelerator mass spectrometry (AMS) at the D-REAMS radiocarbon laboratory.<sup>23</sup> The calibrated ranges were determined using the OxCal 4.2.4 (2013) software<sup>24</sup> and the calibration tables.<sup>25</sup>

Table 1 summarizes the results of the radiocarbon analysis. Though only 45.3% of the initial sample weight survived the ABA pretreatment procedure, the resulting amount of carbon was sufficient for the dating. Radiocarbon date determined with the D-REAMS accelerator was 1690 ± 23 BP. When calibrated, the year of production of the leather ranges between 335–395 CE at 68.2% probability (corresponding to ±1σ standard deviation) and between 320–410 CE at 85% probability. As a conclusion, although there is a small probability that the leather was created between 255–285 CE (9.8% of the total distribution of the calibrated range), the most probable period associated with the leather manufacture is in the fourth century CE.

Table 1: sample information, recovery data and radiocarbon date of the sample.

20 FTIR was applied following the conventional KBr method and analyzed between 400 and 4000 cm<sup>-1</sup> at 4 cm<sup>-1</sup> resolution using a Thermo Scientific Nicolet iS5 spectrometer with Omnic 9.3 software. The reference libraries of the Kimmel Center for Archaeological Science (Weizmann Institute of Science) Spectra were used as control.

21 Brock et al. 2010; Yizhaq et al. 2005.

22 Goldenberg et al 2017.

23 Regev et al. 2017.

24 Ramsey and Lee 2013.

25 Reimer et al 2013.

Sample ID	Sample type	Efficiency %	Carbon %	<sup>14</sup> C Date year BP	Calendar Date CE	
					±1σ (68.2%)	±2σ (95.4%)
RTD 9269 (Inv. 5941)	Leather fragment 1 × 0.5 cm <sup>2</sup>	45.3	43.7	1690 ± 23	335 – 395	255 (9.8%) 285 320 (85.6%) 410

### § 5. Conclusion (Hillel I. Newman and Ira Rabin)

As we have shown, the earlier palaeographically based hypothesis for the dating of MS Cologne, Kölner Papyrussammlung, P. Köln inv. 5941 is strongly

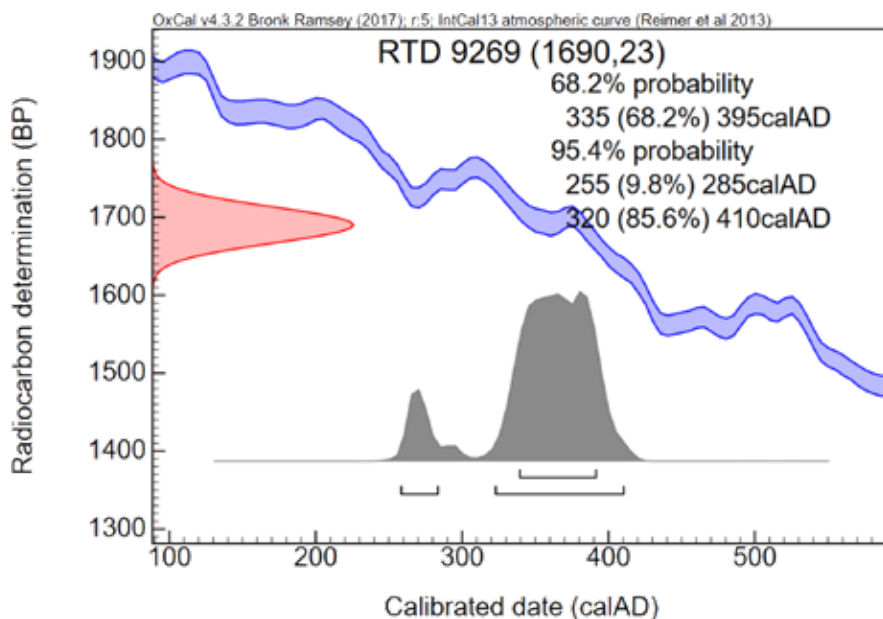


Fig. 7. Illustration of the effect of radiocarbon calibration on the distribution of uncertainty in the calibrated ages of P. Köln inv. 5941. The uncalibrated radiocarbon age and uncertainty are shown as the red distribution, and the marine09 calibration curve representing the apparent radiocarbon age variability caused by changes in the marine  $\Delta^{14}\text{C}$  through time is shown in blue. The resultant calibrated age distribution is shown in gray, with the 95.4% and 68.2% probability bounds shown as bars below.

corroborated and refined by the physical evidence. These results enable us to resolve the chronological uncertainty and place the manuscript confidently in a precise context in Roman-Byzantine Egypt, contemporary with the proliferation of Rabbinic Judaism in Palestine, during a formative period of Jewish liturgy. The date yielded by the physical evidence is fully consistent with the contents of the text itself.

Radiocarbon analysis dates the writing support of P. Koeln Inv. 5941 between 255 CE and 405 CE, heavily weighted to the fourth century. Since in this case there are no visible erasures or other traces of secondary use, we can surmise that we are not dealing with reuse of the support material and that the date of the inscription of the text must be close to the date of the production of the leather.

Ink analysis of the fragment reveals that the inks are of the mixed type, i.e. they contain both vitriol and carbon. Though remarkable, such inks are consistent with the permissible ink ingredients mentioned in rabbinic literature for use in biblical scrolls. Such well-formed iron-gall inks (with a high proportion of iron in the mix) in a manuscript of Late Antiquity is quite remarkable in itself, and in particular in a Jewish manuscript. Currently, we know of only four other manuscripts from roughly the same period where the presence of iron-gall ink was determined by material analysis: MS Berlin, Staatsbibliothek, Ms.or.fol. 987, containing the biblical Proverbs in Akhmimic Coptic,<sup>26</sup> Magic Handbook Berlin P. 5026 in Greek,<sup>27</sup> the literary part of the Montserrat Codex Miscellaneus in Greek and Latin,<sup>28</sup> and MS Vercelli, Biblioteca capitolare, Codice A (Codex Vercellensis Evangeliorum), containing the Four Gospels in Latin.<sup>29</sup>

The significance of these results extends beyond the lone case of the Cologne manuscript. The challenge of dating that manuscript on the basis of its script alone is a function of a much broader problem. As is well known, we possess relatively few Jewish manuscripts in Hebrew and Aramaic from the period following the end of the Bar Kokhba revolt in 135 CE till roughly the tenth century CE.<sup>30</sup> Furthermore, hardly any of the extant items are documents containing explicit dates.<sup>31</sup> Many of the manuscripts have indeed been catalogued by Colette Sirat, but the majority of those have yet to be properly deciphered and published.<sup>32</sup> Yet even if all were readily available for study, palaeographers would continue to be relatively handicapped due to the dearth of material.

32 Sirat 1985. This lacuna should be remedied, at least in part, by the projected fourth volume of the *Corpus Papyrorum Judaicarum*, now in preparation under the supervision of Tal Ilan and Noah Hacham.

It is here that historians and palaeographers stand to benefit by more frequent engagement of chemists and physicists in joint ventures in order to establish more reliable palaeographical benchmarks and material indicators for the purpose of determining the date and provenance of Jewish manuscripts from the lengthy ‘intermediate’ period, still poorly mapped. <sup>14</sup>C dating of Jewish manuscripts from this period is, unfortunately, not a common practice, due to both the challenge of financing and an understandable reluctance to incinerate pieces of ancient manuscripts. The only exception of which we are aware is the charred Leviticus scroll from the ancient synagogue of Ein Gedi, concerning which there is some doubt whether the tested sample in fact originated in the scroll itself or in surrounding material.<sup>33</sup>

The Cologne manuscript now joins this short list. Many of the known Jewish manuscripts in Hebrew and Aramaic await thorough examination, and it is safe to assume that Egypt will yield more such finds over time. We may hope that improving our tools will lead in turn to a deeper understanding of the people who produced these literary and documentary artefacts.

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