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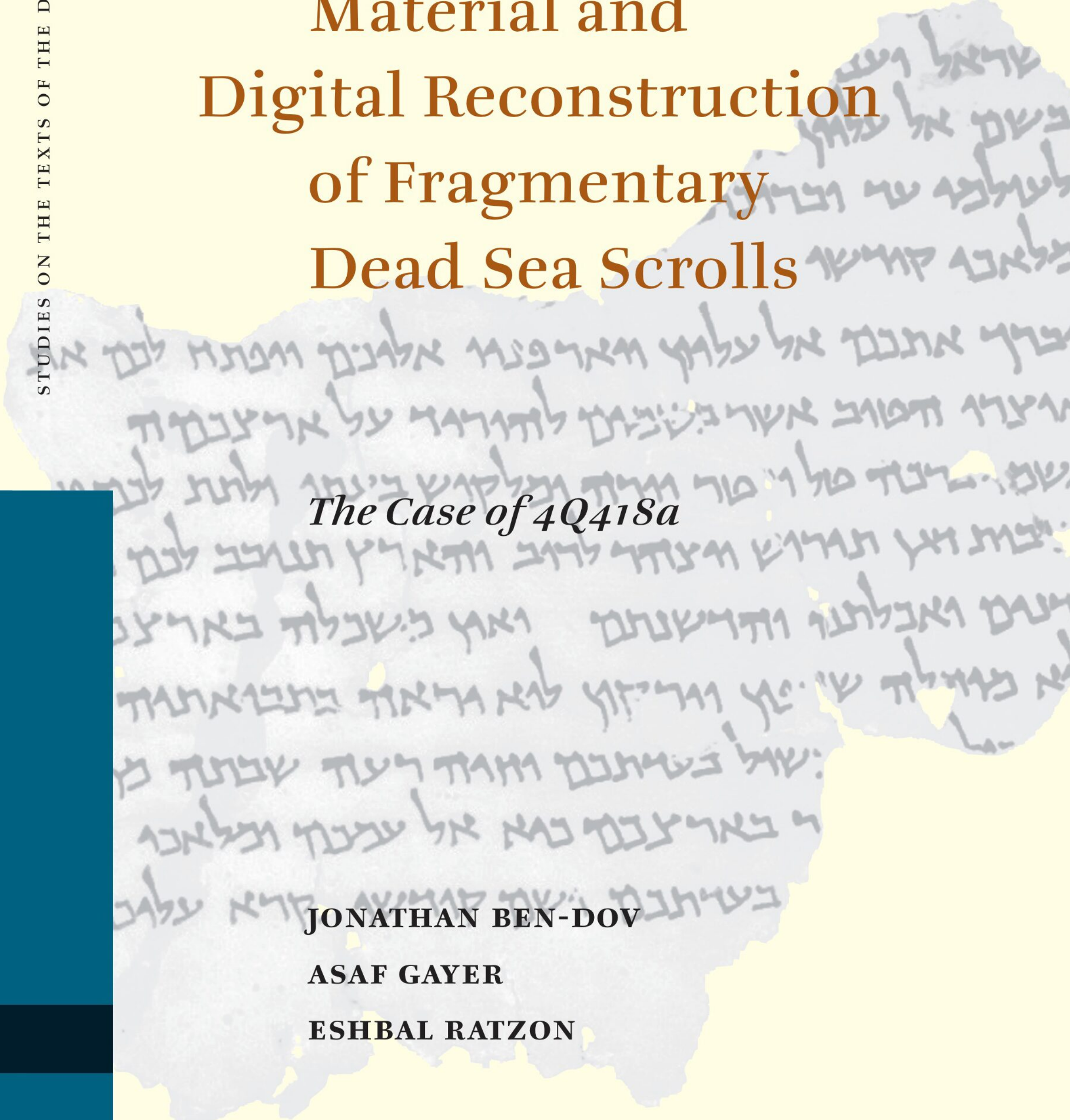

The Case of 4Q418a

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Material and Digital Reconstruction of Fragmentary Dead Sea Scrolls

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By

George J. Brooke

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The present book recounts a series of activities carried out by means of computerized tools, mainly such graphic software as GIMP and Adobe InDesign. These programs were not originally meant for working on scroll fragments, and their abilities and technical requirements thus exceed the normal requirements from the average DSS scholar. The SQE workspace at https://sqe.deadseascrolls.org.il now provides some of the required tools in a dedicated platform for DSS research, and more features will be added in the future. We are grateful to the development team of SQE, headed by Bronson Brown-deVost and Ingo Kottsieper for their continuous efforts in this pioneering task. While learning the aforementioned tools we gained immensely from the advice of many individuals, including Daniel Stökl Ben Ezra and Anthony Perrot from EPHE Paris; Bronson Brown-deVost (Göttingen) initially introduced us to font design, and James Tucker (Göttingen) discussed many themes related to material and digital reconstruction with us.

Our project fundamentally relies on the multispectral images, expertly taken by Shai Halevi and kindly supplied to us by the team of the Scrolls Unit of the Israel Antiquities Authority, headed by Pnina Shor and now by Joe Uziel. The photographer Shai Halevi was most helpful in taking special photos of the fragment 4Q418a 22 and its layers. We are grateful to the IAA team for their cooperation along the way: Orit Rosengarten and Beatriz Riestra for their substantial efforts in numerous matters; Oren Ableman for his attention in registering every fragment and piece of skin, proving useful for locating lost fragments; and the conservators Lena Libman and Tanya Bitler for their useful instruction and expert treatment.

Permission to publish the numerous images from the Leon Levy Digital Library in this volume has been granted according to the regulations of the Israel Antiquities Authority. Images from the Shrine of the Book at the Israel Museum were kindly provided by Hasia Rimon and Yael Barschak.

It has been a pleasure to work in cooperation with computer scientists and software developers, who keep revealing new worlds to us, prompting us into rethinking our methods with an eye towards digitization and data. The team in Tel-Aviv University, headed by Nachum Dershowitz and Lior Wolff and operated most of the time by Adiel Ben-Shalom, has been a constant source of support and advice. The database of the *Qumran Wörterbuch*, developed and run by Ingo Kottsieper and directed by Reinhard Kratz, has been a superb source of inspiration and instruction for us in the ways of storing and handling data. Daniel Stökl Ben Ezra, now a leader of many digital humanities projects, gave us the original impetus for creating digital canvasses of scrolls, and was a constant source of support and advice along the way. The textual branch of SQE at Tel-Aviv University, headed by Noam Mizrahi, proved useful in many ways during our workshops and online discussions.

The present book represents joint and equal work by the three authors, listed in alphabetical order. Joint work also produced chapters 15 and 16, for which Eshbal Ratzon is the primary author. Not a frequent mode of operation in the humanities, this joint work was beneficial for us and for the outcome of the project. It is great pleasure to work in a team, and we would like to express mutual appreciation and gratitude. The team's work gained significantly – in both intellectual content and collegial atmosphere – from additional members of the team at the Universities of Haifa and Tel Aviv. Einat Tamir has been especially resourceful in the complicated matters of font design, and Anna Shirav supported the fragment work on copies of *Instruction* and helped copy-edit the present manuscript. Other friends and colleagues of the team along the years of working on this book are: Moshe Diengott, Hila Dayfani, Shlomi Efrati, Yoel Halevy, in addition to Yigal Bloch, Alexey Yuditsky, and Joshua Matson. Einat Tamir and Rivkah Madmoni helped in performing the font experiment described in Appendix 1.

While working with fragments we benefitted from the wisdom and experience of Elisha Qimron and Eibert Tigchelaar. Eibert Tigchelaar also served as the reader of this volume for STDJ, and together with Torleif Elgvin, who served as the other reader, provided numerous helpful comments. Martin Abegg volunteered to read too and offered valuable comments. We thank them and the editor of the series, George Brooke, for the dedicated feedbacks in various stages of the work. The responsibility of course remains with us.

Rani Arieli and David Guez offered invaluable help in validating the various mathematical formulations found in the book, for which we are enormously thankful. Together with Moshe Diengott, they worked many hours to proofread the calculations throughout the book. Shayna Sheinfeld provided us with dedicated and professional editing: language, style, bibliography, and formatting. The final shape of the book is due very much to her able work. Emma Rapoport prepared the indices and pointed out several last typos. Dirk Bakker from Brill expertly oversaw the typesetting and proofs, for which we are deeply grateful.

Last but not least, we are fortunate to have worked with Reinhard Kratz, who spent an entire semester in Haifa during the project's work, and generously offered us much advice and instructive assistance. In fact, the very idea to make this study into a monograph was suggested by him, and we are deeply indebted to him for that.

Tables and Figures

Tables

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INTRODUCTION

The Present Volume

The study of the Dead Sea Scrolls (DSS) in the twenty-first century stands on the shoulders of giants. Scholars in the first and second generations (roughly 1950–2000), with enormous diligence and more than a touch of brilliance, have made it possible for present-day scholars to pursue the study of the scrolls in advanced ways. This was facilitated by the full availability of the DSS corpus in various editions, by studying scroll fragments and producing new critical editions. This task reached what seemed like a closure in 2010 with the completion of the series Discoveries in the Judaean Desert and the ensuing celebrations. Nowadays, many scholars of the scrolls pay little attention to the actual fragments, relying instead on the masterful editions available in DJD or other editions that have been achieved since then. Yet, the deeper we delve into studying the editions, the more it becomes clear that work remains and that the original fragments cannot be left behind.

The importance of the fragments and scrolls as artifacts rather than mere "texts" was underscored in recent decades, with the strengthening of New Philology or material philology,[1] and with the creation of a new theoretical field of digital scholarly editions.[2] A discipline of "manuscript studies" has

1 The forerunners of this scholarly trend appeared in the late 1980s and early 1990s in the field of Medieval studies, central landmarks being: Bernard Cerquiglini, *In Praise of the Variant: A Critical History of Philology*, trans. Betsy Wing (Baltimore: Johns Hopkins University Press, 1999); Stephen G. Nichols, "The New Philology: Introduction: Philology in a Manuscript Culture," *Speculum* 65 (1990): 1–10. See a convenient recent survey by Matthew Driscoll, "The Words on the Page: Thoughts on Philology, Old and New," in *Creating the Medieval Saga: Versions, Variability and Editorial Interpretations of Old Norse Saga Literature*, ed. Judy Quinn and Emily Lethbridge (Odense: Syddansk Universitetsforlag, 2010), 85–102 (also available at http://www.driscoll.dk/docs/words.html).

2 Patrick Sahle, *Digitale Editionsformen: Zum Umgang mit der Überlieferung unter den Bedingungen des Mediawandels*, 3 vols. (Norderstedt: BOD, 2013); Matthew J. Driscoll and Elena Pierazzo, *Digital Scholarly Editing. Theories and Practices* (Cambridge, UK: Open Book Publishers, 2016); Elena Pierazzo, *Digital Scholarly Editing: Theories, Models and Methods* (Burlington, VT: Ashgate, 2015); Roman Bleier et al., ed., *Digital Scholarly Editions as Interfaces*, Institut für Dokumentologie und Editorik 12 (Norderstedt: BOD, 2018). Articles available at https://www.i-d-e.de/publikationen/schriften/bd-12-interfaces/; Tara L. Andrews, "The Third Way: Philology and Critical Edition in the Digital Age," *Variants: The Journal of the European Society for Textual Scholarship* 10 (2013): 61–76.

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now been established and keeps drawing scholarly attention.[3] Such trends are not new to the field of DSS study but are constantly changing, and should be kept in mind in current and future work.[4] DSS scholars have been applying many material or "new" aspects into their work routine, but a full-length book depicting the entire protocol is still lacking. The present book is an attempt to help fill this lacuna.

Beyond the theoretical frameworks of material philology and digital scholarly editions, recent years have also seen innovations in the resources and the tools available for scholars.[5] A central impetus for renewed editions of the DSS is supplied by the superb new images produced in the Leon Levy Dead Sea Scrolls Digital Library (LLDSSDL) (www.deadseascrolls.org.il), operated by the Israel Antiquities Authority. This project, launched in 2011, has transformed the study of the scrolls, offering scholars an improved high-resolution view of new and advanced images, with useful bibliographic links. The launch of this project initiated a wave of material studies of the scrolls and brought forth numerous improved editions. The LLDSSDL joined forces with the lexical venture of the Qumran Wörterbuch (QWB), operated by the Akademie der Wissenschaften zu Göttingen, which has assembled a massive amount of lexical and morphological information on the scrolls, analyzed and maintained by means of a robust and flexible database. These two datasets, together with associates, created the project Scripta Qumranica Electronica (SQE). The first

3 Alessandro Bausi (general editor), *Comparative Oriental Manuscript Studies* (Hamburg: Tredition, 2015). E-book available at https://www.aai.uni-hamburg.de/en/comst/publications/handbook.html; Liv Ingeborg Lied and Hugo Lundhaug, eds., *Snapshots of Evolving Traditions. Jewish and Christian Manuscript Culture, Textual Fluidity, and New Philology*, TUGAL 175 (Berlin: de Gruyter, 2017); Bradford A. Anderson, ed., *From Scrolls to Scrolling: Sacred Texts, Materiality, and Dynamic Media Cultures* (Berlin: de Gruyter, 2020); Anna Krauss, Jonas Leipziger, and Friedrike Schücking-Jungblut, eds., *Material Aspects of Reading in Ancient and Medieval Cultures*, Materiale Textkulturen 26 (Berlin: de Gruyter, 2020).

4 Mika Pajunen, "Perspectives on the Existence of a Particular Authoritative Book of Psalms in the Late Second Temple Period," *JSOT* 39 (2014): 139–63; Eibert Tigchelaar, "The Qumran Jubilees Manuscripts as Evidence for the Literary Growth of the Book," *RevQ* 26 (2014): 579–94; Matthew P. Monger, "4Q216 and the State of Jubilees at Qumran," *RevQ* 26 (2014): 595–612; Matthew P. Monger, "The Development of 'Jubilees' 1 in the Late Second Temple Period," *JSP* 27 (2017): 83–112; Matthew P. Monger, "4Q216: Rethinking Jubilees in the First Century BCE" (Ph.D. diss., MF Norwegian School of Theology, 2018), https://mfopen.mf.no/mf-xmlui/handle/11250/2491963; Eva Mroczek, "Thinking Digitally about the Dead Sea Scrolls: Book History Before and Beyond the Book," *Book History* 14 (2011): 241–69.

5 This introduction addresses a series of methodological issues, all of which stand in conversation with scores of previous scholarly studies. Since these issues will be addressed in detail in the following chapters, we limit the bibliographical references here to a minimum, focusing on items from the past decade.

aim of the project is to provide full access to the scrolls, both the images and the text.[6] This will be achieved by means of a virtual working environment, whereby users will have access to the information and tools that will enable them to produce canvasses of scrolls and link them to the text of these scrolls. The methodological path depicted in this book is the path of SQE, which will be made available to users on the project's website. Many of the methods described in the present volume were developed within the framework of SQE.

Our work on the treatise known as *Instruction* (or 4QInstruction, or Musar Le-Mevin, or otherwise) is one of the model editions created in the framework of SQE. Since one of our goals in this project is to address texts that present a variety of challenges, we chose *Instruction* because of its numerous codicological and textual problems. In terms of codicology, this is one of the most difficult compositions from Qumran; we will touch on the intellectual content only briefly in this book. We acknowledge that material aspects of *Instruction* have been studied by some of the most competent readers of scrolls: beginning with the edition by John Strugnell and Daniel Harrington, based on the first material reconstruction by Annette Steudel and Birgit Lucassen, through the achievements of Torleif Elgvin and Eibert Tigchelaar, and until the improved composite edition by Elisha Qimron. We nevertheless hope to break new ground, both for *Instruction* and for the scrolls in general. We dare say that almost every previously studied scroll may yield improved results if treated with new material and digital methods such as we are proposing in this book.

In the framework of SQE, James Tucker carried out work on the copies of Serekh Hayaḥad. This dissertation presents digital and material restorations of various scrolls using similar methods to those employed in the present book but at the same time differ from them by presenting a more strictly automated approach.[7] This dissertation has reached us only after the completion of the present book.

Although using many kinds of software, the work presented in this book is not yet automated; it was carried out manually, requiring numerous hours of labor. In the plans of the project SQE, much of this work – such as locating images in the log or calculating the width of reconstructed columns – will

6 For descriptions of the project see Bronson Brown-deVost, "Scripta Qumranica Electronica (2016–2021)," *HEBAI* 5 (2016): 307–15; Eshbal Ratzon and Asaf Gayer, "Scripta Qumranica Electronica – Electronic Resources," in *The Textual History of the Bible. Vol. 3: Dictionary of Textual Criticism*, ed. Sidnie W. Crawford et al. (Leiden: Brill, *forthcoming*).

7 James M. Tucker, "From Ink Traces to Ideology: Material, Text and Composition of Qumran *Community Rule* Manuscripts," (Phd diss., University of Toronto, 2021).

be carried out by means of automated algorithms, rendering it truly "digital."[8] The current SQE platform (https://sqe.deadseascrolls.org.il/) offers the ability to perform some of the required functions using built-in applications, thus absolving the need to rely on commercial software or on complicated software that offers many unnecessary features for the scholar of the DSS.

With technology advancing at the blink of an eye, writing a book about technology is quite tricky. Today's avant-garde will quickly become a mere antiquarian piece in hindsight. The pioneering book of Armin Lange from 1993 is instructive in this regard.[9] In that book, Lange gave detailed instructions, step by step, on how to apply filters to images or to copy and paste the shapes of letters, using programs that are no longer in use today. Giving detailed instructions for working with, say, GIMP or Adobe InDesign, will make this book outdated within a decade or less. We thus convey the principles and methodology for carrying out the work without committing to any one specific software.

The present book offers general guidelines as well as methodological reflections on various aspects of the protocol explored herein, and will thus be useful for scholars as a means of controlling the work and monitoring its results. The book consists of two parts. The first part presents a protocol for studying and reconstructing highly fragmentary scrolls while emphasizing methodological issues derived from it. The second part applies the procedure to the rather meager fragments of 4Q418a (4QInstruction^{e}).[10] This scroll is a worthy

8 See for example Taivanbat Badamdorj, Adiel Ben-Shalom, and Nachum Dershowitz, "Matching and Searching the Dead Sea Scrolls," in *Proceedings of the 2018 IEEE International Conference on the Science of Electrical Engineering in Israel* (*ICSEE*), (Piscataway, NJ: 2018), 1–5; Gil Sadeh et al., "Viral Transcript Alignment," in *Proceedings of the 2015 13th International Conference on Document Analysis and Recognition* (*ICDAR*) (IEEE Computer Society, USA, 2015), 711–15, doi: 10.1109/ICDAR.2015.7333854. The following tool seems to be a promising platform for continuing this research: Benjamin Kiessling et al., "eScriptorium: An Open Source Platform for Historical Document Analysis," in *2019 International Conference on Document Analysis and Recognition Workshops* (*ICDARW*) (Sydney, Australia, 2019), 19, doi: doi.org/10.1109/ICDARW.2019.10032; Maruf A. Dhali, Sheng He, Mladen Popović, Eibert Tigchelaar, and Lambert Schomaker, "A Digital Palaeographic Approach towards Writer Identification in the Dead Sea Scrolls," in *Proceedings of the 6th International Conference on Pattern Recognition Applications and Methods* (Porto: Scitepress, 2017), 693–702; Maruf A. Dhali, Jan W. de Wit, and Lambert Schomaker, "BiNet: Degraded-Manuscript Binarization in Diverse Document Textures and Layouts using Deep Encoder-Decoder Networks," https://arxiv.org/abs/1911.07930.

9 Armin Lange, *Computer-Aided Text-Reconstruction and Transcription: CATT Manual* (Tübingen: Mohr Siebeck, 1993); Armin Lange, "Computer Aided Text-Reconstruction and Transcription (CATT) Developed with the Dead Sea Scrolls," in *New Qumran Texts and Studies*, ed. George J. Brooke and Florentino García Martínez, STDJ 15 (Leiden: Brill, 1994), 223–32.

10 The words "protocol" and "procedure" are used here interchangeably.

example for the suggested method, and indeed we suggest significant improvements to its reconstruction. In research carried out outside this book, we have applied the same method to other copies of *Instruction*, striving to reach a complete edition of this composition and its multiple copies. Work on other copies will be fully addressed in other publications, as well as in the comprehensive framework of SQE.[11]

Many of the elements of what is called here "a method" or "a procedure" are in fact common-sense practices that have been employed by previous competent editors of the scrolls. Digital or not, it is crucial to collect all images of a given fragment and examine them closely, as well as to make reliable estimates of column widths, etc. Scholars have been assembling scrolls and producing editions for many years, and many of them paid attention to the methodological aspects of their work, fleshing out the problems and the rules-of-thumb guiding them. Of special importance in this regard are the series of studies by Hartmut Stegemann on material reconstruction.[12] Significant elucidation of the procedure in other aspects, not necessarily material reconstruction, appears in recent studies by Annette Steudel, Eibert Tigchelaar, Émile Puech, Torleif Elgvin, and Daniel Stökl Ben Ezra.[13] The present book, however, seeks to present a systematized and detailed view of the protocol. Its aim and culmination are in the production of a digital canvas of the scroll under discussion,

11 See for example Eshbal Ratzon, "New Data for the Reconstruction of 4Q418a," [Hebrew] *Meghillot* 14 (2019): 25–38; Asaf Gayer, "A New Reconstruction of the 'Wisdom of the Hands' Unit in 4QInstructiond (4Q418)," *JSP* 30 (2020): 60–73; Gayer, "New Readings and Joins in the Wisdom Composition *Instruction*," [Hebrew] *Meghillot* 15 (2021): 21–44; Hila Dayfani, "Material Reconstruction, New Joins and Readings in 4Q415," *RevQ* 33 (2021): 161–202.

12 The foundational presentation of this method is Hartmut Stegemann, "Methods for the Reconstruction of Scrolls from Scattered Fragments," in *Archaeology and History in the Dead Sea Scrolls: The New York University Conference in Memory of Yigael Yadin*, ed. Lawrence H. Schiffman, JSPSup 8 (Sheffield: JSOT, 1990), 189–221.

13 Eibert Tigchelaar, "Constructing, Deconstructing and Reconstructing Fragmentary Manuscripts, Illustrated by a Study of 4Q184 (4QWiles of the Wicked Woman)," in *Rediscovering the Dead Sea Scrolls: An Assessment of Old and New Methods*, ed. Maxine L. Grossman (Grand Rapids, MI: Eerdmans, 2010), 26–47; Émile Puech, "Édition et reconstruction des manuscrits," *Henoch* 39 (2017): 105–25; Torleif Elgvin, "How to Reconstruct a Fragmented Scroll: The Puzzle of 4Q422," in *Northern Light on the Dead Sea Scrolls*, ed. Anders Klostergaard Petersen et al., STDJ 80 (Leiden: Brill, 2009), 223–36; Daniel Stökl Ben Ezra, *Qumran: Die Texte vom Toten Meer und das antike Judentum*, Jüdische Studien 8 (Tübingen: Mohr Siebeck, 2016). The studies by Tigchelaar and Elgvin give a detailed account of the work on one particular scroll, while Stökl's is a handbook giving a short and updated account of all aspects of DSS research, with special attention given to the reading and reconstruction.

while also addressing the main methodological problems that are involved in the procedure.

The use of computerized tools in order to reconstruct scrolls is not new: scholars have been using such tools for a long time now. After a pioneering study by Armin Lange in 1993, many scholars adopted various computerized tools, including the lexical database of QWB.[14] Not many of these scholars, however, reflected on the use of these tools in a systematic manner. A notable contribution in this respect was achieved by Bruce Zuckerman, who produced an unprecedented comprehensive discussion of many of these tools in several articles since 2004.[15]

What we consider new in our method is, first, the commitment to developing and documenting a comprehensive procedure that encompasses all elements of the reading and reconstruction. This procedure, we hope, will be accessible for lay scholars and may thus transform the field. While constructing

14 Lange, *Computer-Aided Text-Reconstruction*; David Hamidović, "In Quest of the Lost Text: From Electronic Edition to Digital Edition of the Dead Sea Scrolls," in *Lire demain: Des manuscrits antiques à l'ère digitale*, ed. Claire Clivaz et al. (Lausanne: Presses Polytechniques et Universitaires Romandes, 2012), 153–66; Michael Langlois, "Les manuscrits araméens d'Hénoch: Nouvelle documentation et nouvelle approche," in *Qoumrân et le Judaïsme du tournant de notre ère: Actes de la table ronde, Collège de France, 16 Novembre 2004*, ed. André Lemaire and Simon C. Mimouni (Paris-Louvain: Peeters, 2006), 111–21; Tamar Lavee, "Computer Analysis of the Dead Sea Scrolls Manuscripts" (MA thesis, Tel-Aviv University, 2013); Torleif Elgvin, Kipp Davis, and Michael Langlois, eds., *Gleanings from the Caves: Dead Sea Scrolls and Artefacts from the Schøyen Collection*, LSTS 71 (London: Bloomsbury T&T Clark, 2016), passim; Emanuel Tov, Kipp Davis, and Robert Duke, eds., *Dead Sea Scroll Fragments in the Museum Collection* (Leiden: Brill, 2016); Daniel Stökl Ben Ezra, "Interdisciplinary Perspectives from Material and Computer Sciences on the Dead Sea Scrolls and Beyond," *Manuscript Cultures* 7 (2014): 92–103; Ingo Kottsieper, "Scientific Technologies," in *T&T Clark Companion to the Dead Sea Scrolls*, ed., George J. Brooke and Charlotte Hempel (London: T&T Clark, 2019), 178–85; James Tucker and Peter Porzig, "Between Artefacts, Fragments, and Texts: An Analysis of 4Q266 Column i," *DSD* 25 (2018): 335–58; Tucker, "From Ink Traces to Ideology."

15 Bruce Zuckerman, "Every Dot and Tiddle: A Consideration of the Limitations of Computer Imaging for the Study of Dead Sea Scrolls," in *Double Takes: Thinking and Rethinking Issues of Modern Judaism in Ancient Contexts*, ed. Zev Garber and Bruce Edward Zuckerman (Lanham: University Press of America, 2004), 183–96; Zuckerman, "The Dynamics of Change in the Computer Imaging of the Dead Sea Scrolls and other Ancient Inscriptions," in *Rediscovering the Dead Sea Scrolls: An Assessment of Old and New Approaches and Methods*, ed. Maxine L. Grossman (Grand Rapids, MI: Eerdmans, 2010), 69–88. Online, updated, and interactive version: https://dornsife.usc.edu/wsrp/dynamics-of-change/; Bruce Zuckerman, Asher Levy, and Marilyn Lundberg, "A Methodology for the Digital Reconstruction of Dead Sea Scrolls Fragmentary Remains," in *Dead Sea Scrolls Fragments in the Museum Collection*, ed. Emanuel Tov, Kipp Davis, and Robert Duke (Leiden: Brill, 2016), 36–58.

it, we dealt with a series of methodological issues that required justification using experimental methods, as is done in the sciences. For example, one will find below a straightforward calculation of the margin of error incurred while operating the suggested protocol; the report of a scientific experiment about the validity of using custom-made fonts for reconstructing missing columns; an assessment of the validity of the Stegemann method for establishing the length of scrolls, and many more.

The main goal of the suggested method is to produce a digital canvas that contains the best images of fragments (after being read with the best technology), that is designed in accurately measured columns and margins, and is accompanied by text (drawn from parallels and set in custom font) around the fragments in a reliable way. Editions could be improved if all scholars provided a digital canvas for their scrolls. The suggested protocol concentrates on several aspects of the procedure: collecting and managing metadata on the scrolls (chapter 1); reliably enhancing the images and improving the readings (chapters 3–8); assembling scrolls on a canvas using graphic software (chapters 9–12); reconstructing lacunae and entire columns using verified methods (chapters 8, 9); and verifying and enhancing the techniques for material reconstruction (chapters 11, 12, 13). The innovations of the present book pertain particularly to the construction of the canvas and improving the method of material reconstruction accordingly. Other elements discussed here can be found in earlier studies and are included in order to provide a comprehensive and systematized protocol for working on fragmentary scrolls. We survey them here as follows:

Collecting metadata. This theme includes identifying all previous images for a given fragment and tracing the history of its discovery and preservation. The basic information for this procedure was initially collected in groundbreaking projects in the 1990s.[16] A later study exemplifying the right procedure for a concrete scroll was produced by Eibert Tigchelaar in 2010.[17] Various other resources of metadata have since then become available.[18] In this book we call

16 Stephen A. Reed, *The Dead Sea Scrolls Catalogue*, SBL Resources for Biblical Study 32 (Atlanta: Scholars Press, 1994); Emanuel Tov with the collaboration of Stephen J. Pfann, *Companion Volume to The Dead Sea Scrolls Microfiche Edition*, 2nd ed. (Leiden: Brill and IDC, 1995). Emanuel Tov, *Scribal Practices and Approaches Reflected in the Texts Found in the Judean Desert*, STDJ 54 (Leiden: Brill, 2004); Emanuel Tov, ed., *The Texts from the Judaean Desert. Indices and Introduction to the Discoveries in the Judaean Desert Series*, DJD XXXIX (Oxford: Clarendon Press, 2002).

17 Tigchelaar, "Constructing, Deconstructing and Reconstructing."

18 The project SQE spent numerous hours clearing out the log of fragments in the IAA records using both manual and automated procedures. In addition, the CS team at

the scholars' attention to the need of managing this vast metadata using standard means such as spreadsheets or other data-managing programs. In addition, we pay special attention to scrolls preserved in wads, both those in which the wads are recognized and those where wads may be suspected but not hitherto recognized.

Images and readings. The new multispectral images by the LLDLDSS set a new standard for imaging technology, alongside the high-resolution images of the Digital Dead Sea Scrolls project of the Shrine of the Book (http://dss.collections.imj.org.il), and the RTI techniques employed by the West Semitic Research project at the University of Southern California (www.inscriptifact.com).[19] New technologies for image manipulation were employed in the recent volumes on the fragments from the Schøyen collection and from the Museum of the Bible.[20] Yet the images of the PAM and IAA collections require additional preparation in order to be used in the reconstruction, like scaling them and separating them from the background. This book offers practical ways for scaling the fragments, removing the background, and digitally repairing them as preprocessing for the digital canvas. In addition, we draw the guidelines for using digital filters for improved viewing of the images.

Reconstructing lacunae and columns. We discuss various ways to fill lacunae by means of reconstructed words. A first method to do so is "letter cloning."[21] While this method is recommended for filling short lacunae, a more robust but less time-consuming method is required for reconstructing large stretches of text, even entire columns. A meticulous study was published in 1997 by Edward Herbert, suggesting "a battery of tools" for reconstructing biblical DSS.[22] Herbert's book discusses every detail of the edition work, from counting letters in a line, to assessing and comparing column widths, and to policies of using margins and vacats, while making ample use of statistics.

Tel-Aviv University has initially developed an algorithm for searching all available images of a given fragment through the enormous photographic log of the PAM and the IAA.

19 See Zuckerman et al., "Methodology for Digital Reconstruction," 37–42.

20 Elgvin et al., *Gleanings*; Tov et al., *Dead Sea Scrolls Fragments in the Museum Collection*. Unfortunately, most if not all of these unprovenanced fragments were proven unauthentic due to the new technologies applied to them. See Kipp Davis et al., "Nine Dubious 'Dead Sea Scrolls' Fragments from the Twenty-First Century," *DSD* 24 (2017): 1–40; Torleif Elgvin and Michael Langlois, "Looking Back: (More) Dead Sea Scrolls Forgeries in the Schøyen Collection," *RevQ* 31 (2019): 111–33.

21 For a definition and discussion of this method see Zuckerman et al., "A Methodology for the Digital Reconstruction," 43–57. Earlier studies who used this method are quoted below, chapter 8.

22 Edward Herbert, *Reconstructing Biblical Dead Sea Scrolls: A New Method Applied to the Reconstruction of 4QSam^a*, STDJ 22 (Leiden: Brill, 1997).

This book is a commendable move forward inasmuch as it raises awareness to the numerous technical issues not sufficiently addressed in previous studies and to the factor of potential error, created by the gap between the expected reconstruction and reality. We have found, however, that Herbert's methodology is too complicated to be applied by lay scholars and is thus limited as a model for future reconstructions.[23] We propose using custom-made computer fonts. Based on an experiment reported in this book, we demonstrate that this method is cost effective, as it retains minimal error, while its time consumption is reasonable. Some automation of this process is within grasp, as described by Bronson Brown-deVost in Appendix 2.

Assembling scrolls on a digital canvas to enhance the material reconstruction. This aspect is in many ways the essence of the work presented in this book. When all fragments are placed on a canvas, with columns and margins accurately drawn around them and the text (when known) completed within the columns using a custom-made font, the reconstruction work can be truly achieved. Such work has been carried out by those scholars who implemented the Stegemann method for material reconstruction by means of scissoring out images of fragments and pasting them on semi-transparent paper, yet we offer ways to computerize the procedure. We present a prefiguration of this method here, using marketplace graphic software. The canvas can then be extrapolated to include entire columns otherwise unattested. Of special interest in this regard is the calculation of the potential margin of error, supplied below for the method of material reconstruction based on recurring damage patterns, as well as for the digital canvas in general.

Several aspects of advanced technological studies of the scrolls will not be addressed here despite recent advances in them. We shall not address any studies of material science, DNA, chemistry, and physics of the scrolls. Nor shall we discuss the technologies of advanced photography and imaging.[24] This book is not meant to be a comprehensive discussion of scribal practices in the scrolls,

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23 See the well-balanced reviews by Emanuel Tov, review of *Reconstructing Biblical Dead Sea Scrolls: A New Method Applied to the Reconstruction of 4QSam[a]*, by Edward Herbert, *DSD* 6 (1999): 215–20, and James VanderKam, review of *Reconstructing Biblical Dead Sea Scrolls: A New Method Applied to the Reconstruction of 4QSam[a]*, by Edward Herbert, *JBL* 119.3 (2000): 558–60.

24 For both these issues see Kottsieper, "Scientific Technologies," 178–85; earlier Jan Gunneweg, Annemie Adriens, and Joris Dik, eds., *Holistic Qumran: Trans-Disciplinary Research of Qumran and the Dead Sea Scrolls*, STDJ 87 (Leiden: Brill, 2010). For the latter issue see Zuckerman, et al., "A Methodology for the Digital Reconstruction," 37–42. For the technology used by the Leon Levy Library see Pnina Shor, et al., "The Leon Levy Dead Sea Scrolls Digital Library: The Digitization Project of the Dead Sea Scrolls," *Journal of Eastern Mediterranean Archaeology and Heritage Studies* 2 (2014): 71–89.

although some innovations in that respect will be encountered. The book will focus almost entirely on leather scrolls, with papyri requiring a slightly modified methodology. Finally, the book will not involve advanced theory of textual editions, in particular digital scholarly editions. While the above noted aspects carry important implications for our field, they are not pertinent to the subject matter of the present volume.

1 The Stegemann Method Reconsidered

The present study carries out material reconstruction using the Stegemann Method. This method was not invented by Stegemann, since much of it is merely common-sense deduction from the available material data in a way known to papyrologists before Stegemann and independently of him.[25] However, Stegemann was the one who standardized it and presented an expedient procedure to scholars of the DSS. He also produced his own reconstructions of exemplary scrolls, notably the Hodayot scroll from Cave 1.[26] Stegemann instructed his students in this method, and many still make the pilgrimage to Göttingen to benefit from the instruction of Annette Steudel in it.[27] After Stegemann's first programmatic article in 1990,[28] he and Steudel published several useful articles, introducing some updates to the method.[29] We reproduce

25 This method is first mentioned by the great Egyptologist Ludwig Borchardt, "Bemerkungen zu den ägyptischen Handschriften des Berliner Museums," *ZÄS* 27 (1889): 118–22. See also Richard Janko, "Philodemus Retartus: Progress in Reconstructing the Philosophical Papyri from Herculaneum," *Proceedings of the Boston Area Colloquium in Ancient Philosophy* 7 (1991): 271–308; Janko, "Reconstructing (Again) the Opening of the Derveni Papyrus," *ZPE* 166 (2008): 37–51; William A. Johnson, *Bookrolls and Scribes in Oxyrhynchus* (Toronto: University of Toronto Press, 2004), 149–50; Holger Essler, "Rekonstruktion von Papyrusrollen auf mathematischer Grundlage," *Cronache Ercolanesi* 38 (2008): 273–307.

26 This work was carried out in Stegemann's dissertation (1963) but was completed and published much later: Hartmut Stegemann with Eileen Schuller, *Qumran Cave 1 III. 1QHodayot^{a} with Incorporation of 1QHodayot^{b} and 4QHodayot$^{a\text{-}f}$,* DJD XL (Oxford: Clarendon Press, 2009).

27 In our application of the method, we owe a debt of gratitude to the workshop *Data, Vision, and Concepts* organized by Bronson Brown-deVost and Peter Porzig in Göttingen, July 2016. The method was skillfully presented at that workshop by Annette Steudel and Peter Porzig. In this workshop we not only gained awareness of the method, but also learned some new developments and practiced them on exemplary scrolls. In that workshop we also benefitted from questions raised by Drew Longacre.

28 Stegemann, "Methods for the Reconstruction."

29 Hartmut Stegemann, "Towards Physical Reconstructions of the Qumran Damascus Document Scrolls," in *The Damascus Document: A Centennial of Discovery*, ed. Joseph M. Baumgarten, Esther G. Chazon, and Avital Pinnick (Leiden: Brill, 2000), 177–200; Annette

here the main steps ("practical techniques") of the Stegemann method, as presented in his 1990 ground-breaking article.[30]

1. Gather all parts of the scroll that clearly come from the top or bottom of a column.
2. Gather all parts of the scroll that clearly show traces of the right or left margin of a column, the transition from one column to the next, or sewing seams.
3. Take note of all uninscribed drylines or even vacat-lines and every indication of transitional devices within the text.
4. Look for notes in the edition indicating whether a fragment was found on top of or beneath some other part of the scroll: if the scroll was rolled with the beginning of its text in the outer layers, a fragment on top of another belongs to the next layer to the left of it; if the beginning of the text was in the innermost layers, a fragment on top of another belongs to the next layer to the right of it. Correspondingly, reference to a fragment beneath some other parts of the scroll sheds light on its former position.
5. Check the shapes of all parts and fragments of the scroll against one another, looking especially for corresponding points or shapes of damage. The closer the correspondences, the nearer these pieces may have been to one another in the scroll.
6. Establish the average width of the columns. If there is no preserved evidence of column width, one may try to ascertain the limits within which a column of this scroll must have been written.
7. Establish the number of lines in each regular column. If there is no preserved evidence of this kind, i.e., no part of the scroll preserving the lines of a column from top to bottom, one may calculate the minimum and maximum lines possible.
8. Confirm the way the scroll was rolled when deposited in the cave. This is established by observing whether the distances between corresponding

Steudel, *Der Midrasch zur Eschatologie aus der Qumrangemeinde (4QMidrEschat^{a,b}): Materielle Rekonstruktion, Textbestand, Gattung und traditionsgeschichtliche Einordnung des durch 4Q174 ("Florilegium") and 4Q177 ("Catena A") repräsentierten Werkes aus den Qumranfunden*, STDJ 13 (Leiden: Brill, 1994); Steudel, "Assembling and Reconstructing Manuscripts," in *The Dead Sea Scrolls after Fifty Years: A Comprehensive Assessment*, ed. Peter W. Flint and James C. VanderKam (Leiden: Brill, 1999), 1.516–34; Steudel, "Reading and Reconstructing Manuscripts," in Brooke and Hempel, *T&T Clark Companion*, 186–91. The chain of Göttingen studies continues with: Reinhard Kratz, ed., *Interpreting and Living God's Law at Qumran. Miqṣat Maʿaśe Ha-Tora: Some of the Works of the Torah (4QMMT)*, SAPERE 33 (Tübingen: Mohr Siebeck, 2020).

30 Stegemann, "Methods for the Reconstruction," 205–06.

points of damage increase or decrease as one moves from right to left or vice versa.

9. Check the general appearance of all remains of the scroll, whether there are groups of pieces more similar to one another than to others. They may have been close to one another in the former scroll.
10. Check the distances between lines, the height of letters, the flow of ink, and the traces of the pen. They may have been somewhat different in various parts of the scroll.
11. Arrange all parts and fragments of the scroll according to their forms, starting with the larger pieces and with piles of fragments that have similar shapes.
12. Prepare a schematic drawing of the scroll with its sheets, columns, lines in each column, etc. according to the average and within the limits required by positive evidence from the remains.

The method was successfully applied by Steudel to 4Q177 + 4Q174, and more or less contemporaneously by Elgvin to 4Q422.[31] In later years it was successfully applied to various other scrolls.[32] Other scholars, however, abstained from the full application of this method in their reconstructions, due to what they perceive as the subjectivity of the method.[33] For our present purposes, Elgvin has applied the method in his reconstruction of the copies of *Instruction*, while Tigchelaar refrained from using it in his comprehensive volume on the same scrolls.[34] Annette Steudel and Brigit Lucassen presented a preliminary material reconstruction of the copies of *Instruction*, which was also sporadically mentioned in DJD XXXIV, but this attempt was not continued, and cannot thus be taken as a valid position about the configuration of these copies.

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31 Steudel, *Der Midrash zur Eschatologie*; Torleif Elgvin, "The Genesis Section of 4Q422 (4QParaGenExod)," *DSD* 1 (1994): 180–96; and more comprehensively in Elgvin, "How to Reconstruct a Fragmented Scroll."

32 Some recent examples are: Joseph L. Angel, "The Material Reconstruction of 4QSongs of the Sage^{b} (4Q511)," *RevQ* 27 (2015): 25–82; Mika Pajunen, *The Land to the Elect and Justice for All: Reading Psalms in the Dead Sea Scrolls in Light of 4Q381*, JAJSup 14 (Göttingen: Vandenhoeck & Ruprecht, 2013); Eva Jain, *Psalmen oder Psalter. Materielle Rekonstruktion und inhaltliche Untersuchung der Psalmenhandschriften aus der Wüste Juda*, STDJ 109 (Leiden: Brill, 2014); Kipp Davis, *The Cave 4* Apocryphon of Jeremiah *and the Qumran Jeremianic Traditions: Prophetic Persona and the Construction of Community Identity*, STDJ 111 (Leiden: Brill, 2004); Monger, "4Q216 and the State of Jubilees."

33 Tigchelaar, "Constructing, Deconstructing, and Reconstructing," 40.

34 Torleif Elgvin, "An Analysis of 4QInstruction," (PhD Dissertation, Hebrew University of Jerusalem, 1997); Eibert Tigchelaar, *To Increase Learning for the Understanding Ones: Reading and Reconstructing the Fragmentary Early Jewish Sapiential Text* 4QInstruction, STDJ 44 (Leiden: Brill, 2002).

The pros and cons for using the Stegemann method are well-known to all sides of the debate. In fact, Stegemann himself acknowledged that the method relies on some measure of subjective factors and estimated its margin of error to be around 25%.[35] For some scrolls the method is indeed inapplicable, with the fragments better left as they are. As indicated by Steudel in numerous presentations, much of the method's reliability is derived from the control offered by trial and error; the result of the reconstruction procedure is not a certain reinstallation of the state of affairs, but rather a possibility that does not run counter to any other known datum about the scroll and its contents. The more checks and balances one offers in order to cross-check the material reconstruction, the more reliable the method becomes. As we learned when working on the copies of *Instruction*, there are several different constellations of scrolls, some of them boosting the advantages of the method while diminishing its drawbacks. For example, when working with a scroll preserved in wads like 4Q418a, applying the method is required, even compulsory, as the layers of each wad for a fact stood one above the other in sequential layers, diminishing the subjective factor to a minimum. In addition, if a scroll (like 4Q418a) also displays parallel text to that of other copies, the number of checks and balances for verifying the material reconstruction grows, rendering it more reliable.

In chapters 11–12 below we dwell on various elements of the Stegemann method. Qualifications of the method arise not so much from the problem of subjectivity, but rather from the new computerized tools available today, which often make it more accurate and reliable. In particular, what we add to the Stegemann method is concentrated in the following points:

a. Improving the materials for performing the reconstruction. With the new multispectral images and the new methods available for digitally restoring fragments, the objects placed on the canvas are now improved vis-à-vis earlier reconstructions. In addition, corresponding damage patterns can now be traced and compared more easily using graphic software. In that respect, we also pay more systematic attention to pre-processing the images before placing them on the canvas.
b. Improved ability for using parallel texts in the material reconstruction (in compositions whose text is relatively stable) as ancillary information to the method. The text is designed in special fonts prepared for every scroll, and cast in the layout of the given scroll. Once this task is done reliably – and we focus heavily in subsequent chapters on the methods for doing so – one may gain not only additional information for enhancing

35 Stegemann, "Methods for the Reconstruction," 199–200.

the material reconstruction, but also another control over it, verifying the reconstruction by means of trial and error.

c. Calculating the margin of error of the method. Like any other scientific-material procedure, the method incurs a margin of error, which increases the more complicated the reconstruction becomes. For example, while the margin of error is comparatively small for every turn individually, the turns add up as one goes further away from the first reconstructed circumference. The figures, especially when accumulating across multiple actions, become rather significant, and should raise serious reflections about the way of using the method in order to minimize potential error. In Appendix 3 we produce a calculation of the potential margin of error for this method.

At the bottom line, Stegemann's requirement to prepare a schematic drawing of the scroll is now achieved by means of a digital canvas. Our methodological chapters delineate the components of this canvas, both material and textual.

To sum up, in our work we embrace the Stegemann method for reconstructing fragmentary scrolls, while acknowledging its potential pitfalls and enhancing it in various means. We thus increase its computational value on the one hand, while adding checks and balances on the other hand. We offer a mathematical formulation of the potential margin of error resulting from this method, suggesting that in some cases the method would be too crude to rely on. We suggest ways for achieving better subject-matter for the reconstruction and enhance the assembly procedure by allowing a larger role for text in the reconstruction in various ways. The digital canvas is a means for a more accurate and advanced material reconstruction.

This book contains two parts. Part 1 conveys the protocol for reconstructing fragmentary scrolls: from the stage of collecting images and data, through the handling of images and reading the fragments, with the graphic and digital moves required for this purpose. Part 1 also presents the procedure for creating a digital canvas, from the level of the single fragment, the column, the sequence of damage patterns, through to the production of a complete canvas. A concluding chapter demonstrates the way to extrapolate from the canvas of one scroll on the reconstruction of other scrolls, in the case of a composition with multiple copies. Appendices to this part of the book discuss the margins of error that are expected to result from various stages of the protocol. These appendices employ mathematical formulations that may be challenging for many scholars of the humanities; it is recommended that scholars consult colleagues with the sufficient qualifications for estimating the margin of error in their work.

Part 2 of the book applies the protocol to one particular scroll. It opens with an introduction to the material study of *Instruction* and proceeds to a re-edition of the fragments of 4Q418a, and finally to a full material and digital reconstruction of this scroll in the form of a digital canvas. A final chapter then traces the way for a full reconstruction of *Instruction* based on the distinct copies.

PART 1

Methodology

CHAPTER 1

Collecting the Materials

A significant part of working on any manuscript is tracing the history of its discovery, imaging, and preservation. A careful and exhaustive collection of all available images and cataloguing data is the corner stone of any successful research. An important study by Stephen Reed delineated this procedure and described the various points where problems may arise.[1] The information about discovery and cataloguing is not always easily accessible for scholars, but it is worth the search because the finds could be highly relevant for various aspects of the editor's work: assigning fragments to various manuscripts, suggesting new joins and assessing the palpability of earlier joins, and finally for locating unknown fragments. The present chapter is an informative and handy survey, contained here in order to provide a full picture of the protocol for handling highly fragmentary scrolls. It is not meant to be comprehensive, nor does it cover all of the information contained in earlier publications.

Sometime after their arrival at the Palestine Archeological Museum, the fragments were cleaned and placed on the PAM plates for imaging. Each manuscript was assigned a number, including a reference to the cave in which it was (or purported to have been) found (1–11), the site from which it came (e.g. Qumran, Murabbaʿat, etc.), and a serial number.[2] The original team's meticulous work is mostly still accepted as foundational. Most fragments were not excavated by archaeologists, but rather found by Bedouins and subsequently purchased and brought to the Palestine Archeological Museum. The fragments were arranged on plates according to information collected from the sellers, or from the excavators, and according to initial insights on divisions and joins. The plates were photographed at some point after they were acquired by the museum. The certainty regarding the original provenance where a fragment was found depends on the question of whether it was excavated by archeologists or found by Bedouins. A combination of both may also be possible, in cases of fragments that had first been discovered by Bedouins, with additional fragments of the same scroll turning up later in controlled excavations.[3]

1 Stephen Reed, "Find-Sites of the Dead Sea Scrolls," *DSD* 14 (2007): 199–221.

2 Usually, inventory numbers and manuscripts are used interchangeably. Tigchelaar, "Constructing, Deconstructing and Reconstructing," 27, gives several exceptions.

3 In addition to numerus scrolls from Cave 4, this is the case for example with the Greek Minor Prophets scroll from Nahal Hever: see Emanuel Tov, *The Greek Minor Prophets Scroll from Naḥal Ḥever (8ḤevXIIgr)*, DJD VIII (Oxford: Clarendon Press, 1990), 1. Reed, "Find-Sites,"

DOI:10.1163/9789004473058_003

Information on discovery and cataloguing of the images may be found in the various manuals and histories of the scrolls. The first tools are Stephen Reed's *The Dead Sea Scrolls Catalogue* (1994) and Emanuel Tov's *Revised Lists of Texts from the Judaean Desert* (2010), which mainly quotes Reed's log of images for a given scroll, alongside short bibliographical references.[4] A third resource is Tov and Pfann's *Companion Volume to the Dead Sea Scrolls Microfiche Edition* (1995).[5] In addition to various indices, this volume adds valuable historical information on the photographic record. To these, one should add the websites of the LLDSSDL (Israel Antiquities Authority) and the DSSDP (shrine of the Book, Israel Museum). While the great majority of PAM images are available online after having been enhanced and treated by the IAA team, some of them were not uploaded to the website and should be sought in other resources, such as early DJD volumes or Eisenman and Robinson's *Facsimile Edition of the Dead Sea Scrolls*.[6] Another important source of images is *The Allegro Qumran Photograph Collection: Supplement to The Dead Sea Scrolls on Microfiche*.[7] This collection presents John Allegro's private collection and includes a handful of fragment images, mainly – but not solely – of the Copper Scroll. Additional anecdotes on the acquisition and discovery of scrolls can be found in Weston Fields's *The Dead Sea Scrolls: A Full History*, as well as in a survey article by

203–6, describes how the testimony of the Bedouins has been recorded by the scholars, and how it was joined with the evidence of scrolls found in formal excavations. Yet additional fragments of this scroll were discovered and publicized by the IAA during 2021.

4 Reed, *The Dead Sea Scrolls Catalogue*; Emanuel Tov, *Revised Lists of Texts from the Judaean Desert* (Leiden, Boston: Brill, 2010). The inventory for the older PAM series 40, 41 and 42 is not exhaustive, and neither is the log for fragments that have been "moved" to a different scroll since their initial catalogue entry.

5 Tov and Pfann, *Companion Volume*.

6 Robert H. Eisenman and James M. Robinson, *A Facsimile Edition of the Dead Sea Scrolls* (Washington: Biblical Archaeology Society, 1991). Some of these images show unrolled scrolls and may turn out to be highly valuable for physical reconstruction purposes. See for example PAM 40.171 (plate 5); PAM 43.772–43.775 (plates 1632–1635); PAM 43.981 (plate 1690).

7 Many of the photographs were published by Allegro in his monograph: *The People of the Dead Sea Scrolls in Text and Pictures* (London: Routledge and Kegan Paul, 1959). For a detailed analysis of the collection, see George Brooke, "The Allegro Qumran Photograph Collection: Old Photos and New Information," in *The Provo International Conference on the Dead Sea Scrolls: Technological Innovation, New Texts, and Reformulated Issues*, ed. Donald W. Parry and Eugene Ulrich (Leiden: Brill, 1999), 13–29. Allegro's image archive and additional photos from the private collection of Allegro's daughter, Mrs Judith Brown, have been recently published online by The Leverhulme International Network Project for the Study of Dispersed Qumran Cave Artefacts and Archival Sources website: https://dqcaas.com/.

Hanan Eshel from 2010.[8] Additional information can be sought in de-Vaux's reports, only partly published until now, and in the "Network for the study of Dispersed Qumran Cave Artefacts and Archival Sources" (dqcaas.com). The following discussion will dwell on two aspects of the find and metadata that are especially crucial for the edition task: tracing the imaging history and validating the provenance of the fragments.

1 Tracing the Imaging History

Images are the main source of information and a tool in the hands of the scholar executing a material study. Already in the 1950s when the scrolls reached the Palestine Archeological Museum, many of the fragments were unreadable for the naked eye. The editorial team was required to use IR images in order to read and sort the fragments.[9] Needless to say, the condition of the fragments did not improve over the years, and decomposition continues until today. Conservation efforts sometimes require reinforcing the fragments with Japanese paper, making the assessment of the rear side of the fragments even more challenging. Older images may thus preserve information that can no longer be seen on the newer images. Every material study of a fragment should therefore begin by meticulously collecting all available photographic data and becoming extremely familiar with the full photographic record. Since this work produces a huge amount of data, ways should be sought to aggregate, sort, treat and store this data.

Taken between March 1950 (PAM 40.059) to 1969 (PAM 44.199), the PAM images are the main source of data about the material preservation of the fragments in earlier – and often better – stages of their preservation.[10] Images

8 Weston W. Fields, *The Dead Sea Scrolls: A Full History* (Leiden: Brill, 2009). A chronicle on the discoveries and early transactions can be found on 495–515. For the latest revision of Eshel's article see Hanan Eshel, "The Fate of Scrolls and Fragments: A Survey from 1946 to the present," in Elgvin, Davis, and Langlois, *Gleanings from the Caves*, 33–50. Caution should be practiced, however, and significant details should be double-checked after checking both Fields and Eshel.

9 See the words of John Strugnell, describing the state of the fragments on their arrival to the PAM, in: "On the History of the Photographing of the Discoveries in the Judean Desert for the International Group of Editors," in *Companion Volume to the Dead Sea Scrolls Microfiche Edition*, ed. Emanuel Tov and Stephen Pfann (Leiden: Brill, 1995), 125–31, here 124–25.

10 The last images in the PAM collection were taken in 1969 for Strugnell's review of DJD V; see John Strugnell, "VII. On the History of the Photographing of the Discoveries in

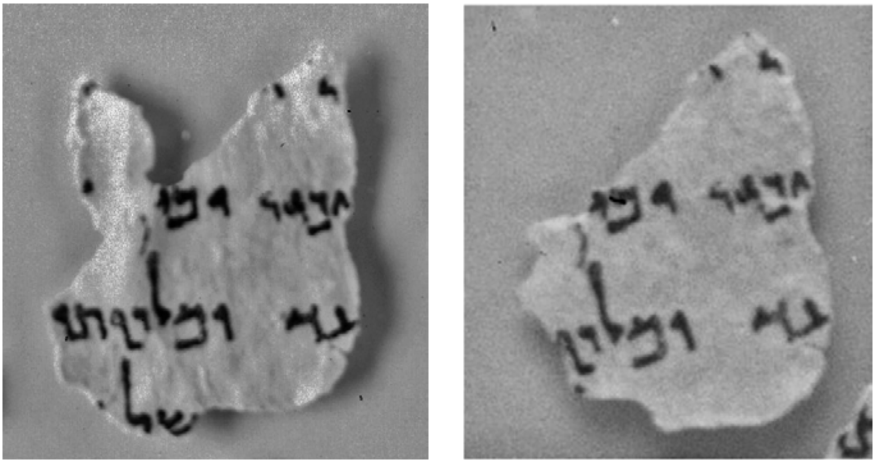

FIGURE 1 Fragment 4Q418 164, as it appears in PAM 40.978 (left) and in PAM 41.905 (right). The older image presents the fragment in a more complete state with an additional piece visible at the top left corner. More letters can be seen on the old image, such as in the bottom line. We thank Eibert Tigchelaar for sharing this observation with us.

of fragments were taken after they reached the museum, having been found either by archeologists as part of an excavation (PAM plates 40.962–40.985) or purchased from Bedouins. Each fragment was then imaged several more times, at different stages of sorting and cataloguing the corpus.[11]

The earliest photos, usually from the 40 and 41 PAM series – but for some of the texts also the 42, and even the 43 and 44 series – document the fragments after their first treatment and cleaning by the editorial team. The gradual advance of subsequent work on sorting and placing the fragments was recorded in the 41 and 42 series. We now bring some examples of cases in which the older images offer important information not found elsewhere for improving the readings or suggesting unnoticed joins.

The later PAM images (43 series) show the fragments as joined and posited by the editors. In some cases, when these joins are disproved, older images indicate the original state of the fragments and assist in disproving the join and in restoring the fragments to their original state. See figure 2, which

the Judean Desert for the International Group of Editors" in Tov and Pfann, *Companion Volume* , 125–31, here 128.

11 John Strugnell ("On the History of the Photographing," 124–25) describes how each member of the editorial team applied his own personal documentation system for recording his work. New editors of a given scroll should learn about the habits of their early predecessors as part of their investigation.

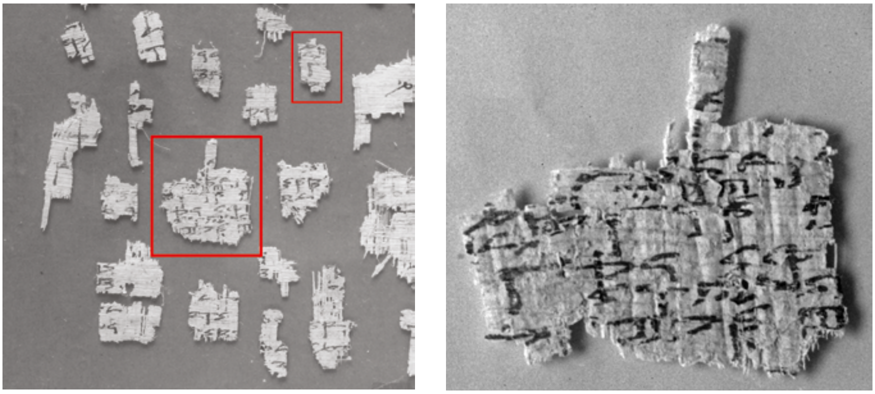

FIGURE 2 Fragments 4Q249a 3 and 4Q249a 5 (two pieces of papyrus formerly joined as 4Q249e 2). The fragments appear separate on PAM 41.990 (left), while on PAM 43.410 (right) they are joined together.
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shows 4Q249a fragments 3 and 5. The join, since proven wrong, was suggested by Milik.[12]

Tracing the imaging history of the PAM plates provides an important glimpse into the editorial team's line of thought, a process that is usually not documented elsewhere. Occasionally, the early scholars left handwritten notes on small pieces of paper, represented in the plates (figure 3). These notes sometimes hold precious insights that were otherwise lost.

Other hints may help to trace back ideas of the early scholars: adjacent fragments on a PAM plate may suggest possible joins or distant joins;[13] proximity may indicate physical similarities between fragments and suggest an order of layers in wads (see below).[14] Fragments placed together on a plate may also provide valuable information on the history of discovery of the scroll, highlighting the question of provenance. The Preliminary Concordance sometimes presents valuable notes from the early stages of editing and variant fragment numbering that attests to early attempts at reconstruction.

12 For a detailed analysis of this case see Asaf Gayer, Daniel Stökl Ben Ezra, and Jonathan Ben-Dov, "A New Join of Two Fragments of 4QcryptA Serekh haEdah and Its Implications," *DSD* 23.2 (2016): 139–54, here 143–45.

13 For example, PAM 43.549 presents Strugnell's suggestion to locate fragments 4Q415 1 and 4Q415 2 in the same column of the scroll. This idea was later presented in the official DJD publication and widely accepted by other scholars.

14 See PAM 41.997, which presents some of the fragments of 4Q418a according to their order in the wad. PAM 40.619 shows that some fragments of 4Q324d had once been attached in a wad, thus providing important data for the reconstruction of this scroll.

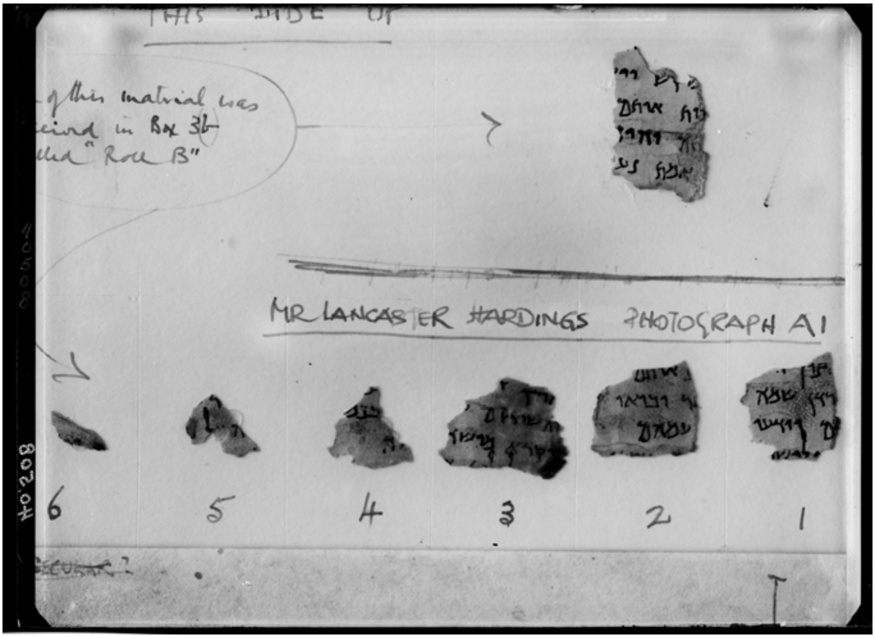

FIGURE 3 Fragments of the scroll 1Q22 (PAM 40.508) with handwritten notations
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Two pioneering projects were launched since 2011, making new advanced images of the DSS available online. The Israel Museum inaugurated the "Dead Sea Scrolls Digital Project" (DSSDP), allowing the public to examine and explore five of the scrolls that are located in the Shrine of Book.[15] The Shrine of the Book holds old and new images of the Cave 1 materials, as well as the Temple Scroll, along with other images of fragments that have ended up at the museum over the years. In 2012 the Israeli Antiquities Authority (IAA) launched the ambitious Leon Levy Dead Sea Scrolls Digital Library which image each and every fragment of the Dead Sea Scrolls using multispectral imaging technology. In the framework of this project each fragment was imaged from its recto and verso sides in multiple wave lengths and from various light angles.[16] This process

15 These are: The great Isaiah scroll (1QIsa[a]), The Rule of the Community (1QS), Pesher Habakkuk (1QpHab), The War Scroll (1QM) and the Temple Scroll (11QT[a]). All five scrolls were imaged in ultra-high resolution digital photography by the photographer Ardon Bar-Hama at 1,200 megapixels.

16 The IAA images each and every fragment, both recto and verso in 12 wavelengths – 5 in the visible spectrum and 7 in the near infra-red – and 28 exposures using lighting from both sides together, from each side separately, and with raking lights. The above numbers amount to 56 images of each fragment. The LLDSSDL website displays the multispectral

results in a battery of digital images, providing scholars with a robust inventory of graphic data. Despite their high quality, however, the LLDSSDL images are not sufficient for material reconstruction, since they capture the fragments after many years, during which some fragments were broken, disintegrated, or simply disappeared.[17] Some of the scrolls ended up in the collections of other institutions, some of which provide digital access.[18] The West Semitic Research Project collection publishes photographs of materials that are now kept in Amman and other collections, many of which are accessible by means of the *InscriptiFact* platform.[19] The Bibliothèque Nationale de France (BnF) holds a small collection of Cave 1 fragments, which is also available online for viewing and downloading.[20] Several additional fragments are in the possession of other institutes and may be accessible through their websites.[21]

The search for all various images of a fragment can be carried out using the bibliographic tools mentioned above. Despite their comprehensiveness, however, these resources are not exhaustive and not always fully accurate. The new IAA and Shrine of the Book images were taken after 2011 and are not catalogued in handy bibliographic resources.[22] The LLDSSDL images are catalogued according to the plate number in the IAA and its internal ordering, a system that does not correspond to the standard DJD numbers. One must therefore first correlate the different numbers and record the finds in a systematic way as an initial step in the work on any scroll. Such a systematic log has enabled us to link hitherto unregistered images to the known fragments, and occasionally even find new fragments previously unnoticed, by methodically browsing

composite image and the highest near IR image (947nm) of the recto of any given fragment. Verso images are presented only when relevant. For digital reconstruction purposes, however, scholars are advised to use both recto and verso of the composite multispectral image, the near-IR image, and the raking light images. In addition, the IAA made available the old PAM images taken in the 1950s and 60s scanned in the best possible resolution.

17 The fragments of 4Q418a are a good example for such processes. Over the years, many of these fragments broke, crumbled, or completely disintegrated, with many pieces also detached and lost. For a detailed report see chapters 15–16 below.

18 For a list of photographs see Reed, *Catalogue*, 465–70.

19 http://www.inscriptifact.com; for a list of photographs see Reed, *Catalogue*, 453–64.

20 Accessible here: https://gallica.bnf.fr/ark:/12148/btv1b8551261c.r=qumran?rk=21459;2. For a list of photographs see Reed, *Catalogue*, 465–66. For other smaller collections, see pages 467–70.

21 For example, the Oriental Institute in the University of Chicago own a single fragment of 4Q184. https://oi-idb.uchicago.edu/id/0cc4a4dd-8de6–4c81–80aa-3217eed23373.

22 The SQE platform provides correlation between LLDSSDL images and DJD fragment numbers, thus facilitating the search. Hasia Rimon at the Shrine of the Book is currently cataloguing the rich photographic archives of the Shrine.

the old PAM plates (mainly series 40–41). It is therefore crucial to accompany the collection of images with a detailed spreadsheet (for example by Microsoft Excel), which collects all the image data about the scroll: catalogue numbers of fragments in both the DJD and IAA formats. The various images of each fragment should be documented: B numbers in the LLDSSDL, PAM plate numbers, etc. This spreadsheet is a necessary tool in the reconstruction process, which can then be mined by data scientists for further systematization. The Computer Science team at the project *Scripta Qumranica Electronica* has initially developed an algorithm for locating all photographic documentation of a given fragment, thus providing scholars with an "image-wheel," allowing them to scroll through all various images as part of their work.[23] Manual verification by a human expert will still be required, however.

Editors of scrolls should be aware of the multiple imaging resources that are now more and more available to them. The information contained in these resources is crucial for producing a reliable edition and should thus be aggregated and managed in an accessible way.

2 Validating the Provenance of the Fragments

While assembling the photographic record for all fragments of a given scroll, it is important to verify the assignment of these fragments to the specific scroll under discussion, and to modify the accepted classification if the evidence require it. If at least one of the fragments of the manuscript was excavated, the provenance is verified. The data about fragments stemming from controlled excavations in Cave 4, which constitutes most of the relevant material, were recorded in series E of the PAM photos. Corrado Martone has recently recorded the manuscripts represented in that series, with links to their images in the IAA archive.[24] This list, however, depends on the identifications contained in Reed's catalogue, and leaves out many fragments that were unidentified at

23 Taivanbat Badamdorj et al., "Matching and Searching," 1–5; Gil Levi et al., "A Method for Segmentation, Matching and Alignment of the Dead Sea Scrolls," in *Proceedings of the IEEE Winter Conference on Applications of Computer Vision* (*WACV*) (Lake Tahoe, CA), 208–17. In addition, the project will also offer a refined inventory sheet for all fragments correlating DJD and IAA numbers. For more information consult https://www.qumranica.org.

24 Corrado Martone, "The Excavated Fragments from Qumran: Steps Toward a Reappraisal," *Kervan* 23 (2019): 101–10. Compare the list of excavated scrolls by Stephen J. Pfann, in "Sites in the Judean Desert where Texts have been Found," in Tov and Pfann, *Companion Volume*, 109–19, here 112; and in Reed, "Find Sites," 206, n. 33.

the time. Eibert Tigchelaar is now working on a comprehensive log of all fragments in the E-series, identifying new fragments (e.g., in 4Q266 and 4Q362) and enlarging the list.[25] In addition to this information, some editors inform their readers about the circumstances of discovery, with information collected from personal communications of scholars of the first editorial team.[26]

While as a general policy the editorial team did not mix fragments stemming from different caves on the same plate, some exceptions do occur. According to Strugnell's testimony, the original team was

> very careful not to confuse material identified to us as coming from different sites in the Judean desert. From the time of the arrival of the fragments in the museum we kept the various groups separated, never working on them in the same room. In those unbureaucratic days the fragments from Murabbaʿat or from the minor caves at Qumran could be carried without objection off to the École Biblique where their editors worked on them each in his room. The negatives usually, the plates and the photographer's register always, preserve the necessary indications of provenance correctly.[27]

Hence, the team was able to mix fragments from different provenances but was careful not to do so. Some exceptions did occur, as for example PAM 41.734, which includes fragments from both cave 4 and cave 6, although the reasons for this mix are not entirely clear.[28] Additional "mixed" plates can still possibly occur.

As with any artifact stemming outside of scientific excavations, the provenance of the Cave 4 fragments not found in excavations will always remain in doubt. For example, doubt has been expressed with regard to the place of

25 Tigchelaar, personal correspondence, 2019; Tigchelaar, "Two Damascus Document Fragments and Mistaken Identities. The Mingling of Some Qumran Cave 4 and Cave 6 Fragments," *DSD 28* (2021): 1–11; Antony Perrot, "Identification d'un fragment en paléo-Hébreu (4Q124) et d'un fragment en écriture Cryptique B (4Q362) de la PAM 43.697," *RevQ* 31 (2019): 307–12.

26 A curious example is the fact that the large fragment 4Q416 2 was brought to the Palestine Archeological Museum under Kando's shirt and thus absorbed much of his perspiration and shrunk accordingly. This information is reported by John Strugnell, Daniel Harrington, and Torleif Elgvin, *Qumran Cave 4 XXIV. Sapiential Texts Part 2. 4QInstruction* (*Mûsār lĕ Mēvin*), DJD XXXIV (Oxford: Clarendon Press, 1999), 73. Another such example is the scroll 11QPs^a, whose story of discovery and purchase is recounted by James A. Sanders, *The Dead Sea Psalms Scroll* (Ithaca, NY: Cornell University Press, 1967), 3–8.

27 Strugnell, "On the History of the Photographing," 124.

28 Tigchelaar, "Two Damascus Document Fragments and Mistaken Identities."

origin of the documentary manuscripts (4Q342–4Q360).[29] Similar doubts have also been expressed (albeit on other grounds) with regard to the proto-Masoretic 4QGen^{b}.[30]

Even more profoundly, it may be worthwhile to employ some skepticism with regard to the report by Bedouins on the place of finding a given scroll. The great majority of the fragments were reported to have come from Cave 4, but that cave in fact comprised two separate caves, seven meters apart: 4a and 4b. As reported, "the Bedouin mixed the manuscripts coming from these caves and, accordingly, de Vaux decided to record all fragments coming from both caves as 4Q."[31] Furthermore, as we now know, other caves were found (like the so-called "Timothy's Cave"), which contained empty and shattered scroll jars, but were never reported by the Bedouins as a site where scrolls were found.[32] It is at least possible that some of the reported "Cave 4" fragments stem from these caves.

New fragments may surface which require the editor's attention. Thus, the fragment XQ7 is identified as a fragment from a copy of *Instruction*, probably 4Q418; this fragment did not reach the Palestine Archeological Museum but was rather donated later by a private person, who claimed to have bought it from the Bedouins.[33]

Only occasionally do scholars suggest separating a fragment from a manuscript,[34] or argue that two or more DJD manuscripts are actually one. Many fragments (mostly very small ones) remain unidentified even today.[35]

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29 Reed, "Find-Sites," 212–20, recounts the doubt while also explaining why it should not be outright embraced. See further George Brooke, "Choosing Between Papyrus and Skin: Cultural Complexity and Multiple Identities in the Qumran Library," in *Jewish Cultural Encounters in the Ancient Mediterranean and Near Eastern World*, JSJSup 178, ed. Mladen Popović et al. (Leiden: Brill, 2017), 119–35, here 125. In this corpus, the papyrus 4Q347 seems to have originated in Nahal Hever rather than at Qumran, but further verification is required.

30 Once again, the doubts are summarized but also critically evaluated by Reed, "Find Sites," 216–17.

31 Pfann, "Sites in the Judean Desert," 112; Reed, "Find Sites," 203.

32 For this cave see Maurice Baillet, Józef T. Milik, and Roland de Vaux, *Les "petites grottes" de Qumrân*, DJD III (Oxford: Clarendon Press, 1962), 11; Fields, *The Dead Sea Scrolls*, 136–37.

33 Émile Puech and Annette Steudel, "Un nouveau fragment du manuscrit *4QInstruction* (XQ7 = 4Q417 ou 418)," *RevQ* 19 (2000): 623–27; Tigchelaar, *Increase Learning*, 125, identifies it as a fragment of 4Q418.

34 Steudel, "Assembling and Reconstructing Manuscripts," 520 n. 17, gives a partial list of such cases updated to 1999. Many of these cases are concentrated in Allegro's editions of DJD V, particularly with regard the scroll 4Q176 (4QTanhumim).

35 Some of these fragments are published in DJD XXXIII. They are shown on PAM images 43.660–43.701 and 44.102. For a discussion of these fragments see Eibert Tigchelaar,

Modern scholars are not exempt from reviewing the older decisions and criticizing them. Tigchelaar points out cases where suspicion should be raised about the assignment of fragments to scrolls: when the first editors express doubts with regard to the assignment of fragments, when letters are used after the figures (e.g. 4Q214a, 4Q418a, 4Q324c), when fragments were moved from one IAA plate to another, or when individual fragments appear in different museum plates than the bulk of other fragments in their purported scroll.[36] Annette Steudel lists the criteria for grouping fragments used by the first team: "the general appearance of the leather, its color, the thickness and the preparation of the skin, the dimensions of the manuscript, the columns, the margins and the carefulness or carelessness of the scribe, the orthography, the language, the content and the genre."[37] Steudel's reservations immediately follow the list, since all of these criteria may vary even within one manuscript, thus casting doubts on the reassignment.

The color of the parchment is very conspicuous, and many scholars use it as part of their considerations while assigning fragments into scrolls. This consideration cannot stand alone, however, since changes in color may be found even on the same fragment (see for example 4Q417 2, image B–371299 in the LLDSSDL).

The thickness of the skin depends on its preparation and may vary between sheets. As Tanya Bitler, a conservator at the IAA conservation lab indicated in a private conversation, it also depends on gelatinization later in the preservation process. Since the thickness is difficult to establish in photographs, it requires an examination of the physical fragments.

Other qualities of the parchment, such as marks of preparation, peels, etc. are visible on the new color IAA images, but checking the original fragments is always necessary. Some information can be found in the sections on physical description in the DJD editions of respective scrolls; it is highly valuable because it documents the state of the fragments when they were first found, a state that is sometimes no longer preserved.

"Gleanings from the Plates of Unidentified Fragments: Two PAM 43.674 Identifications (4Q365 and 4Q416)," in *'Go Out and Study the Land' (Judges 18:2): Archaeological, Historical and Textual Studies in Honor of Hanan Eshel*, ed. Aren M. Maeir, Jodi Magness, and Lawrence Schiffman, JSJSup 148 (Leiden: Brill, 2012), 317–22, and Eibert Tigchelaar, "Pesher on the True Israel, Commentary on Canticles? Józef Milik's Designations for Unidentified Qumran Cave 4 Manuscripts on Museum Plates 303 and 304," *DSD* 26 (2019): 61–75.

36 Tigchelaar, "Constructing," 45; Tigchelaar, "Two Damascus Document Fragments and Mistaken Identities."

37 Steudel, "Assembling," 519. Much of the discussion below relies also on Tigchelaar, "Constructing"; Stökl Ben Ezra, *Qumran*, 48–53.

The style and size of handwriting may indicate the need to sort the fragments into different manuscripts. While paleography experts may distinguish nuanced variations, this consideration cannot stand on its own. A scroll may attest to the replacement of a scribe in its middle, as in 1QH^{a} or possibly 1QIsa^{a}.[38] A somewhat different example from *Instruction* would be the first line of 4Q423 5, which is written by a different scribe than the rest of this manuscript. A scribe often copies more than one scroll, with some scribes copying possibly as many as fifty scrolls, as claimed by Yardeni.[39] A scribe may copy the same document twice, which adds to the confusion. For example, 4Q418 and 4Q418a were once considered as the same manuscript, since their handwriting is so similar. Only after discovering some textual overlaps did it become clear that they are two different copies of the same composition.

Most scrolls contain vertical dry rulings of the column borders as well as horizontal rulings marking the lines. The horizontal rulings dictate the space between lines, which should be continuous throughout a sheet, but can vary between sheets of the same manuscript.[40] If some of the fragments show rulings while other do not, this is a possible yet not sufficient condition to their separation, since the rulings may have disappeared with the scroll's deterioration.[41] In those scrolls that were not originally ruled, neither the writing nor the beginning of the lines is straight.

The scribal habit of horizontal dry rulings creates an even size of the writing block, and of the number of lines and the margins across the columns contained in one sheet, with only slight variations.[42] However, when two different sheets are sewn together, one may expect a large variation in the size of the writing block. For example, in 11QT^{a} the number of lines per column ranges between 22–30 lines, and in 1QIsa^{a} the numbers vary between 28–32 lines.[43]

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38 For more examples see Steudel, "Assembling," 519–20 and Tov, *Scribal Practices*, 20–22.

39 Ada Yardeni, "A Note on a Qumran Scribe," in *New Seals and Inscriptions, Hebrew Idumean, and Cuneiform*, ed. Meir Lubetski (Sheffield: Phoenix Press, 2007), 287–98; Steudel "Assembling," 521; Tov, *Scribal Practices*, 22–24. For the case of 4Q423 see Elgvin, "An Analysis of 4QInstruction," 19–20; Elgvin, "The Reconstruction of Sapiential Work A," *RevQ* 16.4 (1995): 559–80.

40 Tov, *Scribal Practices*, 53–64. In addition, the distance between lines is sometimes marked by means of guide dots/strokes near the beginning or end of sheet.

41 The scroll 4Q417 is a good example. While horizontal rulings can be seen on fragment 3, they cannot be seen on the large fragments 1 and 2, and possibly did not exist at all, since the lines on these fragments are unevenly spaced.

42 Steudel, "Assembling," 521; Tov, *Scribal Practices*, 93–94. As examples for such variations we may cite the columns i–ii in 4Q417 frag. 1 and the torn top margin in 4Q423 5.

43 See Tov, *Scribal Practices*, 93–95; Stegemann, "Methods for the Reconstruction," 198. For 11QT^{a} see Elisha Qimron, *The Dead Sea Scrolls: The Hebrew Writings*, [Hebrew] Between Bible and Mishnah, (Jerusalem: Yad Ben-Zvi, 2010–2014), 1.137.

Opisthographs, that is, scrolls written on both sides of the skin, are a known phenomenon in ancient manuscripts worldwide, and have also been found in Qumran.[44] While a full discussion of this intriguing material phenomenon lies outside the present discussion, it is important to note that examining the verso for additional writing may help in the separating of fragments into discrete scrolls. For example, separating the fragments of 4Q418 from those of 4Q415, with the latter being an opisthograph with 4Q414 on its verso. In this case the separation is confirmed by comparing the parallel text between 4Q415, 4Q418, and 4Q418a. In general, an opisthograph cannot constitute a single argument against assigning two fragments to the same scroll, since some opisthographs contain text only on parts of the verso (for example 4Q201, 4Q338).

In this chapter we underscored the importance of maintaining a robust record of photographic data, while also pointing out the need to verify the classification of all fragments as belonging to the scroll under discussion. We clarified some points about the history of discovery, classification and photography of the scrolls that should be helpful in this regard. We now move to other general premises that underlie the editing task.

44 See recently Antony Perrot, "Reading an Opisthograph at Qumran," in *Material Aspects of Reading in Ancient and Medieval Cultures: Materiality, Presence and Performance*, ed. Anna Krauß, J. Leipziger and Friederike Schücking-Jungblut, Materiale Textkulturen 26 (Berlin: de Gruyter, 2020), 101–14. See earlier Tov, *Scribal Practices*, 64–68; Brooke, "Choosing Between Papyrus and Skin." See also Ayhan Aksu, "A Palaeographic and Codicological (Re)assessment of the Opisthograph 4Q433a/4Q255," *DSD* 26.2 (2019): 170–88.

CHAPTER 2

Margin of Error

In the present book we specify the necessary steps for digital and material reconstruction of a scroll. Although the purpose of this reconstruction is the study of a text, it consists of quantitative methods, such as scaling images, measuring distances, computing geometrical patterns, etc. In some circles these methods enjoy the prestige of objectivity compared to the more subjective literary arguments found in the humanistic traditions. However, as cautious a scholar may be, the outcome of these quantitative methods is never fully objective or error-proof. Every stage includes some obstacles that require personal judgement and creates uncertainty. Good, ethical scholarship requires transparency about these decisions. Moreover, in some instances when a scholar uses a numerical value, a range of values would also be possible in its place, and therefore precision can only be achieved to a certain limit. Thus, before the work begins, it is important that we are aware of these obstacles and their implications for the margin of error. While the humanistic tradition demands the disclosure of uncertainties and contradicting evidence, quantitative estimation of that uncertainty is a complicated task, a task which some would even call impossible. The humanistic academic tradition does not normally require an explicit margin of error for each theory, and its training does not usually include methods for quantitative estimations of that error. Since explicit margins of error are essential for the reconstruction of scrolls, we suggest borrowing these methodologies from the sciences.

In the sciences it is mandatory to accompany any numerical value with a calculation of the potential margin of error. The following simple example demonstrates its importance. If the length of an object is measured as 7 meters, the measurement tools, their precision and the margin of error must be specified. The worth of the result will be much better when using a delicate measurement tool that can give an error of 0.1% than when using a crude estimation that gives an error of 10%. Thus, 7 ± 0.007 meters is completely different than 7 ± 0.7 meters. This example illustrates how crucial it is to specify the margin of error, without which the result may be meaningless. This chapter discusses the terminology and methods required for estimating the margin of error of every step in the process of material and digital reconstruction. Given the rich literature about errors and uncertainties,[1]

1 For some basic reading see Brian D. Ellis, *Basic Concepts of Measurement* (Cambridge: Cambridge University Press, 1966); I.E. Burns, P.J. Campion, and A. Williams, “Error and Uncertainty,”

here we offer a compromise that will be both scientific and practical for humanists.

Every object has certain properties, such as mass and length. The difference between their true value and their measured or calculated value is the error. The true value is unknown, and thus when identifying an error we refer to its limits, i.e., the interval within which the error may lie. The error can be expressed in the same units (e.g., cm for length or kg for mass) as the object's property, called absolute error, or in percentage from the true value, called relative error. One should not confuse the absolute error, which can be either positive or negative, from its absolute value, which is always a positive number. While the absolute error depends on the value of the measured quantity, the relative error characterizes the precision. Thus, if the absolute error is constant (e.g. if it depends on the measurement instrument, and there is no way to decrease it), enlarging the measured value would decrease the relative error. For example, when measuring the scale on a photographic plate to establish the image's scaling, it is best to measure the entire length of the ruler, rather than only one centimeter on it.

1 Measurement Errors

The most basic error is the measurement error. The measurement accuracy and precision depend on 1) the measurement instrument, 2) the method employed in the experiment, and 3) the scholar's competence. When measuring an object's length with a simple ruler, the measurement error is usually stated as a half of its smallest scale or half the distance between two graduation lines. But today when the measurement is performed with digital tools, a precision of up to 1μm or even better may be acquired. The method and scholar's skills have more significant effect on the error.

In the case of DSS images, the effect of the method and the scholar's skills on the error should be assessed during the measurement, with regard to the image resolution, the ability to zoom in, and how precise one can be with putting the cursor on both ends of the measurand. If required, the precision can be improved by multiple measurements. In this case the average value will be used, and the standard deviation will be considered as the error. Nevertheless,

Metrologia 9 (1973): 101–4; International Organization for Standardization, *Guide to the Expression of Uncertainty in Measurement: Corrected and Reprinted, 1995* (Geneva: International Organization for Standardization, 1995); Ifan Hughes and Thomas Hase, *Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis* (Oxford: Oxford University Press, 2010); Semyon G. Rabinovich, *Measurement Errors and Uncertainties: Theory and Practice* (Third Edition; New York: Springer, 2010).

in most cases with digital instruments the basic measurement error is negligible compared to other errors that will be discussed below.

Since the physical fragments are currently unapproachable for most scholars, one has to conduct the measurements on the images of the fragment, rather than the fragment itself. Images need to be rescaled, and the background should be removed. Chapters 4 and 5 discuss the right methods to address these steps and the measurement errors that they may carry. These errors may seem negligible compared to the larger imprecision incurred by the reconstruction of an entire scroll, but when carrying out smaller reconstructions they prove to be significant. For example, a join of two fragments may erroneously be rejected based on the different line spacing in both fragments, but this inconsistency may be caused by wrong scaling. In another case a join may be rejected due to an overlap of the skin of two fragments, while in fact the outer limits of one of them actually include the fragment's shadow cast on the plate. Moreover, the error of other steps with larger error is dependent on these procedures, as will be explained shortly.

Some errors can be estimated by the scholar. Going back to the previous example, in some cases of background removal it is difficult to see where the fragment ends. There may be a strip next to its boundaries that can either be part of the fragment or a shadow cast on the plate. The error in this case is taken to be half the width of the uncertain strip. Since an estimation is not always precise, it is better to overestimate than to underestimate the error.

2 Statistical Errors

In other cases, the scholar has no way to evaluate the error based only on a specific fragment. In these cases, the error can be found using statistical analysis of several other scrolls. We provide some information regarding the error of the scaling procedure in chapter 4, of font usage in chapter 10 and Appendix 1, and of the Stegemann Method in chapter 12 and Appendix 3. We give crude estimations without stating the probability in order to make the results simpler and more practical for DSS scholars. It is important to note that in cases of statistical errors, we do not consider the largest possible error, but the most plausible, usually considering one standard deviation from the average.

3 Indirect Measurements

Many of our measurements in this volume are indirect, i.e. the unknown values are calculated using other, directly measurable values. These latter values are called "arguments." The indirect measurement is a function of the arguments, and its error is a function of their errors. The error function also depends on the relations between the arguments, whether they are correlated to each other, i.e., whether there is any dependency between their values. For example, the average height of a group is a function of the height of each individual in it. If this group is one family, their height is correlated, but if they are members of a school class, their height is usually uncorrelated.

In order to facilitate the discussion, we will skip the theory behind the calculations, and give the traditional equations for two of the most common cases:

A. If a value (f) is a sum of two (or more) quantities (x and y), for example if for some reason the only way to measure the length of a section A–C is by measuring and adding its subsections A–B and B–C, the length of the overall section (f) will be a simple function of its arguments A–B (x) and B–C (y):

$$f = x + y$$

when the arguments are *uncorrelated*, the *absolute* error (Δf) will be the root sum of squares (RSS) of the errors of x and y (Δx and Δy):

$$\Delta f = \sqrt{(\Delta x)^2 + (\Delta y)^2}$$

But if they are *correlated*, for example if the length of the subsection A–B depends on the length of subsection B–C, the estimation of the error is more complicated. We recommend consulting a qualified scientist for these cases. Note that in both cases, if the value (f) is a subtraction of two (or more) quantities, the error will still be the RSS of errors respectively.

B. If a value (f) is a multiplication of two (or more) quantities (x and y):

$$f = xy$$

the *absolute* error (Δf) will be:

$$\Delta f = \sqrt{(y\Delta x)^2 + (x\Delta y)^2}$$

If the quantities are *uncorrelated,* the *relative* error is the RSS of the *relative* errors:

$$\frac{\Delta f}{f} = \sqrt{\left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta y}{y}\right)^2}$$

Again, if the quantities are *correlated*, the estimation of the error is more complicated, and we recommend consulting a qualified scientist for these cases.

In the more general case of the value being any kind of function of two (or more) quantities, its error is the RSS of the partial derivative of the function with respect to each variable times its error:

$$\Delta f = \sqrt{\left(\frac{\partial f}{\partial x}\Delta x\right)^2 + \left(\frac{\partial f}{\partial y}\Delta y\right)^2}$$

This equation can be expanded to include any number of variables. Since the math may become complicated, we recommend consulting a competent scientist.

The more advanced the reconstruction, the more components there are to the final error, and the more complicated it is to compute it. However, some components may be negligible, thus facilitating the computation. For example, when an LLDSSDL image is available, scaling and background removal errors are usually negligible. But when using an older PAM image, the scaling error may reach up to 10%. Imprecise scaling will affect the size of the letters, which in turn will affect the width of the reconstructed column, and so on and so forth.

Thus, for the more advanced steps of the reconstruction one has to be very careful with regard to the measurement's arguments. If a large enough fragment has been preserved and a new image is available (usually meaning that no scaling and background removal problems exist), the error of a column's width may only be the potential variation within the lengths of its own lines. But if the fragment is smaller and the column width is reconstructed using a parallel text that has been typed with a font imitating the scribe's handwriting, the width is considered as a multiplication of the number of letters by the width of each letter. In this case it will be easier to calculate the *relative* error, which is the RSS of the line variation and the font's relative error.

So if, for example, a line contains 50 letters ± 4 letters, let us call the number of letters n and the error for the number of letters Δn. The relative error of the number of letters is 8%. The length of the line in centimeters depends on the number of letters and their size, density, etc., all determined by the used font (f), whose error is 6% (Δf). The length of the line will be calculated:

$$l = nf$$

If the size of the font is uncorrelated to the number of letters in a line, we can calculate the relative error of the length of the line (Δl):

$$\Delta l = \sqrt{\Delta n^2 + \Delta f^2} = \sqrt{8^2 + 6^2} = 10\%$$

In this case, if we measure the length of the line to be 10 cm, it may in fact be something between 9–11 cm. Every subsequent decision in the reconstruction, based on the length of the specific line, should take into account the interval within which this length may lie.

The present chapter introduces the theoretical aspects of estimating the error. Specific obstacles contributing to the error of each step will be discussed in the corresponding chapters. In Appendix 1 we give quantitative estimations and computations of the error incurred by the use of a custom font in the canvas. Appendix 3 computes the error resulting from the reconstruction of an entire scroll using the Stegemann Method.

In chapter 13 we offer a method for using the reconstructed layout of one scroll as a skeleton for the reconstruction of another parallel copy. Since these two scrolls are reconstructed independently, their errors are calculated separately, as explained in Appendix 4. Further information is then added to each scroll based on the data of the other copy. Assuming that these are independent reconstructions, cross-validating the information from both copies may limit the interval within which certain errors may lie, thus reducing the value of the overall error. On the other hand, in the second stage of the procedure described in chapter 13, when information is taken from one copy and applied to the other, the errors accumulate, since the calculations are not independent but rather depend on the imprecision of the original reconstruction.

Eventually, the error for each stage produces an interval, within which the required value lies. Being transparent about the entire range helps the reader to understand the precision of the reconstruction. Furthermore, this range allows reasonable flexibility for a reconstruction of another copy based on the current one. The rules defined in this chapter will be followed in the various stages of the protocol carried out in this book. Despite the technical challenge, these rules are necessary to ensure a sound methodological basis for future reconstructions of Dead Sea Scrolls.

CHAPTER 3

Image Manipulation

While earlier generations usually studied hard copies of the PAM images without any modification, high-quality digitized photos are now available and regularly pass through the PCs of authors and editors before they appear as part of an edition.[1] With graphic software readily available for every scholar, it is essential to define best practices in the manipulation and enhancement of images. This chapter is an attempt to define lines of proper conduct in two ubiquitous practices of working with DSS images, which are also employed in the present volume: enhancing images by means of digital filters and the repairing (or "patching") of images to restore their original state.[2]

1 Enhancement and Manipulation

Good science requires reliable data, and therefore every published image should be an accurate representation of the actual data. On the one hand, scholars should make sure not to misrepresent the data, that is, not to create new data that does not exist on the physical fragment, while on the other hand they should not lose data during manipulation. Another factor to be taken into account is cognitive perception: the minds of various observers would conceive differently of the level of legibility of one enhancing method over another. In this section we offer some reflection and survey of research methods, and finally list several rules that should be followed for appropriate image manipulation.

The use of simple or advanced filters, together with advanced imaging technology, has brought about several exciting discoveries in manuscript studies, and is now indispensable in our field.[3] Given the state of the DSS fragments,

1 In this volume we use the images supplied to us by the LLDSSDL. Most images correspond to the composite color and IR images that are available on the LLDSSDL website, only with higher resolution. Raking light images of the scrolls are now available on the SQE website.

2 This section benefitted from the advice of Prof. Roger Easton, Rochester Institute of Technology (May 2019). For a definition of algorithms for image enhancement see Richard Szeliski, "Image Processing," in *Computer Vision: Algorithms and Applications* (London: Springer, 2011), 99–204. See updates of this volume in https://szeliski.org/Book/.

3 See for example Roger L. Easton, William A. Christens-Barry, and Keith T. Knox, "Spectral Image Processing and Analysis of the Archimedes Palimpsest," in *The 9th European Signal*

DOI:10.1163/9789004473058_005

significant parts of the data will only be discernible after some manipulation, most commonly the adjustment of brightness, contrast, and sharpness of the image. Methods for legibility enhancement are available and have been used for a long time for various artifacts.[4]

The legitimacy of image enhancement is a matter of dispute in various disciplines, from the life sciences and medicine to forensic science and intelligence. One can find two general attitudes to this question. On the one hand, scholarship in the field of biology, especially DNA sequences, has been quite conservative. Thus a rather strict protocol was defined for the use of images and adopted by leading journals.[5] On the other hand, papyrologists working with Egyptian and Greek materials have been freely indulging with various such algorithms for a long time.[6] Proponents of this attitude would say that the preference for the "original" image is no more than a dogma, for "digital reproductions are inherently 'manipulated' images, and an image at the exit point of an imaging system is no more faithful than, say, an image calibrated during post-production."[7] Methodological difficulties have been pointed out, however, together with ways to check the skewing effects of various filters.[8] Noise reduction, for example, is not always beneficial. While it may hide

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Processing Conference (*EUSIPCO 2011*), 1440–44; and the impressive harvest of publications resulting from the "Sinai Palimpsest Project" (https://sinai.library.ucla.edu/).

4 Such is for example the D-Stretch tool (https://www.dstretch.com/) that has been developed for digital enhancement of rock art but has been since used also by papyrologists. A recent innovation in this field, intended primarily for papyrologists, is the program Hierax (https://hierax.ch), that offers a set of novel filters and other methods for the enhancement of legibility.

5 See especially Mike Rossner and Kenneth M. Yamada, "What's in a Picture? The Temptation of Image Manipulation," *Journal of Cell Biology* 166.1 (2004): 11–15. A more detailed discussion is found in Douglas W. Cromey, "Avoiding Twisted Pixels: Ethical Guidelines for the Appropriate Use and Manipulation of Scientific Digital Images," *Science and Engineering Ethics* 16 (2010): 639–67.

6 See for example Melissa Terras, *Image to Interpretation: An Intelligent System to Aid Historians in Reading the Vindolanda Texts* (Oxford: Oxford University Press, 2006); Ségolène Tarte, "Papyrological Investigations: Transferring Perception and Interpretation into the Digital World," *Literary and Linguistic Computing* 26 (2011): 233–47; Anna Tonazzini, "Color Space Transformations for Analysis and Enhancement of Ancient Degraded Manuscripts," *Pattern Recognition and Image Analysis* 20 (2010): 404–17.

7 Vlad Atanasiu and Isabelle Marthot-Santaniello, "Personalizing Image Enhancement for Critical Visual Tasks: Legibility Enhancement of Papyri Using Color Processing and Visual Illusions: A Case Study in Critical Vision," *International Journal on Document Analysis and Recognition* 24 (2021).

8 Jin Chen, Daniel Lopresti, and George Nagy, "Conservative Preprocessing of Documents Images," *International Journal on Document Analysis and Recognition* 19.4 (2016): 321–33.

disturbing factors such as flaws in the skin, dirt, or uneven edges, this very act may also decrease the validity of a reading: one small stain unintentionally removed by a filter may make a difference in the identification of a letter or word. According to the conservative method, while it is acceptable to adjust the overall brightness and contrast of a whole image, such adjustments should not obscure or eliminate any information present in the original and should not introduce new information into it.[9] This matter was raised in a systematic treatment of imaging by Bruce Zuckerman.[10] As he rightly notes, the computerized act of prioritizing visual elements and constructing a distinct image based on them is not different from the same procedure that takes place in the human eye and mind as part of our "objective" human sight. Furthermore, if the alternative to these enhanced photos is the hand-copies produced by expert human paleographers, then these drawings are no less subjective than the image filters. In the words of Zuckerman:

> The graphic representation [...] no matter how realistic it may appear to the eye – is no less and no more reliable than a drawing of this section of the text would be. Nor should it be expected to carry more legitimate weight than a more conventional scholarly drawing of an ancient inscription.[11]

Admittedly, however, the subjective element is more readily recognized in hand-copies made by paleographers than in processed pictures, which still retain an aura of authenticity.

Even the same image will not be identical when observed in two different computers. For example, the operation systems found on Mac and on Microsoft Windows make different assumptions about the gamma settings in the monitor display.[12] Such differences, or others like them, would usually arise between the natural eyesight of two human observers. This problem should be kept in mind to qualify what we intuitively define as information present in the original. In light of this, we proceed to using filters – i.e., algorithms for image enhancement – while attempting to establish parameters for regulating this use.

9 Rossner and Yamada, "What's in a Picture," 12.
10 Zuckerman, "The Dynamics of Change," 19–21.
11 Zuckerman, "The Dynamics of Change," 20.
12 Cromey, "Avoiding Twisted Pixels."

A game-changer is the multispectral technology used by the Leon Levy Dead Sea Scrolls Digital Library and its wide availability. While many of the known enhancements prove useful for the earlier generation of images, it is often the case that the "original" multispectral image supersedes the manipulated products of earlier images. In regular scrolls and fragments, that do not involve a palimpsest or extraordinary damage to the ink, the use of simple tools such as Contrast or Clarity provided by Microsoft Windows should give good results, sometimes even better than advanced algorithm-driven manipulations.[13]

Rule 1: Adjustments should be applied to the whole image, rather than to a single section of it. Adjusting a section in order to highlight a letter or a feature of the skin will skew the relation between that particular feature and the rest of the fragment and may ultimately create a wrong reading or reconstruction. With readings in DSS editions often depending on a tiny speck of ink, every small defect in the enhancement could be meaningful. Specific features of a fragment should rather be pointed out to the readers using other means, such as drawing arrows or circles on the image surface.

Rule 2: Prefer linear to non-linear adjustments, i.e., those adjustments in which the same change is applied to each pixel according to a linear function. Tools such as Brightness or Contrast[14] are therefore more legitimate for enhancing the reading of fragment due to their very nature of linear enhancement. Other filters available through common software such as GIMP of Photoshop alter the pixels according to a nonlinear function, for example by affecting the intensity of specific regions of the image. Such common filters as Sharpness or Clarity function by enhancing the mid-tones of an image, thus yielding stronger contours for the shapes that are otherwise represented in a blurred way. In the biological sciences where work is done with very high-resolution images of minute particles in microscopes, the use of filters from commercial software is not recommended, as they may inadvertently create new factors or eliminate other factors mistakenly deemed less important by the author.[15] The situation is different in DSS studies, where even the minutest trace of a letter or a flaw in the skin is significantly larger than the entities observed by biologists. In our experience, using a mild filter such as Clarity to

13 Our preliminary impression from the use of advanced tools such as the Hierax website with LLDSSDL images is that they do not offer substantial improvement, as the images are nearly optimal to begin with. Further experimentation is required.

14 Rossner and Yamada, "What's in a Picture," 14. In this volume we worked mostly with the simple and accessible application Microsoft Photos, which is standard for handling images in Windows 7 and 10.

15 Cromey, "Avoiding Twisted Pixels."

sharpen a given letter does not obscure or eliminate other essential factors of the image, and is therefore legitimate.

Rule 3: Use filters in a complementary way. Recent experiments in the psycho-physics and perception of images have shown, as can be expected, that no one single filter can be embraced as an optimum for reading ancient papyri.[16] Every pairing of an individual user with a specific document under specific conditions may give priority to one method or another. Various filters should thus be explored, and the results constantly compared.

Rule 4: Reversibility and accountability. All transformations applied to an image must be reversible. Readings produced by means of a filter will be accompanied by a notation of the software version and filter name. In extreme cases, the filtered image should be displayed next to the original one (in DSS studies it is usually the IR image). In an edition that involves multiple such cases, at least one example should be fully represented and explicated in the introduction.

Rule 5: Practice caution when merging discrete images into one. Such a move is needed when pasting the shape of a letter in a lacuna (cloning) or when joining several pieces into one "fragment." It is important to verify that the regions were not separately scaled or enhanced before pasted in the artificially constructed image. The reader should be informed of any such action, the source(s) of the respective images, and the steps applied to each of them.

Rule 6: Control the changes of size and resolution in images. Images arrive in a certain resolution, e.g., 300 dpi. An image may be resized without altering its resolution, with the features of size and resolution traded off: the larger the size, the smaller the resolution.[17] Some programs allow enlarging the resolution of an image without changing its overall size. When this is done, the computer needs to generate data that are not contained in the original image, thus creating unreliable results. Unmonitored resizing or compression often occurs when converting files to PDF format or when pasting them in a PowerPoint presentation. These steps should therefore be avoided in files intended for publication.

In every case of non-linear adjustment, the best practice is full disclosure of the details and logic of the adjustment. In general, scholars will do well to indicate the program and procedure used for every published image if it is not a 100% reproduction of the original.

One characteristic of DSS studies that eases difficulties which may arise from image manipulation is the public availability of the basic, raw images

16 Atanasiu and Marthot-Santaniello, "Legibility Enhancement."
17 Rossner and Yamada, "What's in a Picture," 15.

through the LLDSSDL website and now on the SQE website. While many journals and publishers now require authors to submit their raw data for peer review together with the processed images in the manuscript, this is not necessary in DSS studies since readers can easily check the originals on the web, or submit requests to the IAA staff for further images. Editors who use other photos than those publicly available should report it to their readers accordingly.

2 Digitally Repairing the Fragment

We now discuss a different aspect of image manipulation employed in the present book. The goal of restoration is to produce a single image that resembles the original shape of the fragment as much as possible, in order to support and improve readings and material reconstruction. Since it is no longer feasible in most cases to restore the physical fragment, scholars should achieve it by digital means. The procedure of digital restoration seeks to restore as many pieces of the fragment back into their proper alignment, fixing any damage caused to the fragment over the years. The digital process can fix and restore broken pieces back into their original location, unfold folded edges, repair uneven joining, etc. Information about the fragment's original shape is obtained from its various images, each image with its own merits, as well as by closely analyzing the deterioration of the fragment since its initial discovery.

Before initiating any digital procedure, its ethical consequences must be considered. Modern digital means can easily change any image, leaving nothing but faint traces of the graphic manipulation. The border between restoration and intervention is not always clear. One must therefore make sure that any graphic action does not result with a "new" fragment, one which never existed in reality. While repairing fragments, the rules delineated above for filtering should be kept in mind. More specifically, changes should be applied evenly to the entire piece of skin at hand: moving the fragment and rotating it are legitimate, but stretching parts of it that have shrunk will yield an unreliable representation of reality. Uneven scaling across various images in a canvas, or uneven scaling within the same fragment, i.e., obstructing the height-width ratio, are illegitimate.

In addition, it is crucial to be as transparent as possible. One is required to keep an exact log of all graphic steps taken in the process and duly report them, making the procedure fully reproducible.[18] Repairing (or "patching") a

18 Zuckerman ("Every Dot and Tiddle," 188–89; "The Dynamics of Change," 6–7) defines two levels of graphic manipulation: "invasive" and "noninvasive." As he claims, the former needs

fragment is subject to the above noted rules with regard to filters and manipulation, as well as with regard to the import of images from various plates into one "new" fragment. There is nothing in the repairing process in general, however, which inherently runs counter to the rules. If properly done and documented, it is a legitimate and helpful pre-processing step.

The restoration begins with collecting and comparing all the graphic documentation of the fragment. It is recommended to digitally locate all images of the fragment side by side on one sheet, in order to diagnose conspicuous changes. The goal of this action is to choose the preferable image to use as the *basic* image.

The basic image is the image that works best for reconstruction, depending on the state of the fragment and its unique problems. It will usually present the most complete fragment, upon which all manipulations and additions will be performed. The new LLDSSDL images bear several advantages since they were taken in a controlled environment, under documented conditions of illumination, from the same distance and from the same angle. They provide a large amount of visual data which in many cases allows for better readings and better assessment of the fragment's material properties. However, in numerous cases the old PAM images that were taken closer in time to the discovery of the fragments preserve data that is otherwise lost. In some instances, the newer images document fragments that have entirely deteriorated and crumbled, broken into tiny pieces or simply blackened, rendering their reconstruction not worthwhile. In other instances, when the main goal is creating a physical join, the loss of small pieces from the contours of a fragment may be significant for validating or disproving the suggested join. The process of choosing the basic image, therefore, should be done for each individual fragment.

In his various studies, Zuckerman discussed this procedure, which he calls "Patching."[19] This procedure is employed when the various pieces that comprise the fragment have been moved, deliberately or by mistake, during the various stages of preservation and photography. His main emphasis was to record the stages of patching as distinct layers in Photoshop and to abstain from smoothing the patch, so that the change would be apparent for the observer. The procedure suggested here is similar, with some nuance. The fragment should first be scaled and its background removed (see chapters 4 and 5). If the fragment

to be reported with a "higher critical profile." At this time, many academic journals provide guidelines for proper image manipulation. See, for example, '*PloS One*' figure preparation checklist: https://journals.plos.org/plosone/s/figures#loc-figure-preparation-checklist.

19 Zuckerman et al., "A Methodology for the Digital Reconstruction," 48–49; Zuckerman, "The Dynamics of Change," 5–6; Stökl Ben Ezra, *Qumran*, 58–60.

comprises more than one piece, and the various pieces are improperly placed, the following steps should be followed.

1. Cut each piece of the fragment from the basic image and paste the pieces back as separate layers. Make sure to keep the pieces at the same orientation as they have been imaged.
2. Choose one of the pieces as an anchor piece. If possible, this anchor should keep its original position as documented in the original image. It is preferable to choose pieces whose orientation is certain, i.e., a complete line of writing or a piece with right, bottom or top margin, which can be easily and securely aligned.
3. Adjust all other pieces, piece by piece, according to the anchor. Pay attention to produce straight lines of writings. While in most cases one should make sure that the fragments do not overlap, in some cases the skin has split, showing its flesh and hair sides. In such cases, the hair side of one fragment in the join must cover the flesh side of the other fragment. This is accomplished by defining the hair side as the upper layer in GIMP. When folded or twisted parts of the fragment appear only on the verso side, one should cut the twisted/folded piece from the verso image and paste it as a separate layer into the restored image of the recto.
4. The basic image should now be compared with all other images. The following questions should be considered: Does the basic image contain all the smaller parts represented on all images? Are there parts whose orientation changed vis-à-vis the old images? Are there signs of shrinkage compared to the old images? Did the restoration affect the shape of the basic image? Are there any folded edges of twisted pieces on the verso? (Such phenomena are especially common in papyrus fragments.)

If the answer to any of the above questions is positive, then the missing or damaged parts should be integrated into the image as separate layers from an image where they are more clearly visible, less deteriorated, or otherwise better fit for the join. The newly added parts should then be adjusted to the main piece according to the guidelines drawn above.

Adhering to the above drawn procedure is important for providing reliable images as infrastructure for later stage of the reconstruction. In this chapter we drafted best practices for the appropriate manipulation of images, specifically in two aspects: the application of digital filters and the repair of composite fragments using graphic software. In the next chapter we will define the need of properly scaled images and the methods for attaining them.

CHAPTER 4

Scaling the Images

In order to produce a canvas – a visual file with images of all fragments of a given scroll pasted on it together with the text – scholars need to draw on images of scrolls from various sources. Retaining the correct proportion of the fragments throughout the different stages of this procedure is crucial, while every stage in the procedure creates its own unique challenges. The scaling problems that arise from this complex procedure require a prudent methodology, which is delineated in this chapter.

In the case of the DSS, a scholar is most likely to use the PAM images and the new images from the LLDSSDL. The PAM images present the fragments on plates next to a hand-drawn ruler. These plates were then placed on a photography table, with the camera fixed above at a distance, using a device to hold it still. Until 1954–1955, the photographer, Najib Anton Albina, used to pick the exact place for the camera according to the focusing needs of each photo, while at a later stage he fixed the camera at a constant distance (figure 4).[1]

FIGURE 4 Najib Anton Albina photographing scroll fragments in the 1950s (PAM 43.887) © IAA, LLDSSDL, PHOTOGRAPHER: UNKNOWN. HTTPS://WWW.DEADSEASCROLLS.ORG.IL/LEARN-ABOUT-THE-SCROLLS/CONSERVATION

1 Strugnell, "On the History of the Photographing," 125–31.

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The result is that various PAM plates present the fragments on different scales, thus fragments taken from two different plates cannot be assumed to align. Furthermore, the IAA recently scanned the negatives of the PAM images and uploaded most of them to the LLDSSDL website. The entire process of photographing and digitalization of the PAM images thus includes several variables that influence their scaling.

Measuring the scale on a sample of digitized PAM images may help scholars in their analysis of these variables. The table below includes data about a number of a randomly chosen PAM images from the series 40–43: the length of a measure of 1 cm on the scale, measured digitally; the ruler number – each hand drawn ruler was given a random number in order to allow us to follow the change of rulers on the PAM plates;[2] the date that the photograph was taken;[3] the orientation of the plate; and the location of the ruler on the plate.

TABLE 1 Scaling of PAM plates in relation to features of their rulers

PAM number	**1 cm**	**Ruler**	**Date**	**Orientation**	**Location of ruler**
40.577	0.41	1	May–53	vertical	middle of bottom
40.585	0.41	1	May–53	vertical	right bottom
40.613	0.48	1	May–53	horizontal	top right
40.617	0.49	1	May–53	horizontal	right top
40.618	0.49	1	May–53	horizontal	middle of bottom
41.139	0.37	2	May–54	horizontal	right bottom
41.21	0.54	3	Jul–54	horizontal	right bottom
41.211	0.54	3	Jul–54	horizontal	right bottom
41.306	0.53	3	Oct–54	vertical	middle of bottom
41.348	0.53	4	Oct–54	horizontal	middle of bottom
42.032	0.37	5	Apr–56	horizontal	left bottom
42.034	0.61	5	Apr–56	horizontal	right bottom
42.041	0.37	5	Apr–56	horizontal	middle of bottom
42.042	0.37	5	Apr–56	horizontal	middle of bottom
42.185	0.57	6	Jul–56	horizontal	middle of bottom
42.247	0.57	6	Aug–58	horizontal	middle of bottom
42.701	0.55	7	Aug–58	vertical	left bottom

2 In the current sample of PAM plates nine different rulers were found.

3 Tov and Pfann, *Companion Volume*, 155–62.

TABLE 1 Scaling of PAM plates in relation to features of their rulers (*cont.*)

PAM number	1 cm	Ruler	Date	Orientation	Location of ruler
42.702	0.55	7	Aug–58	vertical	middle of bottom
42.758	0.55	7	Aug–58	vertical	right bottom
43.222	0.56	8	Jan–60	vertical	right bottom
43.223	0.56	8	Jan–60	vertical	middle of bottom
43.472	0.54	9	May–60	vertical	middle of bottom
43.474	0.54	9	May–60	vertical	middle of bottom
43.475	0.54	9	May–60	vertical	middle of bottom
43.479	0.54	9	May–60	vertical	middle of bottom

For most PAM images taken since 1954, 1 cm on the scale measures approximately 0.55 cm. As mentioned, the fact that the rulers were hand-drawn creates variations in their accuracy. The table demonstrates that slight variations between the measured length of 1 cm on the ruler are indeed correlated to the use of different rulers. In some cases, a significant difference occurs, where 1 cm measures as little as 0.37 (PAM 41.139, 42.041, 42.042) or as much as 0.61 mm (PAM 42.034). This discrepancy may be explained either by assuming that Albina chose to change the camera setting for some reason, or by imbuing the changes of scaling through the procedure of saving, compression, and transmission of these specific digital files. Prior to 1954 we find that 1 cm on the ruler is variously represented in the images. As can be seen from the data in the table, the orientation of the plate itself (horizontal or vertical) and the exact place of the ruler may slightly influence the scaling of the image due to the different angle that the light reflects from the ruler to the camera.

In theory, it would be sufficient to measure the ruler and then rescale the image accordingly to make it fit reality on a 1:1 scale. This can be easily done using an image manipulation program. Such a procedure solves the inconsistencies that are due to the distance of the camera from the plate and the file conversion, but it does not solve the more fundamental problems created by the fact that rulers are hand-drawn and variously placed on the plates with unknown accuracy. Due to this problem, comparing different images of the same fragment reveals as much as a 10–15% difference in size, even after a digital process of re-scaling that verifies that 1 cm on the ruler measures 1 cm on the software.

This problem can be solved by using the new LLDSSDL images as a scaling anchor, to which all the previous images of a given fragment can be compared and scaled accordingly. Unlike the photos taken in the Rockefeller Museum, the conditions in the IAA lab follow a strict protocol, and a standard commercial ruler (i.e., not hand-drawn) appears in each of the photos. The camera at the IAA lab is static and constant, and so is the position of the imaged fragments. However, it is important to note that the scaling may be disturbed during the transmission of the image files between the IAA laboratory and the scholars' computers. One should therefore also affirm the scaling of the LLDSSDL images. This can be done by measuring the ruler, and, if needed, rescaling the image accordingly using the same process described below for the PAM images. As explained in chapter 2, in order to maintain the relative errors to a minimum, it is advised to measure the entire length of the ruler on the image rather than only an inch or a centimeter.

When producing material reconstructions, using the PAM images is often preferable over the newer LLDSSDL images. While the latter give a better view of the extant letters, they reflect a later and often shrunk and deteriorated stage of material preservation.

Here are the recommended steps for scaling, focusing on the adaptation of PAM images to the new IAA images:[4]

1. Place both the PAM image and the LLDSSDL image as two separate layers in the same file, with the PAM image as the upper layer.
2. Diminish the opacity to make the PAM image semi-transparent.
3. Make sure that the height and width of all layers are bonded to maintain their ratio.
4. Adapt the scaling of the PAM image according to the new IAA image. Prominent ink marks and spacing between lines should act as control points. The more control points checked, the more accurate the scaling is.
5. Note: the fragments may have shrunk or deteriorated during the time between the taking of the two images. It is important to find an area on the fragment that remained unchanged and adapt the scaling based on that area. It is sometimes best to use both color and IR images for this

4 The questions of scaling were previously discussed by Zuckerman, Levy, and Lundberg as part of their methodology for stacking images of the same fragment as digital layers in Photoshop, yet they do not list concrete steps for scaling. See Zuckerman, "The Dynamics of Change," 69–88. See pages 3–4 in the online version: https://dornsife.usc.edu/wsrp/dynamics-of-change/; and in more length Zuckerman et al., "A Methodology for the Digital Reconstruction," 45–48.

process, since both the ink and the color of the skin are important for evaluating the changes the fragment went through.

Since copying or exporting images between files and software may affect the scaling, it is crucial to verify the scaling of all the images when used on a different file or software.

In conclusion, scaling is mainly a problem for the old PAM images, to which only hand-drawn rulers are attached, but it is important to check if any damage has also occurred to the new IAA images during the process of file transmission. When only PAM images are available for a certain fragment, an error of 10–15% may occur even after a rescaling of the image. But in most cases when an IAA image exists, comparing it with the PAM image using the above protocol makes the scaling error negligible. After all images are properly scaled, they are prepared for the digital canvas in order to begin the reconstruction of the scroll.

CHAPTER 5

Removing the Background

In order to prepare the image of a given fragment, unnecessary data must be removed. This is a prerequisite for any further graphic action, such as restoring of the fragment (chapter 3), filling the lacunae with letters (chapter 8), or placing the image in the digital canvas (chapter 12). The final goal is an image file that contains only the fragment on a transparent background. Graphic removal of the background constitutes a modern application of the Stegemann method. In her meticulous article on the principles of the Stegemann method, Steudel recommends drawing the boundaries of each fragment by hand, disregarding any unnecessary data which does not belong to the fragment and originates from the background.[1] Following Steudel's recommendation, scholars should use digital tools that yield accurate and precise results with regard to minute details. This chapter discusses the digital process of background removal. Following a brief discussion of the methodological aspects, a detailed technical manual of the process is provided.

Producing an image file, clear of unnecessary data from the old PAM images may present challenges to the scholar. For example, the old PAM images often present many fragments together on a single plate, plus a variety of additions, such as the scale, notes, and adhesive paper. Another problem is that the skin and the shadow it casts on the plate are quite similar, making it difficult to distinguish even for the human eye. The new LLDSSDL images (figure 5) capture the fragments with modern additions such the "checkers" plate, the scale ruler, the plate number tag, additional Japanese paper or adhesive tape that support the fragment, all on pitch black background.

Figure 5 shows a fragment that is imaged on a black background with Japanese paper supporting the fragment in the lacunae.

Before initiating any digital reconstruction, the modern trappings of the image should first be removed. The simple way to do this is to use one of the many online background removal tools.[2] These tools can assist in removing the majority of the background, but at present they cannot be fully trusted to only or entirely erase the unnecessary parts of an image. The main problem that scholars may encounter is the similarity in the ink and background colors. Where the letters abut on the background, automated tools may mistakenly

1 Steudel, "Assembling and Reconstructing," 526–27.

2 See for example the Remove Background function in Microsoft PowerPoint or in the Mac Preview app.

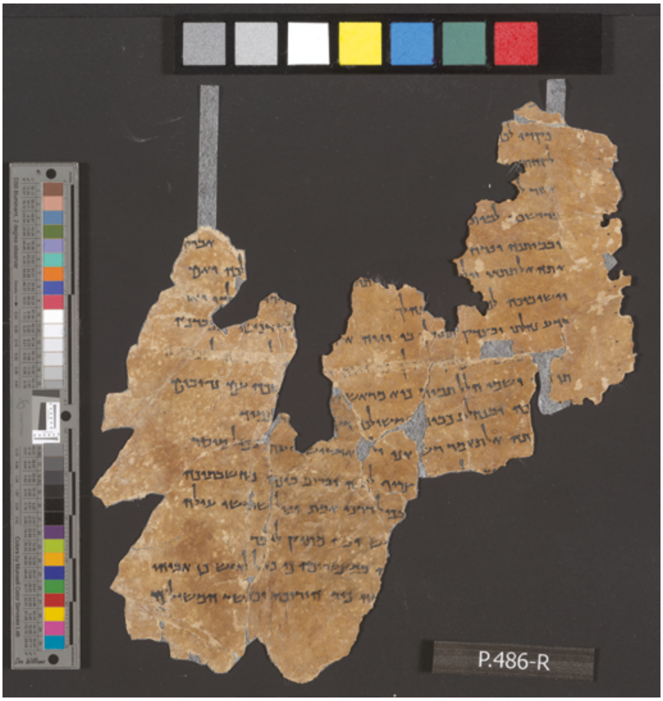

FIGURE 5 Image of fragment 4Q418 9 as supplied by the LLDSSDL (IAA plate 486, frag. 2; B–499679)

identify them as part of the background and remove them accordingly. In addition, some tools may reduce the image resolution and change its scale. The SQE platform applies to each fragment a mask calculated by an advanced algorithm, which in the great majority of pieces captures the borders of the fragment quite accurately.[3] Nevertheless, a careful human eye is still required to validate the automated procedure and correct it when necessary. The platform also provides a handy way for correcting the mask of unproperly separated fragments, usually in the case of pitch black pieces of skin.

1 Manual Removal of the Background

The first step of the process is a quick demarcation of the desired fragment with any of the selection tools. One should then cut out the fragment and paste it as a new image, disposing of all unnecessary data around it (figure 6).

3 See Levi et al., "A Method for Segmentation," 208–17.

FIGURE 6 Image of fragment 4Q418 9 after disposal of its surroundings
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In some programs, such as GIMP, deleting the surroundings of the image will result in an undesired white background, rather than a transparent one, hence the need to cut the fragment and paste it in a new file.

Whatever is left of the background must now be removed. Since the color of the background resembles the ink, special attention is needed in order to not erase any signs of ink during the process, particularly for letters whose ink abuts the background. The removal can be done in several manners. Using the Fuzzy Select/Magic Wand tools requires some experimentation in order to find the proper threshold. Even so, operating these tools may conclude with minute black dots surrounding the fragment, which harms the quality of the result. We therefore advise the use of the Scissors Select (GIMP) or Scissors (PS) tool, which will allow scholars to manually cut out the remains of the background and the Japanese paper (figure 7).

The final step is the removal of the fine details of Japanese paper that stand within the fragment. This step is also the most delicate one. The unique texture of the paper makes it difficult to remove with smart selection tools and requires the use of a free selection tool, carried out manually (figure 8).

FIGURE 7 Fragment 4Q418 9 after removal of background
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FIGURE 8 Fragment 4Q418 9 after removal of rice paper
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The procedure described so far applies to the LLDSSDL images, but its application to the older PAM images is more complex. Unfortunatly here there is no easy solution. The low resolution of the old images and the frequent shading surrounding the fragments require careful and slow manual work with a free selection tool, until the desirable results are reached.

CHAPTER 6

Finding Information on the Verso

The task of editing fragments is not complete without examining their verso, where important clues may be found for the reading and restoration: folded parts of the recto, additional ink marks, unnoticed layers, imprints of seams from adjacent layers, etc. The LLDSSDL provides images of the verso upon request for the entire DSS corpus, and the SQE platform now provides them for the entire corpus. Such images were carried out for only a few scrolls in the PAM collection, when ink signs were evident or in the case of an opisthograph.

Since the marks on the verso are frequently difficult to spot, and are sometimes also covered with Japanese paper as part of the restoration process, it is essential to enhance the verso images with digital filters in order to extract maximum visual information from them (for the correct way to perform this process, see chapter 3). It is also important to compare these finds with the signs on the recto. This chapter surveys the types of signs that can be found on the verso, most of which have been discussed in previous scholarship. However, here we concentrate much of the information in one place, treating the fragment as a three-dimensional artifact rather than a two-dimensional text. In addition, we offer new methods for distinguishing the origins of textual information that was found on the verso, which bears consequences for the material and textual reconstruction.

1 Modern Stamps

One of the most conspicuous ink marks on several scrolls' verso is Latin letters, stamped in modern times. These letters include: G, S, A, R, H, B, V, T, J, and E, which indicate the institution that had purchased the fragment before submitting it to the PAM.[1]

2 The Title of the Composition

In some scrolls the title of the composition was written by ancient scribes on the verso of the very beginning of the scroll, conveniently indicating the

1 Tov and Pfann, *Companion Volume*, 16.

content to the user, who would see it while searching for a specific scroll at the library. Two preserved examples are: the name מדרש ספר מושה written in square script on the verso of 4Q249 1 and the title דברי המאורות written on the verso of 4Q504. 4Q257 is another possible example.[2]

The following marks are crucial for the scroll's reconstruction.

3 Opisthographs

While most scrolls were written only on one side of the surface, usually the hair side of the skin or the side of the papyrus on which the fibers run horizontally,[3] some scrolls were inscribed on both sides. In such cases, each side of the scroll received a separate catalogue number, for example 4Q414–4Q415 (skin) and 4Q503–4Q512 (papyrus). Such scrolls are named opisthographs. In order to write the opisthograph the scroll was flipped either horizontally or vertically.[4] In these cases the verso is as important as the recto. When suggesting a material or textual reconstruction, one must take into account the text and material of both sides of the scroll.[5] Algorithms that help the scholar reconstruct

2 Tov, *Scribal Practices*, 118–22. For a fuller discussion see Jonathan Ben-Dov and Daniel Stökl Ben Ezra, "4Q249 Midrash Moshe: A New Reading and Some Implications," *DSD* 21 (2014): 131–49. We do not discuss here the many cases of titles written as the first few words of the composition. Nor do we discuss 1QS, 4QGen^{h}, where the title is written on the recto of the handle sheet.

3 See Mordechai Glatzer, "The Book of Books-From Scroll to Codex and into Print," in *Jerusalem Crown: The Bible of the Hebrew University of Jerusalem*, ed. M. Glatzer (Jerusalem: Ben-Zvi Printing Enterprises, 2002), 61–101; Tov, *Scribal Practices*, 32–33. For example, the Temple Scroll 11QT^{a} (11Q19) was written on the flesh side of what is probably split skin; see Roman Schuetz et al., "The Temple Scroll: Reconstructing an Ancient Manufacturing Practice," *Science Advances* 5.9 (2019). doi: 10.1126/sciadv.aaw7494.

4 See Perrot, "Reading an Opisthograph at Qumran," 101–14. According to Perrot, horizontal flipping is carried out by the same author of the recto, who aims for both sides to be read continuously, while vertical flipping is carried out by a later scribe.

5 For reconstructions that consider both sides, see, for 4Q503, Francis Schmidt, "Le calendrier liturgique des 'Prières quotidiennes' (4Q503), en annexe: L'apport du 'verso' (4Q512) à l'édition de 4Q503," in *Le temps et les temps dans les littératures juives et chrétiennes au tournant de notre ère*, ed. Christian Grappe and Jean-Claude Ingelaere (Leiden: Brill, 2006), 55–87; for liturgical papyri, see Daniel Falk, "Material Aspects of Prayer Manuscripts at Qumran," in *Literature or Liturgy? Early Christian Hymns and Prayers in Their Literary and Liturgical Context in Antiquity*, ed. Clemens Leonhard and Hermut Löhr (Tübingen: Mohr Siebeck, 2014), 33–87, and for 4Q433a/4Q255, see Aksu, "A Palaeographic and Codicological (re)assessment," 170–88. For more information about opisthographs from Qumran see Tov, *Scribal Practices*, 68–74.

both sides together already exist and may be included in the SQE platform in the future.

4 Evidence for Additional Layers

The phenomenon of fragments preserved in wads occurs more frequently than previously acknowledged in scholarship. While the original scholars did their best to separate the fragments from their piles, some layers were left unnoticed underneath another fragment, or separating them was not possible without damaging the artifacts. Thus, what at first sight seemed like cracks in the skin, may upon closer examination turn out to be evidence for additional layer(s) attached underneath the fragment. Here we bring one small example for such a layer visible on the verso from 4Q397 6, which is part of a copy of Miqṣat Maʿase HaTorah (figure 9). Another example for such layers in the copy 4Q418a of *Instruction* is frag. 22 (figure 10, discussed in chapter 15).

A thorough discussion of this phenomenon and its implications can be found in chapter 7; here we briefly mention it as part of the marks found on the verso. Identifying such layers, even without being able to read the text written on them, is crucial for the reconstruction of the scroll as it suggests how

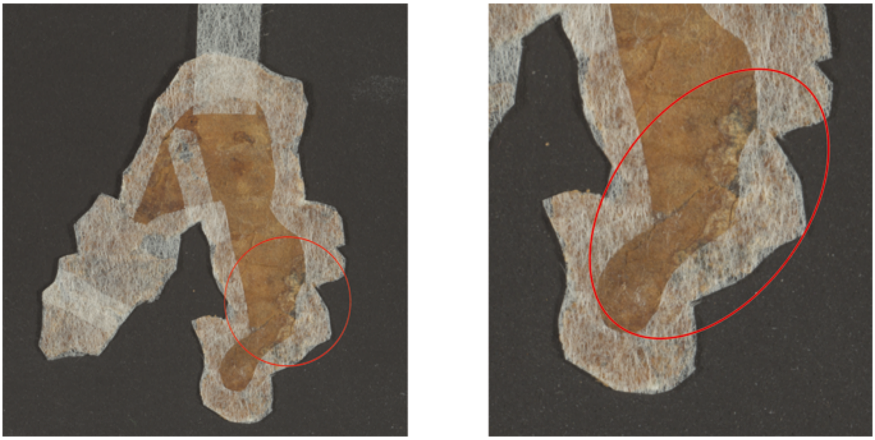

FIGURE 9 Left: 4Q397 6 verso. Right: A close-up of the encircled area. Signs of a small additional attached layer are visible on the verso. The identification of the layer attached to this fragment was done as part of the preparation of a new edition for MMT: Vered Noam, with decipherment and reconstruction by Eshbal Ratzon, *4QMMT: Some Precepts of the Torah* (Oxford: Oxford University Press, forthcoming).

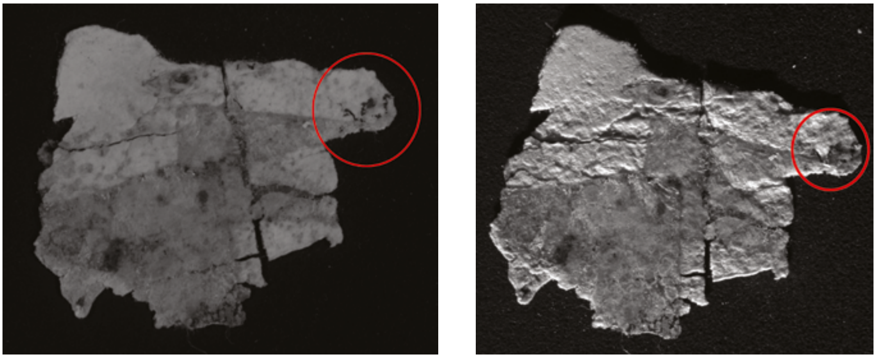

FIGURE 10 4Q418a 22 verso. Left: parts of the ink signs are covered. Right: raking light (left) image demonstrates that the ink is covered with another layer of skin (red circle). © IAA, LLDSSDL, SHAI HALEVI

much text is missing in certain places. The identification requires examining every available image, especially the older PAM images. With regard to the new multispectral images, color (composite) and raking light images are particularly helpful. When the possibility arises that more than one layer existed, it is advisable that the scholar examine the actual fragment under a dino-lite microscope that allows viewing the fragment from different angles.

5 Stitching Impressions

Most scrolls constitute several sheets sewn together. When rolled tightly, the stitches are pressed against the next layer. Finding their impressions on the recto or verso of a fragment may help in reconstructing its place in the original scroll if the actual stitches were preserved on another fragment. Conspicuous examples for this phenomenon include 11Q10 (Targum Job) and 11Q19 (the Temple Scroll), where the stitching and its impression are clearly visible.[6]

6 Examples for clear impressions can be seen on the Temple Scroll on the intercolumnar margin between columns XXVII–XVIII and on column XXXVI, see http://dss.collections.imj.org.il/he/temple. Stegemann, "Methods for the Reconstruction," 195. For examples of using this information, see Florentino García Martínez, Eibert Tigchelaar, and Adam S. van der Woude, *Manuscripts from Qumran Cave 11.II (11Q2–18, 11Q20–30)*, DJD XXIII (Oxford: Clarendon Press, 1998), 101, 163, etc. Other examples for stitching impressions can be found in Tucker and Porzig, "Between Artefacts" and Matthew P. Monger, "4Q216 – A New Material Analysis," *Semitica* 60 (2018): 303–33. Monger attributes the straight boundaries of the 4Q216 fragments to pressure caused by the stitching, but these breaks could have been caused by other reasons as well.

6 Mirror Writing

Unlike in the case of opisthographs, at times a text is found on the verso in mirror writing. Such writing can stem either from bleeding from the recto or from an imprint of an adjacent layer. To be precise, three scenarios are possible:

Option 1: *Bleeding* of ink from the recto of the same fragment.
Option 2: *Bleeding* of ink from the recto of another layer, still attached to the verso of the upper fragment.
Option 3: *Imprint* of ink from the next layer, no longer attached to the current fragment.

Physically, the first two options are similar. In many cases – particularly in thin skins – the ink penetrates through the skin from the recto to the verso. This phenomenon is called *bleeding*. Many of the fragments of 4Q417 and 4Q418a can serve as examples for this phenomenon. The third option is different, created by the attachment of ink from a subsequent layer. This phenomenon is called *imprint*. From the reconstruction point of view, options 2 and 3 are similar because they mean that the text on the verso does not belong to its immediate recto but rather to the preceding layer(s).

Despite the difficulties in identifying the origin of the ink, such identification is crucial for the reconstruction of the scroll and for the correct positioning of its text in the right order. Here we offer some methods for differentiating the three kinds of mirror writing on the verso. Identification of the first option, i.e. bleeding of ink from the recto, is the simplest. One should compare the verso image to the recto. Since in this case the script is seen as mirror writing, the image must be flipped on the horizontal axis with digital means. In option 1, the signs on the verso correspond to the writing on the recto (as can be seen in figure 11). This correspondence is helpful, for example, in cases when the script on the recto side is not visible or is illegible, either partly or entirely, while the verso preserves a better view of the letters.

If a correspondence between the signs on the recto and the verso was not found, one should consider either option 2 or option 3: either it is bleeding from another layer, still attached underneath the original fragment, or it is an imprint of ink from a layer that is no longer attached. Option 2 can occur when two layers of skin remain attached. In this case, the recto shows the writing of the upper layer, while the verso attests to the writing of the bottom layer (see chapter 7). Option 3 occurs when the mirror writing on the verso appears not through bleeding, but rather because the letters imprinted from the next layer, a layer which is either lost or preserved separately. A classic example for this

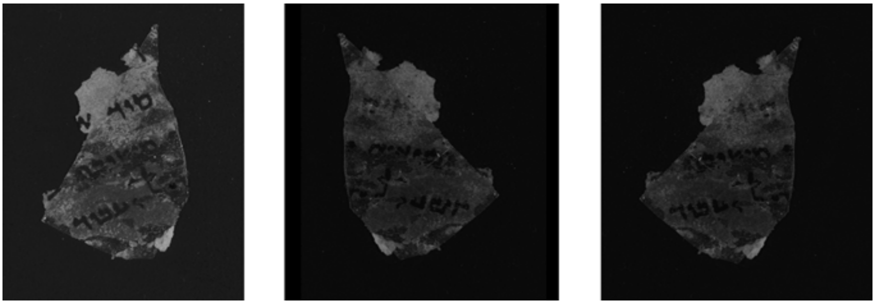

FIGURE 11 4Q418a 12 recto and verso. Left: 4Q418a 12 recto IR image; Middle: 4Q418a 12 verso IR image enhanced; Right: 4Q418a 12 verso IR image enhanced and flipped horizontally.

phenomenon is 11QT^{a}, which shows a large amount of imprinted text on the verso of many of its columns.[7]

In both options 2 and 3, the ink signs on the verso should be compared with the preserved text on the next layer. If it exists there, the ink is definitely an imprint. Full correspondence is a rather rare occasion, however.[8] When the text of the next layer is not known, several other methods can be used to distinguish ink bleeding from imprint:

1. When there are other fragments of the same scroll that show clear bleeding or impression of ink, it is likely (but not necessary) that the other cases of ink on the verso are due to the same phenomenon.
2. The ink signs which bled from the recto tend to appear in a pale color, with blurred boundaries of the letters. In contrast, the signs attached from the next layer show a darker color of the letters with sharper boundaries.[9]
3. When signs of additional layers can be traced on the verso, ink signs that do not correspond to the recto are most likely bleeding from a still attached layer, rather than imprints from past attached ones.

7 See Yigael Yadin, *The Temple Scroll* (Jerusalem: Israel Exploration Society, 1983), 6–7; and more recently Qimron, *The Dead Sea Scrolls*, 1.137–38; Torleif Elgvin and Emanuel Tov, "422. 4QParaphrase of Genesis and Exodus," in *Qumran Cave 4.VIII: Parabiblical Texts, Part 1*, DJD XIII, ed. Harold W. Attridge et al. (Oxford: Clarendon Press, 1994), 417–18.

8 For example, the identification of the imprinted text on the verso of 4Q377 remains debated. James VanderKam and Monica Brady, "377. 4QApocryphal Pentateuch B" in *Wadi Daliyeh II: The Samaria Papyri from Wadi Daliyeh / Qumran Cave 4.XXVIII: Miscellanea, Part 2*. DJD XXVIII. Ed. Douglas M. Gropp (Oxford: Clarendon Press, 2001), 205–17, esp., 205 read it as matching text from the recto of another fragment, but Qimron (*The Dead Sea Scrolls*, 3.141) doubts it. The verso of 4Q377 preserves both text seeping from the recto and imprints from the adjacent layer.

9 Compare, for Genizah documents, the discussion by Eric D. Reymond, "New Hebrew Text of Ben Sira Chapter 1 in MS A (T–S 12.863)," *RevQ* 27.1 (2015): 83–98, esp. 83–84.

Among the copies of *Instruction*, 4Q417 presents ink traces on the verso that show both bleeding from the recto and imprint from the adjacent layer.[10] In order to check whether the signs on the verso correspond to those on the recto, the image of the verso (after being horizontally flipped) should be superimposed on that of the recto as layers on a canvas. Decreasing the opacity of the verso will thus enable easy comparison of the layers. Those signs on the verso that correspond to the recto will prove to be bleeding signs, while the rest of the signs must have originated from the adjacent layer.

Figure 12 shows the result of the complete procedure, accompanied by auxiliary notation. As this image shows, a series of horizontal marks (marked blue in figure 12) on the verso of 4Q417 1 does not correspond to the lines of the recto and must therefore have been attached from the next layer. These marks all stand sequentially in a clear vertical line, indicating the lines of that next layer. The attachment of ink from the outer layer occurred only in a certain area of the scroll, possibly due to humidity or pressure affected at this point. These points of pressure may serve as significant marks for the material reconstruction of the scroll.

The two kinds of writing on the verso (bleeding, imprint) may sometimes overlap, thus disturbing the reading. Imaging and digital tools have been used in the past for enhancing the reading in such cases.[11] To sum up, at times the verso in no less important for the reading and reconstruction of the scroll than the recto, and is now made available by the IAA on the SQE platform. In the present chapter we offered some methodology for analyzing the verso's finding and using them in the reconstruction.

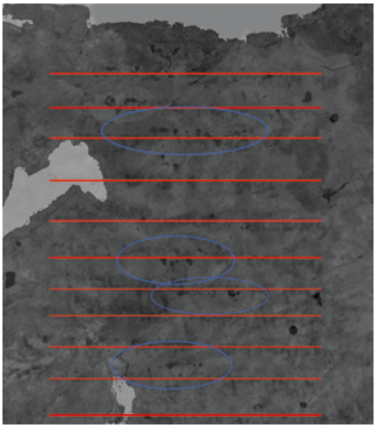

FIGURE 12
4Q417 Fragment 1 recto + verso, a close-up on the ink marks. Lines which correspond to those of the recto side (diminished opacity) are marked red. The remaining signs, which do not correspond to the recto, show consecutive signs, marked in blue. These lines originate from the next layer of the scroll. Graphics: Anna Shirav

10 Eibert Tigchelaar prompted us to examine the verso of these fragments, and the work was carried out together with Anna Shirav. For additional examples see Tov, *Scribal Practices*, 37–38.

11 Keith Knox, Robert Johnston, and Roger Easton, "Imaging the Dead Sea Scrolls," *Optics and Photonics News* 31 (1997): 30–34.

CHAPTER 7

Finding Wads

Scrolls began deteriorating in the caves while still rolled. If the layers of the scroll stuck together while deteriorating, the deterioration resulted in a pile of fragments stemming from the same area of the scroll. Such a pile is called here a wad.

The presence of wads is important not only for joining and reconstructing the columns, but also for reading the fragments and determining their relative order. This chapter will focus on identifying the wads, while the relative order of the fragments will be discussed in chapter 11.

Preservation in wads is documented in a few dozens of scrolls. While the layers of some wads were separated by various teams along the years, the wads of other scrolls remain piled up, either because they were unnoticed or because separating them would harm the skin (figure 14). In many cases the process of separating the wads or even the mere fact of their existence is documented in the formal edition of the scroll. Unfortunately, the existing documentation is not always complete or accurate. The result is that some scrolls that had originally survived in wads now appear as a collection of free-standing fragments. Previous editors of the scrolls have not always been aware of the existence of wads and therefore neglected to analyze them in their editions, sometimes leading to partial or even wrong conclusions. The methods below should thus be used as a standard by editors of the scrolls.

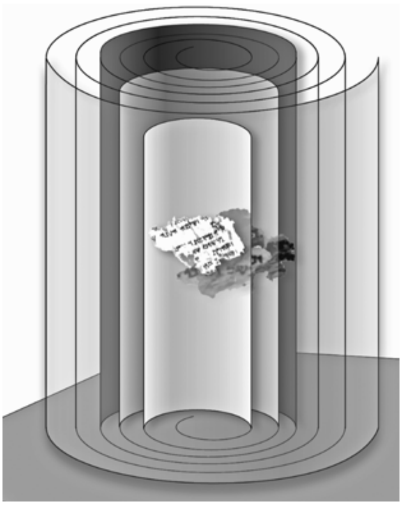

FIGURE 13
3D representation of a wad. Each color represents a layer coming from a different turn of the scroll. After the deterioration of the scroll, some fragments remain stacked, preserving their original order.
GRAPHICS: MICHAL SEMO-KOVETZ, TAU GRAPHIC DESIGN STUDIO

 DOI:10.1163/9789004473058_009

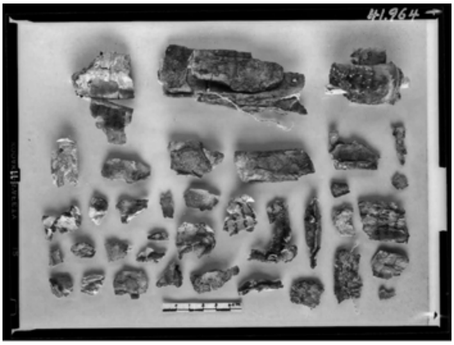

FIGURE 14
4Q82, PAM 41.964. While the innermost part of 4Q82 (top, first and second from right) remained rolled, other parts of the scroll have been separated, and remain wadded.

1 Methods for Tracing Layers that Are Still Attached

The following list describes measures that we used to identify layers that are still attached underneath a fragment:

1. The official publications sometimes record wads. For example, in the case of the scroll 4Q511, the editors note that frag. 51 is still attached above frag. 52, and that frag. 53 is attached above frag. 54.[1]
2. Several indicators for the presence of unidentified layers may be found through examination and comparison of every image of a fragment:
    a. Lower layers may still be seen in the older PAM images near the edges of the main fragment. The edges may appear at first glance to be cracks, but after closer examination they attest to another layer. For example, in PAM 40.619 the fragment 4Q324d 4 is seen with frag. 2 underneath it (figure 15). These layers were later separated, as attested in subsequent PAM images.

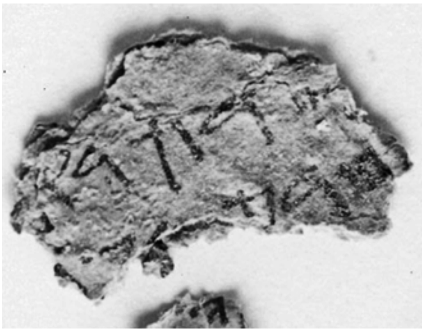

FIGURE 15
4Q324d 4, PAM 40.619

1 This fact is noted in the two editions of 4Q511: Maurice Baillet, *Qumrân grotte 4.III* (*4Q482–4Q520*), DJD VII (Oxford: Clarendon Press, 1982), 243–44; Angel, "Material Reconstruction," 25–82, esp. 39.

b. When inconsistent line heights or of letter shapes is found, the existence of a wad should be suspected. For example, the wads of the scroll 4Q511 are clearly seen on PAM 41.691. The wads can be spotted not only by means of their very clear edges, but also in places where the line of writing from the lower layer is seen next to a line from the upper layer (figure 16).[2]

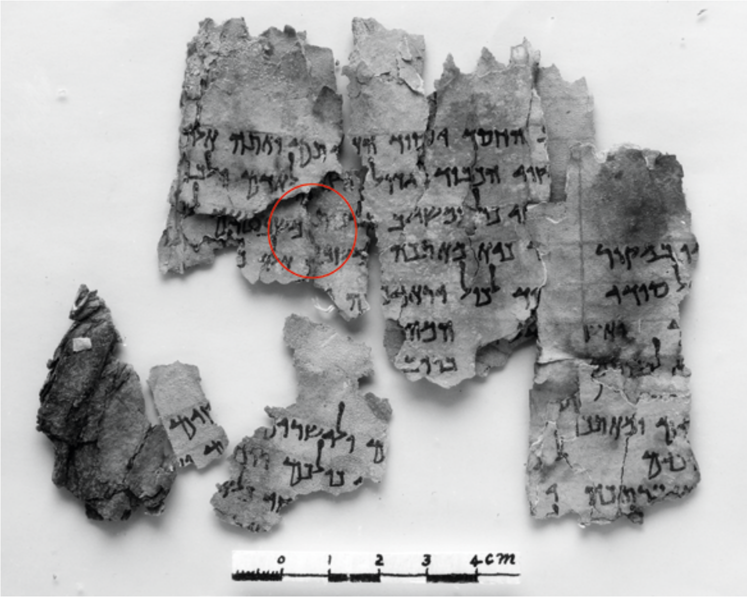

FIGURE 16 4Q511 fragments 52, 54, 55, 57, 58, PAM 41.691. Fragment 57 is seen underneath frag. 54. Inside the red circle, letters that seem cracked are in fact part of two separate layers.
© IAA, LLDSSDL, NAJIB ANTON ALBINA

c. Tracing differences on the surface of the fragment (recto and verso) along its imaging history can also reveal that another layer is attached underneath the upper layer. Such differences are sometimes the outcome of – intentional or unintentional – separation of the upper layer of the wad, revealing sections of the next layer underneath. An example for this procedure is presented in detail in chapters 15–16 regarding 4Q418a 22.

d. There are many sorts of ink marks preserved on the verso of fragments, which can be used for further material observations. It is

2 For a reconstruction of these fragments see Angel, "Material Reconstruction," 39–44.

essential to check for ink marks on the verso, following the method described in chapter 6. While some such marks may have infiltrated from the recto, others did not, and may thus yield new hints for the scroll's composition. Such ink marks may indicate the existence of an additional layer, whose ink has stuck to the upper layer while rolled. Examples are given below for 4Q418a 5, 14, 22 etc.

When clues for the existence of a wad appear, it is important to examine the actual fragment from multiple angles with a hand-held microscope. Having confirmed the preliminary suspicion, one may then estimate the number of layers in the wad. In some cases, letters from the lower layers will be legible. In others, the mere existence of those layers is important for estimating the amount of missing text in certain regions of the scroll and for determining the number of layers in the material reconstruction.

2 Methods for Identifying Fragments that Originated from Wads

The separation of wads was usually, but not always, documented. Documentation is found in the PAM images by means of numbers written on small pieces of paper next to the fragments. For example, Milik, who was the first to work on the scroll 4Q324d, did not achieve an edition of this scroll. If he had any notes about this work, they have been lost. Studying images of 4Q324d, we discovered that some of the fragments were preserved in wads. Information arose from PAM 40.619 (figure 15), where two fragments are still attached one on top of the other, and from PAM 41.962, where the fragments are already separated with numbers written next to them.

The scroll 1Q22, published by Milik in DJD I, is a parade example of recording the wads and using them for reconstruction. The wads are lucidly presented on the older PAM 40.511, shedding light on Milik's reconstruction of this difficult scroll (see figure 17).[3]

3 See Józef T. Milik, "Dires de Moïse," in *Qumran Cave 1*. DJD I. Ed. Dominique Barthélemy and Józef T. Milik (Oxford: Clarendon Press, 1955), 91–97; Ariel Feldman, "Rewritten Scripture: Narrative and Law," in Ariel Feldman and Liora Goldman, *Scripture and Interpretation: Qumran Texts that Rework the Bible* (Berlin: de Gruyter, 2014), 225–61. Note that the handwriting on PAM 40.511 (figure 17) is not Milik's (thanks are due to E. Tigchelaar for this observation). See also Elgvin, "The Genesis Section," 180–96, with regard to the scroll 4Q422, whose wads were marked by Strugnell and materially reconstructed by Elgvin.

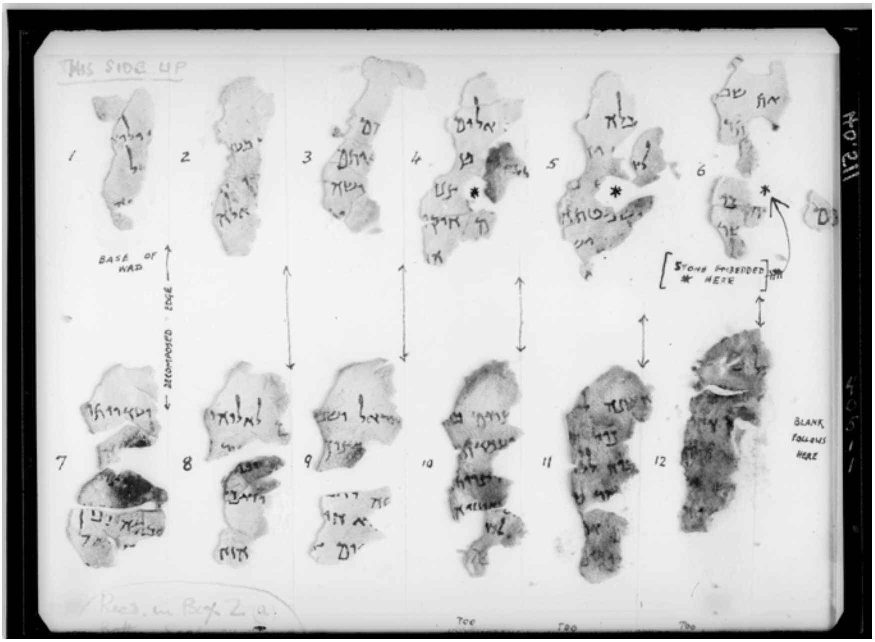

FIGURE 17 1Q22, PAM 40.511
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Not all scholars of the first generation were as careful when recording their wads. Present-day editors should thus be alert to the possibility of finding wads. The possibility for the existence of a wad should be considered when several fragments share common shape and damage patterns, even if they are not preserved attached. This is in fact the case in many of the scrolls that have been restored using the Stegemann Method.[4]

Wads are significant key for the reconstruction of the fragments' order in a scroll. This chapter suggested several methods for finding traces for such wads as a first step for placing the fragments in their original location.

4 For the Stegemann Method, see chapters 11 and 12.

CHAPTER 8

Reading and Text Reconstruction

While earlier chapters focused on the fragments and their images, in this chapter we address the text preserved on them, aiming to raise methodological issues which will ultimately lead to creating a fully-fledged digital canvas for each scroll. Imaging technologies raise new issues that should be addressed in this regard, starting with the basic act of reading the signs and reporting them to the reader by means of transliteration. In broken scrolls, it is sometimes important to suggest textual reconstructions to fill the lacunae, or in other cases to fill the space between two fragments that stand in the same column. We evaluate the technique known as letter cloning, in which lacunae in the scroll are filled by means of cut-and pasted letters, to check the validity of the suggested reconstruction. Finally, we assess the act of suggesting text reconstructions, discuss some of its limitations, and offer guidelines for appropriate conduct.

1 Marking Doubtful Letters

A substantial methodological question arises with regard to marking doubtful letters. Sister-professions like classical paleography, where a lot of text is available and therefore the relative significance of individual signs is diminished, employ only one markup of doubt, usually a dot underneath the transcribed letter.[1] Editions of DSS usually distinguish three levels of doubt for damaged letters, marking them above the letters according to the certainty of the reading: A dot above (אׄ) signals a most probable letter, a circlet (א֯) above an uncertain reading, and an empty circle (◦) in the place of an unidentified letter.[2] In his recent edition, Qimron retained these three levels of doubt, while refining

1 This is the rule in the Leiden Conventions. See: https://wiki.digitalclassicist.org/Leiden-plus.

2 These definitions are our translation from Émile Puech, *Qumran Grotte 4. XXII: Textes araméens, première partie: 4Q529–549*, DJD XXXI (Oxford: Clarendon Press, 2001), xviii. Most DJD authors use the same categories. Barthélemy and Milik, *Qumran Cave 1*, 48, define three levels of doubt, the lowest one being a letter that is paleographically improbable but required by the context; this category appears with a question mark above the letter. The same annotation of a raised question mark had been initially used by Strugnell and Harrington to denote a third level of doubt, but it was removed as part of the preparation for the DJD XXXIV volume (see Tigchelaar, *Increase Learning*, 20).

DOI:10.1163/9789004473058_010

the notation by means of new marks for abraded letters, various types of lacunae, etc.[3] The use of a circlet (א̊) markup presents a problem, however, because scholars use it to express two separate phenomena. While in some cases it does mark an uncertain letter as required, in other cases, especially when parallel texts are used for the reconstruction or when the composition uses highly formulaic, recurring language which enables easy reconstructions, the circlet is an inadequate marker. In such cases, one encounters very small marks of ink, which could in fact be part of many different letters; had there been no textual parallels or formulas, these letters would have been designated as unreadable marks (○). Recording them in the transcription is based solely on other, external indications, while the letters are not there to see.[4] In their edition of 4Qpap cryptic A Serekh haEdah, Ben-Dov, Stökl Ben Ezra, and Gayer used hollow letters to mark such cases, in addition to the two usual levels of markup.[5] This system is particularly useful in highly fragmentary scrolls, where each letter culled from a parallel or formula carries a great value for the overall understanding of the text. Hollow letters will not be used in the present volume however, due to technical limitations of production.

2 Letter Cloning

Scholarly reconstructions are often made with standard Hebrew computer fonts such as SBL Hebrew or David. Since these fonts reproduce neither the sizes of the original letters nor their exact positions when specific pairs of letters are invoked (e.g., in the sequence כו, when the *vav* often touches the bottom stroke of *kaf*), better replacements should be sought. A more reliable technique is employed by skilled paleographers like Émile Puech or the late Ada Yardeni, who draw the suggested letters in the lacuna while perfectly imitating the extant script in the scroll.[6] The use of such a technique, however, depends on the rare skills and widely recognized authority of gifted individuals,

3 Qimron, *The Dead Sea Scrolls*, 1.כח, lists the various markups on an inserted bookmark for use next to the edition. The rules for these new signs are not indicated in the actual book.

4 Such markup is frequent in formulaic texts like the Astronomical Enoch, as amply attested in Henryk Drawnel, *The Aramaic Astronomical Book (4Q208–4Q211) from Qumran: Text, Translation and Commentary* (Oxford: Oxford University Press, 2011).

5 Jonathan Ben-Dov, Daniel Stökl Ben Ezra, and Asaf Gayer, "Reconstruction of a Single Copy of the Qumran Cave 4 Cryptic-Script Serekh haEdah," *RevQ* 29.1 (2017): 21–77, here 38–39.

6 See for example Bezalel Porten and Ada Yardeni, *Textbook of Aramaic Documents from Ancient Egypt, Volume 1: Letters* (Jerusalem: Hebrew University Department of the History of the Jewish People, 1986), 125; Émile Puech, "*11QPsAp*^{a}: Un rituel d'exorcismes. Essai de reconstruction," *RevQ* 14,3 (1990): 377–408, especially 404–8. An extreme application of

and cannot be adopted wholesale by non-trained textual scholars. In addition, hand-drawing the letters retains a certain measure of subjectivity and variation on the part of the expert paleographer, one which cannot be achieved in automated letter reconstruction. Such subjectivity may improve the reconstruction, allowing more flexible results, but may also harm it by producing idiosyncrasies or inexact renderings of letters. In this book we suggest a more standardized solution.

The technique of letter-cloning involves copying the shape of the same letter or letters from a proximate position in the scroll, and pasting them on the extant signs, or in the lacuna, as a new layer of the image.[7] This technique, first suggested by Armin Lange in 1993, is now much easier to achieve using GIMP or Photoshop.[8] Letter cloning is useful when reading fragmentary letters and when completing small-scale lacunae. In the former case, one should validate that the reading fits the actual signs, sometimes no more than minute specks of ink left on the fragment. In the latter case, the suggested reading must fit the space of the lacuna. Letter cloning is efficient and reliable for completing small-scale lacunae. When a reconstruction of longer texts is required, we recommend using custom-designed fonts, as explained in detail in chapter 10.

Adding color to the pasted letters adds transparency to letter cloning, distinguishing the extant text from the artificial one (figure 19). The opacity of the pasted letter can be diminished in order to make the signs of ink on the fragment show more clearly. When completing broken letters, it is advisable to paste the suggested letters only in outline (figure 18).

When copying and pasting letters one should choose the most complete and reliable letter forms.[9] Important methodological points to take into account are:

1. Letters should preferably be copied from a close region on the fragment.
2. Letters should preferably be copied from the same constellation in the word (beginning of the word, position with regard to the neighboring letter, connected letters etc.).

this technique was carried out by Andrew Fincke, *The Samuel Scroll from Qumran. 4QSam^a Restored and Compared to the Septuagint and 4QSam^c* (Leiden: Brill, 2001).

7 The term "letter-cloning" was suggested by Bruce Zuckerman, "Every Dot and Tiddle"; Zuckerman, "The Dynamics of Change." See 13–19 in the online version: https://dornsife.usc.edu/wsrp/dynamics-of-change/.

8 Lange, *Computer-Aided Text-Reconstruction*; Lange, "Computer Aided Text-Reconstruction."

9 These restrictions were formulated by Zuckerman, "The Dynamics of Change," 13–19.

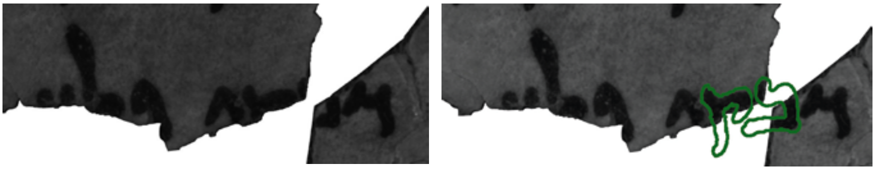

FIGURE 18 Reading the words דבׄקי פלא in 4Q405 19a 5. The suggested letters are pasted in outline on top of the extant signs. Left: the fragment in its original state. Right: the letters ב and ק, cloned from the same fragment and pasted on the extant ink signs. The cloned letters validated Carol Newsom's reading of this fragment ("MasShirot 'Olat HaSabbat" *in Qumran Cave 4 VI: Poetical and Liturgical Texts, Part 1*, DJD XI, Esther Eshel et al. [Oxford: Clarendon Press, 1998], 239–52), *contra* Qimron's later suggestion. For a complete discussion and references see Noam Mizrahi, "Eleventh Song of the Sabbath Sacrifice: Literary form and Exegetical Content," [Hebrew] *Tarbiz* 87.1 (2020): 5–36.
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3. It is preferable to copy-paste the same sequence of letters rather than a single letter.[10]

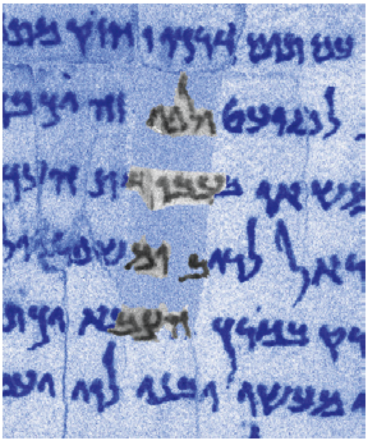

FIGURE 19
A section from 1QSa I 18–21, with suggested completion of the lacunae. The image reproduced (colored blue) is a graphic reconstruction of the scroll based on a photograph taken by Bruce Zuckerman and Kenneth Zuckerman, West Semitic Research, in collaboration with Princeton Theological Seminary.
COURTESY JORDAN MUSEUM. GRAPHICS: EINAT TAMIR

4. Letters should retain the original scaling of the copied letters.

10 See the considerations in Yigal Bloch, Jonathan Ben-Dov, and Daniel Stökl Ben Ezra, "The Rule of the Congregation from Cave 1 of Qumran: A New Edition," *REJ* 178.1–2 (2019): 1–46, here 6. Some earlier studies are: Michael Langlois, "Les manuscrits araméens d'Hénoch," 115–119; David Hamidović, *Les traditions du jubilé à Qumran* (Paris: Geuthner, 2007); Hamidović, "In Quest of the Lost Text"; Bronson Brown-deVost, "4QEn^{c} (4Q204) Column I: A New Reconstruction," in *From Enoch to Montréal and Back: New Vistas on Early Judaism and Christianity. Papers from the Fifth Enoch Graduate Seminar, Montréal, 20–24 May 2014*, ed. Lorenzo DiTommaso and Gerbern S. Oegema (London/New York: Bloomsbury T&T Clark, 2016), 60–84; Tucker and Porzig, "Between Artefacts."

3 Reconstruction Based on Parallels

While scholars often suggest completions of words based on the context or on biblical allusions, lacunae and broken letters are better reconstructed based on a parallel text. A convenient list of overlaps between copies in the non-biblical Qumran corpus was composed by Tigchelaar, but other lists have arisen since then.[11] Caution should be practiced when using the text of other copies of the same composition in textual reconstructions, because copies may reflect different forms of the source composition, and significant variations are ubiquitous in Second Temple compositions.[12] In contrast, quite a few other texts – whether sectarian or not – display a reasonable amount of stability, with copies differing only in minor scribal mistakes and corrections.[13] Reconstructions based on textual parallels seem more justified in these cases. For example, a reconstruction of the highly fragmentary cave 4 copy of Serekh haEdah was made possible by means of a digital reconstruction of its text in parallel to the well-preserved 1QSa, despite some recensional differences between the two.[14] It seems that *Instruction* belongs to the group of scrolls with a relatively stable text. In this composition, the long overlaps preserved between different copies attest to meager textual changes, amounting to several letters or – at a maximum – one word.[15]

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11 Eibert Tigchelaar, "Annotated Lists of Overlaps and Parallels in the non-Biblical Texts from Qumran and Masada," in *The Texts from the Judaean Desert. Indices and an Introduction to the Discoveries in the Judaean Desert Series*, ed. Emanuel Tov. DJD XXXIX (Oxford: Clarendon Press, 2002), 285–322; For new overlaps see for example Ariel Feldman, "An Unknown Prayer from 4Q160 and 4Q382," [Hebrew] *Meghillot* 11–12 (2014–15): 99–109.

12 Famous examples are the differences between the MT and LXX versions of Jeremiah. Among the non-biblical texts, a well-known example is the various texts of S (1QS, 4Q255–264, 5Q11, and 5Q13), see e.g., Philip Alexander, "The Redaction History of 'Serekh Ha-Yaḥad': A Proposal," *RevQ* 17 (1996): 437–56; Charlotte Hempel, "Shifting Paradigms Concerning the Literary Development of the Serekh," in *The Qumran Rule Texts in Context* (Tübingen: Mohr Siebeck, 2013), 109–19; Qimron, *The Dead Sea Scrolls*, 1.209–10.

13 A notable example where only minor variants are attested is Shirot Olat HaShabbat, whose manuscripts were found both in Qumran and in Masada (4Q400–407, 11Q17, Masık). Noam Mizrahi stated the textual stability of Shirot Olat HaShabbat in an oral presentation: "Textual Pluriformity and Literary Development in the Qumran Scrolls," lecture at the conference "Textual Plurality beyond the Biblical Texts," Université de Lorraine, 2017.

14 See Ben-Dov, Stökl Ben Ezra, and Gayer, "Reconstruction of a Single Copy." In turn, this reconstruction called for modifications in the text and reconstruction of 1QSa, see Bloch, Ben-Dov, and Stökl Ben Ezra, "The Rule of the Congregation."

15 This matter will be discussed further in chapter 14. Tigchelaar, *Increase Learning*, 64, mentions "instability of the text" of *Instruction*. This is relative, however, as he refers to instability in terms of spelling and other minor variants, not of large textual differences.

Potential pitfalls of this procedure must be kept in mind.[16] Orthography may be different from copy to copy; for that purpose, the scholar must first establish the orthographical profile of each manuscript, which will then allow them to verify the readings by means of letter cloning. Second, there is the problem of the frequency of vacats, as some scribes insert more or longer vacats in their text than others. For example, in the parallel text appearing in 4Q418 9 and 4Q416 2 iii, the scribe of 4Q418 clearly uses longer vacats, as seen at the end of lines 12 and 16. This problem will be addressed in chapters 9 and 10, as part of the procedure of textual reconstruction.

In general, we are wary of suggesting hypothetical completions of lacunae when a parallel is absent.[17] However, textual completions have often proved useful when a new join or a new arrangement of fragments is suggested. Scholars who suggest the new join can significantly strengthen their case by positing words to bridge the gap between the respective fragments while maintaining valid syntax and reasonable content. Arguably, a new distant join can only be put forward if accompanied by a feasible completion. In such cases, some measure of textual speculation and creativity is indeed warranted, as is employed in the present volume. Of course, scholars may be content with the separate fragments as they are, not suggesting joins and not having to invent text completions. Such minimalism, we fear, is not to the benefit of our profession.

16 See Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 5–6.

17 See Qimron's cautious methodological remark in *The Dead Sea Scrolls*, 1.יב.

CHAPTER 9

Recreating Single Columns Based on Fragments and Parallels

The reconstruction of a fragmentary scroll is a difficult task, similar to putting together a jigsaw puzzle with only a few of the pieces, and with the complete picture unknown. After collecting the various data described in the preceding chapters, we now reach the essential unit for the reconstructed canvas: the column. The work of material reconstruction involves establishing the borders and measurements of all columns, both those preserved intact and the fragmentary ones. Some reconstructions also require positing blank, hypothetical ("dummy") columns, whose existence is proven by the reconstruction procedure. The best way to assemble the data is to recreate them on a digital canvas.[1] Such a canvas and the way to produce it is the heart of the discussion in the present volume. The canvas should contain accurate measurements for all columns and their margins throughout the sheets of the scroll. The length of the scroll is then determined based on the number of fragments and other available information.

In Qumran, scrolls are constructed from a series of leather or papyrus sheets, stitched or glued to each other. Each sheet is divided into columns, i.e., writing blocks. A column is an inscribed surface, limited on four sides by uninscribed surface, i.e., top, bottom, and side margins. Being the essential unit for digital restoration, the definition of a column involves such concepts as width, number of lines, distance between lines, and the size of margins (top, bottom, intercolumnar, and the intercolumnar margin at the seams between sheets of leather). These factors provide the skeleton of a given scroll, which translates into a two-dimensional canvas.

The column is the essential building block of the reconstruction process. Since column features often vary throughout a scroll, each column ought to be treated separately. Reconstruction begins by determining the width and height of the writing block, which is then translated to a square box drawn on the

1 The digital canvas is in fact a modern application of the method presented by Steudel, "Assembling and Reconstructing," 516–34. For a more recent digital reconstruction see Torleif Elgvin, "1QSamuel – A Pre-Canonical Shorter Recension of 2Samuel," *ZAW* 132 (2020): 281–300. This reconstruction was carried out using fonts designed at the Haifa project for the DSS as is duly acknowledged. We thank Prof. Elgvin for sharing his article with us before publication.

 | DOI:10.1163/9789004473058_011

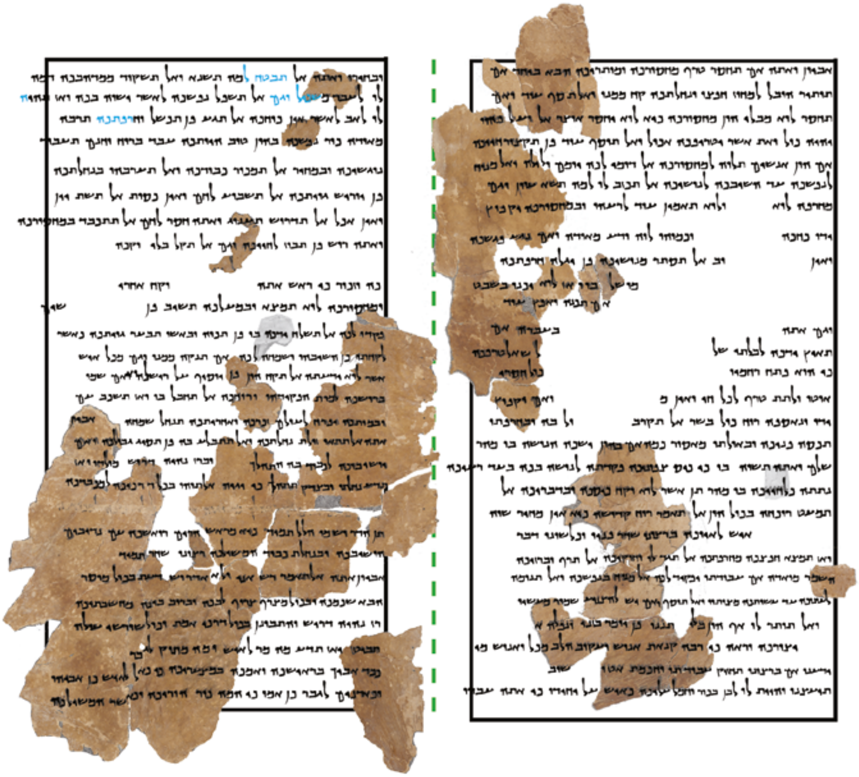

FIGURE 20 Two consecutive columns of 4Q418. Borders are marked in boxes. The broken line indicates the seam between sheets.

digital canvas (figure 20). Thereafter, one should turn to the reconstruction of the top, bottom, and intercolumnar margins. Seams between sheets should be clearly marked on the canvas by means of a broken or colored line.

1 Width

The width of columns in the Qumran scrolls is greatly variable, although it correlates in a general way to the height of the scroll.[2] The last column in a sheet will often have a different width than the preceding ones, in order to fill out the remaining space. The methods for establishing the width of a column in a fragmentary scroll include the tracking of dry rulings, of complete lines of

2 Tov, *Scribal Practices*, 77–84.

text, and of parallel text. The creation of hypothetical columns using material markers is also required. These parameters are discussed below, arranged from the simplest to the most difficult for reconstruction.

1.1 *Dry Rulings or Complete Lines of Text*

When dry rulings are preserved in both right and left margins as for example in 1QM, 1QpHab, and 11QT[a], they indicate the width of the column. The same pertains to scrolls where complete lines are preserved, even without the dry rulings. Note, however, that while all lines begin flush on the right ruling, they deviate from the left ruling by as much as 1–2 words on either side.[3] Tov addressed this issue by recording the width in the form of a range of numbers rather than in concrete terms.[4] However, defining the width in the form of a range is unsuitable for the purpose of digital reconstruction, whereby a definite line is required. One should therefore measure the width of as many lines as possible, and find the mode number of line width, i.e., the most frequent figure for the width of a single line among the lines of a given column.[5] If only a few lines are preserved without a substantial demonstration of width, the average or median width of lines can also be selected.

1.2 *Using a Parallel Text*

When neither dry rulings nor complete lines are preserved, the width of the column should be deduced from the text of parallel copies. Most biblical scrolls fall into this category (notwithstanding the doubt with regard to the nature of the biblical text represented in them), and many non-biblical scrolls as well. One has to fill in the missing text based on the parallel, breaking the lines according to the available place.

Using a parallel text for establishing column width requires the positioning of a fragment within the typed text (see figure 20). This fragment then functions as a textual anchor, pinpointing the text to a specific layout. A fragment whose place in the column is verified by material indicators, such as the existence of margins, is preferable for this purpose. Such a fragment would provide both the width of the column and the exact position of the text within it. A less-securely placed fragment would not allow the secure location of the text

3 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 21–26, conveys a method for calculating a "scribal margin policy" for each scroll, offering helpful hints for where the margin can be expected.

4 Tov, *Scribal Practices*, 82–83.

5 The mode number is more indicative in this case than the mean number because exceedingly short or long lines, such as lines ending with *vacat*, may dramatically affect the mean width and provide a false estimate.

in the exact layout. After placing the fragment, the parallel text would provide the number of letters and points of break between the lines. This parallel text is cast in the layout of the fragmentary scroll (figure 21). If carried out with appropriate methods, this action should provide a solid estimation of the width of the column.

The number of characters in a line and its width in centimeters are not mutually indicative, as there are other factors to consider, such as the sizes of letters and of the space separating them, and size of the inter-word space. Most scholarly reconstructions of texts are made with standard Hebrew computer fonts such as SBL Hebrew or David. Since these fonts reproduce neither the exact size of each individual letter, nor the relationship between the letters in the manuscript, they cannot be used for estimating the width of the line in centimeters.

A method developed by Edward Herbert in 1997 for the reconstruction of long textual units may be used for determining the width of a column.[6] Herbert's method, however, is highly demanding. He suggested six-steps for conceiving the width of letters and columns. Each step is in turn developed into several sub-steps and work stages.[7] They involve not only measuring each letter but also calculating the mean width and the standard deviation, as well as establishing an intricate statistical method for the compilation of this aggregate of data. We find this method inconvenient for use by textual scholars and paleographers in their everyday work.

Instead, the particular characteristics of each handwriting can be represented on the canvas with a custom computer font designed especially for each scroll, which mimics the hand of the scribe, thus sparing the need for a concrete measurement of each letter. This requires some technical skills. By using the excellent new images of the LLDSSDL and the DSSDP and with current computer software, reliable figures of column width can be reached and applied to entire lines. Such fonts are a steady, reproducible tool, easy to measure and compatible for statistical analysis. Carefully designed fonts can account not only for the widths of individual letters, but also for the letter's interaction with neighboring letters (kerning), and for the distance between words and between lines. Chapter 10 discusses the creation of such fonts. Quite

6 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 5–26, 34–62.

7 See Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 5–26. The six steps include: Assessing average width for every letter according to its occurrence in the scroll; employment of vertical dividers for a more accurate assessment of column width; calculation of "critical deviation" for overruling reconstructions that exceed a 5% deviation from the expected deviation; identification and calculation of margins when they are not preserved; developing a scribal margin policy to assess the location of the left margin; and finally, analyzing the columns according to their specificities.

FIGURE 21 Estimation of the width of a column of 4Q82 by casting the text of Micah 1:12–3:36 in the layout and script of 4Q82, fragments 91, 93, 94. Reconstruction and Graphics: Joshua Matson

surprisingly, we will show that reconstructing a column with a custom font gives a good approximation of its width even when the size and location of vacats is unknown.[8]

1.3 *Hypothetical (Dummy) Columns*

The method delineated here requires in some cases the reckoning of "hypothetical" columns, for which neither fragments nor parallel text survived. Concrete numbers for such columns are dictated by the trial-and-error procedure of the material reconstruction, as explained in chapter 12. The starting

8 When the specific habits of the scribe of one particular scroll are known, they should of course also be followed in the reconstruction, for example in scrolls that use indentation at the beginnings of paragraphs, as in 1QS. Elgvin's reconstruction of 1QSamuel incorporates the indentations into his reconstruction in an effective example of using computer fonts and digital canvasses. Even more conspicuously, vacats seem to operate as thematic markers (rather than mere technical spaces) in the *pesharim*; see Bronson Brown-deVost, *Commentary and Authority in Mesopotamia and Qumran*. JAJSup 29 (Göttingen: Vandenhoeck & Ruprecht, 2019), 45–51, 232–33; Gregory H. Snyder, "Naughts and Crosses: Pesher Manuscripts and their Significance for Reading Practices at Qumran," *DSD* 7 (2000): 26–48. In such scrolls, vacats should naturally be placed in the reconstruction accordingly.

point of this process should be the mean number of letter spaces per line (i.e., letters and spaces between letters) of the known neighboring columns.

In her work on the Masada copy of the Songs of Sabbath Sacrifice, Carol Newsom suggested the concept of "corrected letter-spaces" for estimating the column width. According to her method, narrow letters, such as ו, ז, and י, as well as the spaces between words, are counted as half a letter.[9] Newsom's method became the standard method for letter counting, usually without adjustments or considerations.[10] However, according to our investigation, the number of spaces and narrow letters in various lines is not significantly different, and its effect on the overall reconstruction is marginal. Furthermore, in many cases the width of such letters – these so-called *narrow letters* – hold the same width as other *regular* letters and vice versa. Therefore, a simple letter-space count is sufficient and should provide reliable data for estimating the width of the column.[11]

2 Height

The best-case scenario for reconstructing column height is when the column at hand is attested as one complete fragment, or at least attested in physical joins of several fragments. Such joins may be obtained also from material reconstruction of the scroll.[12] When no firm evidence for the column height is preserved, other clues should be sought. When a long parallel text exists, its division between consecutive columns could provide the number of lines per column. Fragments constituting parts of two consecutive columns, or two fragments from two consecutive columns may be used when filling these columns with the parallel text.[13] A custom-made font should be used when

9 Carol A. Newsom and Yigael Yadin, "The Masada Fragment of the Qumran Songs of the Sabbath Sacrifice," *IEJ* 34.2–3 (1984): 77–88.

10 For example, Daniel Falk, *Daily, Sabbath and Festival Prayers in the Dead Sea Scrolls*, STDJ 27 (Leiden: Brill, 1998), 38, 60; Strugnell and Harrington, DJD XXXIV, 4.

11 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 60–62; Puech, "Édition et reconstruction des manuscrits," 111. See also Brown-deVost, *Commentary and Authority*, 52, n. 139. Bronson Brown-deVost demonstrates that when the width of the line is known, the number of missing letters and words can be estimated quite accurately.

12 For an example see Eibert Tigchelaar, "הבא ביחד in 4QInstruction (4Q418 64+199+66 par 4Q417 1 i 17–19) and the Height of the Columns of 4Q418," *RevQ* 18.4 (1998): 589–93, here 592–93.

13 Finding fragments from two consecutive columns may be achieved by searching among those fragments for areas of similarity in shape or damage patterns, which can be assigned to consecutive turns of the scroll, as explained in chapter 11.

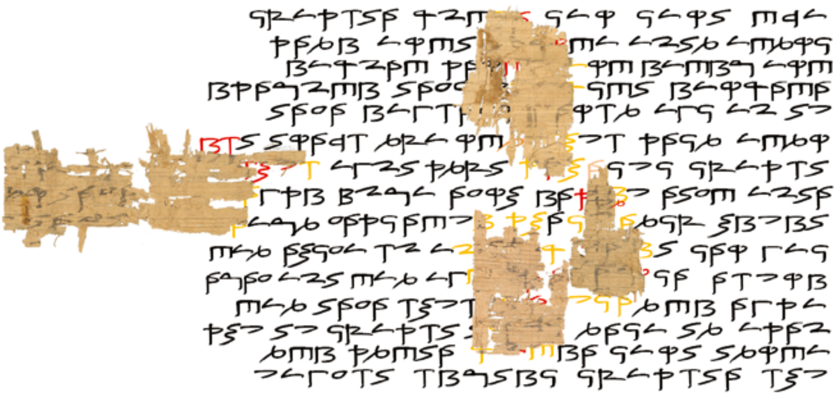

FIGURE 22 Reconstruction of column II of 4Q249a pap cryptA Serekh haEdah. The joins between fragments 4Q249a 6+8+9 (at the center of the image) provide a minimum height of 14 lines. Font design: Nir Yenni
© IAA, LLDSSDL, SHAI HALEVI

reconstructing the partial columns in the layout of the target scroll. Such practice is rather cost-effective, especially when reconstructing large stretches of text, which would otherwise require drawing by hand or meticulous measurements and calculations. The potential error for estimating the number of lines in a column using such font is given in chapter 10.

Another possibility is to try and reconstruct the column height. Joining long and narrow fragments, preferably ones that hold remains of top or bottom margins, may complete the column height.[14] Such a vertical sequence of narrow fragments can be expected mainly in papyrus scrolls, since papyrus tends to break in long vertical stripes. The case of the cryptic copy of the Rule of Congregation from cave 4 (4Q249a) is a good example. This highly fragmentary papyrus shows three fragments joined vertically to produce a length of 14 lines, the minimum column height (figure 22).[15] This join was not sufficient to provide the exact number of lines since it did not contain top or bottom margins, yet it gives a minimum number, which proved significant when combined with other data.

Two parameters establish the column height: the number of lines per column and the height of the writing block measured in centimeters. While the latter is generally stable throughout the scroll, the number of lines may vary

14 Stegemann, "Methods for the Reconstruction," 205.
15 Ben-Dov, Stökl Ben Ezra, and Gayer, "Reconstruction of a Single Copy," 33–34.

between adjacent sheets.[16] In order to convert the number of lines into the height of the column, measured in centimeters, one has to establish also the space between lines. The distances between lines along the height of a column are not necessarily even; in the sheet containing 1QS columns 8–11, for example, the distances between lines increase in the bottom parts of columns.[17] This phenomenon is consistent throughout the sheet and can thus serve as a significant indicator when a fragment from the same height in the sheet occurs. In scrolls containing rulings, the rulings were carried out for each sheet of parchment separately and are thus consistent for each individual sheet but may vary in another sheet.

3 Margins

For the sake of reconstruction, we distinguish the top and bottom margins from the intercolumnar margins. We further distinguish the latter from the intercolumnar margins spreading across the seams of two consecutive sheets.

The presence of top/bottom margins enables the secure location of a fragment on the vertical axis. The size of the bottom or top margins may vary throughout the scroll but is quite consistent within a sheet.[18] It is therefore helpful to group together fragments according to the size of the top or bottom margin. Such grouping may lead to finding fragments that belong to the same sheet.

The width of intercolumnar margins may vary throughout the scroll, and there is no certain way to determine the width of a given margin. This factor is crucial for material reconstruction in the Stegemann Method. In fact, work according to this method begins by collecting all fragments that attest to margins and transitions between columns and sheets, placing them on the canvas, and fitting the text around them as anchors.

Estimating the width of intercolumnar margins uses the same markers as those used above for estimating the width of a column. Excluding cases of indentation,[19] it is safe to say that all lines of a given column stand flush to the

16 In rare cases the difference can grow up to five lines, depending on the size of the sheet. See Tov, *Scribal Practices*, 93–95; Stegemann, "Methods for the Reconstruction," 198. In 11QT[a], for example, the number of lines per column ranges between 22 and 30 lines (Qimron, *The Dead Sea Scrolls*, 1.137), and in 1QIsa[a] the numbers vary between 28–32 lines.

17 See the experiment report in chapter 10.

18 For a detailed analysis of technical aspects of margins see Tov, *Scribal Practices*, 99–104.

19 See for example: 1QS in many instances, 4QEn[c] ar (4Q204) VI 9, 4QapocrDan ar (4Q246), ii 4, 1QSamuel; see Tov, *Scribal Practices*, 146.

right. One fragment showing the beginning of a line is sufficient for indicating the right margins and the beginning of lines throughout the entire column. Left margins are harder to establish, because lines do not end at the same vertical line. Additional indicators such as vertical ruling, guiding dots, or scribal marks may provide further information and increase the level of certainty. The vertical ruling is the most accurate indication for the left edge of the column. When such a ruling is absent, we suggest seeking a sequence of three consecutive lines that end on a vertical line.

Intercolumnar margins that appear between sheets tend to be wider. The exact position of these transitions is important for a reliable reconstruction. It depends on the number of columns in the sheets. The mode number of columns per sheet in Qumran is between 3 to 4, but this number may rise up to seven columns per sheet (1QapGen, 1QpHab) and cases of one column per sheet are also known (4QDeut^{n}, 4QD^{a}).[20] Within the fragments that contain margins, one should therefore look for stitching holes or for the actual thread at the edge of the fragment. Further, oblique indications for stitching may arise from guiding dots that appear in a vertical line at the beginning and ends of sheets and assist the scribe in the drawing of lines. If not the seam itself, one may sometimes see vertical abrasion of the leather caused by the press of the seam on the verso of an inner layer or on the recto of an outer layer, which designates the existence of stitching either at the end or the beginning of the adjacent column, depending on the way the scroll was rolled.[21]

Finally, the edges of a written sheet may be discerned by an unusual width of the last column. A relatively wide or narrow column in comparison to the other columns of the sheet may be a result of the scribe's incapability to divide the sheet into even columns, due possibly to miscalculation.[22] A similar phenomenon may be evident at the beginning of sheets as well.[23]

The column is the fundamental building block of the scroll. Its characteristics, i.e., the column width and height, the size of the margins, and the position of the stitching cord, are essential for a stable and valid reconstruction of the scroll. This chapter highlighted how this essential information can be retrieved and serve the material process. Having established the measurement for every column and sheet, the scholar may proceed to the next step in the material and digital reconstruction.

20 For a detailed description see Tov, *Scribal Practices*, 80–82; Stegemann, "Methods for the Reconstruction," 197–98 n. 70–77.

21 See for example 11QT^{a} col. XLIV; Stegemann, "Methods for the Reconstruction," 212, n44.

22 See for example the change of column width in the final column of fragment 4Q416 2 i–iv.

23 Tov, *Scribal Practices*, 83; Stegemann, "Methods for the Reconstruction," 198.

CHAPTER 10

Font

In chapter 8 we discussed the reconstruction of small lacunae using letter cloning.[1] That method is rather accurate because it accounts for variations in the letter-shapes when they constitute part of different combinations. On the other hand, it is also time consuming, and thus not practical for the reconstruction of large sections of text.[2] A custom computer font designed for each scroll may prove more useful for that purpose. In addition, as discussed in chapter 9, several ways have been proposed in the past for estimating the column width of fragmentary scrolls using parallel text from other copies. We find the use of a tailored font fitting for this latter task, as well as for reconstructing the height of a column and estimating the amount of space occupied in several consecutive columns. This is, to our mind, a cost-effective compromise between the need for utmost precision and limitations in the amount and cost of work that could be invested. To be sure, the *production* of the font is time consuming, but the investment is paid off when using the font in the reconstruction.

Already in 2005 as part of the "Electronic Boethius" Project, Kevin Kiernan presented the transcription of an Old English manuscript that is now lost by using the letters from other manuscripts with similar paleographical features. That program allows replacing transcribed letters for images of letters digitally cut out of manuscripts, choosing between a variety of letters and using ligatures. This project did not, however, perform kerning for the letters.[3] More recently, several scholars used a custom-made font, imitating the handwriting of the scribe, a method we will also use. In 2016 Bronson Brown-deVost created a font for the reconstruction of 4Q204 1 col. i. He measured all the letters in this column and chose the ones closer to the average for his font. In cases where a letter was not represented in this scroll, he completed it from the inventory of letters in 4Q203, which was probably written by the same scribe.

1 We are grateful to Dr. Bronson Brown-deVost (Göttingen) for kindly sharing with us the initial knowledge how to design a font using the Bird Font and Microsoft Volt programs, and for his patient instructions during later stages.

2 For the difference between the reconstruction of small lacunae and of longer sections see Zuckerman, "Dynamics of Change," 13–19, and Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 7–11.

3 Kevin Kiernan, "The Source of the Napier Fragment of Alfred's *Boethius*," *Digital Medievalist* 1 (2005). doi: http://doi.org/10.16995/dm.7.

DOI:10.1163/9789004473058_001

He then adjusted the kerning of the required pairs of letters to what is seen on the fragments. Since handwriting is never as consistent as a computer font, Brown-deVost still had to adjust individual pairs using image manipulation software.[4] In their 2017 publication, Ben-Dov, Stökl Ben Ezra, and Gayer used a font imitating the Cryptic A script to reconstruct a cave 4 copy of Serekh haEdah. This font was designed by a graphic designer, rather by replicating letters from the images of the scroll's fragments.[5] In 2018, Sacha Stern and Jay Birbeck reconstructed a Genizah fragment in a similar way. They chose the most representative letters from the images (without measuring) and then fixed the kerning to match that of the manuscript. According to their description, they too had to adapt certain letters to the image even after the kerning.[6] Similarly in 2019 Ratzon reconstructed 4Q208 with a custom-made font. She had to complete the missing letters from the similar script of 4Q28 (4QDeut[a]), although in this case it was not written by the same scribe.[7] For the creation of the font used in this book we followed Brown-deVost's guidelines, although like Stern and Birbeck we did not find it necessary to measure every letter but rather chose what seemed to our trained eyes as the average size. While the use of custom fonts has started making inroads in scholarly practice, this chapter offers a rigorous theoretical discussion for the validation of the method, the preferred ways to apply it, and its margins of error.

Admittedly, long reconstructed sections are subject to some margin of error, due to two kinds of factors. The first arises from our lack of knowledge of the properties of the scroll, such as the width of the columns, their height, etc. The second is related to the fact that handwriting is not as uniform as a computer font: the shape of every letter and its relation to the surrounding letters vary; spacing between lines is not always constant throughout the height of a sheet;[8] and the size and style of handwriting changes through various parts of

4 Brown-deVost, "4QEn[c]," 60–84. We received this point from him through private correspondence.

5 Ben-Dov, Stökl Ben Ezra, and Gayer, "Reconstruction of a Single Copy."

6 Sacha Stern and Jay Birbeck, "Reconstructing folios from text editions: Lévi (1900) + T-S NS 98.18 and Bodl. MS Heb d.74.27," in *Fragment of the Month*, November 2018: https://www.lib.cam.ac.uk/collections/departments/taylor-schechter-genizah-research-unit/fragment-month/fotm-2018/fragment-9.

7 Eshbal Ratzon, "4Q208: A New Reconstruction and Its Implications on the Evolution of the Astronomical Book," *RevQ* 31.1 (2019): 51–110, especially 110.

8 To be clear, even if the scroll contains dry rulings, the space between lines within one column is not fixed. However, the spaces between corresponding lines in adjacent columns contained in one sheet will remain constant. In other words, the distances between lines 1–2, 2–3, 3–4, etc. will be fixed in all columns of the same sheet.

the scroll. While the former is unavoidable, and will remain unknown for any method of reconstruction – whether letter space counting or letter cloning or fonts – the effect of the latter factor can be, to some extent, controlled.

Control is achieved both by means of the method of font creation and by limiting the kind of scrolls that can be securely reconstructed using this method. Unlike with letter cloning, when using a font all occurrences of the same letter are uniform. Therefore, this method can only be accurately used for the reconstruction of scrolls with comparatively stable features, such as non-cursive script, consistent letter-shapes, scrolls written by an expert scribe, using straight lines and columns, etc. In other cases, a font can be used for visualization only, but cannot be used to accurately reconstruct the measurements of the scroll.[9]

In the following chapter we describe a method for controlled use of a custom computer font for the reconstruction of specific scrolls. This methodology is intended for reducing the error to a minimum, by choosing the best letters, adapting the relations between chosen pairs of letters to the scribe's practice, and properly using the font on a digital canvas. The suggested methodology may reduce the margin of error but it cannot eliminate it. We empirically checked the precision of such reconstructions on comparatively intact scrolls (1QIsa[a], 1QS, and 11QPs[a] [= 11Q5]). The experiment involves, first, using custom-made computer fonts for typing the text of scrolls, and then comparing the results with the actual length of the lines, columns, and a sequence of columns of these scrolls. The present chapter recounts the mode of operation in the experiment and its results, as well as a discussion of these results. A detailed description of the experiment appears in Appendix 1.

1 Designing the Font

As in other chapters of this book, with the rapid change in technology, and the wide variety of font design software, we do not provide a detailed manual how to run the procedure with a specific program. We do provide general instructions for the process, emphasizing its methodological issues.

9 For example, 4Q208 is written in an archaic non-formal script, which is more prone to error than a formal script. In that case, the use of the font was mainly for the purpose of visualization, and the reconstruction itself was based mainly on textual considerations. See Ratzon, "4Q208," 51–110.

1.1 *Choosing Letters*

The first step in font creation is choosing the letters from the scroll which will serve as the basis for the font. While the most accurate way for choosing the letters is measuring a substantial number of examples of any letter and then choosing one that is the closest to the average,[10] the main point of creating a font is to avoid this kind of effort. Such an effort is more easily done when the font is created semi-automatically, as in Appendix 2. When creating the font manually, there are several features to consider while choosing the letters:

a. A practical condition for the success of creating the glyphs is that the chosen letters are complete.
b. After gaining close acquaintance with the manuscript the scholar should choose letters that seem *typical*.
c. Dark letters with a distinct black color are preferable as their outline and various strokes are more easily processed. Some programs overcome this obstacle better than others.[11]
d. The handwriting of each scribe is not consistent throughout the manuscript, and in order to avoid choosing non-representative letters, it is best to examine as many fragments as possible. If the scaling of the images of a specific fragment or an entire scroll is problematic, the scholar must choose all the letters from the same image. For the same reason, fragments that went through shrinkage should not be included in the reservoir of letters.
e. In cases of rare letters such as ט or ס, and in cases of highly fragmentary scrolls, there may not be many complete examples of every letter. One then has to settle for the best-preserved letter rather than the most typical one. For some scrolls, not every letter is documented. In these cases, the missing letters will be taken from another scroll with the closest script possible. For example, in the case of the very fragmentary 4Q418a, we had to use the close handwriting of 4Q418.[12]
f. Letters should preferably be isolated enough in order not to include traces of the surrounding letters in the glyph. It is easier to find spacious writing in fragments coming from the middle of the sheet, whereas in the first and last columns the script tends to be denser.

10 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 7–11, 62–63.

11 The font program allows for binarizing the color of the glyphs and filling their surface in case there are gaps or holes in it. It is important, however, to verify the integrity of the letter's surface after the automatic processing by the program, and manually enhance it where necessary.

12 See chapter 16. For a similar case see Ratzon, "4Q208," 51–110. Ratzon used some letters from 4Q28 for the reconstruction of 4Q208.

g. Designing a font involves not only designing the letters but – just as important – also the size of the space glyph. While font-design software will assign a standard width for the space between words, adapting its width to the particular scroll significantly increases the font's precision. Unlike the choice of the letters, it is difficult to estimate the width of the space since it greatly varies throughout the scroll.[13] In this case, we recommend measuring a substantial number of examples and computing the average size, which will be fixed as the size of the space glyph in the custom font. While the average does not correspond to any one specific space in the scroll, it is functional when reconstructing large stretches of text, as the average evens out. This hypothesis was tested in the experiment described below.

1.2 *Creating the Glyphs*

For the creation of the glyphs, it is extremely important to copy all letters from evenly scaled images (see chapter 4). After that, no zooming in or out is allowed, in order not to tamper with the scaling. All copied letters should be pasted on the same file (see figure 23) with their background removed and all additional ink marks, whether from neighboring letters or otherwise, removed.

The image file with the letters is uploaded to the font program as a background file. The next step is to connect each glyph on this file to the letter it represents, identifying each image of a letter as a character in the Hebrew alphabet. When connecting a glyph to its letter, it is placed inside a grid, setting the exact position of the letter within the rectangle dedicated to it. It is important that the left and right boundaries of the grid be attached to the glyphs, so that their relations to other letters will not be disturbed later. Letters should be suspended from the upper line, rather than standing on a straight baseline.

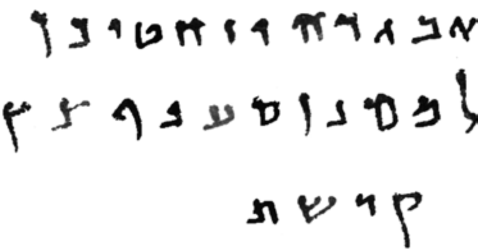

FIGURE 23
An image file of the letters of 4Q417.
GRAPHICS: EINAT TAMIR

13 For inconsistency of the spaces between words, see Tov, *Scribal Practices*, 106–7, 133–35.

1.3 *Kerning*

After all letters and the space glyph have been accurately placed in their grids, the next stage is adapting the kerning, i.e. the distance between specific pairs of characters. These small spacing differences add up to a significant error when reconstructing a whole line, not to mention a whole column. They should thus be designed with utmost care. As mentioned above, each glyph is designated with its own rectangle, which will define the space it occupies on the canvas. Without any adaptation, the right-most edge of the next typed letter will begin after the previous rectangle ends. In handwriting, however, the glyphs do not occupy the entire rectangle, allowing other letters to penetrate to their designated space. Normally, scribes of the DSS tend to align their letters according to certain rules, depending on the characteristics of types of letters. For example, letters with diagonal strokes overlap other letters to some extent (e.g. א, צ); pairs of letters, comprising a letter with a base (like ב, כ, נ, פ), followed by a letter with a right leg (such as ד, ה, ו, ז, ח, ר, ת), touch or even overlap in a way that the leg "stands" on the base of the previous letter (for example: בו).

While general rules may be formulated for the kerning of many DSS scripts, one should also fine-tune the kerning to conform with the handwriting of the specific scribe. The initial kerning should be tested on a digital canvas, by typing letters in the custom font in a separate layer above the layer of the (scaled!) image. If, after adjusting the size of the font, each typed letter does not fully cover its corresponding original letter, the scholar should suspect that additional kerning adjustment is required. The suspicion will be confirmed only if the relationship between the two letters is consistent throughout the scroll. Otherwise, the discrepancy indicates mere variations in the handwriting of the ancient scribe.

When using the font on a digital canvas, some programs carry out their own automatic kerning that may interfere with the adaptation to the scribe's handwriting. This feature should be turned off.[14] After the kerning is ready, when the font is used in the reconstruction, it is important not to adjust every letter or pair of letters individually, but to set the parameters based on the preserved fragments, and to maintain them in the reconstructed text. This is the only way to preserve its precision.

The kerning is the final stage of font creation. After it is accomplished, the font can be exported from the font-creator program. Designers should indicate their copyright in the font file to secure credit and proper licensing. The font

14 For example, in the software Adobe InDesign it is important to choose V/A "metrics" instead of "optical."

is now ready to be exported and then installed on any computer for the work to continue.[15]

Work on the kerning is time consuming, not only due to the need to examine and re-examine the relations between letters in the manuscript, but also due to a variety of practical problems in the capacity of the programs to adjust right to left (RTL) orientation. The community of Hebrew font designers is not large, and finding help online is not easy. When a good program is found, later versions do not always consider the small market of RTL font designers, and a new learning curve is required from the designer. The semi-automatic production of fonts described in Appendix 2 may solve some of these problems.[16]

2 Margin of Error

As in every reconstruction, a margin of error exists, which means that the suggested result does not produce one absolute reconstruction, but rather a range of possible solutions. In Appendix 1 we describe an experiment conducted to check the validity of the custom font as a working method. The experiment also provides the measure of error that can be expected as a result when applying this method. The experiment was carried out in three stages, checking the reconstruction of three sizes pertinent for the verification: the width of a line, the height of a column, and the space required for long textual units.

We tested the method on three comparatively intact scrolls, type-setting their known text in the newly-produced custom font and comparing the required space with the length of the same text in the original scrolls. The difference between the measure of the reconstructed and the original text equals the margin of error. The results vary slightly between the three scrolls, but remain in the same approximate range. While detailed results are provided in Appendix 1, here we provide general impressions.

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15 We would like to stress here the importance of making the fonts available to the wide scholarly public. Open access is the spirit of our age, which has significantly enhanced the advance of many disciplines. The fonts prepared in the SQE project are available for download in https://www.qumranica.org/blog/?page_id=966.

16 There are several font-design programs on the market. It is important to make sure that the chosen program supports Right-To-Left languages. At an early stage we worked with the free software Bird Font, with the kerning done with Microsoft Volt. However, when the workflow did not go smoothly, we switched to High Logic Font Creator (https://www.high-logic.com/), a one-stop program with improved user experience. This software works on PC, while the standard font software for Mac users is Glyphs.

In the first stage of the experiment, we reconstructed the length of a line based on a few preserved letters at its beginning. The error for all three scrolls was around 4% with a standard deviation of approximately 3–4%. As these scrolls differ in many features, this persistent result may be used as the margin of error for the reconstruction of other scrolls as well.

In the second stage, we reconstructed an entire column based on three preserved lines at its top. We then measured the height difference between the reconstructed column and the original column by means of two units: height in centimeters and number of lines. The error for the reconstruction of the height of a column in centimeters was between 6–8% in all three scrolls, but with a standard deviation of approximately 5% for 1QIsa[a] and 11Q5 and of nearly 10% for 1QS. When the height of the column is measured in number of lines the error for 1QIsa[a] and 1QS was around 7% with a standard deviation of approximately 7%, but the error for 11Q5 was less than 3% with a standard deviation of a bit more than 4%. The higher margin of error in the former two scrolls is due to many intervening factors. In 1QS one finds many vacats, significant variations in font size, and many interlinear corrections. The scribe of 1QIsa[a] was more careful, but the length of the lines in the respective columns was less consistent. In contrast, the scribe of 11Q5 was very careful, keeping highly organized script and columns. When reconstructing the column's height in other scrolls, the scholar must first examine the above-mentioned intervening factors in order to assess the margin of error.

The third stage tested the reconstruction of longer textual sections spanning several columns. It had two versions. The first version assumed that the text of the scroll is known as well as the measurements of the first column, but the size of the rest of the columns is unknown; it had to be copied from the first one. The second version assumed that the height and width of all columns were known. For both versions we typed the text of up to eleven consecutive columns, and then measured the space that the text occupied from the beginning of the first column to the final word of each one of the eleven columns. We then compared the difference between the reconstruction and the original scroll. In the first version the average error was quite high: approximately 10% for 1QIsa[a] and over 30% for 1QS with a standard deviation of 3% and 17% respectively.[17] In contrast, when the width of the columns is known from elsewhere, the error is only 4–5% with a standard deviation of 2–3%. Obviously, the more information a scholar has about the reconstructed columns, the more sound the reconstruction is. The variance from the average did not spread equally between columns. The relative error for the first few columns may vary,

17 We were not able to perform this stage on 11Q5, because its bottom part was not preserved.

but the error stabilizes after a few columns. Therefore, while it is difficult to predict the error for a reconstruction of a few columns, a reconstruction of over five or six columns will most likely be as accurate as the reconstruction of the number of lines in a column, that is around 5–8%.

The meaning of these results varies for each purpose. If the purpose of a reconstruction of an entire line based on a few characters is to determine if there was enough space for one additional word, the margin of error will probably not allow such resolution. Alternatively, in material reconstruction, knowing the width of a column with a precision of up to one word is quite good. In contrast, in key columns, on which much of the reconstruction is dependent, this error can be more significant, as explained in chapter 2 and Appendix 3. Eventually, using a font for the reconstructions of long sections of relatively consistent scrolls is the best option, but the results of any reconstruction should be taken as a range of options, and conclusions should be drawn accordingly.

APPENDIX 1

Experiment for Validating the Use of a Custom-Made Font

Eshbal Ratzon, Einat Tamir and Rivkah Madmoni

1 Introduction

Chapter 10 conveys a method for creating fonts by imitating the handwriting of a scribe in order to reconstruct lacunae in a scroll. We claimed that using a custom-made font, while potentially not as accurate as letter cloning, is accurate enough for reconstruction and is less time consuming than cloning. This appendix presents an empirical validation for this claim and provides the margin of error to be expected for it.

The font can be used to reconstruct a missing text in three different stages:

1. the length of a line;
2. the height of a column;
3. long textual units spanning over several columns.

We examined the precision of the font in an experiment conducted on three of the comparatively well-preserved scrolls. The scrolls are 1QIsa[a], 1QS, and 11QPs[a]. We prepared the font for these scrolls especially for this experiment. It is available for download at the SQE website.[1] All three scrolls contain several consecutive columns with at least 17 complete lines each. Before we began the work, we examined scribal practices, such as the frequency of using vacats and the existence of dry rulings in each of the scrolls. While performing the experiment some additional nuanced practices were noticed. These will be summarized for each scroll at the end of the experiment report.

In order to achieve a margin of error for each of the experiment stages, we assumed that only part of the text was preserved, based on which we established the font size. We then typed the rest of the respective unit (lines or columns) using the font to simulate the original textual unit, and compared the size of the simulated text to the size of the original unit in the handwriting of the scribe. The results support the reliability of using a font as a method for reconstruction. All the raw materials for this experiment, including InDesign files on which the simulations were performed and excel files with measurements, are openly available for view and download.[2]

1 https://www.qumranica.org/blog/?page_id=966.
2 https://github.com/eshbal/Digital-and-Material-Reconstruction-of-DSS.

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2 Materials: The Examined Scrolls

2.1 *The Great Isaiah Scroll* (*1QIsa[a]*)

The Great Isaiah Scroll is one of the first seven scrolls found in 1947 in Cave 1 and is the best-preserved scroll found in Qumran. It consists of 54 columns preserving the entire biblical book of Isaiah. Most of these columns are undamaged. It remains debated whether the entire scroll was written by the same scribe or whether columns XXVIII–LIV were written by a second hand.[3] Avoiding the need to decide on this matter, we chose the columns for this experiment from the second half of the scroll, which is better preserved than the first half and which contains fewer supralinear additions. While vertical ruling exists throughout the scroll,[4] the scribe deviates from the borders of the column quite freely.

Choosing the right images for performing the experiment on this scroll proved to be problematic. The optimal images would indicate the accurate scale by means of a ruler next to the scroll. While 1QIsa[a] was photographed several times over the years, fully-scaled images are not easily available. The full set of images from the Shrine of the Book was not available to us, due also to the Covid-19 crisis (2020). Of the earlier sets of images, the set taken by John Trever in 1948 does include a scale but we encountered difficulties when digitally stitching the distinct images together.[5] Therefore, we had to settle for an image from Wikimedia Commons.[6] This stitched image of the entire length of the scroll has superb quality but it does not contain a scale, and provides no information about the way the stitching was made. Since the most important result for this experiment is the error in percentage, the effect of the scaling is less relevant.

The typed text of this scroll is taken from the Accordance program (Oaktree Software).

3 For a summary of both opinions see Tov, *Scribal Practices*, 27 and Eugene Ulrich and Peter Flint, *Qumran Cave 1.II: The Isaiah Scrolls*, DJD XXXII (Oxford: Clarendon Press, 2010), 61–64. Ulrich and Flint claim that a single scribe wrote the entire scroll. See also recently Mladen Popović, Maruf A. Dhali MA, Lambert Schomaker, "Artificial Intelligence Based Writer Identification Generates New Evidence for the Unknown Scribes of the Dead Sea Scrolls Exemplified by the Great Isaiah Scroll (1QIsa[a])," *PLoS One* 16(4) (2021): e0249769. https://doi.org/10.1371/journal.pone.0249769.

4 Ulrich and Flint, DJD XXXII, 2.59.

5 When matching overlapping portions of the scroll from various images one against the other, they were never quite the same. We can only assume that something was not uniform in the photographing process. For a survey of early images see Ulrich and Flint, DJD XXXII, 2.15–21 and 59–61.

6 https://commons.wikimedia.org/wiki/File:Great_Isaiah_Scroll.jpg.

2.2 *Community Rule (1QS)*

This scroll is written over 11 nearly fully-preserved columns including top and bottom margins.[7] The first and final two lines of each column are sometimes broken. The scribe was not very careful, and the scroll has many supralinear corrections and additions. In addition, the scribe's tendency towards adding a comparatively large number of vacats may result in a significant error for the reconstruction. The scroll contains dry rulings; this is helpful for the reconstruction of the uneven column widths. The first column is significantly narrower than the rest of the columns.

Photographer Ardon Bar-Hama imaged some of the large scrolls for the Shrine of the Book at the Israel Museum in Jerusalem in 2010–2011, and the Shrine kindly supplied them to us.[8] These high-resolution images include an industrial standard ruler. However, for some reason the files are not uniformly scaled. We therefore had to rescale each of them individually in order to stitch them together.

The text of the Community Rule used in this experiment is based on Abegg's reading in the DSSEL.[9]

2.3 *The Great Psalms Scroll (11QPs^a^)*

The Great Psalms Scroll is designated 11Q5 or 11QPs[a]. The continuous part of the scroll comprises three whole sheets, plus an incomplete fourth at the end, which add up to nearly 24 columns. The handwriting is very neat and organized. Column and lines are marked by dry rulings. Between each psalm there is a vacat with a varied length between half a line and two lines. While most of the script is quite uniform, the scribe wrote the Tetragramaton with a Paleo-Hebrew script. We prepared a glyph in the font for the Tetragramaton, but it appears that its overall size varied throughout the scroll.

This scroll was imaged by the LLDSSDL in 2015 next to a standard ruler, with the camera set at a permanent position, planned in advance to create 1:1 scaling. However, apparently, over the years the scroll underwent shrinkage. Sanders measured the length of the sheets (with the last one first) to be 77, 72, 87, and 81 cm,[10] while according to our measurements based on the 2015 images, they are now 75.5, 69.3, 83.0, and 72.4 cm, respectively. Since the shrinkage is not constant over the length of the scroll, it seems that reconstructing the length of the original scroll based on the images of its

7 The experiment did not include 1QSa and 1QSb, regardless of the question whether they constitute part of the same scroll as 1QS. For this question see recently Michael B. Johnson, "One Work or Three? A Proposal for Reading 1QS-1QSa-1QSb as a Composite Work," *DSD* 25.2 (2018): 141–77.

8 We would like to thank Hasia Rimon for her help in facilitating the images.

9 Martin G. Abegg, "1QS," in *Brigham Young University: The Dead Sea Scrolls Electronic Library*, ed. Emanuel Tov, rev. ed. (Leiden: Brill, 2006).

10 James A. Sanders, *The Psalms Scrolls of Qumran Cave 11 (11QPs[a])*, DJD IV (Oxford: Clarendon Press, 1965), 3–4.

current state is problematic. Obviously, shrinkage and other damaging processes also occurred during the two millennia prior to the unrolling of the scroll, but these cannot be measured today. Therefore, it is important to keep in mind that the error measured in the following experiment reflects the error compared to the length of the scroll in its current state of preservation. An additional error exists in relation to the original length of the scroll because of shrinkage, but this error cannot be known.

We chose the final columns of 11Q5 for the experiment, as they were best preserved. The text of 11Q5 used in this experiment is based on Sanders's readings taken from the DSSEL, with our own transcription of text when not represented in that electronic resource.[11]

3 Method

3.1 *Stage 1: Length of a Line*

This stage of the experiment simulates the quite common scenario by which a small fragment containing only a few characters is preserved, but the text of the rest of the line is known from elsewhere. We want to verify that the length of the reconstructed text using a custom font corresponds to the real length of the line.

For a given column, we simulated the situation in which a fragment of only eight characters (including spaces) from the beginnings of all lines of the column was preserved. The font size for the rest of the line was set according to these eight "extant" letters. If letter size was not uniform throughout the eight characters, we set it based on frequency, average, or the last letters in the "fragment," depending on our evaluation of the most fitting size. The reason we do not always choose the average is because we wanted to ignore exceptional letters. This required some personal judgement.

After typing the text of the rest of the line, we measured and compared the length of the typed text to the length of the handwritten line of the original scribe. We wrote a continuous text within the line even in cases where the real line contained vacats or interlinear script, to simulate the situation of a real fragment, when one has no way of knowing in advance when to expect vacats or scribal mistakes. Having discovered that a comparatively large contribution to the error is our ignorance regarding the existence and size of vacats, we display the results for lines with no vacats separately.

3.2 *Stage 2: Height of a Column*

This stage of the experiment simulates the scenario by which only part of a column is preserved, but the text of the rest of the column is known from elsewhere.

11 James A. Sanders, "11Q5 (11QPs^{a})," in Tov, *Brigham Young University: The Dead Sea Scrolls Electronic Library*.

We produced a virtual fragment with only the top three lines preserved and filled in the rest of the text in this column using the custom-made font. The three “extant” lines indicated the font size, the space between lines, and the width of the column.

Under these conditions, the text of the entire column is known but not the exact length and layout of individual lines. We typed the text according to the column dimensions known to us. As the space between lines may vary, we then compared both the number of lines and the height in centimeters of the simulated text to those of the original column.

3.3 *Stage 3: Larger Textual Units*

In some cases, a long continuous text is known from parallels. In some overlapping cases, a scholar will need to establish the amount of space this text would occupy in a given scroll where it is not extant. We would like to test the validity of a reconstruction of this long stretch of text using a custom font; the layout of the simulated columns is established based on the extant ones or on material reconstruction of the scroll.

In stage 3 of the experiment, we again created a virtual scroll, in which only the first three lines of the first column are extant but the rest of the text is known. We set the font size and interlinear space based on the first three lines of the first column of each scroll.

Stage 3 was performed in two versions. In version 3.A we assumed that none of the measurements of the following columns is known, and used the height and width of the first column for all of them. In this version the error is expected to be larger since the unknown measurements of the columns contribute to it. In reality, however, for a real scroll some information is available about the size of at least some of the columns. In order to isolate the contribution of the font to the error, we created another version (3.B). In version 3.B, the text of the next columns, the number of lines and column width for each column is known, but not the exact points in the text where each line and column end.

In both versions, we copied the entire text of the next columns continuously from the end of the “extant” lines to the end of the simulated columns. In version 3.A, we made a separate record for each simulated column, recording how many lines in it are in lack or excess vis-à-vis the last word of the original column. Lines that exceed the column are marked in positive numbers; the opposite case being marked by negative numbers. In version 3.B we were unable to use the lines as a measurement unit for the error, because the width of the lines was uneven (matching the actual width of the column, rather than the first column throughout). In this version, the unit for measuring the lack or excess of text was the number of characters.

This stage of the experiment was carried out only on 1QS and 1QIsa[a]. It could not be performed on 11Q5, as all of the columns of this scroll are missing a few lines at the bottom. The number of columns to be examined was dictated by the eleven extant columns of 1QS.

4 Results

4.1 *1QIsa^a*

4.1.1 Stage 1: Length of a Line

Stage 1 was carried out on columns 41–44 of 1QIsa^a. It is reported in Tables 2 and 3 below. As is evident from the table, the average error for each one of the columns ranges between 2.9–5.3%. The error is rarely more than five letters, and usually even less.

FIGURE 24 Stage 1 performed on 1QIsa^a columns 41 and 42. The first eight characters of every lines (yellow) are treated as extant, whereas the rest of the line is simulated.

TABLE 2 Margin of error for the reconstruction of all lines in 1QIsa^a

Column	Average (%)	Standard deviation (%)	Maximal error (%)
Col. 41	5.3	2.7	14.6
Col. 42	3.7	2.9	12.4
Col. 43	2.9	2.6	7.5
Col. 44	3.3	3	9.3
All columns	**3.8**	**2.8**	**14.6**

TABLE 3 Margin of error for the reconstruction of lines with no vacats in 1QIsa[a]

Column	Average (%)	Standard deviation (%)	Maximal error (%)
Col. 41	5.4	3	10.4
Col. 42	2.9	3	12.4
Col. 43	2.5	2	6.2
Col. 44	3	2.7	8.5
All columns	**3.45**	**2.7**	**12.4**

Exceptions, however, do exist. The two largest errors in col. 41 are caused by vacats (lines 1 and 12 with 14.6% and 13.2% respectively). While the first vacat occurs also in MT (49:4), the second one does not (49:12).[12] Vacats cannot always be anticipated, and the error caused by them cannot be reduced by different means of reconstruction such as letter cloning. Even without considering vacats, the handwriting in col. 41 is less regular than the handwriting in other examined columns. Other large errors in this column are 10.4%, 10.1%, 9.9%, 9.4% (lines 15, 9, 5, 17 respectively). All of these errors are caused by the inconsistent handwriting of the scribe.

In column 41, in approximately 20% of the lines the error was below 3%, while in col. 42 it was true for nearly 50% of the lines, over 65% of the lines of col. 43, and approximately 60% of the lines in col. 44. Column 41 thus produced a large number of lines in which our reconstruction did not match the true length of the lines. We may speculate that this incongruity is due to the scribe's fatigue in this particular column. The scribe would have restored his usual habits in the next column after taking some rest.

Exceptionally long or short lines may affect the error. The largest error is in Col. 42, line 22 (12.4%). This is an exceptionally long line, where the scribe made an effort to fit a large amount of text. In column 41, the largest error occurs in line 17, which is a comparatively short line, and the scribe was generous with spaces between words. The same is true for cols. 43 and 44. In col. 43, only one comparatively short line (1) has an error of approximately 10%. All the rest of the errors are significantly lower. In col. 44 four lines show an error of 8–9% (6, 15, 19, 22). Three of these lines are comparatively short, while all the rest show a lower rate of error. Apparently, when scribes leave a long vacat at the end of a line, they tend to write the text more spaciously than usual.[13]

12 For the correlation of vacats in this scroll vs. the medieval Masoretic codices, see Yeshayahu Maori, "The Tradition of Pisqāʾôt in Ancient Hebrew MSS. The Isaiah Texts and Commentaries from Qumran," [Hebrew] *Textus* 10 (1982): נ–א; but see the opposite conclusion in Ulrich and Flint, DJD XXXII, 2.82–86.

13 For other scribal practices in this scroll, see Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 64–68.

The columns examined in this scroll, and the scroll in general, does not contain many vacats, and therefore they do not contribute much to the average error.

4.1.2 Stage 2: Height of a Column

This stage was examined on cols. 41–51. We chose exactly eleven columns in order to match the number of columns in 1QS. These particular columns were chosen because they are not damaged, contain a minimum of second-hand additions, and were written by the same scribe.

We compared each simulated column to the original one with regard both to their height in centimeters and the number of lines contained in them. Differences in both cases are reported in percentages, in Table 4 below. The average error in both factors is approximately 6–7%, but the standard deviation of the difference in the number of lines is higher.

The largest error occurs in column 51. It seems that the first three lines of this column, according to which the width of the column was set, were narrower than the average line in the column. A similar situation occurs in column 46, the final column of its sheet. The lines grow wider from the upper part of the column to its bottom together with the physical shape of the sheet, with the seam going down in a diagonal rather than straight line. In this particular column, the space between the first three lines was larger than average, which caused the error in centimeters to be lower than

TABLE 4 Margin of error for the reconstruction of column height in 1QIsa[a]

Column	Error of height (%)	Error of # of lines (%)
Col. 41	10.53	10.34
Col. 42	5.90	0
Col. 43	4.53	10
Col. 44	9.46	2.50
Col. 45	4.59	7.14
Col. 46	7.71	15.36
Col. 47	3.44	3.45
Col. 48	1.68	1.03
Col. 49	1.18	3.45
Col. 50	3.55	3.45
Col. 51	18.23	22.41
Average	**6.44**	**7.19**
Standard deviation	**4.91**	**6.85**

the error in the number of lines. The large error in column 41 was caused by significant vacats. In column 44 the number of simulated lines was very close to the number of original lines, but the upper lines were denser than the following lines. This anomaly created a large error with regard to the column's height. In terms of the absolute number of lines, columns 46 and 51 were exceptional with an additional 4.3 and 6.5 lines respectively. Columns 41 and 43 were missing 3 lines. Column 45 had an additional 2 lines. All the rest of the simulated columns show a difference of one line or less.

While the average error in stage 2 of the experiment is higher than that of stage 1, it remains within a reasonable level of error, error which may be unavoidable.

4.1.3 Stage 3: Larger Textual Units

In version 3.A, all columns were assumed to show the same measurements (height and width) of the first column. We then examined how much the final words of the simulated columns deviate from their original position. The error is expressed in the number of lines (Table 5).

In column 41, the largest contribution to the error is caused by large vacats separating the paragraphs. The second column, 42, is wider than the first one. The large difference between the two created an error in the opposite direction, thus mostly annulling the error from column 41. Columns 43–47 and 50 are much narrower than column 41,

TABLE 5 Margin of error for the reconstruction of several consecutive columns in 1QIsa[a] – version 3.A

Column	Error (# of lines)	Error (%)
Col. 41	−2	−6.90
Col. 42	−1.5	−2.59
Col. 43	−5.6	−6.36
Col. 44	−11.5	−9.91
Col. 45	−18.8	−13.06
Col. 46	−21.7	−12.62
Col. 47	−25.6	−12.74
Col. 48	−27.6	−12.00
Col. 49	−25.3	−9.77
Col. 50	−29.2	−10.14
Col. 51	−30	−9.46
Average		**−9.59**
Standard deviation		**3.23**

TABLE 6 Margin of error for reconstruction of several consecutive columns in 1QIsa[a] – version 3.B

Column	Error (# of characters)	Error (abs. %)
Col. 41	−130	7.40
Col. 42	−174	4.75
Col. 43	−176	3.36
Col. 44	−69	1.04
Col. 45	22	0.27
Col. 46	333	3.48
Col. 47	877	7.72
Col. 48	732	5.51
Col. 49	780	5.01
Col. 50	729	4.21
Col. 51	847	4.38
Average		**4.28**
Standard deviation		**2.28**

a fact that drastically enlarged the error. While the error in the absolute number of lines grows larger with the progression of the reconstruction, the error in percentage stabilizes after a few columns around 10% with a standard deviation of approximately 3%. The specific error for each column mostly depends on the width of that column compared to the width of the first one.

In version 3.B we assumed that the size of each column is known. In this version of stage 3, the average error is significantly reduced to a little more than 4%. The first columns show a negative error resulting from vacats. However, the size of the script in the original diminishes as the columns progress, which creates the opposite kind of error. These two phenomena nullify each other, creating a very good reconstruction around column 45. The very low error of this column does not attest to outstanding consistency but is rather the outcome of the nullification of the errors by the contradicting causes, as can be seen in stage 2 above.

As expected from the results of stage 2, a comparatively large error occurs in column 41. While a significant error existed for column 46 when examined by itself in stage 2, in this stage it is lower thanks to the lower error of the previous columns. In stage 2, column 51 produced the largest error, but it was then dependent on the exceptionally narrow first lines of this column. These did not affect the simulation in stage 3, thus keeping the error for this column in stage 3 close to the average.

4.1.4 Unique Scribal Practices

While working on the simulation of 1QIsa[a], a few scribal practices of this scroll became evident. We summarize them here. These are small-scale practices not evident to the naked eye, which have been revealed by means of the minute numerical attention in this experiment. They are thus additional to the practices enumerated by the editors of DJD XXXII.[14]

Generally speaking, in columns 41–51 the size of the script is reduced as the columns progress. The handwriting of some columns is less consistent than others. This problem was especially evident in columns 41, 46, and 51. The consistent gap of five columns may indicate that this phenomenon is caused by the scribe's fatigue. Perhaps after paying attention to the reduced quality of the work, the scribe took a break, and was able to retain the earlier standard for the next few columns.

Some of the inconsistency of the handwriting is related to exceptionally long or short lines. In long lines, the scribe made an effort to fit a large amount of text, thus making the script denser. On the other hand, when the scribe left a long vacat at the end of a line, the text was more liberally spaced than usual.

4.2 *The Community Rule (1QS)*

4.2.1 Stage 1: Length of a Line

This stage of the experiment was carried out on columns 8–11 of 1QS.

The average value of the errors in the reconstruction of 1QS is similar to that of 1QIsa[a]. Here too some of the largest errors are caused by unpredictable vacats (11.4% in col. 8 line 5; 13% in col. 8 line 7; 8.8% in col. 11 line 2). The phenomenon of spacing the letters or crowding them in shorter and longer lines respectively, encountered in 1QIsa[a], was not noticed in 1QS. Some further errors are caused by defects in the skin that forced the scribe to deviate from the usual handwriting (e.g. col. 8 line 19), or from omissions that are completed above the line (e.g. col. 8 line 8; col. 10 line 19).

TABLE 7 Margin of error for the reconstruction of all lines in 1QS columns 8–11

Column	**Average (%)**	**Standard deviation (%)**	**Maximal error (%)**
Col. 8	4	4	13
Col. 9	3.1	1.8	6.3
Col. 10	4.5	3.3	12.9
Col. 11	2.8	2.6	8.8
All columns	**3.7**	**3**	**13**

14 Ulrich and Flint, DJD XXXII, 63–64.

TABLE 8 Margin of error for the reconstruction of lines with no vacats in 1QS columns 8–11

Column	Average (%)	Standard deviation (%)	Maximal error (%)
Col. 8	2.2	2.1	6.6
Col. 9	2.9	1.8	6.3
Col. 10	4.5	3.2	12.9
Col. 11	2.3	2.1	7
All columns	**3.1**	**2.6**	**12.9**

As in 1QIsa^{a}, here too an exceptionally irregular column was noted. In col. 10, two of the errors are above 10% (lines 13 and 23) even without vacats, and only 25% of the errors are less than 3%. But in col. 11 the scribe returns to the consistent writing mode, with approximately 68% of the lines showing less than 3% errors. Only two of col. 8's lines that do not contain vacats (19 and 22) show errors larger than 3%, and one of them (line 19) includes a supralinear correction. Col. 9's maximal error is only 6.3%, and nearly 60% of the error are less than 3%.

4.2.3 Stage 2: Height of a Column

This stage was examined on all eleven columns of 1QS. Since the first three lines of column 1 are damaged, we established the font's parameters based on lines 4–6 of this column. In addition, we ignored the line 7:27, which contains only one word. This scroll contains vertical dry rulings for every column, thus does not raise the problem of the unknown measurements of column width.

For the most part, the use of a font gives very good results for the reconstructed number of lines in this scroll. The error amounts to only 1–2 lines (and an average for all lines of 1.81), which is a common variation even between columns of the same scroll. This is the highest precision a scholar can expect from a reconstruction of a column.

Column 7 is exceptional with an error of 4.5 lines. This column includes many scribal mistakes, erasures, and corrections in addition to large vacats, the largest of which is approximately 2–3 lines long. The error incurred in this line is thus not caused by the use of a font but rather by unpredictable variables. Similar error would have occurred had we used other means too.[15] Other smaller vacats also have a significant effect on the error. All the simulated columns are shorter than the original ones. This should be explained by the existence of frequent vacats in this scroll.

In this scroll the vacats of every column amount to an average of one blank line per column. But the average result at this stage of the experiment is larger (1.81 lines), and

15 See Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 19–20.

TABLE 9 Margin of error for the reconstruction of column height in 1QS

Column	Error of height (cm)	Error of height (abs. %)	Error of # of lines	Error of # of lines (%)
Col. 1	0.6	3.40	0	0
Col. 2	−0.45	2.23	1	3.8
Col. 3	−3.45	17.17	2.5	9.6
Col. 4	−0.3	1.43	1.5	5.8
Col. 5	−0.39	1.92	2.2	8.5
Col. 6	−0.34	1.63	2.5	9.3
Col. 7	−6.61	31.52	4.5	18.0
Col. 8	1.5	7.50	0.5	1.9
Col. 9	−1.85	8.61	2.2	8.5
Col. 10	−0.53	2.51	1.5	5.8
Col. 11	−2.24	14.70	1.5	6.8
Average		**8.42**		**7.08**
Standard deviation		**9.41**		**4.74**

thus cannot be explained by the presence of vacats only. The rest of the error should therefore be explained by the fact that the scribe of 1QS had a tendency to use smaller script in the first few lines of the column, enlarging the letters down the column.[16] The source for this error is thus definitely related to the use of font. It is difficult to avoid the problem, since in fragmentary scrolls scholars depend on the material that survived, having no way to determine the size of the letters that was used in the non-extant parts. Thus, even if the problem caused by vacats and blank lines is accounted for, the reconstruction must acknowledge an extra error of ca. 5% for each column (in this case only one line per column).

Unlike the reconstructed number of lines, the error of the reconstructed height in cm is lower. This is due to the above-mentioned phenomenon: the scribe's tendency to enlarge the script towards the end of the column and the many vacats. In addition, the space between lines in 1QS usually increases towards the end of the column. Since we established the simulated space based on the upper lines, the simulated lines turned out to be denser than the original ones.

The average error for both the height and number of lines is approximately 7–8%, but the standard deviation in this scroll is larger for the height error than for the number of lines. The error in column 7 is exceptional not only with regard to the number of

16 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 72–74, already noticed this tendency.

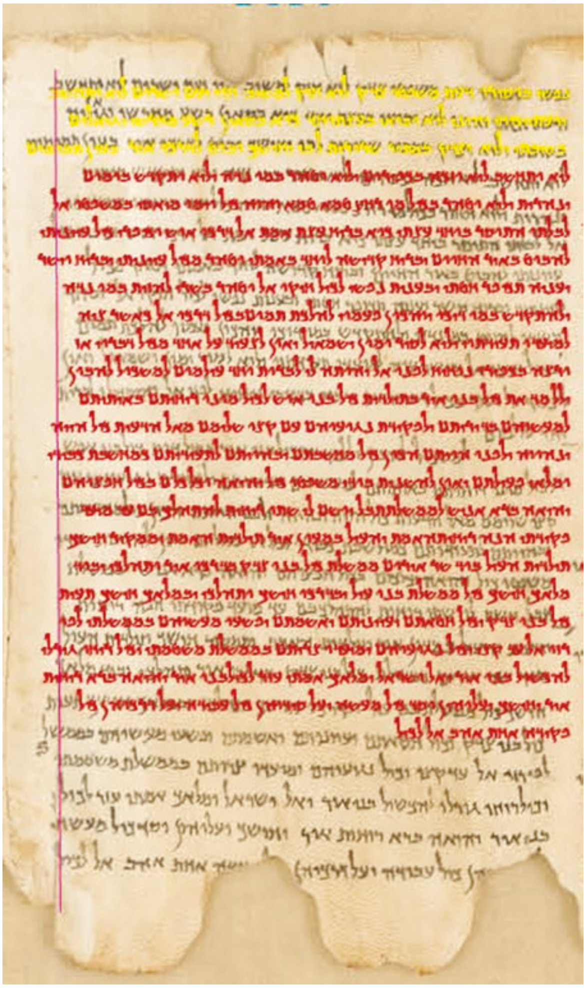

FIGURE 25
1QS Column 3 with the top three lines extant and the rest of the column simulated. In this visual representation, the "red" column ends ca. 4.5 lines before the real one, but the line count shows only 2.5 lines difference.

simulated lines, but also with regard to the simulated height, with the error reaching over 30%. Large errors occur also in columns 3 and 11.

4.2.4 Stage 3: Larger Textual Units

In 1QS the first column is significantly narrower than the rest of the columns. This oddity created huge mistakes in stage 3.A of the experiment, in which the size of the columns is based solely on the measurements of the first column. Had we encountered a scroll in which only this exceptional column is preserved, the results would indeed be substantially wrong. Not only the absolute number of lines is in error, but also the relative error (expressed in percentage of the overall text) increases as the simulated text is longer.

TABLE 10 Margin of error for the reconstruction of several consecutive columns in 1QS – version 3.A

Column	Error (# of lines)	Error (%)
Col. 1	1	4.35
Col. 2	6.5	13.27
Col. 3	9.4	12.53
Col. 4	26.5	26.24
Col. 5	49.3	38.82
Col. 6	72.8	47.27
Col. 7	82.8	46.26
Col. 8	93.6	45.66
Col. 9	107.3	46.45
Col. 10	124.3	48.37
Col. 11	139.1	49.86
Average		**34.46**
Standard deviation		**17.11**

TABLE 11 Margin of error for the reconstruction of several consecutive columns in 1QS – version 3.B

Column	Error (# of characters)	Error (abs. %)
Col. 1	50	4.12
Col. 2	87	3.27
Col. 3	25	0.60
Col. 4	−112	1.80
Col. 5	−351	4.17
Col. 6	−707	6.67
Col. 7	−1010	8.20
Col. 8	−1249	8.97
Col. 9	−1506	9.61
Col. 10	−1537	8.74
Col. 11	−1931	10.05
Average		**6.02**
Standard deviation		**3.35**

The situation is significantly improved in version B, under the assumption that the height and width of each column is known. The average error is around 6%, slightly higher than for 1QIsa^{a}.

Since in Stage 2 of the experiment all simulated columns of 1QS turned out to be shorter than the original ones, it is expected that over a longer text comprised of several columns the error will sum up and increase as the amount of simulated text grows. However, since the script was smaller in the first columns and grew larger as the scroll progressed, the simulated text held more characters than the original one in the first three columns, but that changed in the following columns. After the accumulation of enough columns the simulated text became shorter than the original one. The simulated text in fact ended after ten columns, leaving no column corresponding to the last, 11th column of 1QS. Note that this column is shorter than the rest of the columns. While 1QS is anomalous in the amount of uninscribed space, this is still something to consider when reconstructing long sections. Interestingly, the relative error decreases in the first few columns, and then gradually increases. with the numbers behave similarly to 1QIsa^{a}, but the positive and negative numbers are opposite. In both scrolls, the larger the simulated text is, the more prone it is to errors in absolute numbers; however, while in 1QIsa^{a} the relative error becomes stable after a few columns, in 1QS it keeps growing at a small rate.

4.2.5 Unique Scribal Practices

Some unique scribal practices were noticed during the simulation. As in 1QIsa^{a}, here too some columns were less regular than others. Thus, columns 3, 7, and 10 were inconsistent. This supports the suggestion that the inconsistency is affected by the scribe's increased fatigue every three or four columns.

In addition, as Herbert has already noted, the scribe of 1QS has a tendency to use smaller script in the first few lines of the column, enlarging the letters down the column.[17] Together with the script, the space between lines in 1QS usually increases towards the end of the column.

The phenomenon of spacing the letters or crowding them in shorter and longer lines respectively, encountered in 1QIsa^{a}, was not noticed in 1QS.

4.3 *11Q5*

4.3.1 Stage 1: Length of a Line

This stage of the experiment was carried out on columns 20–24 of 11QPs^{a}. Since fewer lines of this scroll's columns were preserved, we decided to include five columns rather than four in this stage.

17 Herbert, *Reconstructing Biblical Dead Sea Scrolls*, 72–74.

Since the columns in this scroll are comparatively narrow, the contribution of the vacats to the relative error is larger than usual: 20.7% in col. 20 line 8; 25.2% in col. 21 line 1; 28.2% in col. 22 line 1; more than 8% in col. 22 lines 4, 7, and 16. Removing these lines from the statistics gives similar results to those of the first two scrolls. The phenomenon of higher errors in shorter or longer lines (observed in 1QIsa[a]) was not noticed. In addition, there were no conspicuous second-hand corrections.

The least regular column of this scroll is col. 22, with less than a third of its lines containing errors lower than 3%. After removing the lines with the vacats, the more accurate lines increase to 50%, similar to the rest of the columns. The irregularity is thus explained by the large number of vacats rather than by the scribe's fatigue.

TABLE 12 Margin of error for the reconstruction of all lines in 11Q5 columns 20–24

Column	**Average (%)**	**Standard deviation (%)**	**Maximal error (%)**
Col. 20	4.9	5	20.7
Col. 21	4.4	6	25.2
Col. 22	5.6	6.4	28.2
Col. 23	3.6	2.2	8
Col. 24	2.5	1.4	5.3
All columns	**4.2**	**4.2**	**28.2**

TABLE 13 Margin of error for the reconstruction of lines with no vacats in 11Q5 columns 20–24

Column	**Average (%)**	**Standard deviation (%)**	**Maximal error (%)**
Col. 20	3.9	3	10.9
Col. 21	3.1	2.9	9.4
Col. 22	3	1.8	5.9
Col. 23	3.6	2.2	8
Col. 24	2.5	1.4	5.3
All columns	**3.2**	**2.3**	**10.9**

4.3.2 Stage 2: Height of a Column

Since all of the columns of 11Q5 are damaged at their end, we worked with only 11–17 lines in a column, much less than the previously examined scrolls. Vertical dry rulings are preserved, facilitating the reconstruction of the column's width. The script is highly uniform. Vacats are regularly added between psalms. In most columns, despite the vacats, no error was found in the simulated number of lines. Only in two cases is the error larger than a few words. The error of the simulated height in cm is larger, due to irregularity in the spaces between lines. In cases of an error of a few words, the effect on the height of the column is larger, because the addition of the few words adds another line to the column. A space of two lines was left by the scribe between psalms in column 18, which created a larger error in the reconstruction of this column. It is difficult to explain the error in column 23. A vacat of half a line is not enough as an explanation, because similar vacats appear in other columns as well. An additional explanation may result from the many occurrences of the Tetragrammaton in this column, which in this scroll is written in Paleo-Hebrew script, whose size is difficult to predict.

TABLE 14 Margin of error for the reconstruction of column height – 11Q5

Column	**Error of height (cm)**	**Error of height (abs. %)**	**Error of # of lines**	**Error of # of lines (abs. %)**
Col. 18	−18.94	12.37	−2	12.50
Col. 19	8.71	5.73	−0.4	2.35
Col. 20	−7.16	5.28	−0.5	3.45
Col. 21	−16.46	11.56	−1.5	9.38
Col. 22	0.34	0.26	0	0
Col. 23	15.01	11.42	0.2	1.33
Col. 24	17.43	12.57	0	0
Col. 25	0.00	0.00	0	0
Col. 26	1.75	1.47	0	0
Col. 27	−3.01	3.07	0	0
Col. 28	−7.77	6.64	0	0
Average		**6.40**		**2.64**
Standard deviation		**4.92**		**4.32**

4.3.3 Unique Scribal Practices

This scroll is highly formal and regular, and no previously unknown scribal practices were noticed during the experiment.

5 Discussion

Stage 1 of the experiment was tested on all three scrolls (1QIsa^{a}, 1QS, and 11Q5). The results exhibit average errors of 3.7–4.2% for the reconstructions of a length of a line. Errors are sometimes caused by vacats, which are not always predictable, but the effect of this factor is not high: computing the average error without those lines that contain vacats only reduced the error to 3.1–3.45%. Other causes for the error include the scribes' inconsistency likely due to fatigue, some tendency to crowd or space the writing at the end of lines, damages to the skin, and scribal corrections. Whatever the reasons, usually the errors are not large, and rarely reach or exceed 10%. In order to improve the results, a scholar must pay close attention to the scribal practices in the extant fragments before the beginning of the reconstruction. We anticipate that additional practices may surface during the reconstruction work, and these should be taken into account as well. When reconstructing a column width using a font, we recommend to give a range of ±4% for each column, and to draw further conclusions accordingly.

Stage 2 examined the precision of the reconstruction of column height. While in 1QIsa^{a} and 1QS full columns were preserved, the bottom lines of 11Q5 were destroyed, and we had to reconstruct only the preserved lines. In this stage we measured the error for the column height both in centimeters and in the number of lines. The average error in cm was 6–8% for all three scrolls, while the average error for the number of lines was approximately 7% for the first two scrolls, and less than 3% for 11Q5. In all three scrolls the error for most columns was less than 2 lines. Larger mistakes were caused by large or numerous vacats, inconsistency of column width and inconsistency of handwriting. As for the height of the column in centimeters, inconsistency in the spacing of lines has a significant contribution to the error. Large errors for the number of lines of over 10% were rare, occurring in only 1–3 columns in each scroll. When reconstructing the height of a column whose text is known with a font, a scholar should be aware of an error of approximately two lines in most scrolls,[18] but perhaps only one line if the scroll is exceptionally formal and consistent.

Due to the damages to the bottom part of 11Q5, we were unable to include it in stage 3 of the experiment, which involves the reconstruction of text along a large number of

18 In exceptionally high or short columns the number may change accordingly.

columns. We performed this stage in two versions. In version 3.A, we reconstructed the space required for copying the text of the scroll based on the size of the first column without assuming the height and width of the rest of the columns. In this version, the results were not good. The average error in 1QIsa[a] was approximately 10%, and in 1QS it was over 30%, and it seemed to increase the longer the reconstruction goes. However, if the measurements of the following columns are indeed known (version 3.B), the average error is approximately 4% and 6% in in 1QIsa[a] and 1QS respectively. Reality is somewhere in the middle between these two versions, as scholars usually have clues for the dimensions of at least some of the columns.

In both scrolls, establishing the space required for a small number of columns is different than for a larger number of columns. While in the first columns, vacats and inconsistencies of the handwriting are more significant, sometimes annulling each other, later on the relative error stabilizes around a certain number.

To summarize this stage, the reconstruction of a large number of columns with unknown dimensions may not be considered reliable, unless some information may be culled for the dimensions of the missing columns. At the same time, it is important to set this caveat in perspective. Even without any prior knowledge of the dimensions of the columns, the error incurred by the procedure described here is smaller than the error obtained by other methods commonly accepted in our field. For example, the error incurred when using the Stegemann Method for the reconstruction of a length of a scroll.[19]

Overall, the outcomes for the reconstruction of all three sizes: width of a line, height of a column, and space required for longer textual units, yield comparatively small errors. When considering the precision of the "font method" compared to other reconstruction methods, it has been demonstrated here that most of the errors are not caused by the use of font, and are in fact unavoidable even with other means of reconstruction, such as letter cloning. Such errors are caused by unpredictable scribal practices such as vacats, defects in the skin, inconsistencies in column width, etc.

One cannot avoid errors, but these errors are usually small enough to keep the reconstruction reliable. Nevertheless, errors should be kept in mind, especially when using the reconstruction for other purposes. Scholars should remember that a reconstruction does not give an absolute result, but a range of possibilities, and they should therefore conduct their reconstructions accordingly. The reconstructions provided in this book (chapter 15) are aware of this factor and will demonstrate its correct usage.

19 For criticism on this aspect of the Stegemann method see Eshbal Ratzon and Nachum Dershowitz, "The Length of a Scroll: Quantitative Evaluation of Material Reconstructions," *PloS One*, 2020. doi: 10.1371/journal.pone.0239831. The criticism pertains only to the assessment of the length of scrolls, while other parts of the Stegemann method are used in this book with a smaller level of potential error.

APPENDIX 2

Automated Font Generation

Bronson Brown-deVost

The Scripta Qumranica Electronica project provides a web-based platform for exploring the Dead Sea Scrolls and creating critical digital editions of them.[1] Among the many features this online virtual research environment provides is the ability to mark the region outline of letters on an image of a manuscript. This is accomplished by recording the exact vector coordinates – a series of x,y points – that encompass the ink of individual letters on the manuscript and linking it with its corresponding letter in a digital transcription of the text. The isolation of each letter and its linkage to a transcription is currently done manually within the platform, but automation of the process is underway.[2] This linked data provides a large paleographical repository of information about extant letter forms and their relative placement which can be used to answer many different questions related to scribal habits and fragmentary manuscript remains. Relevant to the present book, this information can be used to automatically generate fonts matching the scribal practice in individual manuscripts.

The shape of a given letter that will be used to present it in the automated font is called "a glyph." The automated process to produce such fonts involves analytical routines to determine typical values for: 1) glyph shape, 2) glyph size, 3) vertical glyph positioning, 4) kerning of glyphs, 5) word spacing, and 6) line spacing. All of these script features are subject to variation throughout the course of a manuscript, but a model font will aim toward a representation of the average and the prototypical.

1 Glyph Shape

The glyphs in a SQE paleographical repository (figure 26) will often include many damaged or otherwise incomplete forms. Nevertheless, the presence of these incomplete

1 Brown-deVost, "Scripta Qumranica Electronica (2016–2021)"; Ratzon and Gayer, "Scripta Qumranica Electronica."

2 See Daniel Stökl Ben Ezra, Bronson Brown-deVost, Nachum Dershowitz, Alexey Pechorin, Benjamin Kiessling, "Transcription Alignment for Highly Fragmentary Historical Manuscripts: The Dead Sea Scrolls," *International Conference on Frontiers in Handwriting Recognition (ICFHR) 2020*, 361–66.

DOI:10.1163/9789004473058_014

forms alongside intact ones presents little difficulty for algorithmic analysis so long as there is a sufficient number of examples (typically 5 or more good examples of each glyph). The prototypical shape for each character is determined using the Anna Karenina principle: all good character shapes are alike in the same way, each bad one is bad in its own way – an oversimplification from a paleographical perspective, but nevertheless serviceable.[3]

FIGURE 26 A vector glyph in SQE

FIGURE 27 Simplified vector glyph

This approach is carried out by gathering all shape forms for a given letter in a manuscript. Each shape is geometrically simplified using the Douglas – Peucker algorithm to obtain a more basic shape (figure 27).[4] This result is further processed by means of morphological thinning, which reduces the shape into a "skeleton" approximation of its component strokes (figure 28). In order to find the single glyph form that is most similar to all others, the mathematical distance between every possible pairing of the simplified, thinned glyph forms

3 A more formal expression of this concept can be found in Vladimir I. Arnold, "Principle of the Fragility of Good Things," in *Catastrophe Theory*, trans. G.S. Wassermann (Berlin/Heidelberg: Springer, 2004), 31–32. It has been applied specifically to image analysis by Arjan Kuijper and Luc M.J. Florack, "Using Catastrophe Theory to Derive Trees from Images," *Journal of Mathematical Imaging and Vision* 23 (2005): 219–38.

4 David Douglas and Thomas Peucker, "Algorithms for the Reduction of the Number of Points Required to Represent a Digitized Line or its Caricature," *The Canadian Cartographer* 10.2 (1973): 112–22.

of a character is calculated using a set of values known as Hu moment invariants,[5] which enable the comparison of images without being affected by their rotation or scale. A score is calculated for each glyph form by summing its distance to every other form. Badly damaged glyph forms will have a high score, since they tend to deviate from the normal glyph shapes in many different ways. The character glyph with the lowest aggregate distance to all other glyphs of that character is selected as the most "prototypical" form available in the set, being the most similar to all other forms.

FIGURE 28 Rasterized and thinned glyph

2 Glyph Size

The scores gathered in the previous step can be used not only to find a single exemplary form, but also to define a grouping of good glyph forms by selecting every shape whose score falls below a specified distance threshold. Since these all represent acceptable alternative glyph shapes for that character, the form that is closest to the mean height/width size for the group can be selected as representing the optimal character glyph in terms of both its shape and its dimensions.

3 Vertical Glyph Position

When creating a font, it is also necessary to determine where each glyph sits on the base (or hanging) line of writing. An abstract base (or hanging) line is derived from a control character, which is either the character with the highest number of unique

5 See Zhihu Huang and Jinsong Leng, "Analysis of Hu's Moment Invariants on Image Scaling and Rotation," in *2010 Proceedings of 2nd International Conference on Computer Engineering and Technology*, ICCET V7 (Chengdu, 2010), 476–80, doi: 10.1109/ICCET.2010.5485542. Out of the various possible formulae, I found the following to produce the most satisfying results: $D(A,B) = \sum_{i=0}^{6} \left| \frac{1}{H_i^B} - \frac{1}{H_i^A} \right|$.

neighbor characters in the text or a character manually determined based upon specialist knowledge of the character set being analyzed. The topmost point of each glyph form of that character is treated as lying directly on an imaginary hanging line, regardless of its actual vertical positioning with respect to the hanging line. The vertical position of all other character forms is calculated based on their relative position on the vertical or y-axis in comparison with the glyph form of the control character that immediately neighbors it (figure 29). The y-offsets for all pairs of adjacent character glyphs are collected and then the absolute baseline offset for each character glyph is calculated based on the average value relative to the control character. For any characters that never occur directly adjacent to a glyph of the control character, the baseline (or hanging line) is set similarly in relation to any other characters for which a vertical position has already been established.

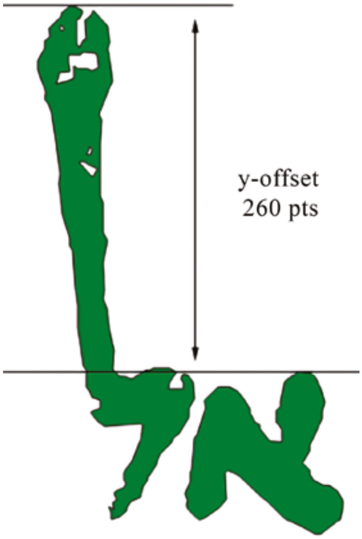

FIGURE 29 Relative hanging lines

4 Glyph Kerning

The horizontal kerning is an essential part of every font design and may carry significant implications for the overall reconstruction of a manuscript, as described in chapter 10. The kerning for every possible pairing of characters is calculated by finding the distance from the tail edge of the first character glyph's bounding box to the leading edge of the second character glyph's bounding box along the base (or hanging) line of the text (figure 30). The average kerning value for each unique character pair is used in the font. When a character pairing cannot be found in the paleographical repository, the algorithm can resort to the global averages. It would also be possible to attain a more likely kerning

FIGURE 30 Kerning distance

value by manually or automatically defining classes of characters and borrowing values from extant pairings of glyphs belonging to the same respective classes.

5 Word and Line Spacing

Word spacing can be calculated by collecting the size of each space between words in the entire manuscript and then calculating the average. The vertical distance from the hanging line in one line of text to the next one can be calculated by measuring the distance between the hanging lines of each pair of sequential line of text in each column and averaging the result.

The caveat remains that for any given Dead Sea Scrolls manuscript the glyph sizing, shape, kerning, and word and line spacing vary, sometimes considerably. The reduction of that variation to singular values for usage in a digital font results in a necessarily imperfect model of the scribal artifact, which might only minimally reflect reality – or even not at all. Nevertheless, such fonts produce models that do have a use in some contexts and the process as outlined above should be applicable or adaptable to any script that is linear in sequence, regardless of directionality. The measure of approximation that can be achieved by such a font vis-à-vis the real manuscript is discussed in detail in chapter 10 and Appendix 1.

CHAPTER 11

Damage Patterns

The complete or almost-complete scrolls known to scholars began deteriorating while still rolled, thus creating recurring damage patterns, as is evident in large scrolls like 1QS and 11QPs[a]. These patterns constitute significant benchmarks for the material reconstruction, i.e., for finding the relative position of the fragments within a scroll. In this chapter we present the core of the Stegemann Method together with updates from recent scholarship, adjustments to digital tools, and a critical view of the method's precision.[1] Establishing the sequence of fragments used to be carried out with images of fragments pasted on semi-transparent paper, which was subsequently rolled.[2] Today we do the same work digitally, but the main principle has not changed. Similar digital work has been carried out by some scholars for a while, and here we seek to stabilize a pipeline for it.

In standardizing his method, Stegemann offered a list of steps for reconstructing scrolls. Some of his points, like collecting the data and reconstructing the columns, were discussed elsewhere in this book, and are in fact used by all editors of the scrolls whether or not they use unique points of the Stegemann Method. The heart of the method, which differentiates it from all other methods, lies in the assumption that the scroll was deposited in the cave while still rolled, and began deteriorating in that condition. Since certain areas of the scroll were damaged by the same causes (humidity, animal activity, stress from cords, strings or stones, seam imprints, etc.), these areas may present similar damage patterns. In many cases, sections of several turns of the scroll remained stuck together even when the rest of the scroll decomposed. Stegemann offers a way for finding the fragments stemming from the same area of the scroll, and arranging them according to their original order, relying on the fact that in scrolls the outer circumference is larger than that of the inner turns. Thus, fragments with larger distances between similar damage patterns stem from

1 Stegemann did not in fact invent the method, which had been in use by papyrologists beforehand. The method was passed orally and was not published in print as a formal method. Stegemann standardized it for the study of the DSS (Stegemann, "Methods for Reconstruction.") For a recent summary of the method and its later developments see also Stökl Ben Ezra, *Qumran*, 53–55, and the introduction to this volume. For its earlier use in the field of the DSS, see Milik, "Dires de Moïse," 91.

2 Stegemann, "Methods for Reconstruction"; Steudel, "Assembling."

 | DOI:10.1163/9789004473058_015

the outer turns of the scroll. However, arranging the fragments in the inside or outside of the scroll does not necessarily indicate their order in the composition, since while most scrolls were rolled with the beginning on the outside, some were left rolled with the beginning on the inside.

The natural processes of shrinkage and detachment of parts of a given fragment may cause irregularities in the measured increment of gaps between respective damage patterns. The increment may stop or even be reversed in the middle of the incremental series, due to shrinkage at one specific spot, thus rendering the Stegemann method inaccurate.[3] It is therefore preferable to run the procedure on old PAM images – provided they are properly scaled – rather than on the scroll in its present condition or on the new IAA images. Ratzon and Dershowitz have shown, however, that even the use of the oldest images does not entirely resolve the problem.[4] Best results are achieved if at least four or five consecutive damage points are preserved (NB: not reconstructed but physically preserved), in which case the effect of skin irregularities is minimized. Thus, in the case where one increment is negative and the other is positive, the prudent scholar would be aware of the discrepancy and would seek more data to normalize. In order to choose the right increment, it is important to examine all images and detect places where the scroll has shrunk or where cracks affect the distance between damage points, rendering one of the measurements less reliable.

We divide the discussion into three main topics: 1) the direction in which the scroll was rolled, i.e., was it rolled in the normal way with its beginning on the outside or the other way around?; 2) the application of the method to cases in which fragments were preserved in wads (stacked in piles), for example in 4Q418a discussed extensively in the present book; and 3) the more common case, in which the fragments were found scattered and a spatial reconstruction is sought using the recurring damage patterns. We will not discuss here the more classical methods for the joining of fragments that are surveyed by Stegemann himself, since they were not in use in the current manuscript of 4Q418a. Reading this chapter assumes prior reading of several previous chapters: Verso (chapter 6), Finding Wads (chapter 7), and Recreating Single Columns (chapter 9).

3 For this difficulty and others like it in determining incremental growth of damages, see Ratzon and Dershowitz, "The Length of a Scroll."

4 Ratzon and Dershowitz, "The Length of a Scroll."

1 The Direction in which the Scroll Was Rolled

The normal way of rolling would be with the *end* of the scroll at its inner part, so that the reader will encounter the beginning of the scroll, or the handle sheet, at its outermost turn.[5] For a reader finishing a scroll, re-rolling it from the end towards the beginning would require some effort, but users usually took the time to do so. In some scrolls, however, this effort was not carried out and the scroll is rolled with its *beginning* at the inner part.

The direction of rolling can be determined in scrolls that show a significant series of damage patterns. Thus, for example in this image of a section of the scroll 11QpaleoLeviticus[a] (11Q1):

FIGURE 31 Section of the scroll 11Q1
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One can clearly see the recurring patterns of deterioration at the bottom of the scroll. These patterns are small and close to each other at the left end of the scroll, whereas the damages grow larger and the gaps grow wider apart at its right end, closer to the beginning. This is a sign of the "normal" state of affairs. The same is true for 11Q5 (11QPs[a]):

FIGURE 32 The inner sheet of the scroll 11Q5
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In contrast, as the scroll 1QS was found rolled "backwards," the damage patterns are closer at the beginning of the scroll and grow wider at its end.

5 See the discussion with additional background in Tov, *Scribal Practices*, 40.

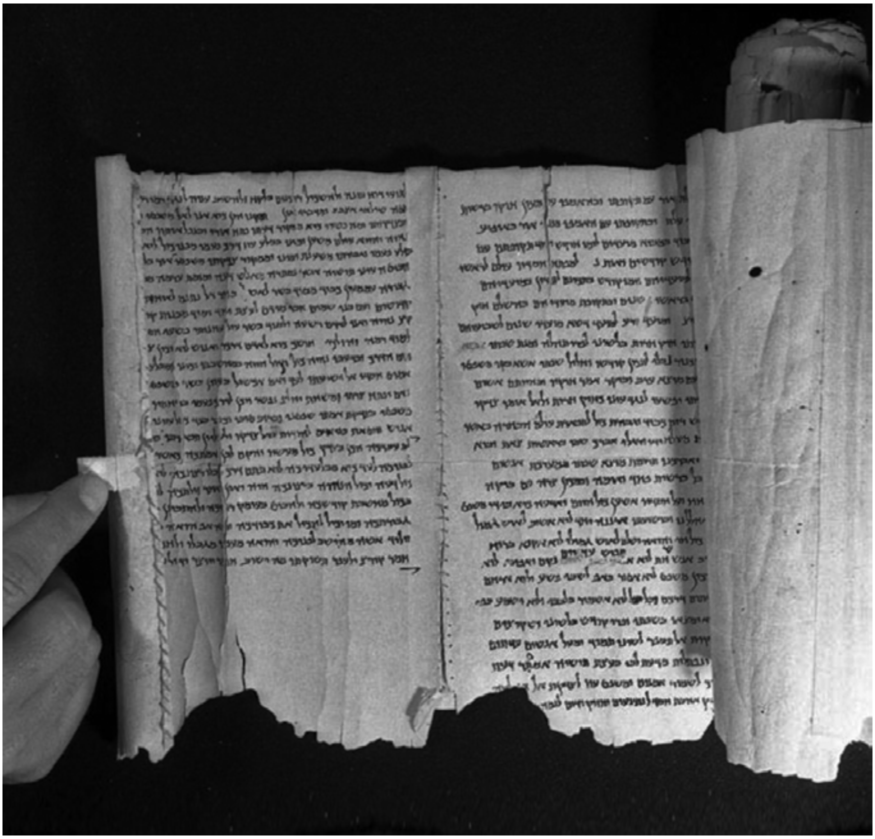

FIGURE 33 Columns 10–11 of 1QS in the early stages of their being opened
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1QS and 1QM are the only large scrolls preserved while rolled backwards.[6] While this situation can easily be discerned in well-preserved scrolls, it is quite difficult to discover in fragmentary scrolls.

Tov added a second indication for identifying the direction in which the scroll was rolled. He suggested that the end of the scroll, which was also probably located at the innermost roll, was thus protected from decay by the outer layers.[7] Hence, if only the *end* of a composition is extant, one may posit that the scroll was properly rolled, and vice versa. This rule of thumb is applicable, however, only in cases where the very first or very last pages survived; it is harder to implement when various fragments survived that are hard to place

6 Another example of a smaller scroll is 1Q22. See Milik, "Dire de Moïse," 91.

7 Tov, *Scribal Practices*, 108–12.

in a serial manner. Moreover, while Tov's suggestion sounds reasonable, he did not test it against additional factors. The statistics in fact point against his conclusion. Based on his data, the beginnings of approximately 5.5% of the scrolls (51 manuscripts) were preserved, compared to only 3.1% (29 manuscripts) of the ends, implying that only a little less than half of the scrolls were rolled the normal way.[8] However, the great majority of those scrolls that have been found as extant rolls (i.e., from caves 1 and 11) had clearly been rolled in the standard way. If they represent the entire corpus, their evidence counters Tov's sample. The fact that more beginnings of scrolls were preserved than ends may be explained by other means. For example, it is possible that the fabric wrapping the scrolls protected the external layers, while the inner layers were more exposed to humidity and insects, penetrating through the exposed upper and bottom parts of the scroll and the space left in the middle.[9] This may explain why most scrolls preserve neither the beginning nor the end. In addition, it might be worth not only inquiring about the first and last columns, but also running a more systematic log of the scrolls, examining ranges rather than specific points: which percentage of the fragments remained from the first region of the scroll, and which remained from its concluding part? This may lead to refined results. One may not overrule the possibility that some scrolls were left open in the middle, rolled from both sides or folded or in another condition; but such cases are hardly attested and difficult to prove.[10]

2 Wads

In some fragmentary scrolls, the fragments are preserved stacked in piles. In chapter 7 we explained how to identify such wads; here we focus on their use

8 Tov, *Scribal Practices*, 108–12. In addition, Elgvin claimed that if damage patterns indicate that a fragment reflects tiny turns, i.e., a circumference of the scroll of 2.5–4 cm, the fragment should be located at the innermost end of the scroll. See Elgvin, "1QSamuel."

9 For a survey of the fabrics found in Qumran see G.M. Crowfoot, "The Linen Textile," in *Qumran Cave 1*, DJD I, Dominique Barthélemy and Józef T. Milik (Oxford: Clarendon Press, 1955), 18–38; Mireille Bélis, "The Unpublished Textiles from the Qumran Caves," in *The Caves of Qumran: Proceedings of the International Conference, Lugano 2014*, ed. Marcello Fidanzio, STDJ 118 (Leiden: Brill, 2016), 123–36; Naama Sukenik, "The Temple Scroll Wrapper from Cave 11," in Elgvin, Davis, and Langlois, *Gleanings from the Caves*, 338–50.

10 Ariel Feldman suggested that the scroll 4QJosh[a] was folded rather than rolled: Ariel Feldman, "Reconstructing 4QJosh[a] (4Q47): The Contribution of Frag. 21," [Hebrew] *Meghillot* 14 (2018/19): 3–12. The study of 4Q57 (Isaiah[c]) by Asaf Gayer shows that it may have been rolled from both sides.

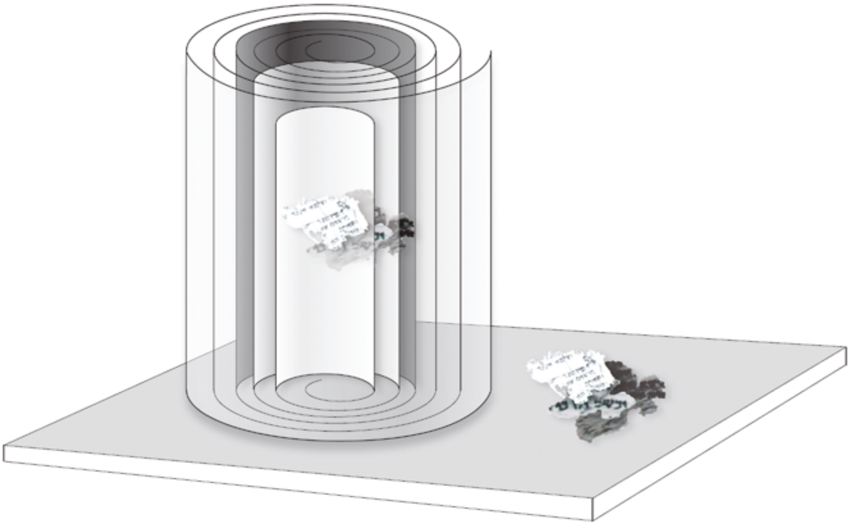

FIGURE 34 3D representation of a wad. Left: Each shade of gray represents a separate turn of the scroll. After the scroll had deteriorated, the preserved fragments keep their original order. Right: When the fragments lie on a surface the order of the fragments when laid with the written side (recto), from top to bottom, represents their order in the original scroll from inside to the outside. GRAPHICS: MICHAL SEMO-KOVETZ, TAU GRAPHIC DESIGN STUDIO

for ordering the fragments and reconstructing the scroll. Observing the wad with the text on top, fragments from external turns of the scroll are attached underneath fragments from the subsequent turn towards the inside. Thus, the order of the layers from the top to the bottom of the pile represents their original order from the inner turns of the scroll to its external turns.

Knowing the material order of the fragments in the original scroll does not necessarily indicate the order of the text in the original composition, however, as the scroll may have been rolled either way. Knowledge of parallel copies may solve this problem, as in the case of 4Q418a and other scrolls preserved in piles such as 4Q385a and 4Q82.[11]

As mentioned in chapter 7, although the peeling of wads was carried out with great care and documented both on the PAM images and in the editions, it was not devoid of problems. Some mistakes remained in the record, as we were

11 For 4Q385a see Davis, *The Cave 4 Apocryphon of Jeremiah*, 73–84. A series of images depicting these patterns are reproduced passim. For 4Q82 see Russell Fuller, "The Twelve: 82. 4QXII^{g}," in *Qumran Cave 4, X: The Prophets*, eds. Eugene Ulrich et al., DJD XV (Oxford: Clarendon Press, 1997), 271–318.

able to detect, either with regard to switching the order of layers (for example in 4Q418a 7 and 8, see chapter 15), or – quite rarely – by reversing the order of the entire wad. It is therefore vital to re-examine the order of layers using close inspection of the PAM images. Here is the procedure for tracking down the wads and establishing their order, exemplified by the wads of 4Q418a:

1. The procedure begins with the oldest image in which the wad can still be seen before separation. A close examination of the earliest available image may shed light on the order of the wad, allowing a critical view of the scholar's documentation. For example, in the case of wad A of 4Q418a we learned that the original order of two fragments had accidentally been reversed in later photographs. In addition, we located an early image for one of the wads, taken prior to the earliest documentation mentioned by Strugnell. This early image showed additional pieces of parchment, not accounted before (see chapter 15).

FIGURE 35 Wad A. 4Q418a 6–8, PAM 41.973

2. Whether or not an image of the unseparated wad is found among the PAM images, later PAM images may also add further documentation on the separation stage. This information is culled from the next image, in which the layers of each wad are placed sequentially on the plate. Numbers indicating the order of layers are usually recorded on pieces of paper in the photograph. Sometimes the layers were separated in several stages, with each of the stages documented on a separate PAM image. In such cases it is important to search for the earliest image of each layer.

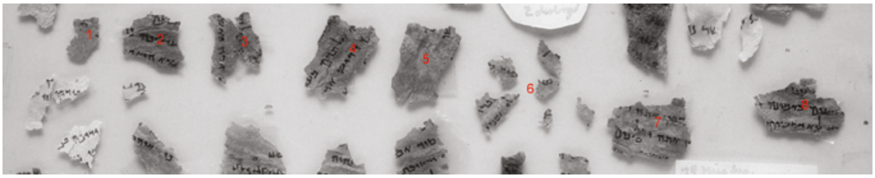

FIGURE 36 Documentation of the layers of 4Q418a wad A (frags. 1–8) after their separation (PAM 41.997). In this case, there are no numbers next to the layers, but their position on the PAM plate indicates their order within the wad. The red numbers were added by the present authors.
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3. After adapting the scaling of all images (chapter 4) and removing the background from all images (chapter 5), an image manipulation program is used to place the respective fragments as layers on top of the image of the original wad. The borders of the respective layers should be matched with the pertinent points on the original wad. In cases where the individual layers disintegrated while being separated, the individual pieces should be collected and virtually reassembled on the canvas.

Our treatment of wad A exemplifies the insights gained from this procedure. 4Q418a frag. 6 broke into many pieces while being separated from other layers, all recorded on PAM 41.997. We re-organized these pieces, placing them in their original position. Information on this original position was culled from the earlier images before separation, as seen, for example, in PAM 41.973.

As can be seen in the image (figure 37), the reassembled pieces of frag. 6 only cover about a half of the surface of the wad, while the upper half of the wad seen in the image comes from the next layer, not from frag. 6. That missing upper part of frag. 6 can now be found in a separate layer, where it is part of frag. 8 (figure 38). Surprisingly, that part is not found on frag. 7 – which is purportedly the next layer in the wad according to DJD – but rather on frag. 8. We are thus able to conclude that it was frag. 8, not frag. 7, that stood directly underneath frag. 6. This find contradicts the order recorded in the PAM image and reported by the editors.[12]

The same procedure carried out with regard to 4Q418a frags. 6–8 can be expected to confirm the documented order of the layers. In any event, the documentation should be examined critically by cross-checking it against other evidence.

12 In chapter 15 we discuss the significance of this find for the reconstruction of the scroll.

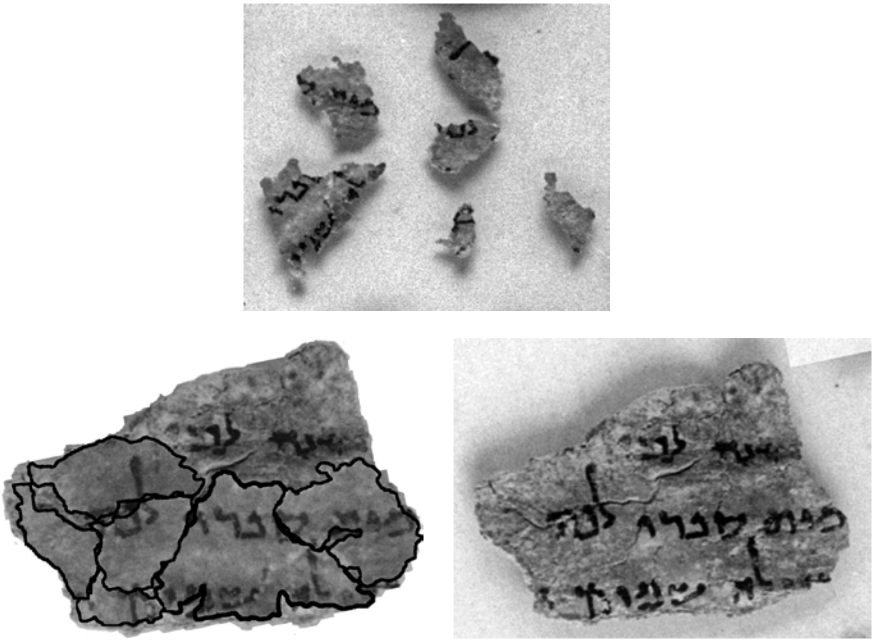

FIGURE 37 4Q418a frag. 6: the separation of layers. Top: Fragment 6 disintegrated after being peeled off wad A, as seen in PAM 41.997. Right: frag. 6 is still on top of the unpeeled wad A (PAM 41.973). Left: the small pieces of frag. 6 from PAM 41.997, pasted on top of its older image (PAM 41.973), seen on the right

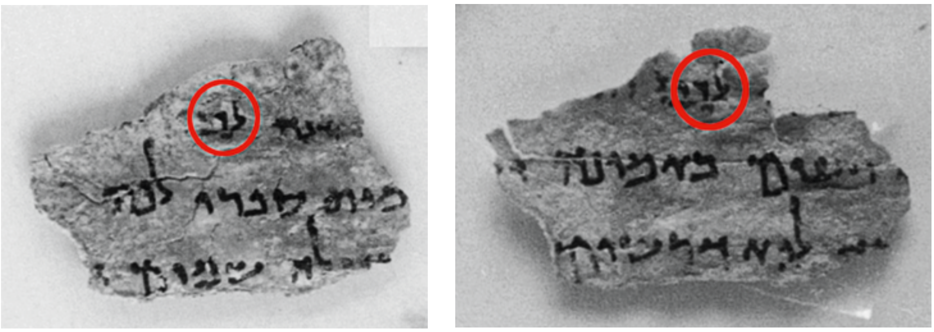

FIGURE 38 Left: 4Q418a frags. 6 and 8 while still attached on PAM 41.973. Fragment 6 is the top of the pile, with frag. 8 underneath it. Right: frag. 8 after separation, PAM 41.997. The letters encircled in red are identical in both images, demonstrating that they belong in fact to frag. 8, which is the second layer of this pile.

3 Establishing the Order of Scattered Fragments

The discussion thus far involved cases in which the wads reached the editorial team while still attached, with information on the separation stage duly documented. However, in most cases the fragments appear separately, whether received by the editorial team in this state or being separated by them without proper documentation. In these cases, the physical shape of the fragments may indicate their original order. Fragments with similar damage patterns may have originated from the same vertical height in the scroll, possibly from close – though not necessarily consecutive – turns of the scroll. One should search for similarities in the external borders of each fragment, and for cracks and breaks on their surface. In addition, look for the information available on the verso that may have been derived from the recto, for example impressions of the seams from the previous or the next turn that are left on the scroll.[13] Some damages may have been caused by a string holding the scroll tight.[14] After collecting and recording such information, the editor can suggest the placement and configuration of the fragments. This is in principle an objective suggestion, based on the data, i.e., on the objective recurring patterns of deterioration. However, since the separate fragments continued to deteriorate even after their separation, suggesting a material reconstruction involves a certain measure of subjective judgement.

The subjectivity involves not only pointing out the decay patterns, but also – mainly – marking the exact point from which measurement should take place. The similar pattern spreads over quite a wide area, and the choice of the exact point from and to which the distances are measured is not at all obvious. Ratzon and Dershowitz demonstrate that this choice significantly influences the computations of the length of the scroll and their errors.[15]

The procedure for finding fragments with similar patterns of damage was proposed by Stegemann and Steudel:

1. Detect the most significant fragments with recurring contours or other damage patterns (figure 39). Fragments showing upper, lower, and intercolumnar margins are especially helpful.

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13 Stegemann, "Methods for Reconstruction," 195.

14 Stephen Pfann and Menahem Kister, "4QcrypA Words of the Maskil to All Sons of Dawn," in *Qumran Cave 4. Sapiential Texts, Part 1*, ed. Torleif Elgvin et al., DJD XX (Oxford, Clarendon Press, 1996), 5–6.

15 See Ratzon and Dershowitz, "The Length of a Scroll." Consider for example the series of holes in 4Q550 frag. 7 (B-363164). While they give a clear example of growing intervals of damage, the exact point from which to measure the growth is hard to determine.

FIGURE 39 4Q415 fragments 2, 9, 11. These fragments contain margins and include some indications for a repeating pattern of damage. Elgvin, "An Analysis of 4QInstruction," 26–27, suggests that fragments 4Q415 9 and 11 come from a wad that had been separated. The figures supporting his suggestion were created by Asaf Gayer, who also added to this suggestion fragments 4Q415 10 and 2. For a detailed analysis of the wads in 4Q415 see Dayfani, "Material Reconstruction."
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2. Using an image manipulation software, mark the borders and every crack and hole in the fragment, while removing the image of the actual fragment.

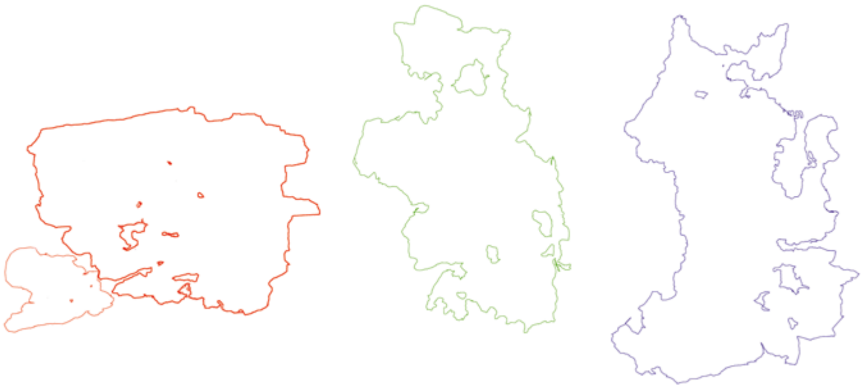

FIGURE 40 Borders and damages of 4Q415 fragments 2 (red), 9 (green), 11 (blue)

3. Place the fragment outlines one on top of the other as digital layers in a canvas. Check whether at least three damage patterns correspond and therefore indicate a wad.

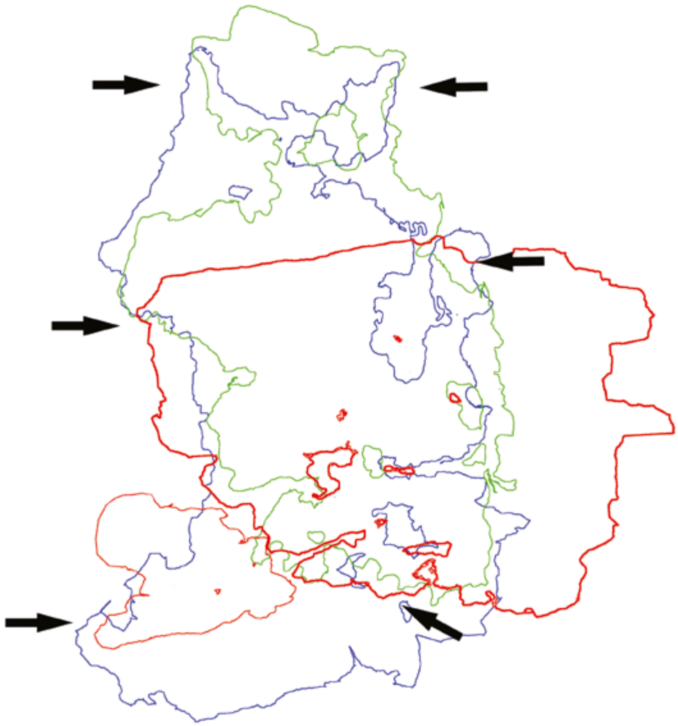

FIGURE 41 The outlines of 4Q415 fragments 2 (red), 9 (green), 11 (blue) superimposed. The arrows around the outlines indicate points of correspondence between the damage patterns.

4. Repeating damage patterns may indicate that the fragments come from the same vertical location in the scroll. If they also come from the same sheet, space between lines may serve as further verification of the suggested correspondence, since in many scrolls the space between lines remains stable, at least in the same sheet (see chapter 9).

The order of the fragments with similar contours should now be established. The Stegemann method is based on the intuitive principle that the distances between damage points stemming from an external part of the scroll are larger than those stemming from its inner parts. The scholar should conceive an order of the similar fragments based on various textual and material observations. Of the former type, an order may be shown by a parallel text, or, in its absence, may be posited by the thematic sequence. Of the latter, an order may be conceived by means of the size of each point of the recurrent damage, for example a gradually growing size of a hole in the successive layers. The method offers rules for establishing the circumference of the scroll in each of its subsequent turns. If no textual evidence is available, and the fragments were not preserved in a wad, the certainty of the restoration is diminished. This suggested restoration may gain support, however, by means of checking that the material traits of the fragments fall into place according to the suggested order, and according to the known size of columns and margins. For example, one should establish that fragments showing an inter-column margin would indeed reproduce that margin in the exact spot according to the suggested order. This protocol in turn dictates the exact distance between the respective fragments, as described in detail in the next chapter.

CHAPTER 12

Placing the Fragments on the Canvas Using the Stegemann Method

In the previous chapter we established the way to determine the order of fragments in the scroll and their height in the column. This chapter will focus on the last stage of the Stegemann Method, namely, finding the precise distance between fragments that were identified as part of the same wad. The final purpose of this step is to estimate the amount of missing text between fragments on the canvas. This task was described in detail by Stegemann in his seminal article and later by others, and is summarized here.[1] Some of Stegemann's premises have been contested in subsequent scholarship. We address the reservations in this chapter, but will expand on the method's margin of error in Appendix 3.

In order to find the distance between fragments, the first step is to find out the circumference of at least one turn of the scroll through either measurement or reconstruction. Measurement is possible in cases when a long fragment preserves at least two, preferably three points of damage, which would indicate the circumference of the scroll at those points (figure 42). If no such fragment exists, one can reconstruct the circumference of the scroll at an area where at least two fragments, textually overlapping a long enough section from other copies, are preserved. In this case it is possible to apply the methods for the reconstruction of column and intercolumnar width described in chapter 9. The known circumference is in fact the distance between two layers that will serve as the anchor of the reconstruction. The fragment or fragments from which we begin our reconstruction are named in this book the "anchor fragment(s)."

From the first known circumference one has to measure the distances to other layers of the scroll. It is easier to find these distances in the case of documented wads, or when other material indications exist, with the relevant fragments representing consecutive turns of the scroll. The distance between fragments increases toward the outer part of the scroll and decreases toward its inner part. Thus, if one knows the circumference of the scroll at a certain

1 Stegemann, "Methods for the Reconstruction"; Steudel, "Assembling"; Stökl Ben Ezra, *Qumran*, 53–55.

FIGURE 42 Columns 8–11 in 1QS. The distance between two adjacent damages at the bottom of the scroll indicates the circumference of the scroll at this point.

point, one should be able to place the rest of the fragments, which originated in other – inner or outer – turns.

Instead of conceiving the scroll as a spiral, the Stegemann Method approximates its shape to concentric cylinders, assuming that the circumference of succeeding turns of the scroll changes linearly, i.e., that the increase and decrease of the distances between every layer of the wad is constant throughout each scroll. This assumption is not realistic. The growth is affected primarily by the thickness of the skin and the tightness of the rolling, which are uneven throughout a scroll.[2] But since we have no way of knowing these variations for every layer, one has to estimate the average difference, keeping in mind that the actual difference can vary, as will be specified in Appendix 3. Thus, we take the known circumference at a certain point, and add or reduce a constant number for every turn or layer. If all fragments are extant, we can place them one by one according to the calculation.

Finding the average difference for a specific scroll is not always possible. The thickness of the skin is not regularly indicated in publications, and the IAA has just recently acquired the instrumentation to measure it without damaging the skin. Moreover, gelatinization has changed the skin's original thickness.[3]

2 For an empirical examination of these variations see Ratzon and Dershowitz, "The Length of a Scroll." They also claim that the difference in the error caused by a spiral approximation compared to concentric circles is negligible, and is not worth the extra effort of the computations. Another example can be found in Elgvin, "1QSamuel" (284–85), who notes that in 1QSamuel the two innermost columns (= 7 turns) were rolled in a tighter way than the preceding ones.

3 According to the information given to us by the IAA conservator, Tanya Bitler, in a private conversation.

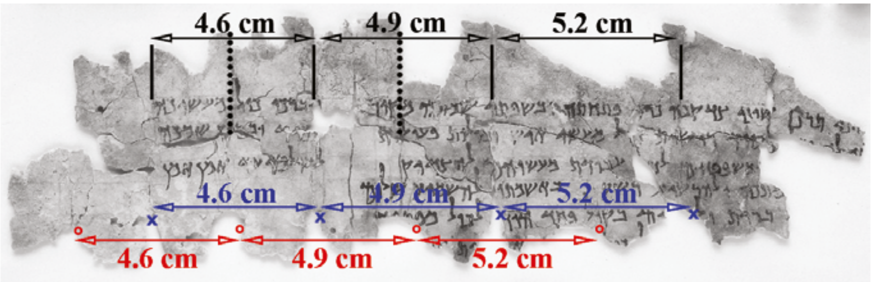

FIGURE 43 Corresponding Damage points on 4Q511 fragments 63 iii–iv. Angel, "Material Reconstruction," 32.
PHOTOGRAPHER: NAJIB ANTON ALBINA. ILLUSTRATION COURTESY OF JOSEPH L. ANGEL

In addition it is not always possible to know how tightly the scroll was rolled. Thus, since no better option is available, it is advised to rely on Stegemann's dataset which is based on earlier computations. According to Stegemann, the minimum increase per turn in a very thin scroll such as 11QT[a] (11Q19) may be 1 mm, while the maximum can reach up to 5 mm in the rather thick scroll 11QPs[a] (11Q5).[4] Comparing the thickness of the skin under discussion to these two scrolls may help.

After establishing the increase or decrease between 1–5 mm, one can proceed to placing the next layers. 4Q511 is a good example, where three consecutive circumferences were measured. The constant difference is 3 mm, thus the circumference is growing from the inner turn to the outer turn, beginning with 4.6 cm, continuing to 4.9 cm, and ending with 5.2 cm (figure 43).

1 Columns and Margins in the Material Reconstruction

After the fragments are placed in a certain position based on their decay pattern, it is time to divide the rest of the canvas into columns. The first step is to mark on the digital canvas all the column borders and intercolumnar margins preserved on the actual fragments (see chapter 9). These data constitute anchors for the subsequent procedure. We digitally attach these borders to their respective fragments, so that if the fragment moves the borders will move accordingly.

4 Ratzon and Dershowitz, "The Length of a Scroll," measured an average growth of 4 mm in 11QPs[a] with a standard deviation of 1 mm and a maximum of 6 mm.

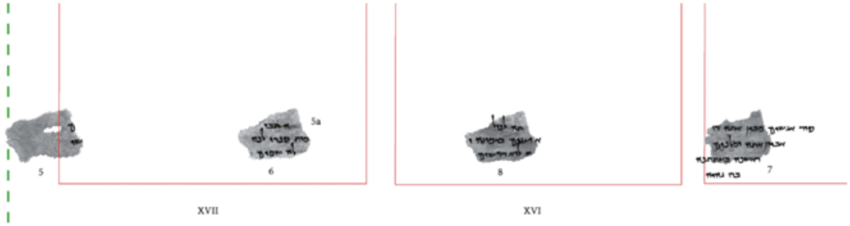

FIGURE 44 4Q418a cols. XV–XVII. The end of col. XVII was set by the left margin preserved on frag. 5. The text of frag. 7 parallels the text of 4Q415 6, which suggests some limitations for the reconstruction (see chapters 15 and 16). The rest of the space between frags. 5 and 7 does not include any clues for the reconstruction. We fill it with two columns based on the remaining space. The fact that these two columns are within the range of the known columns of 4Q418a validates the reconstruction.

The next step is to determine the widths of all other columns and margins, both those known from the large fragments and those reconstructed based on line width (which are, in turn, known from textual parallels). Since the width of columns and margins can vary within one scroll, one should follow the general limit for the narrowest and widest possible widths (see chapter 9). Deviating from these limits is possible when necessary, but it is best to keep deviations small.

The empty space on the canvas is then divided into columns, in an attempt to place all extant and computed column borders in their right place. The idea is to draw the column borders in such a way that all extant columns, margins, and borders could be placed on the canvas without conflict (see figure 44).

Drawing the column borders is a crucial move for the verification of the material reconstruction. While the Stegemann method is based on several approximations, and a certain reconstruction can never be proven correct beyond any reasonable doubt, the certainty can be improved by using a process of trial and error. Scholars should try positing various configurations until one of them cannot be contradicted. Recall that the outcome of the method is not a positive reconstruction of the scroll as it really was, but rather one possible reconstruction out of several others within a certain limit, whose main merit is that it does not contradict any other known data.

If the suggested reconstruction is not possible, this proves that one of the previous steps needs to be adjusted. The mistake may result from one small detail, which can be mended by altering that detail and will then make the reconstruction work. If this is not the case, the basic figures may be wrong, such as the stage of reconstructing the first circumference. An easy and common solution, applicable in cases when the known circumference is placed in a column whose text appears in parallel copy, is to change the width of the intercolumnar margin within the reasonable range found among the fragments of the scroll.

After the reconstruction based on the preserved fragments is completed, Stegemann suggests the reconstruction of the length of the rest of the scroll inwards, using the same assumption that the decrease of circumference between every consecutive turn is constant, in addition to the assumption that the core of the scroll has a minimum size. He estimated the error for such a computation as approximately 25%.[5] Later, Dirk Stoll suggested another mathematical computation for the length of the scroll. It was more complicated, but eventually equivalent to a simple sum of an arithmetical series.[6] Based on Stoll's computations, Drew Longacre mathematically estimated a larger margin of error (approximately 50%). Longacre claimed that even with this large margin of error, some conclusions can be drawn regarding extra-long scrolls.[7] However, Ratzon and Dershowitz empirically estimated the margin of error for such reconstruction, based on the information preserved in the long, comparatively intact scrolls. Their experiment showed an enormous margin of error of several hundreds percent, and sometimes even more.[8] This means that, at the bottom line, the Stegemann Method cannot be used for the estimation of the length of the unpreserved part of the scroll.

The present chapter described the creation of a canvas for one given scroll. In chapter 13 we will show how the results of this procedure can be extrapolated for the reconstruction of yet other copies of the same composition (in our case, *Instruction*). For that purpose, however, it is important to keep track of the margin of error of the original anchor. Thus, while the visual reconstruction of the first scroll must – by definition – contain only one accurately delineated option, this representation must be accompanied by a written account, in which the width of each column should include a range of numbers instead

5 Stegemann, "Methods for the Reconstruction," 199–200.

6 Dirk Stoll, "Die Schriftrollen vom Toten Meer – mathematisch oder Wie kann man einer Rekonstruktion Gestalt verleihen?" in *Qumranstudien: Vorträge und Beiträge der Teilnehmer des Qumranseminars auf dem internationalen Treffen der Society of Biblical Literature, Münster, 25.–26. Juli 1993*, ed. Heinz-Josef Fabry et al., Schriften des Insitutum Judaicum Delitzschianum 4 (Göttingen: Vandenhoeck & Ruprecht, 1996), 205–18.

7 Drew Longacre, "Methods for the Reconstruction of Large Literary (Sc)rolls from Fragmentary Remains," in *The Hebrew Bible Manuscripts: A Millennium*, ed. Élodie Attia-Kay and Antony Perrot, Supplements to the Textual History of the Bible 6 (Leiden: Brill, 2021), 110–141.

8 Ratzon and Dershowitz, "The Length of a Scroll."

of one specific figure. The entire range should be taken into account when extrapolated. This range may be narrowed down when working on a parallel copy with its own limitations. Trial and error are the main check on the validity of this rolling procedure. One should posit numbers for the next fragments and the next copies while making sure that they do not contradict any other known data.

APPENDIX 3

Margin of Error for Placing the Fragments on the Canvas

The ultimate purpose of the procedure suggested in this book is creating a digital canvas for every scroll. In this section we calculate the error that may be incurred when a fragment is placed using the Stegemann method, as described in chapter 12. The distances within the canvas (i.e., the coordinates for the placement of each fragment) should be expressed by means of a mathematical equation, from which the error can be derived.[1]

As was explained in chapter 12, according to the Stegemann Method, a reconstruction begins with an anchor fragment, around which the circumference of the scroll is known. Other fragments, belonging to consecutive layers, are placed in relation to that fragment. The distances between consecutive layers of the scroll increase or decrease. Most scholars who have used the Stegemann method calculate the sum of these distances, layer after layer, and treat them mathematically as a series of concentric circles with an increasing diameter and circumference. While the scroll is closer to a spiral than to a series of concentric circles, the concentric circles approximation is easier and more practical for DSS scholars, and the difference between the error caused by the two mathematical approximations is negligible.[2] We thus prefer to use the concentric circles approximation.

A concentric circles approximation means that the circumference of each consecutive layer grows linearly.[3] We can therefore regard the distances as an arithmetical series, and calculate the distance of a certain layer from the known circumference as the sum of all distances of the missing layers in between. The formula for the sum of arithmetical series can be used for this purpose. The first term of the series will be the known circumference, and from that point the distances will increase or decrease.

Let us call S_n the distance of a fragment n from the anchor fragment (to be precise, the distance of a specific point on fragment n, whose damage pattern recurs in other turns of the scroll, from the same damage pattern in the anchor fragment). The equation for the sum of an arithmetical series is:

1 As the known factors for every scroll vary, estimating the error with empirical means may be complicated and irrelevant for every specific scroll. We therefore chose to compute the error theoretically.

2 Ratzon and Dershowitz, "The Length of a Scroll."

3 For a mathematical proof of this conclusion see Stoll, "Die Schriftrollen vom Toten Meer," 205–18.

$$S_n = na_1 + \frac{n}{2}(n-1)d$$

where

- $S_n = a_1 + \cdots + a_n = \frac{n}{2}(a_1 + a_n)$. This is the sum of the series, which in turn equals the position of fragment *n* in relation to the anchor fragment;
- a_1 is the first term of the series (i.e., the first known length of a turn, derived from the anchor fragment);
- d is the difference between successive terms a_i and a_{i-1} for each $i = 2, \ldots, n$;
- $a_n = a_1 + (n-1)d$: this is the *n*th term.

In the case of concentric circles of a scroll,

- S_n= the distance between the same damage pattern on the anchor fragment and fragment n;
- n = the number of layers between a_1 and a_n;
- d = the difference in circumference between two consecutive turns;
- a_1= the known circumference;
- a_n= the circumference of the scroll between the discussed fragment and the one preceding it.

Based on the formula of the distance, we can now compute its error. The potential error resulting from material reconstruction in the Stegemann method is comprised of three factors:

1. The error for the first reconstructed or measured circumference (Δa_1). In the optimal case of a fragment containing at least one complete turn of the scroll, the error will arise only from the potential error in measurement and from the changes that the fragment may have gone through during the years (such as shrinkage, cracks, twists, etc.). If, however, the first turn of the scroll is not known but rather reconstructed based on parallels and other information, an additional error should be taken into account, its exact magnitude to be estimated by the editors to the best of their knowledge. Factors to be considered are the width of the intercolumnar margin that may vary within the same scroll and the width of the columns if they are reconstructed. If the columns are reconstructed using a font, the experiment described in chapter 10 may help in determining the margin of error for the width of the column. The basic factors described above, i.e., scaling, background removal, and fragment restoration, can also create some error; if not negligible, they too should be taken into account.
2. The next factor to be considered is the error incurred by the different consecutive damage distances (Δd). Stegemann's assumption that this difference is constant is a mere approximation, which would have been justified only if the thickness of the skin was even throughout the scroll, and if the tightness of the roll was

even throughout. However, empirical examination of the distances between recurrent damages in complete scrolls proves this assumption to be wrong, as the change of distance can vary immensely. Even within one and the same scroll it may vary between less than a millimeter and over a centimeter.[4]

We derive our estimation of this error from measurements carried out on 11Q5 (= 11QPs[a]), a scroll that was preserved comparatively intact. One of the damage patterns of this scroll comprises holes, created by a worm eating from the outside through all layers of the scroll to its middle. The distances between sequential wormholes give excellent indication for the circumference of every turn, and can be measured with very good precision. The situation of 11Q5 is thus outstandingly favorable for carrying out these measurements. The growth of the circumference in this scroll between subsequent turns varies between 0.15 cm and 0.6 cm, with an average of 0.4 cm and a standard deviation of 0.1 cm.[5] Therefore, even in this favorably preserved scroll the results are far from stable. 11Q5 is the only well-preserved scroll with wormholes, and accordingly there is no way to measure the growth of circumference with sufficient precision in other scrolls. We will therefore use the standard deviation of the differences of 11Q5 as the error (Δd) for other scrolls, too.

A deviation of 0.1 cm per turn is rather meager, but the errors add up as we continue to shift away from the known circumference into the calculations of more and more fragments in the periphery of the scroll. Moreover, even the first circumference itself usually bears some error.

3. Finally, it is not always certain how many layers (n) are missing between the anchor fragment and the fragment under discussion, when placed using the Stegemann Method. If all fragments were preserved in one wad, the number of layers is certain, but if they are preserved in several wads or separately, this number is reconstructed based on other considerations, and the measure of uncertainty should be stated. We mark this number Δn.

Δd is the error for d. It equals 0.1 cm. Δn is the error for n, and Δa_1 is the error for a_1. As is customary in the sciences, ΔS_n (= the error for the position of the nth fragment) depends on all of these values as well as on n, and equals:

$$\Delta S_n = \sqrt{\left(\frac{\partial S_n}{\partial a_1}\Delta a_1\right)^2 + \left(\frac{\partial S_n}{\partial d}\Delta d\right)^2 + \left(\frac{\partial S_n}{\partial n}\Delta n\right)^2}$$

$$= \sqrt{(n\Delta a_1)^2 + \left(\frac{n(n-1)\Delta d}{2}\right)^2 + \left\{\left[a_1 + d\left(n - \frac{1}{2}\right)\right]\Delta n\right\}^2}$$

4 Ratzon and Dershowitz, "The Length of a Scroll."

5 Ratzon and Dershowitz, "The Length of a Scroll."

If an argument is computed from other values, one should substitute it with them, in order to avoid using correlated arguments. Let us present an absolute value for this formula in a theoretical example. In this case:

the known circumference at one given turn of the scroll is 10 cm ± 2 cm;
we estimate the difference between the circumference of every consecutive turn as 0.3 cm ± 0.1 cm;
the number of turns is known for certain;
We seek to compute the relative position of the tenth fragment.

The calculation runs as follows:

$$S_n = na_1 + \frac{n}{2}(n-1)d = 10\times 10 + 5\times 9\times 0.3 = 113.5 \text{ cm}$$

This means that the tenth fragment will be 113.5 cm away from the fragment around which the circumference is known. We compute the error as follows:

$$\Delta S_n = \sqrt{(n\Delta a_1)^2 + \left(\frac{n(n-1)\Delta d}{2}\right)^2} = \sqrt{(10\times 2)^2 + \left(\frac{10\times 9\times 0.1}{2}\right)^2} = \sqrt{400+20.25} = 20.5 \text{ cm}$$

The margin of error is 20.5 cm, hence the tenth fragment will be between 93 and 134 cm (113.5 ± 20.5) away from the original fragment. In this case, the error comes to approximately 18%.

Let us now examine a different case, in which the number of turns is not certain, and may vary between 9–11 layers. Thus Δn = 1. The computation of the error will be:

$$\Delta S_n = \sqrt{(n\Delta a_1)^2 + \left(\frac{n(n-1)\Delta d}{2}\right)^2 + \left\{\left[a_1 + d\left(n-\frac{1}{2}\right)\right]\Delta n\right\}^2} =$$

$$\sqrt{(10\times 2)^2 + \left(\frac{10\times 9\times 0.1}{2}\right)^2 + \left\{\left[10+0.3\left(10-\frac{1}{2}\right)\right]1\right\}^2} = \sqrt{400+20.25+165.1225} \approx 24.2$$

As expected, in this case the error is larger and the tenth fragment can be placed in the range between 89.3 and 137.7 cm (113.5 ± 24.2) away from the original fragment. In this case, the error comes to approximately 21%.

This large error may be reduced if additional types of information serve as anchors for the reconstruction, such as the amount of text in the intermediate space or other textual data, as described in chapters 9–10.

The distance of a fragment from the anchor fragment gives the length of the scroll between these fragments. A scholar may also be interested in the distance between two consecutive fragments, whose placement is based on the same anchor fragment using the Stegemann Method. In this case, the distance is:

$$a_n = a_1 + (n - 1)d$$

The error is based on the same parameters specified above:

$$\Delta a_n = \sqrt{\left(\frac{\partial a_n}{\partial a_1}\Delta a_1\right)^2 + \left(\frac{\partial a_n}{\partial d}\Delta d\right)^2 + \left(\frac{\partial a_n}{\partial n}\Delta n\right)^2} = \sqrt{\Delta a_1^2 + [(n-1)\Delta d]^2 + (d\Delta n)^2}$$

Again, it is important to avoid correlated arguments. The equations for a_n, Δa_n, S_n, and ΔS_n will be used in chapter 16 in the reconstruction of 4Q418a.

CHAPTER 13

Using One Prepared Copy as a Skeleton for a Second Copy

This chapter presents one of the main innovations of the present book, i.e., the method to extrapolate information from one known copy to other scrolls. The procedure described thus far for creating a digital canvas is based on material reconstruction of a specific scroll. However, even after extracting all available data from each of the copies independently, no matter how detailed or rich this data is, several open questions and loose threads would remain. Some fragments, for example, may fit into more than one place in the reconstruction, and others may or may not constitute parallels with other copies, if the amount of parallel text is rather small. Solutions for such problems may rise when applying data from an additional copy of the same composition. This kind of "cross validation" increases the reliability of reconstructions that would have otherwise remained dubious, having been based on one copy only. This process is valid for textually stable compositions such as *Instruction* or Shirot Olat HaShabbat. The process was intuitively used by previous scholars. In this chapter we only suggest a coherent working protocol.

The present chapter describes the protocol for projecting information from the canvas of one copy to the canvas of another copy. This move can be carried out even in the absence of an overlapping fragment between the two canvasses, and in cases where the intervening text between proven points of overlap is not known and thus these textual sections are but blank columns, or "dummy columns."[1] The only thing we know about these blank sections is their length, that is, the space occupied by the missing text between two located fragments.

In the material reconstruction carried out thus far, an *anchor fragment* served as common ground between the distinct copies. The anchor fragment and its overlapping text in other copies were placed on their respective digital canvasses, and the composite text was cast into the layout of each scroll accordingly. Further fragments that are not directly connected to the anchor were then placed on the digital canvas of each copy. Information about the location of those fragments may come from material reconstruction or other clues (see chapter 12). Having measured the space between the fragments of the first canvas, one can now implement this data on the second canvas.

1 For a discussion on dummy columns see chapter 9.

 | DOI:10.1163/9789004473058_018

Having located the anchor fragment in the second canvas, the following step is placing further fragments or bulks of text in the canvas. This step is based on assessing the number of missing lines between two objects (i.e., fragments or bulks of text) that have been located in canvas A. This figure is then projected into canvas B, providing the distance between these objects. However, since the properties of the canvasses (i.e., column width and the density of the writing, that is, the number of letters per centimeter) are not identical, the measuring units of the number of lines in the first copy should be converted to the total number of letter-spaces between the objects. Letter-spaces provide a neutral measurement, unaffected by the peculiarities of the script of each copy. When the missing lines come from more than one column, the width of each column should be measured and multiplied by the number of letters per centimeter (the density of the writing) in order to calculate the number of letters per line for each column. The number of missing letters (which should be approximately equal in both copies) could be converted back to the number of missing lines in the second copy and provide the distance between the objects in the second canvas. Table 15 clarifies this transformation.

For *Instruction* we have defined as anchor the large fragment 4Q416 2, representing four sequential, well-preserved columns. The text preserved on this fragment parallels multiple fragments in the copies 4Q417, 4Q418, 4Q418a, and possibly also 4Q418*.[2] We then projected the text of this fragment plus its overlaps onto the canvas of 4Q418a, while casting it in the format of the latter scroll. In the reconstruction of 4Q418a, the anchor comprises columns IX–XII. In addition to the textual data, material considerations allow the location of further fragments (figure 45):

– 4Q418a 17+14a can be placed at the bottom of column XII.
– fragments 4Q418a 14+16+16b can be placed at the bottom of column XIII.

TABLE 15 Projecting the number of missing lines from one copy to the other

Number of missing lines in canvas A	→	Number of missing letters in canvas A	=	Number of missing letters in canvas B	→	Number of missing lines in canvas B

2 For the composite text of 4Q416 2 i–iv see *Qimron, The Dead Sea Scrolls*, 2.152–57. The fragments overlapping 4Q416 2 i–iv are: 4Q417 2 i–ii; 4Q418 7a, 7b, 8, 8c, 8d, 9, 9a, 9b, 9c 10a, 10b, 11, 13, 26, 27, 64, 66, 199; and 4Q418a 18, 20, 22, and possibly fragment 4Q418 33 which may belong to copy 4Q418*. See further details in Strugnell and Harrington, DJD XXXIV, 88–131; Tigchelaar, *Increase Learning*, 44–48, 56–57, 75–80; *Qimron, The Dead Sea Scrolls*, 2.156.

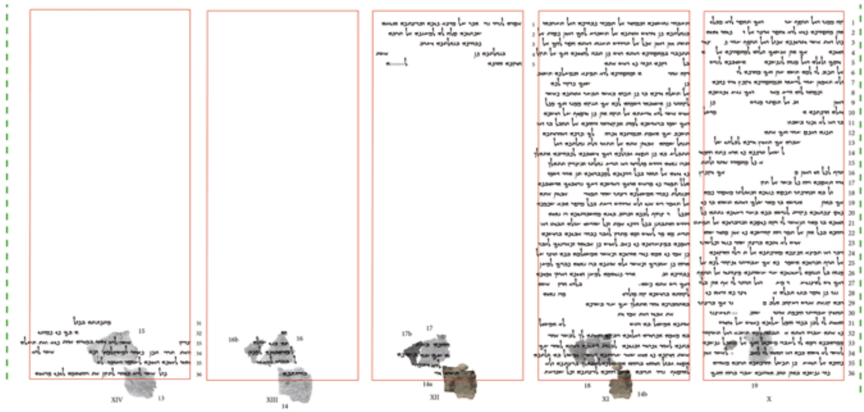

FIGURE 45 Columns of 4Q418a. Columns X–XI with the text of 4Q416 2 i–iv and its overlaps; column XV with the text of 4Q415 11 and its overlaps. Fragments belonging to columns XI–XIV are located according to material considerations.

– fragments 4Q418a 13+15 which overlap fragments 4Q415 11 and 4Q418 167a+b can be placed at the bottom of column XIV.

Additional fragments are then placed according to the principles of the Stegemann method, as described in detail in chapter 16.

Having established the order of 4Q418a, one could now begin establishing the order of fragments in other copies. In order to further extend the canvasses of other copies, the data from 4Q418a should now be projected onto their canvas by means of an integration of the scrolls. While the actual *content* standing between the text of 4Q416 and the next fragment on the canvas of 4Q418a is unknown, it is possible to calculate *the amount of space* that stood between them. This number could be further used to set the position of overlapping fragments in a third scroll, this time 4Q418, on the canvas of that copy.

In the same method used for 4Q418a, the text of 4Q416 2 can be projected into the layout of 4Q418, based on overlaps with multiple small fragments of that copy. A sequence of four consecutive columns is created, spread between two sheets of leather. Yet, while additional fragments were placed in the canvas of 4Q418a before and after this textual block based on the order of the fragments in the wads (see chapter 16), the third copy 4Q418 does not provide similar material considerations. The only way to extend this latter canvas is by building on the material data from 4Q418a.

Let us examine as an example the fragments 4Q418 167a+b, which overlap fragments 4Q418a 15+13. The latter are located in column XIV of the respective canvas. Since the number of missing lines between the end of the text of 4Q416

TABLE 16 Projecting the number of missing lines from 4Q418a to 4Q418

Number of missing lines in canvas A: the distance between the end of the text of 4Q416 2 to the text of 4Q418a 13+15 in the format of 4Q418a	→	Number of missing letters in this section of 4Q418a	=	Number of missing letters in this section of 4Q418	→	Number of missing lines in canvas B: the distance between the text of 4Q416 2 to the text of 4Q418 167a+b in the format of 4Q418	=	Location of frags. 4Q418 167a+b || 4Q418a 13+15 on Canvas B, 4Q418

2 and the location of fragments 4Q418a 13+15 in the canvas of 4Q418a is known, it could provide the distance between these objects in the canvas of 4Q418 too, thus indicating the location of fragments 4Q418 167a+b (table 16).

Moreover, the canvas of 4Q418 can also be enriched by placing in it the text from other columns of 4Q418a, using the same protocol. This protocol enables a significant enhancement of the canvas of 4Q418, as described in figure 46.

After placing all available data, text, fragments, and empty spaces on the canvas, and projecting the skeleton of the composition onto the canvas of the scroll, further hitherto unlocated fragments of the second copy can be placed in these spaces.

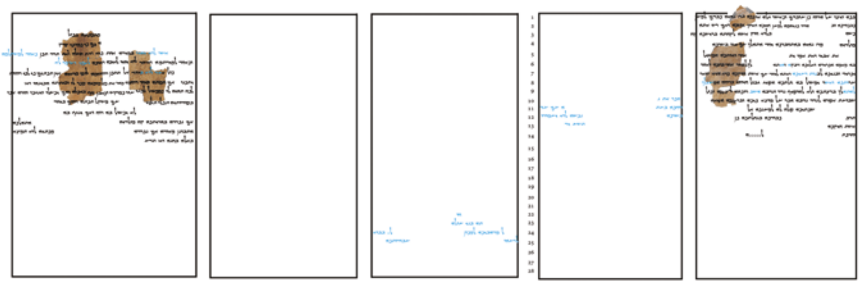

FIGURE 46 Columns of 4Q418. Column i: 4Q418 fragments 10a, b and the overlapping text of 4Q416 2 iv and 4Q418a 18 (blue); column ii: text of 4Q418a 17+17b+14b; column iii: text of 4Q418a 14+16+16b; column iv: 4Q418 fragments 167a+b, placed according to the distances between columns 4Q418a XII to XIV. Column numbers of 4Q418 are for illustration purposes only.

APPENDIX 4

Margin of Error for Chapter 13

Since the procedure described in chapter 13 involves multiple transformations, it is necessary to estimate the margin of error incurred by it. Most of the effort in this appendix will be spent in finding the mathematical formulation that would allow the calculation of the error. The complex mathematics is due to the abundance of arguments. We therefore recommend collaborating or consulting with a scholar with scientific background when applying it.

As already described in chapter 2, since this process adds information to the second copy based on the reconstruction of the first copy rather than on solid existing fragments, it is prone to larger error. The error derives from the uncertainty of the reconstruction of both copies. Elements of the error may rise from the change in the measurements of the columns: width of lines across columns, change in the number of lines per column, the width of "dummy" columns, etc. However, taking into account additional material details such as the presence of margins (which anchors the margins to a point on the canvas), as well as increasing the number of copies involved in the procedure, may keep the growing error in check and may bestow more validity on the procedure.

As explained in Table 15 in chapter 13 the procedure is:

Number of missing lines in canvas A (LNa)	→	Number of missing letters in canvas A (LTa)	=	Number of missing letters in canvas B (LTb)	→	Number of missing lines in canvas B (LNb)

When expressed mathematically, the conversion from number of lines (LN) to number of letters (LT) depends on the length of a line (LL) and the density of writing (the number of letters per centimeter; D):

$$LTa = LTb = Da * LLa * LNa$$

Eventually, when we want to convert the number of missing letters on canvas B again to the number of missing lines, we should run the opposite process, that is, to divide the number of letters (LT) by the density of writing (D) and the length of the lines (LL) of canvas B:

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$$LNb = \frac{Da * LLa * LNa}{Db * LLb}$$

From this equation it is possible to derive an expression of the error of the number of lines (LNb), as a function of the known errors of the other arguments:

$$\Delta LNb == \sqrt{\left(\frac{LLa * LNa * \Delta Da}{Db * LLb}\right)^2 + \left(\frac{Da * LNa * \Delta LLa}{Db * LLb}\right)^2 + \left(\frac{Da * LLa * \Delta LNa}{Db * LLb}\right)^2 + \left(\frac{Da * LLa * LNa * \Delta Db}{LLb * Db^2}\right)^2 + \left(\frac{Da * LLa * LNa * \Delta LLb}{Db * LLb^2}\right)^2}$$

$$= \frac{Da * LLa * LNa}{Db * LLb} \sqrt{\left(\frac{\Delta Da}{Da}\right)^2 + \left(\frac{\Delta LLa}{LLa}\right)^2 + \left(\frac{\Delta LNa}{LNa}\right)^2 + \left(\frac{\Delta Db}{Db}\right)^2 + \left(\frac{\Delta LLb}{LLb}\right)^2}$$

While in chapter 13 we demonstrated the placement of three bulks of texts, here we illustrate the procedure for only one of them: placing the text of 4Q418a 17+17b+14a (canvas A) on the canvas of 4Q418 (canvas B). The same process can be carried out for every other bulk of text. The numerical data is taken from the reconstruction in chapter 16.

On the 4Q418a canvas, fragment 17+17b+14a is placed in column XII, one column apart from fragment 18+14b (column XI). Both fragments are placed at the bottom of their columns.

- LLa – The length of the lines in 4Q418a column XII is 95.4±13 mm.
- LNa – Column XII has 36 lines; subtracting the 3.5 lines from the beginning of fragment 17 to the end of the column leaves 32.5±2.5 missing lines.
- D – The writing in both copies 4Q418 and 4Q418a is very similar, and therefore their density could be considered equal. The computed density of writing in 4Q418a is 0.49±0.04 letters per cm.
- LLb – The reconstructed length of lines in the columns following the text of frags. 18+14b, when placed in the layout of 4Q418, is 125±5 mm and 115±40 mm respectively.

The number of lines between the two texts in the canvas of 4Q418 is therefore:

$$LNb = \frac{Da * LLa * \Delta LNa}{Db * LLb} = \frac{0.49 * 95.4 * 32.5}{0.49 * 125} = 24.8 \textit{ lines}$$

Based on the above equation for ΔLNb, the error is 4.9 lines.

This number of lines (24.8) exceeds the number of remaining lines in this column of 4Q418 (see figure 46 in chapter 13). We must therefore have the text spread over two columns, and concurrently add more complication to the calculation of error. The position of the text of 17+17b+14a in the column ii can be calculated based on the width of the two columns and the height of the first column:

$$LNBii = \frac{(LNb - LNBi)LLbi}{LLbii} = \frac{Da * LLa * LNa * LLbi}{Db * LLb * LLbii} - \frac{LNbi * LLbi}{LLbii}$$

Column i in 4Q418 is missing only 19.5±1 lines. The rest of the text (5.3 lines) must be moved to the next column, according to the width of the latter column (reconstructed as 115 mm). The length of 5.3 lines of column i equals 662.5 mm; in turn, this number equals 5.76 lines of column ii.

The error of LNbii is accordingly:

$$\Delta LNbii = \sqrt{\begin{aligned}&\left(\frac{LLa*LNa*LLbi*\Delta Da}{Db*LLb*LLbii}\right)^2+\left(\frac{Da*LNa*LLbi*\Delta LLa}{Db*LLb*LLbii}\right)^2+\left(\frac{Da*LLa*LLbi*\Delta LNa}{Db*LLb*LLbii}\right)^2+\left(\frac{Da*LLa*LNa*\Delta LLbi}{Db*LLb*LLbii}-\frac{LNbi*\Delta LLbi}{LLbii}\right)^2+\left(\frac{Da*LLa*LNa*LLbi*\Delta Db}{LLb*LLbii*Db^2}\right)^2\\&+\left(\frac{Da*LLa*LNa*LLbi*\Delta LLb}{Db*LLbii*LLb^2}\right)^2+\left(\frac{Da*LLa*LNa*LLbi*\Delta LLbii}{Db*LLb*LLbii^2}-\frac{LNbi*LLbi*\Delta LLbii}{LLbii^2}\right)^2+\left(\frac{LLbi*\Delta LNbi}{LLbii}\right)^2\end{aligned}}$$

$$= \sqrt{\begin{aligned}&\left(\frac{95.4*32.5*125*0.04}{0.49*125*115}\right)^2+\left(\frac{0.49*32.5*125*13}{0.49*125*115}\right)^2+\left(\frac{0.49*95.4*125*2.5}{0.49*125*115}\right)^2+\left(\frac{0.49*95.4*32.5*5}{0.49*125*115}-\frac{19.5*5}{115}\right)^2+\left(\frac{0.49*95.4*32.5*125*0.04}{125*115*0.49^2}\right)^2\\&+\left(\frac{0.49*95.4*32.5*125*5}{0.49*115*125^2}\right)^2+\left(\frac{0.49*95.4*32.5*125*40}{0.49*125*115^2}-\frac{19.5*125*40}{115^2}\right)^2+\left(\frac{125*1}{115}\right)^2\end{aligned}} = 5.8$$

The relative error is thus close to 25% (5.8 out of a total of 24.8 lines). In this particular case, in which the text has to be placed in another column whose reconstruction is not based on preserved fragments, many factors attribute to the potential error. It is therefore much larger than the potential error if the text would have been included in the same column. When the reconstruction continues to further columns, the error might even grow, but eventually it will reach a place with more material information preserved in copy B. At that point it will be possible to validate the reconstruction and reduce the error.

PART 2

4Q418a (4QInstruction^{e})

CHAPTER 14

Introduction to the Material Study of *Instruction* (*Musar LaMevin*)

The wisdom composition called here *Instruction* is a Second Temple Jewish work, unknown until the discovery of the Dead Sea Scrolls. This composition is the main representative of the genre of wisdom literature at Qumran, a genre which sparked significant interest when discovered and continues to draw much scholarly attention. This document is important for a variety of topics, among which one may count: relation to traditional wisdom literature, accommodation of apocalyptic ideas into the wisdom genre, unique vocabulary and style, relation to other literature from Qumran, the authority of scripture within the composition, relation to sectarian and other halakhah, and the role of the composition as a forerunner to early Christian literature.[1] Since *Instruction* is represented in highly fragmentary copies, its publication was heavily delayed, with a first official publication only appearing in 1999, after many efforts were invested in its reconstruction.[2] The content of *Instruction* has sparked much scholarly attention, but will not be discussed in the present introduction. This is an introduction to the material study of the copies of *Instruction*, which lays the ground for the material innovations suggested below.

The composition is named differently in various publications. The Preliminary Concordance reflects the nomenclature of the first editorial team, who

1 None of these topics stand at the focus of the present book, which is primarily concerned with material aspects and a new textual edition. References will therefore be limited here. For Qumran wisdom in general see Matthew Goff, *Discerning Wisdom: The Sapiential Literature of the Dead Sea Scrolls*, VTSup 116 (Leiden: Brill, 2007); Menahemem Kister, "Wisdom Literature at Qumran," [Hebrew] in *The Qumran Scrolls and Their World*, ed. Menahem Kister (Jerusalem: Yad Ben Zvi, 2009), 1.299–319. A convenient commentary on the major sections of *Instruction* with references to earlier bibliography is Matthew Goff, *4QInstruction*, Wisdom Literature from the Ancient World 2 (Atlanta: SBL, 2013). For other studies on *Instruction* see Armin Lange, *Weisheit und Prädestination. Weisheitliche Ordnung und Prädestination in den Textfunden von Qumran*, STDJ 18 (Leiden: Brill, 1995); Matthew Goff, *The Worldly and Heavenly Instruction of 4QInstruction*, STDJ 50 (Leiden: Brill, 2003); Jean-Sébastian Rey, *4QInstruction: Sagesse et eschatology*, STDJ 81 (Leiden: Brill, 2009); Benjamin Wold, *Women, Men, and Angels: The Qumran Wisdom Document Musar leMevin and its Allusions to Genesis Creation Traditions* (Tübingen: Mohr Siebeck, 2005); Benjamin Wold, *4QInstruction: Divisions and Hierarchies*, STDJ 123 (Leiden: Brill, 2018). See also the English translation by John Kampen, *Wisdom Literature*, Eerdmans Commentaries on the Dead Sea Scrolls (Grand Rapids: Eerdmans, 2011).

2 Strugnell and Harrington, DJD XXXIV.

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called this work "Sapiential Work A." Strugnell and Harrington, in the title of the DJD volume mention the name 4QInstruction,[3] but mostly use a newly suggested Hebrew name: מוסר למבין. Both names are widely used today. Menahem Kister suggested a different Hebrew name: חוכמת רז נהיה, which was later adopted by Qimron as well as in the online database of the Historical Dictionary Project by the Academy of Hebrew Language (Maagarim).[4] In the present book we shall use the designation *Instruction* in italics. Note that the common designation 4QInstruction is a misnomer, since fragments of the work are also known from cave 1 (1Q26).

Scholars debate the date and provenance of *Instruction*, whether it is a sapiential and apocalyptic composition predating the *yaḥad*, or rather part and parcel of the literary heritage of the *yaḥad*, together with such compositions as the Hodayot or the Serekh. The former position usually entails assuming an early date of composition, in the second or third century BCE, while the latter position conceives *Instruction* as a sectarian composition, authored together with other such literature in the late second century BCE or even later. This latter opinion dovetails with the late date of the extant copies, which are all written in late Hasmonean or early Herodian scripts, but the date of the copies does not provide proof for authorship.[5] The former opinion was quite popular in the early stages of research and is retained by many, while the latter opinion, held primarily by Israeli scholars, now seems to have gained wider support.[6]

3 As Torleif Elgvin kindly informs us, he has suggested this name, which was later accepted by the general editor Emanuel Tov and by the other authors of DJD XXXIV.

4 Kister, "Wisdom Literature," 304; Qimron, *The Dead Sea Scrolls*, 2.144. The editors of the DSS in the Maagarim repository are Qimron together with Chanan Ariel and Alexey Yuditsky.

5 Strugnell and Harrington, DJD XXXIV, 21. The script of 4Q416, 418, and 418a is dated as "between late Hasmonean and early Herodian," with slight variations inside this range (Strugnell and Harrington, DJD XXXIV, 76, 217, 476).

6 For *Instruction* as a pre-sectarian text embraced by the *yaḥad* see Lange, *Weisheit und Prädestination*; Strugnell and Harrington, DJD XXXIV, 36 ("between Proverbs and later books like Sirach and Qohelet"); Goff, *Discerning Wisdom*, 65 ("probably written in the second century BCE, but a third century dating is not impossible"); Rey, *4QInstruction*, 333–36, considers it as contemporary with Ben Sira and preceding the redaction of the Serekh and the Hodayot, but originating from a similar milieu. In contrast, Kister, "Wisdom Literature," stresses the proximity to the heritage of the *yaḥad*, especially with regard to S, H, and D, and concludes that *Instruction* shares the same environment as the above noted compositions. He carries this idea forward in Kister, "Qumran, Jubilees, and the Jewish Dimensions of 2 Corinthians 6:14–7:1," in *The Religious Worldviews Reflected in the Dead Sea Scrolls. Proceedings of the Fourteenth International Symposium of the Orion Center for the Study of the Dead Sea Scrolls and Associated Literature, 28–30 May, 2013*, ed. Ruth A. Clements, Menahem Kister, and Michael Segal, STDJ 127 (Leiden: Brill, 2018), 103–39. A similar opinion is expressed by Devorah Dimant, "The Vocabulary of the Qumran Sectarian Texts," in *History, Ideology and Bible Interpretation in the Dead Sea Scrolls*, FAT 90 (Tübingen: Mohr Siebeck, 2014), 57–100,

The intellectual background of *Instruction* has been a matter of debate and has contributed to scholarly ideas about its composition. Scholars disagree about the relation between *Instruction* and other early Jewish literature, such as Ben Sira and various parts of 1 Enoch.[7] Jewish Hellenistic Literature is also an important possible contemporary to examine for potential relationships.[8] Fruitful discussion continues also with regard to the relation between *Instruction* and the "Treatise of the Two Spirits," which constitutes a central part of

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here 79–81. Bilhah Nitzan, "Key Terms in 4QInstruction: Implications for Its Ideological Unity," [Hebrew] *Meghillot* 3 (2005): 101–24, here 120–21, is even more explicit about its sectarian authorship, the differences from sectarian literature stemming in her opinion from mere generic considerations. More recently, Arjan Bakker ("The Figure of the Sage in Musar le-Mevin and Serekh ha-Yahad" [PhD diss., KU Leuven, 2015]) challenged the view of *Instruction* as a pre-sectarian text and reassessed its connection with the Serekh. He was followed by Meike Christian, "The Literary Development of the 'Treatise of the Two Spirits' as Dependent on Instruction and the Hodayot," in *Law, Literature, and Society in Legal Texts from Qumran: Papers from the Ninth Meeting of the IOQS, Leuven 2016*, ed. Molly M. Zahn and Jutta Jokiranta, STDJ 128 (Leiden: Brill, 2019), 153–84. A similar conclusion was reached by Anna Shirav, "The Social Setting of 4QInstruction Reconsidered. Wisdom, Inheritance and Priesthood in 4Q418 frg. 81," *DSD* 28 (2021): 1–28. The most recent discussion of *Instruction* in the sectarian context is George J. Brooke, "Esoteric Wisdom Texts from Qumran," *JSP* 30.2 (2020): 101–14.

7 On Ben Sira see Rey, *4QInstruction*; Benjamin Wright, *Praise Israel for Wisdom and Instruction: Essays on Ben Sira and Wisdom, the Letter of Aristeas and the Septuagint*, JSJSup 131 (Leiden: Brill, 2008); Samuel L. Adams, "Rethinking the Relationship Between '4QInstruction' and 'Ben Sira'," *RevQ* 24 (2010): 555–83. On 1 Enoch see Torleif Elgvin, "Early Essene Eschatology: Judgment and Salvation according to Sapiential Work A," in *Current Research and Technological Developments on the Dead Sea Scrolls*, ed. Donald W. Parry and Stephen D. Ricks, STDJ 20 (Leiden: Brill, 1996), 126–65; Loren T. Stuckenbruck, "4QInstruction and the Possible Influence of Early Enochic Traditions: An Evaluation," in *The Wisdom Texts from Qumran and the Development of Sapiential Thought*, ed. Charlotte Hempel, Armin Lange, and Hermann Lichtenberger BETL 159 (Leuven: Leuven University Press, 2002), 245–62; Tigchelaar, *Increase Learning*, 212–17; Goff, *4QInstruction*, 226–27, presents a more moderate evaluation of the connection. For a connection with the later Enochic Book of Parables see Arjen Bakker, "The Praise of the Luminaries in the Similitudes of Enoch and its Parallels in the Qumran Scrolls," [Hebrew] *Meghillot* 13 (2017): 171–84.

8 See, for instance, Matthew Goff, "Genesis 1–3 and Conceptions of Humankind in 4QInstruction, Philo and Paul," in *Early Christian Literature and Intertextuality, Vol. 2: Exegetical Studies*, ed. Craig A. Evans and Daniel H. Zacharias, LNTS 392 (London: T&T Clark, 2009), 114–25; Matthew Goff, "Adam, The Angels and Eternal Life: Genesis 1–3 in the Wisdom of Solomon and 4QInstruction," in *Studies in the Book of Wisdom*, ed. Geza G. Xeravits and Joszef Zsengellér, JSJSup 142 (Leiden: Brill, 2010), 1–21; Hindy Najman, "Jewish Wisdom in the Hellenistic Period: Towards A Study of A Semantic Constellation," in *Is There Text in this Cave? Studies in Textuality of the Dead Sea Scrolls in Honor of George J. Brooke*, ed. Ariel Feldman, Maria Cioată, and Charlotte Hempel, STDJ 119 (Leiden: Brill, 2017), 459–72.

the Serekh tradition.[9] Stressing the point of view of form criticism, Elgvin highlighted that *Instruction* attests to both pragmatic wisdom sayings and eschatological discourses; he therefore posited a redactional process, in which the eschatological content was added as a second layer on an earlier wisdom composition.[10] None of these debates will concern us in the present book however, where the emphasis is on the reading and material reconstruction of the copies of *Instruction*.

Instruction belongs to the group of Qumran compositions whose text transmission remained relatively stable. In this composition, the long overlaps preserved between different copies attest to meager textual changes, amounting to several letters or one word at maximum.[11] We have found one omission of an entire line, which resulted from textual mishap rather than editorial recension.[12] Torleif Elgvin and Armin Lange postulated that *Instruction* appears in two recensions, the latter one being a Qumranic product that added the prologue in 4Q417 1; this view did not receive wide support, however.[13] Since we do know of several examples of textual stability but very few or even no example of textual fluidity, nearly all previous scholars of *Instruction* work with the assumption that the copies attest to a similar or nearly identical text.[14] While we pay

9 See a summary of the various opinions and updated bibliography in Bakker, "The Figure of the Sage," 1–16; Christian, "The Literary Development."

10 Elgvin, "An Analysis of 4QInstruction"; Nitzan, "Key Terms," opposes this claim.

11 Tigchelaar, *Increase Learning*, 64, mentions "instability of the text" of *Instruction*. This is relative however, as he refers to instability in terms of spelling and other minor variants, not of large textual differences.

12 The omission appears in 4Q418 10a line 6 (see Strugnell and Harrington, DJD XXXIV, 237 and chapter 15 in this book).

13 Elgvin, "An Analysis of 4QInstruction," 54; Armin Lange, "Musar leMevin," in *Outside the Bible: Ancient Jewish Writings Related to Scripture*, ed. Louis H. Feldman, James L. Kugel, and Lawrence H. Schiffman (Philadelphia: Jewish Publication Society, 2013), 3.2437. A material reconstruction of some of the copies, suggested by Annette Steudel and Birgit Lucassen, supported this view (see below), but has not been published. In the reconstruction suggested in this book we follow Qimron, *The Dead Sea Scrolls*, 2.147–49, who contained both 4Q416 1 and 4Q417 1 within the introduction of *Instruction*. The prolonged introduction fits with the material finds, as described in chapter 16 of this book.

14 With the exception of Armin Lange (see previous note). For the similarity between copies, compare, for example, 4Q416 2 i || 4Q417 2 i – ii || 4Q418 7–8 || 4Q418a 22; 4Q415 11 || 4Q418 167a+b || 4Q418a 13+15. Tigchelaar, *Increase Learning*, 147–54, surveys all the textual overlaps and variants in *Instruction*. There are cases where several words or even a short sentence is found in two separate copies, but they are not considered overlaps because the rest of the text around them does not correspond. In these cases, scholars attribute the similarities to the repetitive style of *Instruction*. By assuming repetitive style in every case of similar but not identical parallels, we may miss overlaps with greater textual fluidity, which may be seen as circular reasoning. However, since none of the above-mentioned

due attention to the treatment of each copy as an *artifact*, as the reader will discern later in this monograph, the copies will also function as text-witnesses to a *literary work*.[15] This is an important insight for the reconstruction not only on the textual aspect but also on the material aspect, as lacunae are filled and fragments joined based on small-scale textual parallels.

1 Copies, Editions, and Reconstructions of *Instruction*

The composition we call *Instruction* is recorded in eight different copies, seven of them from cave 4 and one from cave 1: 1Q26, 4Q415, 4Q416, 4Q417, 4Q418, 4Q418a, 4Q418*, 4Q423. Although this book will concentrate on the copy 4QInstruction[e] (4Q418a), a few words on all other copies are in order, since we shall frequently refer to them. The manuscript 4Q418 will be discussed last, with the scrolls that were separated from it through the history of research.

The present survey contains several fragments found or identified as belonging to copies of *Instruction* after the publication of DJD XXXIV. Tigchelaar identified a fragment of 4Q416 among the unidentified fragments of DJD XXXIII.[16] Eshbal Ratzon located additional glued fragments under fragment 4Q418a 22, as described in chapters 15–16. Puech and Steudel demonstrated that the fragment dubbed XQ7, which had been donated to the shrine of the Book, belongs to 4Q418.[17] Two fragments that appeared in the antiquities market after 2002 were claimed to be part of *Instruction*, but are now proven to be fakes.[18]

1Q26 comprises five fragments, published in DJD I under the title "une apocryphe." It was later re-identified as part of *Instruction* and republished in

cases were proven a parallel beyond doubt, we can still use textual stability as a working assumption.

15 See the methodological reflections by Søren Holst, "Fragments and Forefathers: An Experiment with the Reconstruction of 4QVisions of Amram," in *Vision, Narrative, and Wisdom in the Aramaic Texts from Qumran: Essays from the Copenhagen Symposium, 14–15 August, 2017*, ed. Mette Bundvad and Kasper Siegismund (Leiden: Brill, 2020), 137–52, here 139–41.

16 Tigchelaar, "Gleanings from the Plates," 317–22, here 321–22.

17 Puech and Steudel, "Un Nouveau fragment."

18 See Esther Eshel and Hannan Eshel, "A Preliminary Report on Seven New Fragments from Qumran," [Hebrew] *Meghillot* 5–6 (2007): 271–78; Michael B. Johnson, "A Fragment of Instruction (Inv. MOTB.SCR.000123)," in [Retracted] *Dead Sea Scrolls Fragments in the Museum Collection*, ed. Emanuel Tov, Kipp Davis, and Robert Duke, PMB 1, ST (Leiden: Brill, 2016), 222–36; Art Fraud Insights, *Museum of the Bible Dead Sea Scroll Collection: Scientific Research and Analysis: Final Report* (*November, 2019*), 43–5 (https://museumofthebible.cdn.prismic.io/museumofthebible/8ee1c3b3-8398-481a-bc7a-4da593c38728_MOTB-DSS-Report-FINAL-web.pdf).

DJD XXXIV. The fragments of this scroll are kept in the Bibliothèque nationale de France (BnF), Paris. High resolution images are available through the *InscriptiFact* website.

The copy 4Q415 is written on the hair side of a skin, whose flesh side contains the liturgical text 4Q414. There are altogether 38 fragments of this manuscript: 32 are designated in DJD XXXIV, while six more fragments carry only an IAA record number.

4Q416 preserves 23 fragments,[19] two of them of special importance. Fragment 1 preserves an especially wide right margin, which is taken as a sign that its contents stood at the beginning of the entire composition. Fragment 2, itself consisting of many pieces of skin joined together by the editors, is especially large, representing four consecutive columns of text. This fragment serves as the anchor for reconstructing the original order of the composition and will be referred to often in chapter 16.

The manuscript 4Q417 comprises 29 fragments. The two largest, fragments 1 and 2, contain two columns each, with fragment 1 preserving text from the beginning of the scroll, while fragment 2 preserves overlapping text to fragment 4Q416 2 i–ii.

4Q423 comprises 24 fragments, which are rather small but important due to their parallels with other copies. These parallels include 1Q26 (establishing that manuscript as a copy of *Instruction*), 4Q418a frag. 3 (discussed in detail in chapter 15), and various fragments of 4Q418.

4Q418 comprises over 300 numbered fragments, of small and medium size, and thus constitutes the main building block for the text of *Instruction*. The number is not conclusive, however, because work on this scroll showed that not all fragments assigned to it belong to the same manuscript. As we delineate that some of the fragments have been assigned elsewhere, it is important to note that this work is not yet over, and that other fragments now called 4Q418 could still be assigned to 4Q418*. Since the paleography of 4Q418, 4Q418a, and 4Q418* is similar, this task is all the more tricky. The present book, however, will primarily treat the fragments that have already been assigned to 4Q418a.

Some fragments were separated from 4Q418 and named accordingly 4Q418b, 4Q418c, and 4Q418*. 4Q418b comprises two fragments (*olim* 4Q418 112 and 116) that the editors of DJD XXXIV separated from 4Q418 based mainly on their contents, with a quote or maybe paraphrase of Psalm 107.[20] 4Q418c (*olim* 4Q418

19 Twenty-two fragments were published in DJD XXXIV, while another one was found among the unclassified fragments recorded in DJD XXXIII; see Tigchelaar, "Gleanings from the Plates."

20 Strugnell and Harrington, DJD XXXIV, 497.

161) was declared a separate scroll due to several material traits.[21] Neither of these two scrolls seems conclusively separate and may well be proven part of 4Q418.

The manuscript called 4Q418* is a different story altogether. Its existence was established by Tigchelaar after initial indications by Strugnell and Harrington and by Elgvin. The distinction is based on the conviction that the fragments 4Q418 1 and 2 are materially different from the rest of 4Q418, and that they overlap some text from 4Q418.[22] Tigchelaar has rejected the earlier suggestion by Strugnell and Harrington that these fragments stemmed from a separate sheet intended to replace the opening sheet of 4Q418. This find was corroborated by Qimron.[23]

The manuscript 4Q418a is the subject of this book and will be discussed separately below.

The *editio princeps* of *Instruction* is the DJD XXXIV volume published by Strugnell and Harrington with a contribution by Elgvin in the form of an edition of 4Q423. The history of discovery of this composition is briefly described by Strugnell in DJD, but Tigchelaar has subsequently modified this hindsight account by tracking the early records of the various scrolls and fragments in the PAM images and the Preliminary Concordance.[24] Pertinent points from DJD and Tigchelaar's account will be summarized here to introduce our renewed discussion.

The cave 4 copies comprise several hundred fragments, the great majority of them brought to the PAM by the Bedouins, who reported them as stemming from cave 4. Not all of them were proven beyond doubt to belong to cave 4; such a proof is provided for *some* of the copies, fragments of which were found in the archeological excavations of cave 4 after the Bedouins had left. John Strugnell declared that "fragments of each of the larger manuscripts (416, 417, 418) were also found among the fragments deriving from the museum's own excavations."[25] This statement, however, does not agree with the evidence of the PAM images taken at the museum immediately after the excavations. This photographic series consists of PAM images 40.962–40.985 and is commonly called "series E" (see chapter 1). According to the finds of Eibert Tigchelaar, who studied these PAM images and recorded their content, the copies of *Instruction* discovered in cave 4 contain the following: 4Q418 frags. 28, 52, 75, 78, 126, 163,

21 Strugnell and Harrington, DJD XXXIV, 501.
22 Tigchelaar, *Increase Learning*, 60–63.
23 Qimron, *The Dead Sea Scrolls*, 2.146, 156.
24 Strugnell and Harrington, DJD XXXIV, xiv–xv; Tigchelaar, *Increase Learning*, 5–17.
25 Strugnell and Harrington, DJD XXXIV, 4.

164, 222, 224, 288, 300; 4Q418a frag. 23 (which is not part of 4Q418a, as claimed in chapter 15), 4Q418c (see above); and 4Q423 frags. 7, 9, 10, 20. Therefore, we cannot be sure about the exact provenance of those cave 4 copies that are not represented in the list above, but this situation pertains equally to the great majority of Qumran scrolls. Specifically, The larger fragments – 4Q416 2, 4Q417 1 and 2, 4Q418 81 – were purchased (at least the former but probably also the others) from Kando and gradually brought to the scrollery later.[26]

The great majority of small fragments of the various copies reached the scrollery in 1954, and were initially sorted by Milik, Cross, and Allegro until responsibility was handed over to John Strugnell in September 1954.[27] The Cave 1 fragment 1Q26 was published in DJD I in 1955 with the generic title 'une apocryphe,' but by the time the volume appeared the editors had already acknowledged its belonging to the Sapiential Work, as it was called then.[28]

The main copies were defined and transcribed in the 1950s: the opistograph copy 4Q415, as well as 4Q416, 4Q417, 4Q418, and the fragments of 1Q26. Since the latter was identified by means of its parallel with 4Q423, it stands to reason that 4Q423 was also acknowledged as a copy of *Instruction*; however, in the Preliminary Concordance it is not registered as a copy of the work, nor do the parallels contained in it appear in it.[29] In fact, it is fair to say that 4Q423 was firmly identified as a copy of *Instruction* and treated as such only in the 1990s. In addition, Strugnell has doubted some of the fragments assigned to the multi-fragment scroll 4Q418, such as the fragments collected in PAM 43.687. Readings of these fragments were not contained in the PC under 4Q418. A finite decision on the separate copies contained under the siglum in 4Q418 only arrived in the 1990s.

In the early 1990s Strugnell and Harrington co-edited the sapiential work, while other younger scholars began working on it independently after several decades in which relatively little was achieved. One of these scholars, Torleif Elgvin, reached important insights about the material configuration of the individual copies and of the composition in general.[30] At the same time with Strugnell and Harrington he formally interpreted 4Q423 as a copy of the work and made use of its points of overlap with other copies. He also established

26 See Strugnell and Harrington, DJD XXXIV, xiv, 73. For concrete dates see Tigchelaar, *Increase Learning*, 6.

27 See John Strugnell, "Le travail d'édition des fragments manuscrits de Qumrân," *RB* 63 (1956): 64–66.

28 Tigchelaar, *Increase Learning*, 5.

29 Tigchelaar, *Increase Learning*, 10.

30 Elgvin, "An Analysis of 4QInstruction"; Elgvin, "The Reconstruction of Sapiential Work A."

that the fragments on PAM 43.687 are rather part of a different, additional copy, rather than of 4Q418.[31] Unfortunately, he designated this copy 4Q418b, which can cause confusion for future work. It is now known as 4Q418a. Elgvin suggested material reconstructions for the individual copies of the work, leading towards a tentative outlook of its literary structure. The efforts in the 1990s culminated in the *magnum opus* by Strugnell and Harrington in 1999 (DJD XXXIV), comprising an edition of the various copies with detailed notes and comments. This work still serves as the basis for all study of *Instruction* until today. It clearly acknowledges 4Q418a as a distinct copy, and in addition defines several stray fragments as different copies: 4Q418 112 and 116 (*olim*) are now called 4Q418b, and 4Q418 161 (*olim*) is now called 4Q418c.[32] Strugnell and Harrington considered 4Q418 frags. 1 and 2, which share some parallels with other fragments of 4Q418, to be remnants of a repair sheet or a patch containing the beginning of the composition.[33]

Annette Steudel and Birgit Lucassen produced a material reconstruction of several of the copies of *Instruction*, including 4Q418a (although this copy was discussed only in outline), but their work, sporadically mentioned through DJD XXXIV, was never published, and is no longer endorsed by Steudel.[34]

Material work on the copies of *Instruction* culminated in 2001 with the publication of a book by Eibert Tigchelaar, who reconsidered all previous information, analyzed it in a systematic way, and provided many new finds.[35] Among his numerous contributions, he clarified the configurations of fragments and readings at the beginning of the composition, and settled some of the disputes around stray fragments on the fringes of 4Q418. Three copies are now acknowledged: the multi-fragment 4Q418; the wadded scroll 4Q418a; and the scroll

31 Strugnell has expressed some doubts about this distinction but left it unsettled; see Strugnell and Harrington, DJD XXXIV, xiv.

32 The separation of these fragments was mainly based on their content, which seemed to Strugnell and Harrington to be atypical of *Instruction*. The material considerations adduced by them (Strugnell and Harrington, DJD XXXIV, 497, 501) are not compelling. In our work we consider them to be parts of 4Q418.

33 "Codicological Excursus," Strugnell and Harrington, DJD XXXIV, 226–27.

34 Birgit Lucassen and Annette Steudel, "Aspekte einer vorläufigen materiellen Rekonstruktion von 4Q416–4Q418," Handout in *Forschungsseminar: Die Weisheitstexte aus Qumran, Tübingen, 22–24 Mai, 20–21 Juni 1998*. See Strugnell and Harrington, DJD XXXIV, 19; Tigchelaar, *Increase Learning*, 17. We thank Prof. Steudel for kindly discussing this reconstruction with us in Göttingen.

35 Tigchelaar, *Increase Learning*. For the opening of the composition see further Tigchelaar, "Towards a Reconstruction of the Beginning of 4QInstruction (4Q416 Fragment 1 and Parallels)," in *The Wisdom Texts from Qumran and the Development of Sapiential Thought*, ed. Charlotte Hempel, Armin Lange, and Hermann Lichtenberger, BETL 159 (Leuven: Leuven University Press, 2002), 99–126.

4Q418*, known from 2–3 fragments only, which preserves mainly the beginning of the composition (*olim* 4Q418 frags. 1, 2, 2b).[36] Most importantly for the present volume, Tigchelaar has thoroughly studied the wads of 4Q418a. He was the first to suggest the order of the wads, an order which we accept, corroborate, and expand.

In 2013 Qimron published an edition of *Instruction* as part of his comprehensive DSS edition.[37] His work was achieved in collaboration with Chanan Ariel and Alexey Yuditsky. Qimron generally endorsed Tigchelaar's work, applying his suggested joins and locations in a full-scale edition, while adding many new and improved readings. In Qimron's edition, Ariel and Yuditsky assigned another fragment (4Q418 33) to 4Q418*.[38] Interestingly, this fragment does not belong in the beginning of the composition like the previously acknowledged fragments of 4Q418*. Qimron later produced an improved edition of the entire DSS Hebrew corpus, with many changes particularly in *Instruction*, some of them based on the work in the present book.[39]

As part of the Haifa team of the project *Scripta Qumranica Electronica* (later at Tel Aviv University), we began working on the copies of *Instruction* in 2016, using the material and digital reconstruction methods described in this book. The project aims to produce a full-scale digital canvas for each of the copies, as well as to make full use of the available parallel texts. Many new joins and rearrangements have been found during this work. The results for 4Q418a are described in chapters 15 and 16 of this volume. We have published several articles on 4Q415 and 4Q418, and many other material reconstructions will be contained in a future edition of *Instruction* as well as in digital form in the SQE platform.[40]

After building on the achievements of earlier editors, the problem remaining in the reconstruction of *Instruction* is that an absolute sequential order of most of the textual passages is lacking. Scholarly discussions of *Instruction* revolve around discrete sections of it,[41] but no anchor has yet been suggested for the order of these sections, despite the great achievements of previous editors. Tigchelaar contributed greatly towards achieving this goal by means of establishing the opening section of the composition and the order of the wads

36 Tigchelaar, *Increase Learning*, 61–64.
37 Qimron, *The Dead Sea Scrolls*, 2.146–84.
38 Qimron, The *Dead Sea Scrolls*, 2.156.
39 The edition is offered to the public online: Elisha Qimron, *The Qumran Texts: Composite Edition* (Zenodo, 2020), doi: 10.5281/zenodo.3737950.
40 See Gayer, "A New Reconstruction"; Gayer, "New Readings"; Dayfani, "Material Reconstruction."
41 This is best seen from the table of contents of the commentary by Goff, *4QInstruction*.

in 4Q418a. Based on his work, Qimron divided the text into two "chapters": the prologue, which he calls "Divine Mighty Acts and Providence," and a chapter that he calls "Interpersonal Matters." Many other fragments remain without an assigned spot in this suggested sequence, however. Within the chapters he orders the textual pericopae of *Instruction* according to considerations of material and content: many of these are commendable but others may be disputed.[42]

With the rules of material philology in mind, and with the new LLDSSDL images and the use of digital tools, thorough work in this regard may help establishing a more solid order for the textual passages of *Instruction*. For the purposes of this study, which concentrates on material reconstruction rather than on improving readings, we ignore minor disagreements and accept Qimron's readings of all scrolls except for 4Q418a. For the latter we offer new and updated readings below. Fragments not included in Qimron's edition will be quoted according to Tigchelaar's readings.

2 Material Information on 4Q418a

A material reconstruction of 4Q418a was achieved by Tigchelaar and serves as the basis of the present study. We suggest an improvement to his method, however, by using graphic visualizations of the individual columns and of the entire scroll. The result of the reconstruction will not only take the shape of a digital canvas, but will also convey the full context of these fragments in the text surrounding them. This work adds a new dimension to the reconstruction and underscores the inherent mechanism of trial-and-error in it. Since we treat the scroll 4Q418a – and equally so all other copies of *Instruction* – as artifacts, the method involves redesigning the text of *Instruction* in the unique layout of this particular scroll. The measurements induced by the Stegemann method can now be tested in a close-to-reality simulation of the actual artifact.

The fragments of 4Q418a are presently held by the IAA on plate number 511. Most of them were found wadded in five multilayered piles. They were severely damaged in the course of separating the wads, which took place in 1955–1956, with many of them crumbling into tiny pieces. The fragments were quite small

42 Qimron numbers the lines of each chapter in a sequential manner, a method which may imply to the reader that the sequence is proven and secure. This is not the case, however, since there is no evidence that the respective fragments formed a continuous sequence. For example, in his chapter 2, the sequence of lines 1–86 is proven by the large fragment 4Q416 2, but the numbering of lines 87–135 (*The Dead Sea Scrolls*, 2.158–60) is less secure.

even in their original state prior to separation, with their size ranging between 5 mm × 3 mm (for frag. 5a) to 30.5 mm × 25.5 mm (frag. 22). None of the fragments contains more than five lines with a dozen (sometimes broken) words. The skin is very dark, and the ink is illegible without IR imaging. According to Tigchelaar,[43] the skin of most fragments is rather thin, while Strugnell and Harrington claim that the single layered fragments 20–25 are thicker than those that were preserved in wads.[44] Our observations in the IAA laboratory confirm that most fragments of 4Q418a are thinner than those of 4Q418, and as thin as the fragments of 4Q415. In addition, fragments 20 and 21 do not differ in thickness from the rest of the fragments of this copy. We accept Tigchelaar's suggestion that fragments 23–25 are not part of 4Q418a.[45] Fragment 22 is therefore the only piece of 4Q418a that is thicker than the rest. The reason for this change is that it is in fact a fifth wad, rather than a single layer as previously thought (see chapters 15–16).

After the "discovery" of this scroll, the editors of DJD XXXIV stated "As for the poorly preserved and often illegible fragments of 4Q418a [...] any certain identification, however, would have to wait for better photographs and further study."[46] Having recorded the layers in each wad of this scroll, Strugnell and Harrington left most of the material reconstruction to future scholars.[47] A reconstruction of the order of the fragments of 4Q418a was finally carried out by Tigchelaar, and subsequently verified and expanded in the present volume, with many new details and improved readings presented in chapters 15 and 16.

The fragments of 4Q418a that are the focus of this book are very small, but the fact that they were preserved in five wads allows for deduction of their

43 Tigchelaar, *Increase Learning*, 126.

44 Strugnell and Harrington, DJD XXXIV, 475. While Strugnell and Harrington later write that "the fragments (of 4Q418a) are generally thicker than the norm in those manuscripts (4Q415 and 4Q418)," it is unclear whether they refer to the single layered fragments or the multilayered. The identification of some of the single layered fragments as part of 4Q418a was rejected later by Tigchelaar (*Increase Learning*, 131, 139). In addition, in a private correspondence from August 2017, Tigchelaar confirmed that according to his observation all fragments except for frags. 1, 22, 24, and 25 are very thin. He suggests that the comment quoted here from DJD XXXIV is either mistaken or pertained to the measurement of exceptional fragments.

45 Tigchelaar (*Increase Learning*, 131, 139). The color of fragments 24 and 25 is lighter than the color of the rest of the fragments of 4Q418a, their skin is thicker, their shape is different, and there is no textual reason to assume that they belong in here. We agree with Tigchelaar (*Increase Learning*, 139) that there is no valid reason to identify fragment 23 as part of 4Q418a.

46 Strugnell and Harrington, DJD XXXIV, xiv.

47 Strugnell and Harrington, DJD XXXIV, 475–96.

original order within the scroll. Some of the 4Q418a fragments have parallel text in other copies of *Instruction*. This manuscript is thus the key to unlocking the main problem that remains for *Instruction*: determining its order and internal structure. Based on these parallels we can suggest a location for the fragments of the other copies, and vice versa: the information from other copies informs us about the order of the 4Q418a wads. Despite its fragmentary condition, 4Q418a is therefore a very important – if not the most important – copy for reconstructing the sequence of this immense work, *Instruction*.

Much of the information contained in the meager fragments of 4Q418a can only be made available when accessed with new tools and established with new methodological foundations. The ultimate aim is to visualize the entire scroll and calculate its size and the amount of text missing, using textual and material information culled from other copies. The tools and methods used in our reconstruction will not only yield improved readings based on the LLDSSDL images but will also point out a few previously unknown fragments which remained attached to some of the already documented fragments. These fragments affect the general reconstruction of the scroll and its estimated size.

In the following chapters the reader will find an improved reading of the fragments of 4Q418a (chapter 15), and a detailed material reconstruction of this scroll, which will also provide an anchor for the textual sequence of the entire composition (chapter 16). Both chapters operate according to the method delineated in part 1 of this book and have achieved much progress thanks to it.

CHAPTER 15

Re-Edition of 4Q418a

Eshbal Ratzon

Due to the delicate state of preservation of this scroll, with fragments that had been glued to each other and subsequently peeled off, sometimes disintegrating and leaving crumbles behind, the reading of this scroll requires extraordinary care. Some of the fragments have disintegrated during the process of their peeling. Their text can only be documented from older images, in which they are still glued to other layers, and the boundaries between them are not always clear. In other cases, crumbles of skin from an upper layer remained attached to a lower one, covering some of the latter's letters and misleading the eye with irrelevant ink. As it turns out, the older editions sometimes erred by imbuing a continuous text to a specific layer while in fact it was part of several distinct layers.

In order to distinguish the different layers, the new readings presented below rely on the oldest PAM plates and track the subsequent development of each fragment, pointing out previously unnoticed layers and fragments. While some of this work was already done by previous scholars, notably by Eibert Tigchelaar, the digital tools at our disposal enable us to significantly improve this work. Teams at the Leon Levy Dead Sea Scrolls Digital Library (LLDSSDL) scanned the old PAM plates at a very good resolution, and made them available to the public. By examining them on a computer screen, we are able to zoom in on the images and detect even the smallest details. In addition to these images, we compared and enhanced the new IR and raking light images of the recto and verso of each fragment and examined the physical fragments under a microscope at the IAA lab.

In several cases, we found ink on the verso that does not match the writing on the recto. There are two possible explanations for the source of the ink on the verso: bleeding of the ink from the recto, or impression of ink from an outer layer that is no longer there (see chapter 6). Since the skin of 4Q418a is very thin, multiple cases of bleeding are found (frags. 1, 2, 4, 6, 7, 8, 9, 12, 17, 19, and 20). Therefore, it is most likely that the ink on the verso that does not correspond to the recto is another case of bleeding, but from an additional layer, thus indicating the existence of another layer underneath the fragment.[1]

1 This case does not agree with the rules suggested by Eric Reymond for distinguishing ink that has bled from the recto from ink, imprinted from an outer layer of the wad. Despite that, our conviction is supported by closer examples from 4Q418a. See Reymond, "New Hebrew Text of Ben Sira," 83–98, esp. 83–84. We thank Eibert Tigchelaar for drawing our attention to the

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The improved readings of known fragments are presented below alongside the readings of the newly discovered fragments. The new readings often carry implications for identifying the text and its parallels, and hence for the reconstruction of other copies and of the entire composition.

In this chapter we describe each wad and the process of its separation. All known images of each wad appear below, followed by a discussion of its fragments. Our examination supports the documented order of the fragments for most large fragments, but it contradicts it for many of the small pieces. In addition, we find several new fragments that still remain attached underneath some of the fragments. We then continue to discuss each fragment separately. For each fragment we list: the images in which it appears, an explanation when required, parallel text when extant, transcription, and notes on readings. Notes on readings are not included when we follow the reading of a previous edition. Due to the fragmentary nature of the text, its readings are mainly useful for the sake of reconstruction, rather than for producing a continuous and meaningful text. A translation of the text is thus not included.

1 Conventions of this Chapter

Unless otherwise mentioned, we present the new IAA image alongside the reading. Since they were all dark, the presented images have been brightened using the Clarity filter in Microsoft Photos. In this chapter we abbreviate the names of the DJD editors, Strugnell and Harrington, as SH.

2 Wad A (frags. 1–8)

PAM images: 41.973, 41.997, 43.687.

FIGURE 47 The two piles of wad A, PAM 41.973. Fragments 1–5 (right); fragments 6–8 (left) © IAA, LLDSSDL, NAJIB ANTON ALBINA

bleeding phenomenon in this scroll. Attachment of ink between layers is known from other DSS, e.g., 4Q252, 4Q422, and 1QSa.

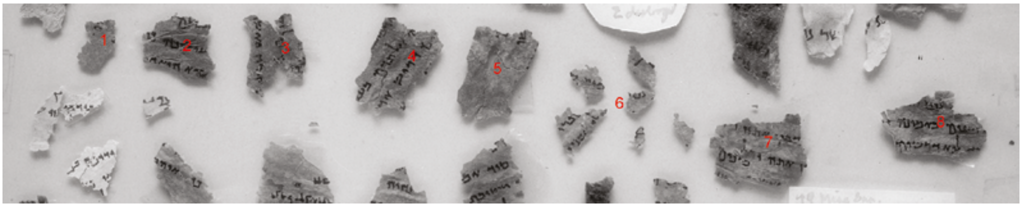

FIGURE 48 Fragments 1–8 of wad A after separation, PAM 41.997
© IAA, LLDSSDL, NAJIB ANTON ALBINA

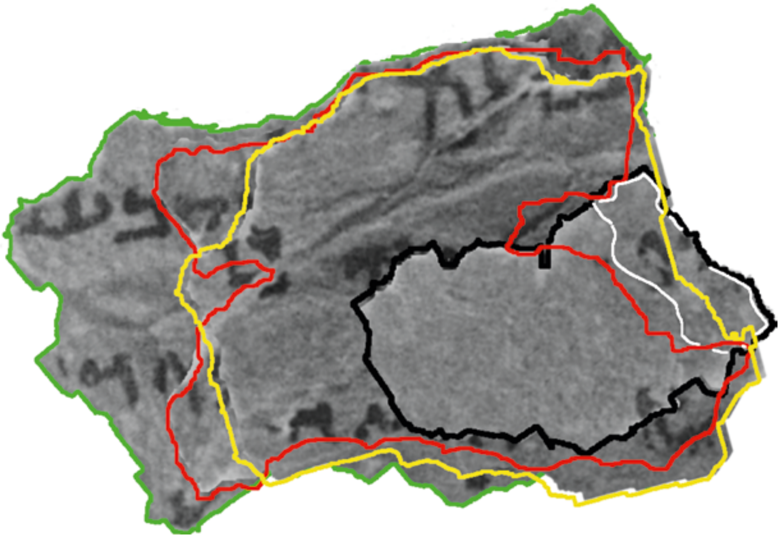

FIGURE 49 The contours of the various fragments in wad A: fragment 0 – white; fragment 1 – black; fragment 2 – yellow; fragment 3 – red; fragment 4 – green.
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According to our reconstruction below, the fragments of wad A stand at the end of the extant part of the scroll. In its earliest image (PAM 41.973, taken March 1956), it is already separated into two piles (figure 47). The right pile had originally stood on top of the left pile. Fragment 1 can be seen at the top of the right pile, covering only a small part of the surface of the wad. The edges of frags. 2, 3, and 4 are visible underneath it (figure 49).[2] Crumbles remaining

2 Although Tigchelaar, *Increase Learning*, 127–28, did not notice frag. 1 on PAM 41.973, it does appear in this photograph. It is a very small fragment, mostly containing an intercolumnar margin. Its placement between lines 2 and 3 of frag. 2 makes it difficult to detect.

from another unidentified layer are also visible on top of frag. 1, henceforth fragment 0. While they provide no more than two fragmentary letters, they prove that the scroll continued after frag. 1.

Fragment 6 is visible on top of the left pile, which had originally stood underneath the right one. The edges of frag. 8 can be discerned beneath frag. 6 when closely observed. In the later PAM 41.997, the order of the fragments corresponds to their DJD numbering. Fragment 6 is now dismembered into several small pieces (figure 48). Tigchelaar notes "that the numbering of the fragments goes from the top of the wad towards its bottom, or, stated otherwise, from the interior of the scroll towards the exterior."[3] However, since frag. 8 is visible immediately underneath frag. 6 in PAM 41.973, we conclude that the order of frags. 7 and 8 was mistakenly flipped (see below).

2.1 *Fragment 0*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 4. B-506479, 506480.

Scarce crumbles of skin are preserved on top of frag. 1. They had been read as part of frag. 1 by previous scholars. The traces of ink on these crumbles seem to indicate two letters: ו/י followed by either ו, י, or פ.

2.2 *Fragment 1*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 4, B-506479, 506480.

The fact that the ink remains of lines 1 and 2 end on the same vertical line may indicate the existence of a left margin. This is significant for the material reconstruction below. Some of the ink that had originally been part of frag. 1 (PAM 41.973) broke off this fragment, remaining instead on frag. 2 (figure 50). These signs should be read together with the ink that did remain on frag. 1.

1]קׄ[ו]פֹ○
2]שׁׄרׄ

Line 1. Traces of ink below the line indicate the letter ק. While the second letter is covered by the tiny frag. 0, the width of the space requires ו, ז or י. The letter that SH considered to be פ, is in fact divided between two layers,[4] with its upper part belonging to the previously unnoticed frag. 0. This letter (פ) is not the end of the word, since a trace of ink is preserved from the next letter. Based on the vocabulary of *Instruction*, the preserved letters can be part of the word

3 Tigchelaar, *Increase Learning*, 127.
4 Strugnell and Harrington, DJD XXXIV, 478.

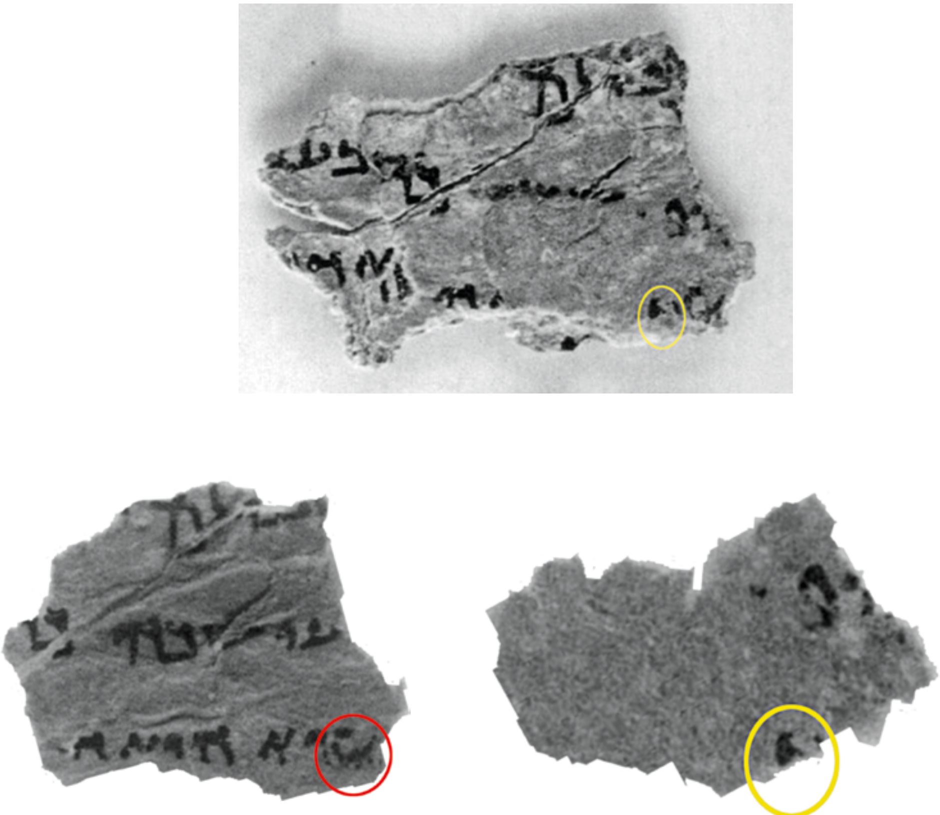

FIGURE 50 Top: Wad A in its original state, PAM 41.973. Bottom: frags. 1 and 2 after their separation, PAM 41.997. Red circle: ink marks that had originally been part of frag. 1, but after peeling, remained on frag. 2. Yellow circle: ink marks that were originally part of frag. 1, and remain on the same fragment even after the peeling process.
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תקופה (preserved in 4Q423 5 5).[5] In fact, from the entire vocabulary of Qumran the only possible reconstructions here are either תקופה, which appears 26 times in the Qumran corpus, or משקוף, which appears only once. It is not surprising that 4Q423 5 contains similar vocabulary, since its text belongs to the same column XX of 4Q418a (see chapter 16).

Line 2. As mentioned above, the first letter broke off frag. 1, and remained on top of frag. 2. The highly irregular strokes on frag. 2 seem to be a ש belonging to frag. 1 and peeled in its middle, showing the כ from frag. 2. The ש may also

5 These letters are also found in a scribal mistake in 4Q418 88 ii 5: יקופיץ.

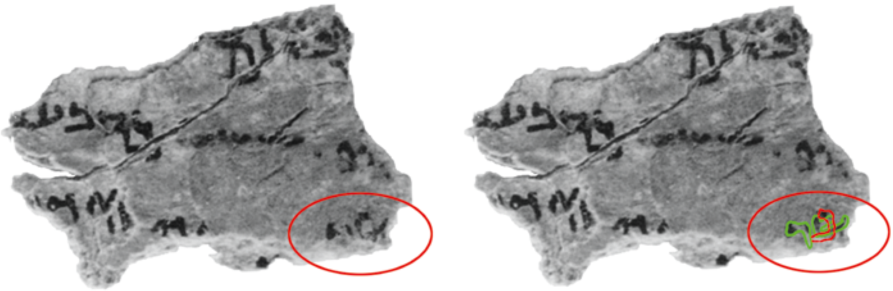

FIGURE 51 Wad A, pile 1, PAM 41.973. The hollow letters שר and כ are written on top of the fragment, demonstrating that the broken שר reveals a כ from a lower layer underneath it.
© IAA, LLDSSDL, NAJIB ANTON ALBINA

be עו. The ink marks of the second letter appear to be the two serifs of a ד, but this is a wrong impression created by a small piece of skin that covers this letter. It is probably a ר (figure 51).

2.3 *Fragment 2*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 3, B-506473, B-506474.

As mentioned above, small traces of ink from frag. 1 remained on the right bottom edge of frag. 2.

1]לׄעׄוׄלם ○[
2]עושׄיׄכה כי[
3]כׄיא הואהׄ[

FIGURE 52 Fragment 2, IR image, B-506474
© IAA, LLDSSDL, SHAI HALEVI

Line 1. SH read]יׄשׄכׄילם.[6] Tigchelaar reads]שׄכׄילם י[or]שׄכׄילם לה[. However, there is no bottom angle of a ש, and the bottom stroke of the alleged כ is too high. In contrast, the oldest image PAM 41.973 shows the signs of an ע. The reason that its two parts seem to be separated is that a small piece of skin from frag. 1

6 Strugnell and Harrington, DJD XXXIV, 478.

is covering it. The upper stroke of the alleged כ belongs to frag. 3. In the new IAA image, a dot of ink is visible below the rightmost stroke of the first letter, rendering its identification as ל quite probable. The word לעולם appears also in 4Q416 2 iii 7 and 4Q418 9 6, but they do not constitute parallels to this fragment. Its occurrences in 4Q417 4 ii 3, 4Q417 20 4, and 4Q418 40 2 cannot be overruled as parallels.

Line 2. SH read עושכה, saying that "a reading עושיכה must be excluded – the traces to the left of the break also belong to the *śin*." However, the new IAA images show both the head of the י that cannot belong to the left stroke of the ש, and another ink mark that should be identified as the left stoke of the ש. The reading עושיכה is grammatically preferable, since the י is part of the root.[7]

Line 3. We accept SH's readings for line 3.

Our reconstruction supports Tigchelaar's suggestion that frag. 1 belongs to the same column as frag. 2, and preserves the end of the same lines.[8] In this column there are around 55 letters per line (see chapter 16), and we count around 40 letters between frags. 1 and 2 (see below). The conjoined reading should thus be:

Fragments 1+2

1 [[ל֯ע֯וֹלם ○]]
2 [[עוש֯יכה כי] ת[ק֯וֹפ֯○
3 [[כ֯יא הואה֯] א[ש֯ר֯

2.4 *Fragment 3*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 2, B-506470, B-506475.

Parallel: 4Q423 5 1 (underlined).

We agree with SH's suggestion that this fragment parallels 4Q423 5, as accepted also by other scholars.[9]

1 [[ב֯וז֯ה֯ פ֯וֹ]]
2 [ע[ם כול זקֹ]ני]
3 [<u>ה את משפ]ט֯ קורח ואשר֯[גלה אוזנכה</u> ברז נהיה]

7 Strugnell and Harrington, DJD XXXIV, 478. We thank Elisha Qimron for encouraging us to seek the remains of the י due to the orthographical problem. We duly note that the defective spelling is also attested in the DSS, as in Isa 44:2 according to 1QIsa[a].

8 Tigchelaar, *Increase Learning*, 138.

9 Strugnell and Harrington, DJD XXXIV, 480; Tigchelaar, *Increase Learning*, 137; *Qimron, The Dead Sea Scrolls*, 2.181.

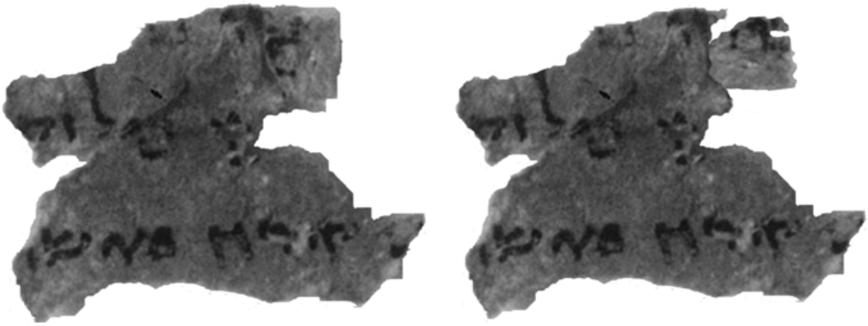

FIGURE 53 Fragment 3, PAM 41.997. Left: The fragment before manipulation. Right: The broken right upper part was rotated back to its original position using digital means.
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Line 1. The first three letters had been broken off from the main fragment, and attached to it in a 90° angle. The reading ב֯וז֯הׄ "contemptful," fits the context of Qorah in the following lines. The ה is nearly complete. Although the ink of the horizontal line is slightly faded, it is visible throughout the letter, thus making its identification certain. The second word may be reconstructed פו]שע (פושעים is found in 4Q418 222 3) or פו]תה (פותיים is found in 4Q418 221 2), but בוזה and פותה may be opposites. These two reconstructions create a grammatical problem, since a conjunction is missing between the two adjectives. In an oral conversation Qimron offered the reconstruction ב֯וז֯ה נ֯ד֯]יבים[, based on שפך בוז על נדיבים (Ps 107:40). Reading נד instead of פו fits less with the ink marks, as the beginning of a vertical top appears at the top of the first letter, but is not impossible.

4Q423 5 has an additional line written with a different hand in the upper margin. We cannot be certain that this addition was included in all copies, hence we do not reconstruct it as part of the text of 4Q418a. We accept Tigchelaar's readings for the next two lines.[10]

2.5 *Fragment 4*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 1, B-506466, B-506467.

SH proposed that frag. 4 overlaps 4Q418 103 ii. As will be demonstrated below, we do not accept their suggestion.

10 Tigchelaar, *Increase Learning*, 137. Tigchelaar's readings are minutely different from those of Strugnell and Harrington, DJD XXXIV, 479.

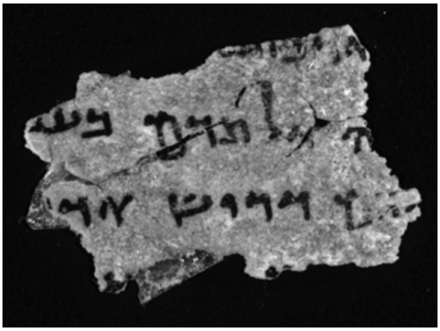

FIGURE 54 Fragment 4, IR image, B-506467
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1]אׄדׄמׄתׄכ֯ה֯[
2]ה֯ אל תדם בעב֯[
3]ל֯ח֯ם דרוש אדמ֯[תכה
4]○○ [ ]○[

Line 2. SH reconstruct the first word as דורשמ]ה, based on the parallel text that we do not accept. Further on, at the end of the line, the ink preserved from the last letter shows a right-hand lower corner, which is probably a ב. Based on the DSS vocabulary, it may be בעב֯[ור or בעב֯[ודתכה.

While other declinations of the root עבד with the preposition are theoretically possible, the use of the second person in line 1 makes this declination more probable.

Line 3. While SH read the first word as כ֯ו֯ל֯ם, the new IR images make it clear that what SH read as the two letters ול is in fact one letter, either א or ח. From the previous letter a left part of a base line is preserved. It is slightly tilted, but quite low. If the second letter is א, reconstruction options are נאם and צבאם. The latter option appears in 4Q416 1 6 || 4Q418* 1 3, but these two occurrences cannot constitute parallels because of their location in the composition. The same word appears also in 4Q418 126 ii 1, where it is followed by ה, and in a fragmentary way in 4Q418 132 2, which cannot be ruled out as a parallel. If the second letter is ח, the reading may be לחם, which fits the context of אדמתכה in line 1. The word לחם appears twice in 4Q416 2 ii, which cannot be a textual overlap to the present passage, and once in 4Q423 1+2 i 9. There are no further indications for a parallel in 4Q423 1+2, but if the context is similar, they may stem from close sections of the composition. Accepting this reading makes the reconstruction of the third word אדמ֯[תכה highly probable.[11]

Line 4. The three dots of ink on line 4 are illegible. SH read them as]כ֯ה֯[י]מ֯[צא based on their identified parallel, which we reject (see below).

11 We thank Elisha Qimron for the reading לחם.

SH proposed that frag. 4 overlaps 4Q418 103 ii. However, their claim that “the text of line 2 coincides almost exactly with that of 4Q418 103 4” is more of an overstatement.[12]

4Q418 103 ii:

3	] [דֿש הבא בטנאיכה ובאסמיכה כיאֿ]	
4	ישוה עת בעת דורשם ואל תדם בֿ]	]בֿודו ולוא תֿ]
5	כֿי כולם ידרשו לעתם ואיש כפי חפצֿ]	]בֿכה ימצא הלוכו והֿ]

Since the column of 4Q418a is narrower than the column of 4Q418, as suggested by SH, it is possible to fit אֿדמֿתֿכֿהֿ from line 1 after]דֿש הבא בטנאיכה ובאסמיכה כיאֿ of 4Q418 103 ii 3. However, the correspondence of 4Q418a 4 2 with 4Q418 103 ii 4 may be contested. We can accept that the difference between אל תדם and ואל תדם is insignificant as claimed by SH, and that 4Q418a had דורשמה before that expression, where 4Q418 has דורשם, to match the ה preserved in the former. But the alignment of 4Q418a 4 3 with 4Q418 103 ii 5 is less convincing. While 4Q418 has ידרשו, 4Q418a reads דרוש, followed by the letters ○אד, which do not fit to the reading לעתם in 4Q418. SH suggest reading in 4Q418a דרוש אדרֿ]וש as a variant for ידרוש of 4Q418, but this improvised solution is problematic because there is no use of the first person elsewhere in the immediate context. The previous readable word in 4Q418 103 ii 5 is כולם, but as explained above such a reading cannot be maintained in 4Q418a 4 3. We thus reject the suggested parallel.

2.6 *Fragment 5*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 7, B-506490, B-506492.

This fragment shows a rather wide left margin and a wide horizontal crack in its middle. The scarce traces of letters do not allow any reconstruction.

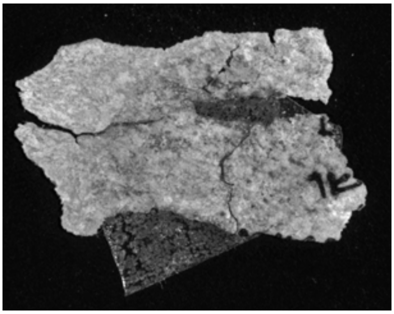

FIGURE 55 Fragment 5, IR image, B-506492
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1]םֿ

2]שׁי̄

3]לֿ ○○○○

12 Strugnell and Harrington, DJD XXXIV, 480–81. Their proposal was accepted by Tigchelaar, *Increase Learning*, 137 and Qimron, *The Dead Sea Scrolls*, 2.169.

2.7 *Fragment 6*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 9, B-506500, B-506498.

The best readings of fragment 6 can be achieved from PAM 41.973, because the fragment later disintegrated. The disintegrated pieces still appear in PAM 41.997. We marked their boundaries and pasted them on top of the oldest image of the unseparated wad. The result makes clear that the top part of frag. 6 including the first line is missing (figure 56).

A comparison with frag. 8 on PAM 41.997 reveals that most of the upper line, which is not represented in the surviving fragments, actually belongs to frag. 8 which had stood immediately below frag. 6 (figure 57). This part of frag. 6 is missing already in the oldest image on PAM 41.973. As explained above, while the numbering of the fragments for the most part reflects their order in the wads, in the case of frags. 6–8 there was a mistake, and the right order should be 6–8–7.

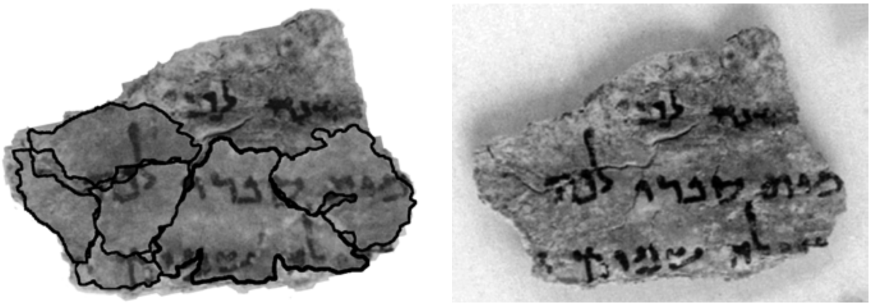

FIGURE 56 Right: fragment 6 on top of half of the unpeeled wad A, PAM 41.973. Left: the small pieces of frag. 6 from PAM 41.997, pasted on top of its older image. Note that the top part remains uncovered by the pieces.
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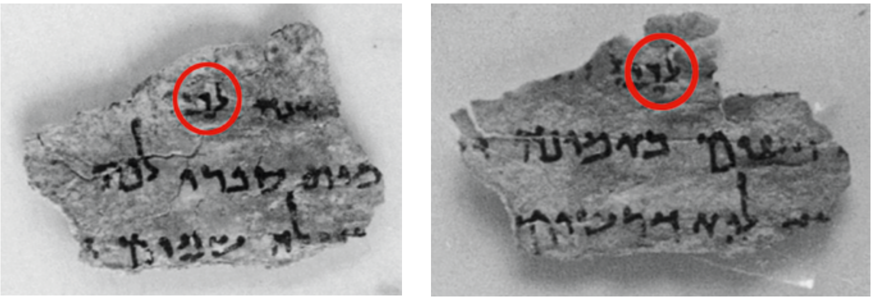

FIGURE 57 Left: frags. 6–8 still attached on PAM 41.973. Fragment 6 on the top of the pile, and frag. 8 underneath it. Right: frag. 8 after separation, PAM 41.997. The red circle on both images shows that the ל and כ supposedly seen in the first line when the pile was still attached are the same letters, belonging to frag. 8 after it was separated.
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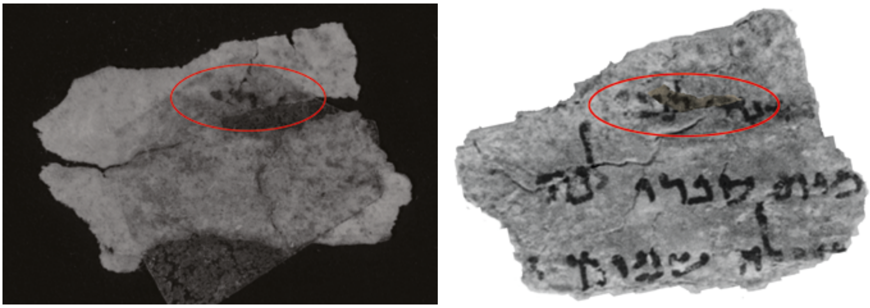

FIGURE 58 Left: IR image of frag. 5 (verso) digitally flipped and enhanced. Right: the letters found on the verso of frag. 5 are placed in their original location on frag. 6 (taken from PAM 41.973). While cutting and pasting the letters, the scaling of both images was adapted to ensure a proper joining.

The top part of frag. 6 is not entirely lost, however, and may be recovered from various pieces of evidence. Some crumbles of skin with ink from frag. 6 still cover line 1 of frag. 8. In addition, the verso of frag. 5 contains traces of three letters coming from a small piece of skin that was detached from frag. 6 (these letters do not correspond to those on the recto). The conjoined evidence allows a reading of a few letters (figure 58).

We read frag. 6 as follows:

1]○[ ]ה̊ תׄב̊ו̄[
2]מות ספרו לכה vacat[
3]○לׄהׄ שמים ○[

SH and Tigchelaar read another line at the top of the fragment, before our line 1,[13] but the traces of their two first lines stem from frag. 8, as explained above.

Line 1. The reading of line 1 is based on the join of evidence mentioned above. In the new configuration of the pieces of skin, only the roof of the ה is visible. While the sign is ambiguous, the way it is tilted to the left supports this reading. The left of the upper and lower horizontal strokes of the ב are seen in PAM 41.973, and the upper right edge is preserved on the verso of frag. 5. Reconstructions based on the preserved vocabulary of *Instruction* are: תׄב̊ו̄]ז, תׄב̊ו̄]אתכה, תׄב̊ו̄]א, תׄב̊י̄]ט, or תׄב̊י̄]ן. Other options exist, of course, in the DSS vocabulary.

13 Strugnell and Harrington, DJD XXXIV, 481; Tigchelaar, *Increase Learning*, 137.

Line 2. SH see two additional unidentified ink signs at the end of this line.[14] We cannot see them, however. The large blank space at the end of the line may be either a vacat or erased ink. Tigchelaar on the other hand claims that the word לכה, visible on PM 41.973, does not belong to frag. 6, but is part of the word מלכים from the layer beneath it (frag. 7).[15] The remains of frag. 6 visible on PAM 41.997 next to frag. 7 prove him wrong, however (see figure 56). A possible reconstruction may be תהו]מות ספרו לכה. In that case this fragment may be related to a marine scene, attested on a series of 4Q418 fragments: 4Q418 42, 69, 116, 119, 160 and 227.

Line 3. SH read the grammatically awkward phrase]מ֯ע֯ל֯ה֯ שמים ה֯[,[16] but the first two ink traces actually belong to frag. 8. 4Q423 20 1 has]ה֯ שמים[. A word ending with a ה that precedes the word שמים is common in the Hebrew Bible but uncommon in non-biblical scrolls, and does not appear elsewhere in *Instruction*. Since other fragments of 4Q423 have parallels to wad A of 4Q418a, a parallel is plausible, but the content of these two fragments is too poor for any definite conclusion.

2.8 *Fragment 8*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 8, B-506494, B-506495.

As explained above, the order of frags. 7 and 8 was in error, and the layer immediately following frag. 6 is actually frag. 8. Its first line is partially visible on PAM 41.973 underneath frag. 6. The fragment was later captured in PAM 41.997, but its upper right part is missing on that plate.

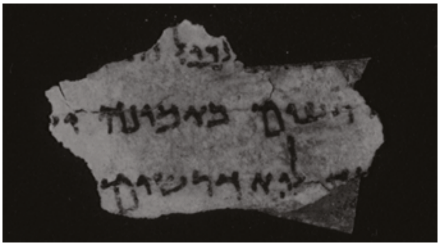

FIGURE 59 Fragment 8, IR image, B-506495
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1]○תה לכ֯ול ○○[
2]א֯ ועׄנום באמונה ו○[
3]○ה֯ לוא דרשום[

14 Strugnell and Harrington, DJD XXXIV, 481.
15 Tigchelaar, *Increase Learning*, 137.
16 Strugnell and Harrington, DJD XXXIV, 481–82.

FIGURE 60 4Q418a fragment 8. The right-hand side image shows the letters of the first word of line 1 as visible on PAM 41.973. On the middle image, the hollow letters תה are written in the font of 4Q418a on top of frag. 8. On the left image, the hollow letters נה are written in the same font on top of frag. 8. As can be seen, a ת gives a better match with the bottom left stroke.

Line 1. The first word is seen on PAM 41.973, but it is broken off of frag. 8 in the later PAM 41.997 and all subsequent photos. The identification of this word is demonstrated in figure 60, where the letters תה and נה cloned from elsewhere in 4Q418a and placed on top of the ink remains, demonstrate that תה is a better fit. The first two letters are covered by a small snippet of skin with a horizontal stroke on it, probably originating from frag. 6. The ו of לכול is revealed only in PAM 41.997, where it is still partially covered with traces from frag. 6. A few vertical strokes are preserved at the end of this line, but the letters are unidentifiable.

Line 2. The first word is slightly covered with remains of skin from frag. 6, and the letters of this word are quite crowded. The word is thus difficult to decipher. SH read י֯בינ֯ו֯ם[, and Tigchelaar reads מ֯ע֯נים[. The reading ד֯עים[may also be possible. In a private conversation Qimron suggests reading ר֯עום באמונה. The current suggested reading may be similar to 1 Enoch 69:24 (cf. 41:6), which suggests a connection with the faithful conduct of the heavenly luminaries.[17] 4Q418 126 ii does not textually overlap frag. 8, but line 10 ובאמונתו ישיחו כול היום תמיד י֯הללו שמו is similar in content and vocabulary. Other fragments of *Instruction* deal with the luminaries, for example 4Q418 55 and 69. The root דר״ש that appears in 4Q418a 8 3, also recurs several times in 4Q418 126 ii.

17 In 1 Enoch 46: 5–7 the sun and moon repeatedly praise God during their periodic course. Their seamless praise is referred to in Ge'ez as *hāymānot*, which translates the Hebrew אמונה in the Ethiopic Bible. 1 Enoch 69:24 refers to the treasures of astronomical and meteorological phenomena that confess (*yəʾəmānu*) and give thanks before the Lord. Again, *yəʾəmānu* is etymologically identical to the Hebrew root אמ״נ. If this reading and connection are correct, this fragment may be discussing the ceaseless toil of the luminaries, which is equivalent to the toil of the angels in 4Q418 55 and 69. For this connection see Bakker, "The Praise of the Luminaries," 171–84.

2.9 *Fragment 7*

PAM images: 41.973, 41.997, 43.687; IAA plate 511, fragment 6, B-506485, B-506487.

The fragment was slightly broken while peeled, and has later disintegrated into many small pieces. The left dry ruling, indicated by SH, is in fact not discernable.

Parallel: 4Q415 6 (underline).

FIGURE 61 Fragment 7, PAM 43.687
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1]]וׄכׄוׄ[ל [
2]]מׄבין אתה רזׄ
3]נהיה ו <u>סוד אנש</u>ים <u>אבי]וׄן אתה ומל</u>כים לׄ[ ]
4]]<u>רׄאׄשׄכׄהׄ[ ]בׄעׄ[צתכה</u>]

Line 1. The ink of line 1, left undeciphered by SH, can in fact be read in PAM 43.687 by means of digital filters. The reading remains insecure, however.

Line 2. Both SH and Tigchelaar read here מבין, but Qimron reads תבין.[18] However, the upper right corner of a ת is rounded, while here it is angular,

18 Strugnell and Harrington, DJD XXXIV, 482; Tigchelaar, *Increase Learning*, 136; Qimron, *The Dead Sea Scrolls*, 2.161.

befitting rather the shape of a מ. The bottom stroke of the מ possibly shifted to the right together with the lower part of the fragment. The second letter is slightly too narrow to be a ב. If this reading is correct, it deviates from the ordinary order of words in *Instruction*: אתה מבין. Another possible reading is אביון. Moving on, SH and Tigchelaar read the penultimate letter of this line as a ו, but it is too wide.[19] We read ר, but even this letter is too narrow to fit the preserved traces, before the next letter, which may be a ז. רז is a possible reading that fits the context of the word סוד (secret) preserved in the parallel text. Qimron suggests to read רש.

Line 3. A drop of ink above the end of the line is visible in PAM 43.687 and in the new IAA image. It is either a ל or a superscript ו or י. According to our reconstruction (see below) the final letter stands right at the end of the line. It is not uncommon that a last word intrudes the left margin, but since the intercolumnar margin between columns XV and XVI is narrow, we expect this word to be comparatively short, perhaps ל]א.

Line 4. As Tigchelaar puts it, this reading "suggested by 4Q415 6 3, is in accordance with the remaining traces."[20] In 4Q415 6 the reading is רישכה. The difference of *yod* and *alef* is an orthographic variant, and the meaning remains "your poverty."[21] The overlap suggests that a few more letters are required at the end of line 4. The parallel to 4Q415 6 suggested by Tigchelaar based on lines 3–4 seems plausible. It indicates that the lines in this column (XV) in 4Q418a are 6 letters shorter than the parallel column (III) in 4Q415. However, a comparison between the material reconstruction suggested in the following chapter to Hila Dayfani's reconstruction of 4Q415, demonstrates the opposite: 4Q418a XV is wider than 4Q415 III. A possible solution may be that a large vacat was included in the unpreserved part of line 4 in 4Q418a.

3 Wad B (frags. 9–12)

PAM images: 41.410, 41.965, 41.972, 41.997, 43.687.

PAM 41.965 and 41.972 show the wad before its layers were separated (figure 62). Frag. 9 is seen on top of the pile, with the edges of frags. 10 and 11 seen underneath it. In PAM 41.997 the four layers of wad B are already separated into frags. 9–12 (figure 63).

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19 Strugnell and Harrington, DJD XXXIV, 482; Tigchelaar, *Increase Learning*, 136.

20 Tigchelaar, *Increase Learning*, 137.

21 *Qimron, The Dead Sea Scrolls*, 2.161, and Elisha Qimron, *A Grammar of the Hebrew of the Dead Sea Scrolls* (Jerusalem: Yad Ben-Zvi, 2018), 78.

FIGURE 62
Wad B before seperation, PAM 41.972:
Red – frag. 9; black – frag. 10

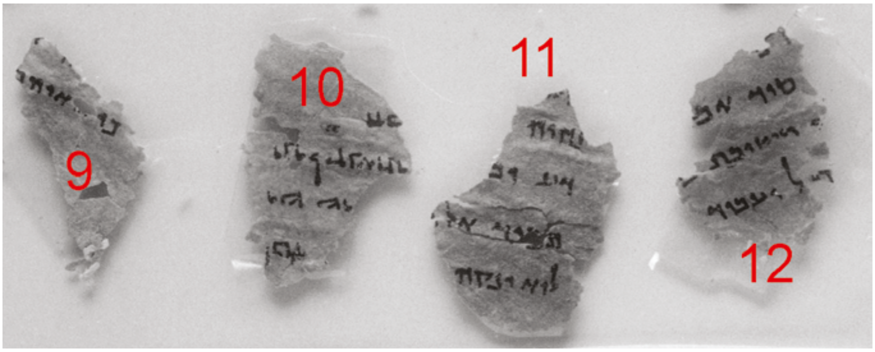

FIGURE 63 Wad B after separation, PAM 41.997

We have recently identified an even earlier image of wad B at the center of PAM 41.410, including two additional layers on top of frag. 9, and a few additional letters in the previously known fragments 9 and 11. These layers were not known either to Strugnell and Harrington or to Tigchelaar and they supplement the earlier known fragments of 4Q418a. While the letters preserved on these fragments are scant, their very presence carries important implications for the material reconstruction (see chapter 16).

Based on PAM 41.410, 41.965, and 41.972 it is possible to determine the boundaries of these two additional layers, to which we assign the numbers 9a and 9b, and to detect a few letters belonging to fragment 9a. This is a difficult move due to the poor quality of some of the images, and we shall thus describe it in detail. Ultimately it can be shown that frags. 9a and 9b in fact supplement frags. 22c and 20+21, and must have been peeled from them at an early stage and subsequently lost (see the detailed account in chapter 16).

Fragment 9a is seen as the top layer of the wad. It is a rectangular fragment containing mainly bottom and right margins but also several previously unattested letters. Its borderline is marked red in figure 64.

Fragment 9b appears under 9a and is marked blue in figure 64. Its contours are better discerned in PAM 41.972, where fragment 9a no longer covers it. None of the PAM images shows any visible writing on fragment 9b, either because all that is preserved is its bottom margin or because the ink faded away. The edge of frag. 9, containing also the stitching thread, can still be seen extending beyond frag. 9b.

The bottom of the wad as imaged on PAM 41.410 shows two previously unattested letters, circled yellow in figure 64. These letters belong to frag. 11 and supplement the text previously known for it.

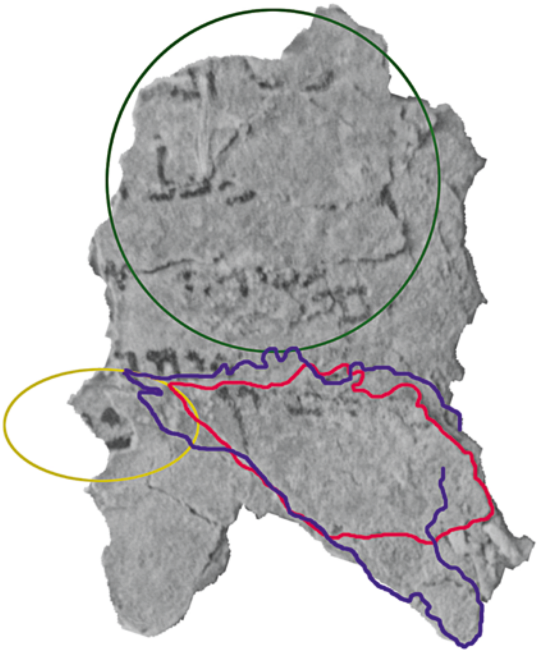

FIGURE 64
The earliest image of wad B before separation, PAM 41.410. Red: boundaries of fragment 9a; blue: boundaries of fragment 9b; yellow: additional letters from fragment 11; green: additional letters from fragment 9

Let us move now to the upper part of the wad, which shows fourteen new letters. It is difficult to infer from the image to which layer they belong, but since some of them are still visible on top of fragment 9 in later PAM images when it is separated from the wad, it is plausible that they also belong to the layer that contains fragment 9. Further reasoning about the assignment of layers is unfortunately impossible since the text of this section is not attested on later images of this wad or on other copies of *Instruction*.

All fragments of this wad show remains of a bottom margin, and all but frag. 12 also show a right margin.

3.1 *Fragment 9a*

PAM image: 41.410.

The fragment shows a large bottom margin. This fragment is joined beneath frag. 22c, see below.

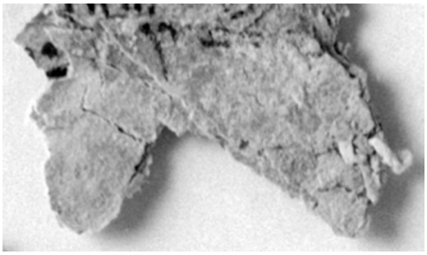

FIGURE 65 Fragment 9a, PAM 41.410
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]◦[]בׄ◦◦ון[1
Bottom margin

3.2 *Fragment 9b*

PAM image: 41.410, 41.972.

There is no visible ink on this fragment. This fragment is joined below with frag. 20+21.

3.3 *Fragment 9*

PAM images: 41.410, 41.965, 41.972, 41.997, 43.687, IAA plate 511, fragment 5, B-506482, B-506483.

The fragment shows a large bottom margin and parts of a right margin (figure 66). Stitches and a stitching cord can be seen in its bottom right part. The peeled fragment is presented to the right, while the left image presents it before it was peeled, with frags. 9a and 9b layered on top of it. This image adds a few letters to the reading of frag. 9 in lines 1–3, which were not known in earlier editions. We attribute all of these letters to fragment 9 for the reasons mentioned above, but this attribution is by no means certain.

1 [ ]○○ ו֯פ֯]
2 [ ]מׄעל א֯]
3 [ ]מׄא֯ו֯ד֯ה֯ אׄ]
4 כיא אוהב]
Bottom margin

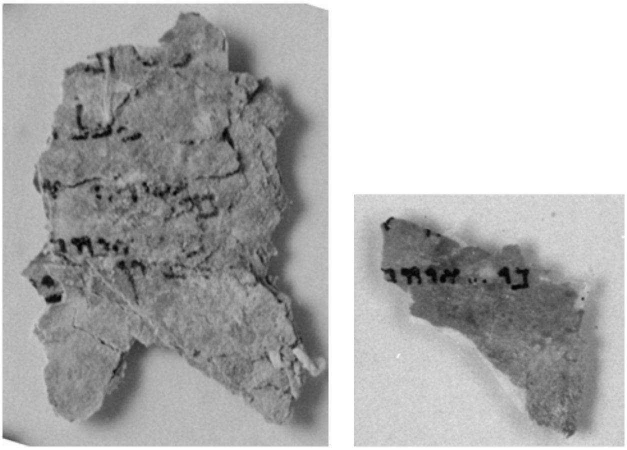

FIGURE 66 Fragment 9. Left: as seen on PAM 41.410 before wad B was peeled; right: PAM 43.687 already separated

Line 1. This line is only visible on PAM 41.410. The remains of the first letter include a vertical line connected to a horizontal base, thus ב, כ, מ, נ, פ are all possible. The second letter is quite far from the first one. It is possible that a י or a ו was once between them and did not survive. From the second letter a horizontal base survived. A reconstruction of כ֯[ו]ל֯ is possible. The first letter of the second word is very narrow. It can also be a י or a ז, but its place at the beginning of the word makes ו more plausible. The identification of the פ is not certain. A כ is also possible.

Line 2. This line is only visible on PAM 41.410. The first word is quite clear. The shape of the ל is quite odd being more rectangular than most other examples. The diagonal angle of the final ink trace best fits an א.

Line 3. Parts of the two final letters are still extant. Their reading is much clearer on PAM 41.410, and confirms Tigchelaar's identification of the second letter as א.[22] The first letter מ is broken but clear. The א is less certain. The third letter is a narrow one. The fourth may be ר or ד. The word מאודה in this spelling appears also in 4Q416 2 ii 16 || 4Q417 2 ii 21.

Line 4. The א of כיא is clearly visible in 41.972, but when the layers were separated, it was detached, and remained at the top of frag. 10. The words כיא אוהב appear also in 4Q416 4 1, but the overlap is too limited to conclude that this is a certain parallel.[23]

22 Tigchelaar, *Increase Learning*, 132.

23 Strugnell and Harrington, DJD XXXIV, 484 and Tigchelaar, *Increase Learning*, 132 hesitantly suggest this parallel.

3.4 *Fragment 10*

PAM images: 41.410, 41.965, 41.972, 41.997, 43.687, IAA plate 511, fragment 12, B-506510, B-506511.

Like the previous fragment 9, frag. 10 shows both right and bottom margins.

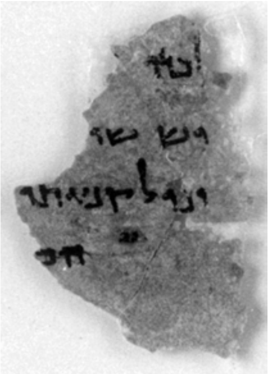

FIGURE 67
Fragment 10, PAM 43.687
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1 לׄכה ○[
2 יש שוׄ[
3 וכול קנאתו[
4 vacat הבׄ[
Bottom margin

We agree with the reading suggested by earlier scholars. The ink marks inside the vacat of line 4 come from frag. 9.

3.5 *Fragment 11*

PAM images: 41.410, 41.965, 41.972, 41.997, 43.687, IAA plate 511, fragment 11, B-506506, B-506507.

Parallels: 4Q417 1 i 21–24 (underlined), 4Q418 43–45 (bold).

Frag. 11 shows both right and bottom margins. It textually overlaps 4Q417 1 i 21–24 (underlined) and 4Q418 43–45 (bold).

1	וׄבׄ[סודכמה	חפציכה **ברז**]
2	**נהיה**] [ל[	י כול חזון]
3	דע וב[כול	וה**תחזק**]
4	תמׄיד אל תׄ[יגע בעולה	בה]
5	לוא ינקה כׄפׄ[י נחלתו בה יר	בן]
	Bottom margin	

Line 2. The tip of the ל appears only in PAM 41.972 and 41.965 underneath fragment 10.

Line 5. The letters כׄפׄי appear only on PAM 41.410. Their size and place make the assignment to fragment 11 certain. The ink remains fit the parallel text of 4Q417.

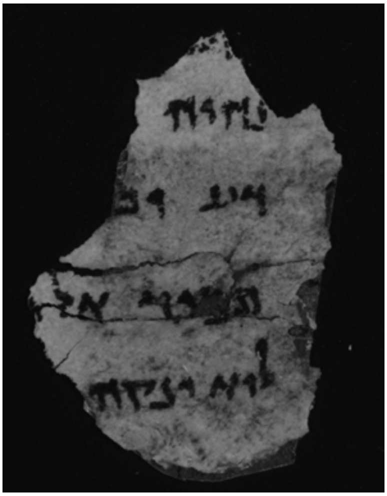

FIGURE 68
Fragment 11, IR image, B-506507
© IAA, LLDSSDL, SHAI HALEVI

3.6 *Fragment 12*

PAM images: 41.965, 41.972, 41.997, 43.687, IAA plate 511, fragment 10, B-506502, B-506503.

Frag. 12 contains a bottom margin, but is the only fragment in wad B not showing a right margin.

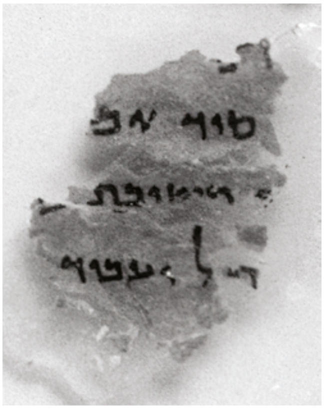

FIGURE 69 Fragment 12, PAM 41.997
© IAA, LLDSSDL, NAJIB ANTON ALBINA

1]ק֯צׄי̅[
2]סוד אמ[ת
3]◦ תׄשׁובת כ֯ו֯[ל
4]כׄול ועבוד[
bottom margin

Line 3. SH see two letters at the beginning of the line, while we only see one.[24]

Line 4. SH and Tigchelaar read the first word as ו֯ב֯ל probably because of the gap between the two final letters, but the upper stroke of the first letter is too wide, and the stroke of the second one is too narrow.

4 Wad C (frags. 13–14c)

PAM images: 41.410, 41.972, 43.687.

Fragment 14 is first attested in PAM 41.972. Fragment 13 is present in PAM 41.410, but is now lost.[25] These two fragments are not documented together on any PAM image, and the only evidence that they once belonged to the same wad is Strugnell's testimony in the DJD edition.[26] On the verso of frag. 14 a few letters can be seen, which do not match the text on the recto and thus cannot have seeped through the skin (figure 72). They must therefore belong to additional layers of wad C, standing underneath frag. 14, but not peeled yet. The ink of these letters bled through from the recto of the respective fragments. These letters are discussed below. Since the fragments of wad C can be joined to fragments from wad D, we bring the joint readings below.

4.1 *Fragment 13*

PAM image: 41.410.

Fragment 13 contains a bottom margin. The actual fragment was photographed only once and has since been lost. It overlaps 4Q418 167a+b (bolded) and 4Q415 11 (underlined). Since frag. 15 overlaps the same fragments, they can be distantly joined (see below).

We agree with the reading suggested by earlier scholars.

24 Strugnell and Harrington, DJD XXXIV, 486.

25 One image of this fragment is found in the DJD edition, where the editors state that its source is unknown.

26 Strugnell and Harrington, DJD XXXIV, 487.

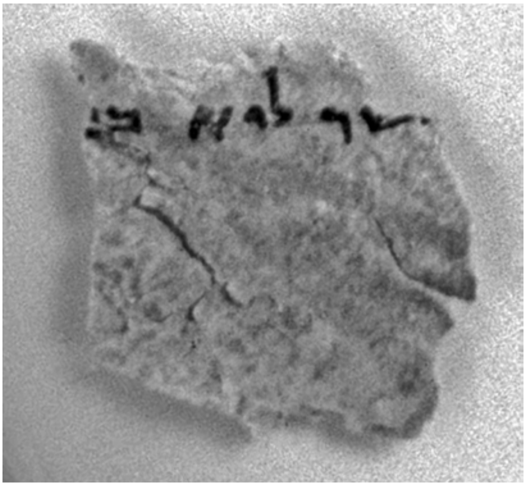

FIGURE 70 Fragment 13, PAM 41.410
© IAA, LLDSSDL, NAJIB ANTON ALBINA

1 [כול]א֯שר לוא בי[חד לתכן את רוחיהמה ליפי מראיה]
Bottom margin

4.2 *Fragment 14*

PAM images: 41.972, 43.687; IAA plate 511, fragment 13, B-506512, B-506514.

Fragment 14 contains a bottom margin. It can be distantly joined to frag. 16 (see below).

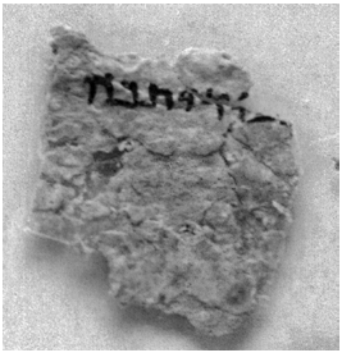

FIGURE 71 Fragment 14, PAM 41.972
© IAA, LLDSSDL, NAJIB ANTON ALBINA

1]ע֯ב֯וד֯ותכה [
Bottom margin

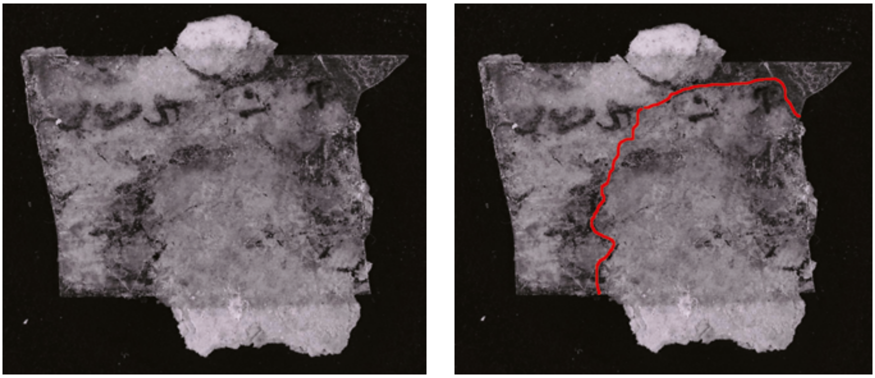

FIGURE 72 Left: frag. 14 verso flipped and enhanced. Right: the borders between layer 14a and 14b are marked with a red line.

Line 1. What we read as ד may also be a ר. SH read here גבורותכה. Paleographically, both suggestions are possible. Grammatically, both words are problematic due to the plural form of the noun with the suffix כה- instead of יכה-. Albeit less frequent, other examples of this phenomenon exist in the DSS (e.g. 1Q36 8 2 מלחמותכה; 4Q402 1 3).[27]

4.3 *Fragment 14b+14c*

Applying digital filters to the verso of frag. 14 reveals additional letters that do not originate from the recto of that fragment, and must thus belong to at least one additional unnoticed layer. In fact, the material remains point to two additional layers underneath frag. 14 (figure 72). The letters to the left belong to one layer, which we name 14a, while the letters to the right belong to another layer, named 14b. Both layers also contain a bottom margin.

4.4 *Fragment 14a*

Fragment 14a contains a bottom margin. It can be distantly joined to frag. 17 (see below).

]תשע̊○[1
Bottom margin

27 For further discussion in this form see Strugnell and Harrington, DJD XXXIV, 487. The opposite phenomenon of the use of e.g. דבריכה for both the plural and the singular is documented by Qimron, *A Grammar*, 267, who states that "DSS Hebrew does not distinguish between such singular and plural suffixes." Martin Abegg kindly informs us that the forms without *yod* are not unusual with the long 2m.s. suffix and the feminine plural.

The letter-sequence תשע appears also in 4Q417 22 2. While the text is too meager to confirm or overrule an overlap, the expression תשע יד, written on 4Q417 22 2 may be explained by the context of 4Q418a 17 (see below).

4.5 *Fragment 14b*

Fragment 14b contains a bottom margin. It can be distantly joined to frag. 18 (see below).

1]הׁשׁב[

Bottom margin

The ש is covered with some skin. The word השב appears in 4Q416 2 iv, a parallel which offers textual support for joining frag. 14c to frag. 18. A small piece of skin above the inscribed line may overlap the previous line, but no ink bled through the skin in that area.

5 Wad D (frags. 15–19)

PAM images: 41.891, 41.909, 41.973, 41.997, 43.687.

This is the only wad whose separation procedure was fully recorded in images. PAM 41.891 shows wad D before it was separated (figure 73). In this photo, frag. 15 is seen on top of the pile. The first two letters on line 1 belong to the edge of frag. 16 standing underneath it, but previous editions mistakenly read them as part of frag. 15.

PAM 41.909 represents the first stage of separation (figure 74), with two piles visible in it. Fragment 15 stands at the top of the left pile, divided into two parts (15b to the left of the pile), with two letters from frag. 16 line 1 still visible on its first line. Fragment 16 is also broken into two parts, with frag. 16b placed to the right of the pile.[28] Fragment 18 stands on the top of the right pile. The first three letters on line 1 of frag. 18 in fact belong to frag. 19, but were read by previous scholars as belonging to frag. 18 (see below). To the left of frag. 18 there is a small fragment with faded ink. Its correspondence to the layer of frag. 19 can be confirmed by its shape, by the fading of the ink in a similar manner to frag. 19, and textually (see below). Tigchelaar rightly discerned that the fragment lying to the top right of frag. 18 is part of frag. 17,[29] naming it 17c. At the bottom left

28 Strugnell and Harrington, DJD XXXIV, 489 suggest that frag. 16b should either be joined to frag. 17 or belong to an intervening layer. However, Tigchelaar, *Increase Learning*, 134–36 correctly joins it to frag. 16.

29 Tigchelaar, *Increase Learning*, 134.

FIGURE 73 Wad D before separation, PAM 41.891. Fragment 15 stands at the top of the wad. Fragment 16 is located underneath at the top right edge.
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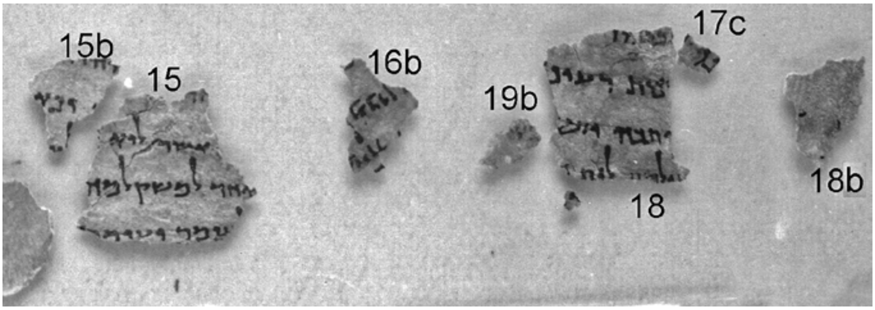

FIGURE 74 Wad D separated, PAM 41.909
© IAA, LLDSSDL, NAJIB ANTON ALBINA

of frag. 18 there is a tiny fragment. Tigchelaar joins it to frag. 17,[30] but it is too small to be certain about. The rightmost fragment in this row on PAM 41.909 must be 18b.

The second stage of the separation of wad D appears in PAM 41.973 (figure 75). Fragments 15 and 18 disintegrated during the peeling process. Only

30 Tigchelaar, *Increase Learning*, 134.

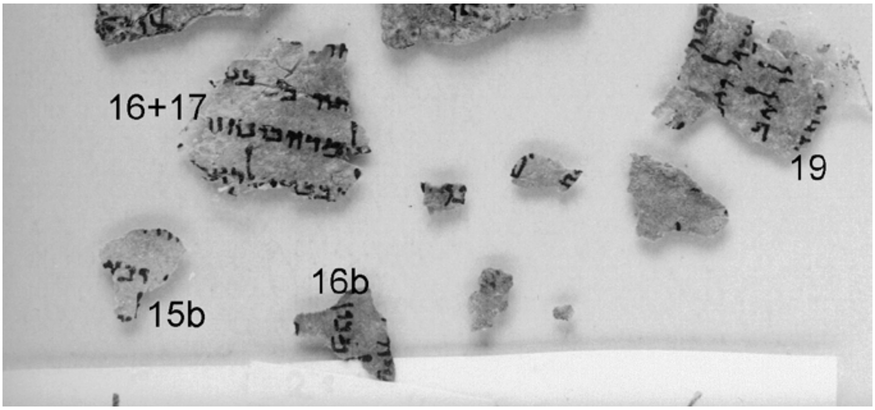

FIGURE 75 The second stage of separation of Wad D, PAM 41.973

a few crumbles of them remain in PAM 41.997, and PAM 43.687 shows only a small piece. Fragment 16 is now on top of its pile, with frag. 17 visible below it. Fragment 19 stands alone.

The last stage is visible on PAM 41.997, where the fragments are placed according to their DJD numbering (figure 76). The fragment below frag. 15b is not related to this scroll. While the order of the larger parts of the fragments was correctly recorded, the place of the smaller pieces needs modification using the available photographs. In addition, some of the layers were not properly peeled. An examination of the verso of several fragments reveals more unpeeled layers, the identification of which is presented below.

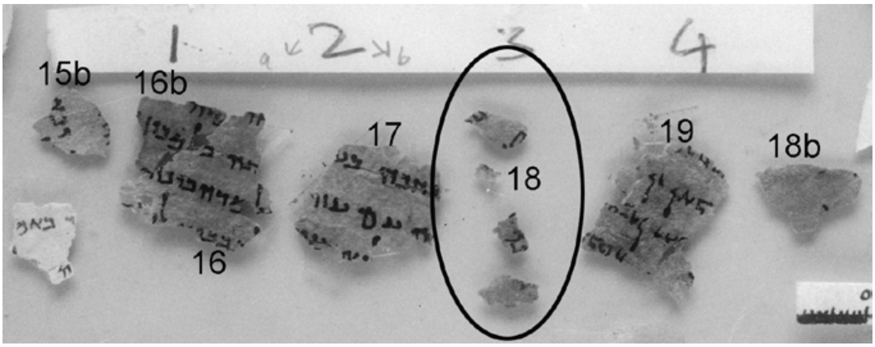

FIGURE 76 Wad D, PAM 41.997

5.1 *Fragment 15*

PAM images: 41.891, 41.909.

Fragment 15b: PAM images 41.891, 41.909, 41.973, 41.997, 43.687; IAA plate 511, fragment 17, B-506530, B-506531.

Parallels: 4Q415 11 (underlined), 4Q418 167a+b (bold).

Fragment 15 overlaps 4Q418 167a+b (bold), as well as 4Q415 11 (underlined). The reconstruction of the width of the column is based on the text preserved in these two copies. In this particular case we include a reconstructed text, although it is not attested in any copy, because it is required for estimating the column width.

FIGURE 77 Fragment 15, PAM 41.891

1 [ ] °°[ ]° **ה בםׄ כי כמוזני**]
2 **[צדק** כול [אשר לוא יהיׄוׄ]**במידה אחת כיא זאת תעלה**]
3 [**וזאת** תרד ת<u>כן</u> כ]אחד למשקל<u>מה</u> וכא[**אשר לוא**]
4 [יהיו לאיפה **ו<u>איפה</u>** <u>]לׄעומר ועומׄרׄ</u> לאׄ[ ]

Line 1. SH, followed by Tigchelaar and Qimron, read חד in an additional line above line 2, but these letters belong to frag. 16 (see figure 78).[31] The only visible sign is a vertical stroke at the end of a word that cannot be identified.

Line 3. Tigchelaar suggests that the א at the end of the line overlaps the word כ]אשר in 4Q418 167 line 4. However, this suggestion produces a textual variant between the copies, because a space of approximately two more words is left

31 Strugnell and Harrington, DJD XXXIV, 488; Tigchelaar, *Increase Learning*, 136; *Qimron, The Dead Sea Scrolls*, 2.160.

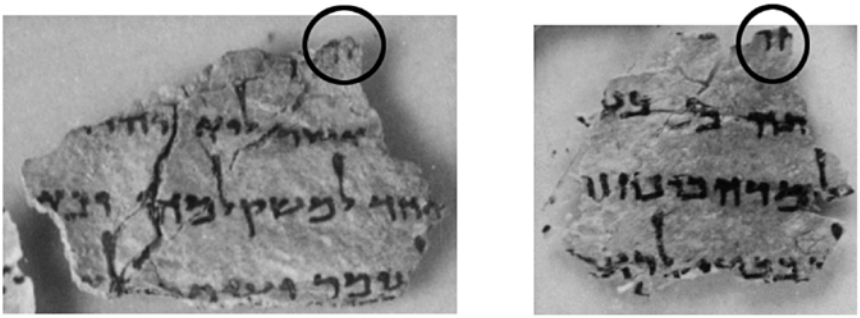

FIGURE 78 Left: frag. 15 on top of the unpeeled wad D, PAM 41.891; Right: frag. 16 on top of frag. 17, PAM 41.973. The comparison shows that the letters that seem to be on the first line of frag. 15 actually belong to frag. 16.
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between the words יהיו and לאיפה in the copies of 4Q418a and 4Q415, but not in 4Q418. Since this kind of variant is rare in *Instruction*, we follow Shlomi Efrati's suggestion to reject the overlap with 4Q418. The result is that the gap between כא in 4Q418a and אשר in 4Q418 allows approximately one or two words there.

Line 4. 4Q418 and 4Q415 read here לאיפה ואיפה לעומר ועומר. SH and Tigchelaar reconstruct a variant in 4Q418a לעומר ועומר לא]יפה ואיפה in reverse order. This reconstruction is not necessary, however. As we do not have the rest of the line in 4Q415 and 4Q418, the word לא] after ועומר may indicate the beginning of a new word rather than לאיפה.

5.2 *Fragments 13+15*

As SH suggest, since both fragments 13 and 15 overlap the same fragments from the other copies, they must be joined, albeit with some distance.[32]

32 Strugnell and Harrington, DJD XXXIV, 488.

FIGURE 79 Fragments 13 (PAM 41.410) and 15 (PAM 41.891), distantly joined

Composite Text

1 [◦◦]◦[ה בםׄ כי כמוזני]
2 [צדק כול] אשר לוא יהיוׄ[במידה אחת כיא זאת תעלה]
3 [וזאת תרד תכן כ]אחד למשקלמה וכא[אשר לוא]
4 [יהיו לאיפה ואיפה]לׄעומר ועומׄרׄ לאׄ[ ]
5 [כול]אׄשׁר לוא ביׄ[חד לתכן את רוחיהמה ליפי מראיה]

Bottom margin

5.3 *Fragment 16+16b*

PAM images: 41.909, 41.973, 41.997, 43.687; IAA plate 511, fragment 15, B-506522, B-506523.

Fragment 16 broke into two parts. While the larger one to the right was properly documented, the smaller one was misidentified as 17b.[33] Our new findings support Tigchelaar's identification of this fragment as 16b.

33 Strugnell and Harrington, DJD XXXIV, 489–90. The mistake was noted by Tigchelaar, *Increase Learning*, 135.

FIGURE 80 Fragments 16 (PAM 41.973) + 16b (PAM 41.909)
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]ח֯ו֯○[
]תה בנ֯[י]ע֯ול֯ה ○[
]○לׄ מדהביכה למכון ○[
]לׄ○ בבו֯א֯ לרעׄה֯ו֯[

Line 1. The ו may also be ר. SH and Tigchelaar read one more unidentified letter here, but it probably belongs to the next layer. The small stroke at the top of frag. 16b is seen between lines 1 and 2, but not in later PAM images. We do not consider it as part of the original fragment 16b. If it were part of the original fragment it should have been visible underneath frag. 15b in PAM 41.891 before the wad was peeled. Perhaps a skin crumble was accidentally attached to frag. 16b from elsewhere.

Line 2. We read the third word (stemming from frag. 16b) in agreement with SH. Tigchelaar disputes the reading of ל based on PAM 41.909, which he thinks preserves the upper part of the fragment. However, this upper part deviates from the borders of the original unpeeled wad. It seems that this part had been folded above the upper layer (frag. 15), and was later broken while peeled, and rotated in 90°. The horizontal line visible in PAM 41.909 is actually the turned vertical stroke of the ל, supporting the reading by SH.[34] There is not much left of the second sign of the second word. Its shape is a little too curved for a נ, but the reading בני עולה seems appropriate.

Line 3. SH reconstruct the first word as ע[מ֯ל,[35] but the ink traces of the first preserved letter are very slim. The reconstruction is thus possible, but not certain.

Line 4. SH read the last word as לר֯[ ]○○[, and Tigchelaar reads it לרו֯○[.[36] However, the ע is quite clear in the oldest PAM image of frag. 16 (41.973).

34 Strugnell and Harrington, DJD XXXIV, 489; Tigchelaar, *Increase Learning*, 135.
35 Strugnell and Harrington, DJD XXXIV, 489.
36 Strugnell and Harrington, DJD XXXIV, 489; Tigchelaar, *Increase Learning*, 135.

5.4 *Fragments 16+16b+14*

As mentioned above, frag. 13 (wad C, layer 1) is distantly joined to frag. 15 (wad D, layer 1), both stemming from the same turn of the scroll. The next layer of each wad (wads C and D) originate from the next turn, and should also be distantly joined. Thus, frag. 14 (wad C, layer 2) that had been located in wad C underneath frag. 13, before being separated, is distantly joined to frag. 16 (wad D, layer 2). Their relative positions are similar to those of frags. 15 and 13.

Composite Text

FIGURE 81 Fragments 14 (PAM 41.972), 16 (PAM 41.973), and 16b (PAM 41.909) distantly joined © IAA, LLDSSDL, NAJIB ANTON ALBINA

]ח֯ו֯[
]תה בנ֯[י]ע֯ול֯ה ◦[
]◦ל֯ מדהביכה[]למכון ◦[
]ל֯◦ בבו֯א֯ לרע֯ה֯ו֯[
]ע֯ב֯ודו֯תכה [
Bottom margin

5.5 *Fragment 17+17b+17c*

PAM images: 41.909, 41.973, 41.997, 43.687; IAA 511, 15 verso, 16, 32, B-506526, B-506527, B-506590, B-506591.

Applying digital filters to the verso of frag. 16b reveals additional letters that do not originate from the recto of that fragment. Thus, they must belong to an additional, unnoticed layer. We name the additional layer frag. 17b (figure 82).[37]

Tigchelaar joins a small fragment, placed to the right of frag. 18 in PAM 41.909, to frag. 17, and names it 17c.[38] Examining the verso of this small fragment shows

37 The number 17b is assigned to different fragments by SH and Tigchelaar. Our designation fits none of them.

38 Tigchelaar, *Increase Learning*, 134.

FIGURE 82 Left: frag. 16b, PAM 41.909. Right: IR image of 16b verso, flipped and enhanced. The text on both sides is not identical.

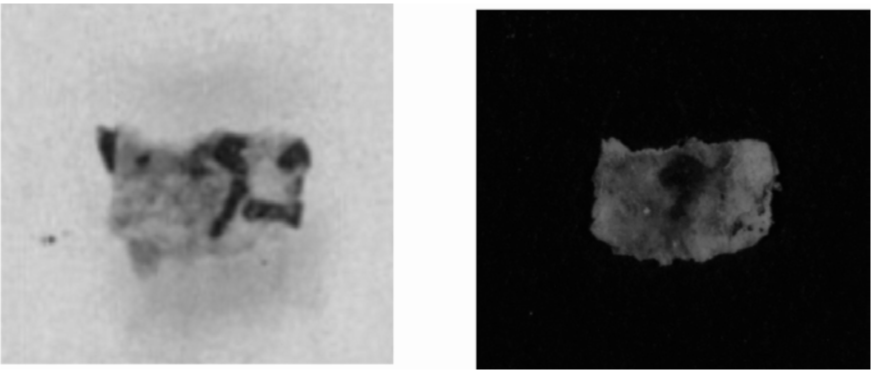

FIGURE 83 Left: frag. 17c, PAM 41.973. Right: IR image of IAA plate 511, fragment 32 verso (= 17c verso = 18c.) flipped and enhanced. The ink on the recto and verso is not identical.

that here too another layer is attached underneath (figure 83). Since the only fragments originating from wad D which miss a piece in that shape are frags. 17 and 18, our examination confirms Tigchelaar's identification. Consequently, the layer underneath frag. 17c should be identified as 18c (see below).

Finally, at the bottom of the verso of frag. 16, two letters that vary from the text of the recto are visible (figure 84). These letters must come from frag. 17 that broke off while being peeled.

The various pieces joined to frag. 17 enable a significant improvement of its reading (figure 85).

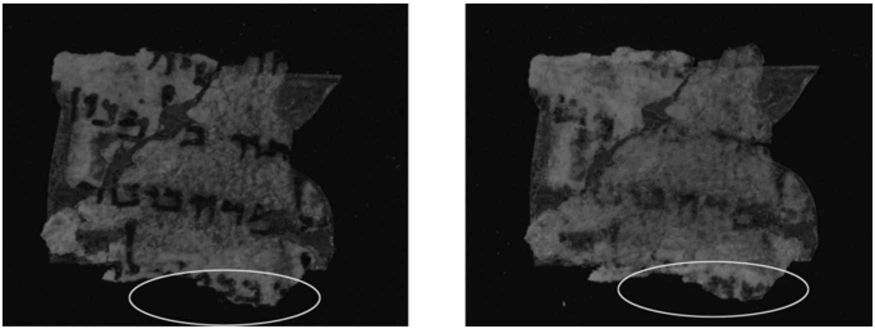

FIGURE 84 Right: IR image of frag 16 recto; Left: IR image of frag. 16 verso flipped and enhanced

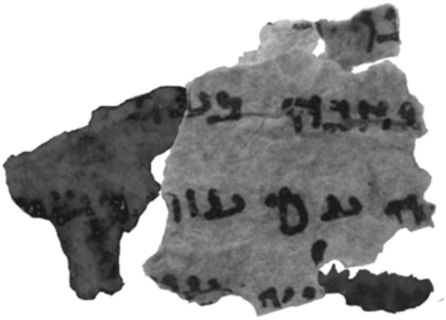

FIGURE 85 Fragment 17 with all the small pieces joined to it

1 ה]פר א֯ת֯ נ֯[דרה
2 ר]ו֯חכה בעת[
3]ה עם עזר בׄשר֯[כה
4 נפ]שׄהׄ ל֯וא י֯עמ֯[וד

Line 1. The ר of the first word was read by Tigchelaar as a ן. But the upper part of ן in 4Q418a is usually tilted to the right (see for example the word מכון in frag. 16b). While the shape of the ר is also unusual, it is close to a cursive ר, similar to the shape attested in 4Q416 2 iv 3.[39] Only two traces of ink are preserved from the א on frag. 17c. The last two ink marks are only visible on PAM 41.973 underneath frag. 16. From the ת only the roof is preserved. Finally, only a small dot is preserved from the last letter. The suggested reading and reconstruction

39 In a private conversation, Qimron pointed out a similar ר in 4Q163 2 5.

of line 1 fit the context of the beginning of the column, preserved on 4Q416 2 iv, although there are a few lines between them.

Line 2. The horizontal line seen on PAM 43.687 and in the new IAA image below the ו is a mere crumble of skin attached above the fragment. Since nothing is missing from frag. 16 at that point, this piece has probably moved from elsewhere on frag. 17, likely from the now broken ל of line 4. The end of the letter ע, and the entire letter ת are seen on our "new" frag. 17b (the verso of 16b).

Line 3.]בׄשרׄ is preserved on frag. 17b. This reading confirms the join of 17 and 17b, since the phrase עזר בשרכה also appears in proximity in 4Q416 2 iii 21.

Line 4. The letters of the first word stem from the verso of frag. 16. The sequence of שה לוא] in the DSS or the Bible recalls נפשה לוא יקום from the law of women's vows in Numbers 30, with the same topic invoked at the top of the column. Indeed, the new reading of line 3 refers explicitly to a woman. While the last word preserved on frag. 17 contains ע, which cannot be part of the word יקום, we suggest its synonym יעמוד. The term יעמוד regarding an oath is also preserved in Jubilees 4Q223–224 2 ii 9 אם ישבע לא יעמוד.[40] The scant remains of the last letter may be a מ. SH and Tigchelaar read here]○מׄעׄ, but on PAM 41.997 the first two strokes are connected, thus belonging to ע. For the context of laws on women's vows compare 4Q416 2 iii 21–iv 10.

5.6 *Fragment 17+17b+17c+14a*

Similar to frag. 13+15 and 14+16, the third layers of wads C and D are also distantly joined. Fragment 14a (wad C, layer 3) must stand below frag. 17 (wad C, layer 3). Fragment 14a may overlap 4Q417 22 (underlined).

1 ה]פר אׄתׄ נׄ[דרה
2 ר]וׄחכה בעת[
3]ה עם עזר בׄשרׄ[כה
4 נפ]שה לׄוא יׄעמׄ[וד
5]<u>תשעׄ] יד○</u>
Bottom margin

The general context of this section is the possibility of a husband to nullify his wife's vows. The expression תשע] יד, coming from the parallel in 4Q417 22, may

40 For the use of עמ"ד in the sense on קו"ם in Late Biblical Hebrew and Rabbinic Hebrew under the influence of the Aramaic, see Yehezkel E. Kutscher, "Aramaic Calque in Hebrew," [Hebrew] *Tarbiz* 33.2 (1963): 118–30, here 124–25.

FIGURE 86 Fragment 17, small pieces, and frag. 14, joined
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be related to the expression תושיעך ידך or הושיע ידו found CD IX 8–10 in respect to a specific case, in which a man's vow is annulled. Although the ו is part of the root, an exceptional deficient spelling is found also in 1 Samuel 25:26, 33 והשע ידי לי, where David thanks Abigail for preventing him from fulfilling his vow and killing Nabal and his household.[41]

5.7 *Fragment 18+18b+18c*

PAM image: 41.909, 41.997, 43.687; IAA 511, fragments 24, 32 verso, 33 verso, B-506557, 506560.

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41 For a discussion of this section in CD in the context of 1 Sam 25 see Shlomo Zuckier, "The Neglected Oaths Passage (CD IX:8–12): The Elusive, Allusive Meaning," in *Hā-ʾîsh Mōshe: Studies in Scriptural Interpretation in the Dead Sea Scrolls and Related Literature in Honor of Moshe J. Bernstein*, ed. Binyamin Y. Goldstein, Michael Segal, and George J. Brooke, STDJ 122 (Leiden: Brill, 2018), 343–62, here 346–47. The section from CD was differently

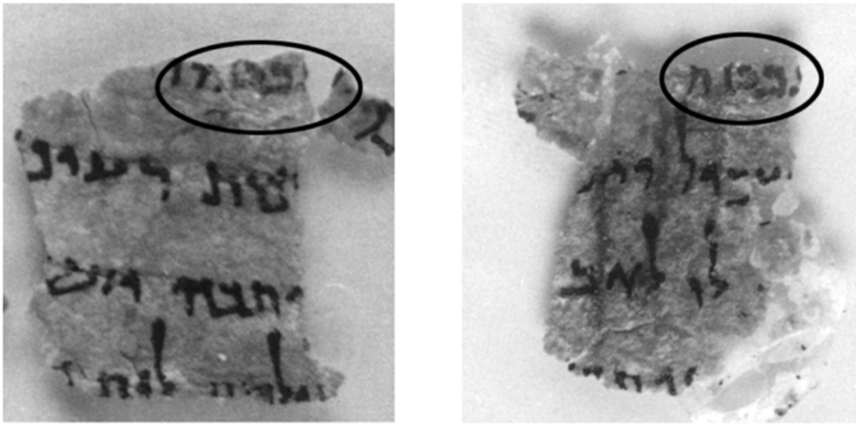

FIGURE 87 Left: frag. 18, PAM 41.909. Right: frag. 19, PAM 43.687. The first two letters seen in line 1 of frag. 18 are identical to those in the same place of frag. 19.

In PAM 41.909 fragment 18 stands on top of frag. 19, before the two layers were separated. Fragment 18 has later disintegrated into tiny pieces, most of them lost by now. In PAM 41.909, the upper right part of frag. 18 was peeled, and the two letters visible there (read by previous scholars as part of frag. 18) actually belong to frag. 19 (figure 87). Instead, the missing part of frag. 18 is found underneath what we identified above as 17c (figure 83). We name it 18c.

Yet another piece should now be joined to frag. 18. This piece, similar in shape to 15b, 16b, and 17b, can be seen to the right of the series of fragments belonging to wad D, on PAM 41.909 and 41.997. Only two dots of ink are preserved on it. It cannot be joined to frag. 19 because when joined they exceed the size of the entire wad D. Thus, based on elimination, it must be joined to frag. 18 and called frag. 18b. According to our reconstruction, and based on the textual overlap, we expect frag. 18b to contain some words. Since it only shows two dots of ink, we must assume that its ink has faded.

Fragment 18 textually overlaps 4Q416 2 iv 3–7 (underlined) and 4Q418 10 6–8 (bold).

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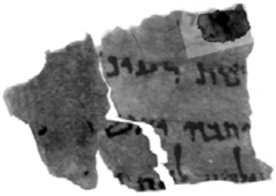
interpreted by Elisha Qimron and Alexey Yuditski, "Two New Readings in the Damascus Document," [Hebrew] *Meghillot* 15 (2021): 97–105.



1 [בה מאמה הפרידה ואליכה דבק]ה֯ [ו]ה֯י֯[תה לך **לבשר**]
2 [**אחד בתכה לאחר** יפריד ובניכה לב]נות רעיכה֯[ו]א֯[תה]
3 [ליחד עם אשת **חיקכה כי היא שאר** ער]ו֯תכה ו֯אש[ר ימשול]
4 [בה זולתה הסיג גבול חייהו **ברוחה המ**]ש֯י֯ל֯כ֯ה֯ ל֯ה֯ת֯ה֯[לך]

FIGURE 88 Fragment 18 (PAM 41.909) after a fold of the skin was digitally opened. Fragment 18c is pasted at the right top of frag. 18. To the left of frag. 18, we placed an IR image of what we identify as frag. 18b (enhanced).

Line 1. The readings of previous scholars are based on the letters from frag. 19 that were still attached underneath frag. 18 in PAM 41.909. According to our updated identification however, only the left part of the first ה is visible. We accept Qimron's reconstruction, which is based on Genesis 2:24, although we identify the letters differently.[42]

Line 2. SH read here]◦פ֯ו֯ת רעיכה֯[. We follow the better reading offered by Tigchelaar and Qimron, which is paleographically possible, and fits the context better. The sign of ink preceding נ is not the ב of לב]נות, but rather likely belongs to frag. 19.

Lines 3–4. We accept the readings of previous scholars, having digitally unfolded the fragments to render the letters clearer.

5.8 *Fragments 18+18b+18c+14b*

As explained above, two additional layers appear on the verso of frag. 14. Based on the join of frag. 13 (wad C, layer 1) to frag. 15 (wad D, layer 1), frag. 14b (wad C, layer 4) can be distantly joined to frag. 18 (wad D, layer 4). The text on frag. 14b overlaps 4Q416 2 iv (underlined), which also overlaps frag. 18.

1 [בה מאמה הפרידה ואליכה דבק]ה֯ [ו]ה֯י֯[תה לך **לבשר אחד**]
2 [**בתכה לאחר** יפריד ובניכה לב]נות רעיכה֯[ו]א֯[תה ליחד עם]
3 [אשת **חיקכה כי היא שאר** ער]ו֯תכה ו֯אש[ר ימשול בה זולתה]
4 [הסיג גבול חייהו **ברוחה המ**]ש֯י֯ל֯כ֯ה֯ ל֯ה֯ת֯ה֯[לך ברצונכה ולא]
5 [להוסיף נדר ונדבה]ה֯שב[רוחכה **לרצונכה** וכל שבועת]
Bottom margin

42 *Qimron, The Dead Sea Scrolls*, 2.157.

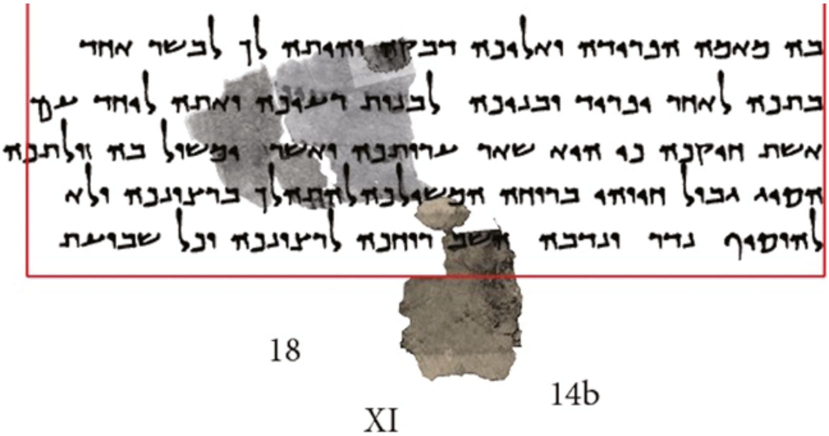


FIGURE 89 The reconstruction of column XI containing frags. 18 (PAM 41.909) and 14b (from the verso of frag. 14)

5.9 *Fragment 19+19b*

PAM images: 41.909, 41.939, 41.973, 41.997, 43.687, IAA plate 511, fragment 14, B-506518, B-506519.

Fragment 19 textually overlaps 4Q416 2 ii 14–16 (underlined), 4Q417 2 ii 18–21 (bold), and 4Q418 8c and 8d (red).

Since wad D broke into two parts, all of its layers must have also separated into two, with one part larger than the other. After matching all other fragments of this wad (16, 17, 18) with their smaller part, one last small piece is left to be identified as 19b. The ink on frag. 19b is almost entirely faded and hence may reflect any reading suggested by the parallels.

We accept the readings of previous scholars.

Fragment 20+21 is not part of any wad and thus discussed separately below.

]עב רו ואתה א]תׄבטח לׄ[מה תשנא ואל תשקוד[
]ממדהבבכה דמה לו לעבד מ]שׄכיל וגםׄ [א]לׄ תׄשׄ[פל נפשכה[
]לאשר לא ישוה בכה ואז תהי]הׄ לו לאב[ ]○[לאשר אין[
]כוחכה אל תיגע פן תכשל וח]רׄפׄתׄכׄהׄ[תרבה מאודה[

FIGURE 90 Fragment 19 (PAM 41.997) + 19b (PAM 41.909)

6 Wad E

All previous studies mention only four wads (A–D) of 4Q418a, in addition to other fragments preserved separately.[43] However, more layers apparently exist underneath frag. 22, constituting a fifth wad (E). The following discussion partially repeats a recently published article.[44] Deciphering the ink marks and carefully comparing the old PAM images, we discovered that there has been an attempt (by Strugnell?) to peel frag. 22 in order to reveal the layers underneath it, but this attempt remained undocumented.[45] The oldest available image of frag. 22 (PAM 42.247)[46] shows differences in hue and texture that indicate a peeling of the skin.

Already in this early image, a diagonal stroke is apparent between the word בריבך and the following ש. This stroke does not belong to any word. The crack to its right supposedly suggests that it once belonged to a letter from frag. 22 that is now broken. However, in a later image, PAM 43.687, the peeling expands, and this diagonal stroke is seen as part of a different letter, written on the second layer of wad E (henceforth frag. 22a).

A comparison of these two images shows that the word בריבך is broken in the later image, revealing new ink marks underneath it. In PAM 43.687 the diagonal stroke is part of a ט. Before the ט, the upper part of a ו, י, or פ is visible. The broken letters to the left of the same line are almost entirely lost in the later image. It is thus clear that at least one more layer exists underneath frag. 22 (figures 91–92).

The image B-506539, taken at the LLDSSDL in 2012, shows additional progress in the peeling process. Here, in line 3 above the second ב of בריבך, an edge of yet another letter is visible. Furthermore, parts of line 4 are also peeled, but the peeling was not deep enough on the right-hand side, and the first layer is only split. The IR image still shows remains of ink from the upper layer. At the

43 Tigchelaar, *Increase Learning*, 130.

44 Ratzon, "New Data," 25–38.

45 SH claim that frags. 20+21 were once placed one on top of the other (Strugnell and Harrington, DJD XXXIV, 492), but, as Tigchelaar, *Increase Learning*, 138–39 has demonstrated, frags. 20+21 constitute one fragment that fell apart in the older PAM images 42.760 and 41.375. Perhaps the source of this mistake is in the old notes of Strugnell, stating that frag. 22 was part of a wad, but somehow this note was read as referring to frag. 21.

46 Interestingly, all wads and their separation process are documented on the 41 PAM series that was taken between 1955–1956. The only exception is fragment 22 that appears to be a fifth wad, unseparated and unnoticed before. This fragment first appears only on PAM 42.247 that was taken on January 1959.

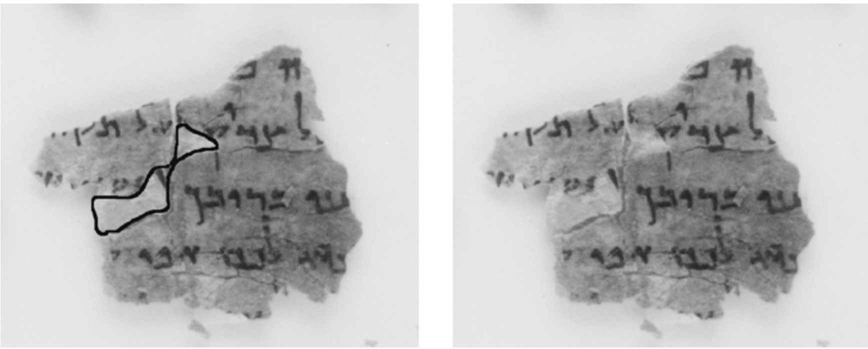


FIGURE 91 The oldest available image of frag. 22 from January 1959 (PAM 42.247), in which the top layer began to be peeled.
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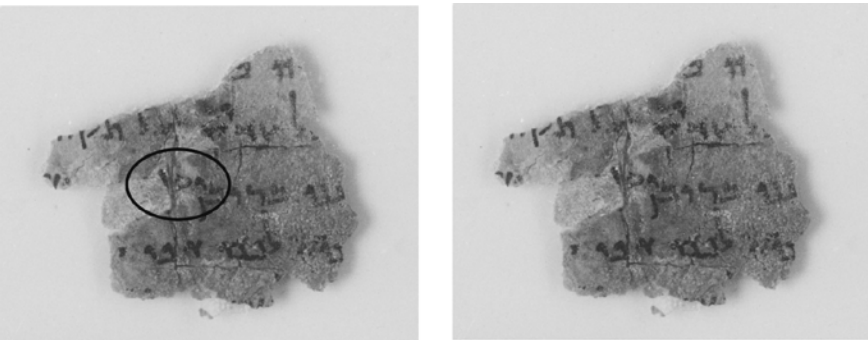

FIGURE 92 The first layer continues to be peeled in an image from July 1960, PAM 43.687.
© IAA, LLDSSDL, NAJIB ANTON ALBINA

left-hand side, the end of the word אפו is missing, and so is the last letter that was once visible on line 4.

In the color image B-506538 it is also evident that wherever the skin is peeled, its color is lighter. No other ink marks can be traced after the ט of the second layer. This fact may have caused the researchers to stop peeling in order not to destroy the upper layer, while no text is found underneath it. This point presents an intersection of the readings with the material reconstruction, since our reconstruction suggests that the left part of frag. 22a preserves a left margin, hence the absence of ink at that point.

A physical examination of the fragment at the IAA lab, as well as of additional images supplied to us by the dedicated team of the LLDSSDL, confirms our suggestion. Figure 94 marks in black the outer boundaries of the entire

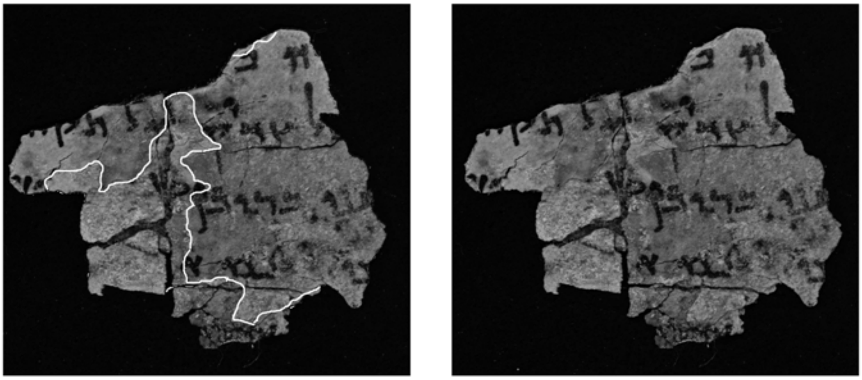

FIGURE 93 IR image of frag. 22, taken especially for the current study at the IAA lab
© IAA, LLDSSDL, SHAI HALEVI

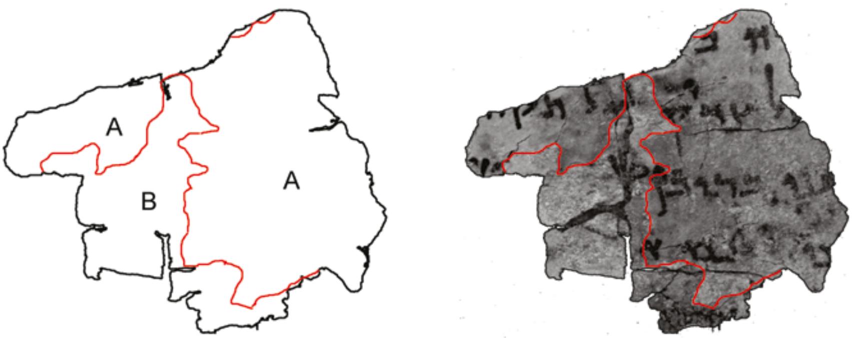

FIGURE 94 Layers 1 and 2 in wad E
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wad. It is the maximal area of each layer, though not necessarily its current size. The red line designates the border between layer 1 (frag. 22) and 2 (frag. 22a). The current area of layer 1 after its peeling is marked with “a”; “b” designates the visible part of layer 2.

In addition to this “new” fragment, a few more letters are visible on the verso of frag. 22 (figure 95). They cannot come from either 22 or 22a. As in other cases of ink on the verso which does not correspond to the recto, we conclude that the ink on the verso of wad E indicates the existence of a third layer (22b) underneath frag. 22a. Since the right part of the first letter is covered with skin, it is even possible that an additional fourth layer (22c) covers part of 22b. This observation is confirmed by the join of fragment 9a to its bottom (see chapter 16). Unfortunately, we have no information about the content of this

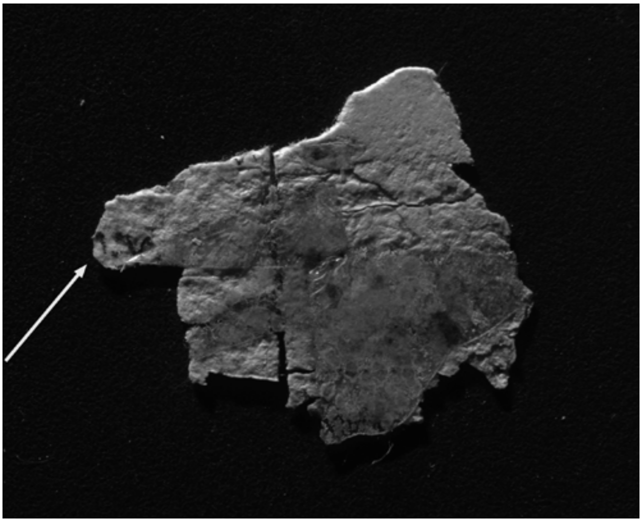

FIGURE 95 The verso of frag. 22 flipped. The arrow points to the letter remains.
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layer. While the information on wad E is not significant in terms of readings, it is highly significant for the material reconstruction of the scroll.

Based on the professional assessment of the conservation team of the IAA, frag. 22 cannot be peeled without further damage. Future technologies will hopefully enable reading the lower layers through the upper ones, with no need to physically peel them. Such a process may elucidate how many layers are hidden in wad E and the content of those layers. These layers will be unquestionable authentic new Dead Sea Scroll fragments.

6.1 *Fragment 22*

PAM images: 42.247, 43.687; IAA plate 511, 19, B-506538, B-506539.

Fragment 22 parallels 4Q417 2 i 12–17 (underlined), which in turn parallels 4Q416 2 i 7–10 (bold) and 4Q418 7a 1–2 (red).

1]ועל הלוא **ולאבליהמה** שמחת עולם הי[ה בׄ[על ריב לחפצכה ואיש[

2 [**לכל נעויתכה דבר** משפטיכה כמו]שׄל צד˙ק אלׄ תקׄחׄ[]

3]ה ואל תעבור **על** פשעיכה היה כאיש]עׄני בריבך [מ]שׄפׄטׄכׄהׄ[קח[

4]ואז יראה אל ושב אפו ועבר על חטאתכה]כיא לפני אפו לׄ[א יעמוד כול ומי[

5]יצדק במשפטו ובלי סליחה איכה]לׄ אׄ[ביון]וׄאׄ[תה אם תחסר טרף[

Line 1. The left part of the second letter is missing. It can be either ב or מ. The former is preferred based on the parallel text in 4Q417.

Line 2. The י of צדיק is superlinear. In the new IAA image another horizontal ink mark is visible after the י. Between the words צדיק and אל the peeling of the skin ends with a crack. A vertical ink mark is visible next to the crack. Although it looks like the flag of a ל, no indication exists that the rest of the letter is missing. In addition, a ל does not fit the context, and is not attested in the parallel copies. SH and Tigchelaar read this sign as ו,[47] but it exceeds too far above the line. It is more likely that this ink belongs to the next layer (22a). The same applies to the horizontal stroke above the ל of אל.

Line 3. The crack that begins in line 2 continues into line 3 between the words בריבך and משפט. To the left of the crack the skin is lighter, because it was peeled. A diagonal stroke is visible there. Scholars assumed this is a broken מ of the word משפט, clearly visible in 4Q417.[48] However, as mentioned above, the right part of the מ is missing. Later images show that the diagonal stroke is in fact part of a ט, coming from another layer (22a). The new IAA image shows also the upper part of ו, י, or a פ to the right of the ט, preceded by an unidentified letter all on frag. 22a. On frag. 22 the ש of משפט is broken, but perfectly clear. The rest of the letters are legible, and their identification is based on the parallel text of 4Q417. They are no longer visible in the later images of this fragment.

Line 4. The word כיא is partially peeled now and hence blurred in later images. Above it, unclear ink marks from the next layer can be traced. A horizontal stroke appears above the נ of לפני. Since it is not close to any peeling or crack, it is difficult to say to which layer it belongs. In the new IAA images, everything past the א of אפו is already peeled.

Line 5. Only the upper part of the first two letters is visible, but because of their unique shape they are easy to identify. The remains of the last two letters are scant, and they only appear in the old PAM images. Their identification must rely on the parallel text of 4Q417. SH reconstruct here ובלי ס]ל֯]י[ח֯ה֯]א[י֯כ֯[ה, but the present reading follows the more convincing suggestion of Tigchelaar and Qimron.[49]

47 Strugnell and Harrington, DJD XXXIV, 493; Tigchelaar, *Increase Learning*, 132.

48 Strugnell and Harrington, DJD XXXIV, 493 and Tigchelaar, *Increase Learning*, 132 read here משפטו, while *Qimron, The Dead Sea Scrolls*, 2.152 reads משפטכ[ה.

49 Strugnell and Harrington, DJD XXXIV, 493; Tigchelaar, *Increase Learning*, 132; *Qimron, The Dead Sea Scrolls*, 2.152.

6.2 *Fragment 22a*

Distinguishing the ink marks from the two separate layers enables a reading of the few visible letters from frag. 22a. This fragment ends with a left margin. Lines 1–3 correspond to lines 2–4 in frag. 22:

1]○○○[
2]○י̊ט
3]○○○[

Line 2. The final letter is clear, but only the upper part of the preceding letter is visible. It may be a ו, י, or a פ. Only the upper left part of the first letter is preserved, and it looks like part of a horizontal stroke, which indicates a letter with a roof on top. Based solely on the *Instruction* vocabulary this word can be: ת]ב̊י̊ט, יש]פ̊ו̊ט, א̊ו̊ט, ש]ו̊פ̊ט, or מ]ש̊פ̊ט. The first two options are more likely, because of the width of the roof of the first preserved letter.

6.3 *Fragment 22b*

As mentioned above, the verso of wad E, seen in new images supplied to us upon request by the IAA, shows more letters (figure 95).[50] These letters cannot come from the first two layers (22 and 22a). Thus, we name their layer 22b. We read those letters:

]ת̊בו[

The final letter can be either י or ו. Choosing from *Instruction* vocabulary, the reconstructed options are: ה]ת̊בו[נן, ת̊בו[ז, ת̊בו[אתכה, ת̊בו[א, ת̊בי[ט, or ת̊בי[ן.

6.4 *Fragment 22c*

Glued to the back of frag. 22b, only the verso of this fragment is visible, and most of it is covered with conservation paper. Fragment 9a is joined to the bottom of this fragment, showing a few letters from the last line as well as a bottom margin. The reader is referred to chapter 16, where the join is merged in the canvas of the entire scroll.

50 The IAA team supplied us with both IR images and photographs taken using a Dino Lite handheld microscope, which allows imaging of the fragment from different angles. We horizontally flipped the image in figure 95 using an image manipulation program (GIMP).

FIGURE 96 The maximal boundaries of frag. 22c joined to frag. 9a
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7 Single-Layered Fragments

7.1 *Fragment 20+21*

PAM images 41.375, 42.760, 43.687, IAA plate 511, fragments 20, 22; B-506542, 506543; 506550, 506552.

In PAM 41.375, frags. 20+21 constitute one fragment. In PAM 42.760, they are still not separated, but surprisingly the first line has disappeared. That line reappears in PAM 43.687, but the bottom part is detached. Our reading of this fragment agrees with Tigchelaar's.[51]

51 Tigchelaar, *Increase Learning*, 138.

FIGURE 97
Fragment 20+21, PAM 41.375
© IAA, LLDSSDL, NAJIB ANTON ALBINA

1]פׄקוד[
2]○בנפלאׄ[ות
3]ל כיא א[
4]כׄול נעשׂ[ה

7.2 *Fragment 20+21+9b*

The bottom boundaries of frag. 20+21 are similar to the top boundaries of frag. 9a. In addition, the material reconstruction predicts that both their horizontal and their vertical placements match each other (see chapter 16). No ink traces are preserved on frag. 9b, and it only adds a bottom margin to frag. 20+21.

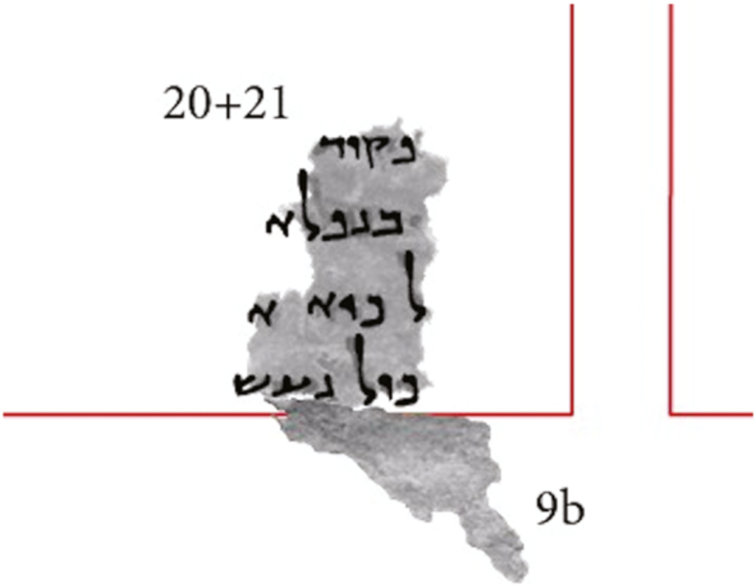

FIGURE 98 Fragment 20+21 joined with frag. 9b
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7.3 *Fragments 23, 24, 25*

SH state that frag. 23 can be identified as part of either 4Q418a or 4Q418. We agree with Tigchelaar that there is no valid reason to include this fragment in 4Q418a.

The skin of frags. 24 and 25 is significantly thicker than the skin of the rest of the fragments of 4Q418a. In addition, they do not resemble the shape of the other fragments. Thus, again with Tigchelaar, we dismiss their identification with 4Q418a.[52]

52 Tigchelaar, *Increase Learning*, 139. Already SH identify it only tentatively in Strugnell and Harrington, DJD XXXIV, 494–95.

CHAPTER 16

Material and Digital Reconstruction of 4Q418a

Eshbal Ratzon

After editing each wad and fragment of 4Q418a it is time to present their original order together with the known text from parallel copies, based on the protocol presented in the methodological chapters of the present book (see chapter 12). The following reconstruction of the copy 4Q418a is not the final word in the reconstruction of *Instruction*, but rather only a skeleton, on which the reconstruction of other copies can rely (see chapter 17).

While the digital canvas suggests an exact placement of each fragment and a specific width for each column (figure 119), the accompanying comments give an additional range for these data. Providing a margin of error alongside the reconstruction is a methodology not previously used in the study of the DSS. We borrow it from the exact sciences and introduce it here as a proper way to present the uncertainty of any reconstruction. Establishing a margin of error requires quantifying all elements of the reconstruction using a numerical figure, a rather difficult and sometime counter-intuitive act. While most of the errors were calculated mathematically, some elements are impossible to express in numbers and could only be demonstrated verbally. Moreover, a certain subjectivity remains in the estimation of several components of the errors. Keeping that in mind, these reservations do not mean that the attempt to estimate errors should be abandoned as scholars should be as transparent as possible about their uncertainties. The data arising from the reconstruction of the other manuscripts of *Instruction* will allow us to narrow down this range, producing an increasingly accurate reconstruction.

1 The Reconstruction of 4Q418a: State of the Art

The main advancement in ordering the fragments and wads of 4Q418a was achieved by Eibert Tigchelaar.[1] The fact that the fragments were preserved in wads indicates that deterioration took place while the scroll was still rolled, and that all fragments belonging to a respective wad were located on the same height in the scroll in consecutive turns. Since the fragments of each wad remained glued even after the rest of the scroll had vanished, the order of the

1 Tigchelaar, *Increase Learning*, 126–31.

 | DOI:10.1163/9789004473058_022

fragments in each wad corresponds to their original order. Tigchelaar consulted the PAM images that documented the peeling process, achieving additional material and textual insights for the various fragments. He concluded

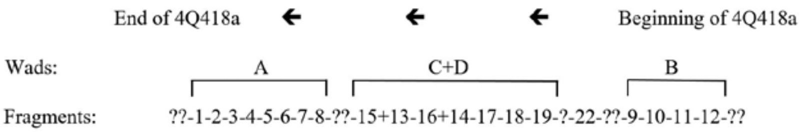

FIGURE 99 Tigchelaar's reconstruction of the order of fragments in 4Q418a

that all extant wads were once part of a single stack of fragments, which originated from an area near the bottom margin. In addition, he successfully reconstructed the order of the wads as follows[2]:
The beginning of the scroll stands at the right-hand side of the sequence, its end to the left. Capital letters indicate the particular wads, marked above the list of fragments that are included in that wad. In Tigchelaar's notation, one question mark represents one potentially missing layer, while two question marks represent an unknown number of missing layers.[3]

According to Tigchelaar, the scroll was rolled in the normal way with the beginning of the composition to the outside. Therefore, the more a fragment is located in a lower layer when the wad is placed on a table, i.e., the more it lies to the outside of the scroll, the earlier it belongs in the composition.[4] He also established the height of all columns as 36–37 lines.[5] The reconstruction suggested hereby confirms this number, which is higher than the average of 20 lines per column in the DSS corpus.[6] However, as demonstrated in Appendix 1, an average error of ±7% may be expected for the number of lines in a column, which amounts to 2.5 lines. Thus, the number of lines in this scroll may be between 34–39. Other copies of *Instruction* have fewer lines per column (21 in 4Q416, 28 in 4Q417 and 4Q418). Variation of the number of lines in copies of the same composition is frequent in other DSS.[7] According to the current reconstruction, these 36–37 lines add up to 23.3–23.8 cm, and including the potential error of the height the range is between 22–25 cm (see Appendix 1). No upper

2 Tigchelaar, *Increase Learning*, 130.
3 Tigchelaar, *Increase Learning*, 130.
4 Tigchelaar, *Increase Learning*, 127.
5 Tigchelaar, *Increase Learning*, 130–31.
6 Tov, *Scribal Practices*, 84–91. Tov classifies the scrolls that contain such writing blocks as "very large." This group of scrolls contains mainly scripture. Scrolls with the same number of lines per column are 4QProv^{a}, 11QPs^{a}, and 4QGen-Exod^{a}. Tov debates whether or not the size of the non-canonical very large scrolls indicates their authoritative status.
7 Tov, *Scribal Practices*, 95–98.

margins were preserved, and the bottom margins that were preserved are broken. Thus, we have no way of measuring the full height of the sheets. Tov's data shows that upper and bottom margins in Qumran are usually between 1.5 and 2 cm, but larger margins of up to 8 cm exist too.[8] Thus, an educated guess would point to a sheet height of around 24–27 cm or slightly higher.

In addition, we were able to determine that the width of the columns of the scroll varies between 40 and 60 letters per line or between approximately 9 and 12.5 cm, with an average column of 10.7 cm and a standard deviation of 1.1 cm. This fits Davis's note that most large scrolls, measuring over 30 cm in height, have columns 10–13 cm wide.[9] According to the present reconstruction, the width of the intercolumnar margins *within sheets* is approx. 0.8 to 1.5 cm, with an average of approx. 1 cm and a standard deviation of 0.25 cm. The width of intercolumnar margins *between sheets* is 1.3 to 3 cm including the stitches, with an average of 2.3 cm and a standard deviation of approx. 0.8 cm.[10] The number of columns from the beginning of the scroll to the last preserved fragment (frag. 1, which is the first layer of wad A) is 20, but crumbles of skin attached to the last fragment (named here fragment 0) testify to the existence of at least one more column. As mentioned in chapter 12, it is impossible to determine the length of the rest of the scroll with any accuracy. The results can be seen in figure 119.

In addition to establishing the above data, we were able to answer some of the questions left open by Tigchelaar:

1. Only one column preceded the column attested in fragment 12.
2. Fragment 20+21 belongs to the left of fragment 9, and is joined to another fragment that was originally in wad B on top of fragment 9, to which we assign the number 9b.
3. Fragment 22 is in fact a wad, containing several new fragments layered underneath. Although they cannot be separated without damage, the examination of this wad sheds more light on the length of the scroll.
4. Several more hitherto unknown fragments remain attached underneath other fragments of wads A, C, and D, and on top of wad B. Some of them are legible.
5. Fragment 19 follows immediately after fragment 22.
6. At least one layer is missing between wad A and wads D+C. It may be found underneath fragment 7, the last fragment of wad A.

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8 Tov, *Scribal Practices*, 94.

9 Kipp Davis, "High Quality Scrolls from the Post-Herodian Period," in Elgvin, Davis, and Langlois, *Gleanings from the Caves*, 129–138, here 130, n. 3. Note that the scrolls discussed in his paper are slightly later than 4Q418a.

10 This is an average width of margins compared to other DSS, see Tov, *Scribal Practices*, 103.

7. In addition, we offer some corrections to the number and order of fragments in wad A.

Incidentally, the chain of events that took part as we created this reconstruction is quite significant. After the present reconstruction had already been finalized, an examination of earlier images yielded two more fragments that were once attached on top of wad B. In an astonishing way, these new fragments constituted a perfect match to fragments 20+21 and 22c, according to the place assigned to them in the reconstruction. Not only did the boundaries of one fragment (9b) match the boundaries of fragment 20+21, but also the remains of a right margin on the second fragment (9a) fell into place exactly where our reconstruction predicted it will be (see chapter 15). This new find significantly buttresses our suggested reconstruction.

2 The Wads

We will now present our digital and material reconstruction of 4Q418a with the additions and improvements of the work of previous scholars. While the methodological chapters of this book discussed each topic separately to facilitate understanding, in reality the order of work is not as clear-cut. We therefore first present each wad and the information learned from it, including textual parallels to other copies, identification of additional layers, joins, margins, and other clues that helped the reconstruction. This presentation includes analysis related to the above methodological chapters: "Recreating Single Columns Based on Fragments and Parallels" (chapter 9) and "Damage Patterns" (chapter 11). After the presentation of the wads, we return to the order of the methodological discussion above. We begin with wads D and C, which include the anchor fragments. They are placed approximately in the middle of the reconstruction. We then proceed with wads E and B to their right, which include additional important information that validates the exact place of the fragments. We finally end with wad A to the left of the scroll, with its own information.

2.1 *Wad D (fragments 15–19; PAM 41.891, 41.909, 41.973, 41.997, 43.687; IAA Plate 511, fragments 14–16)*[11]

Wad D contains several textual overlaps with other copies, which makes it the key for the entire reconstruction. Its most important parallel is 4Q416 2 i–iv, the largest fragment of *Instruction*, preserving four consecutive columns. Due

11 Fragments number 15, 16, and 18 have deteriorated and are no longer represented on the IAA plate.

FIGURE 100 The text of 4Q416 2, 4Q417 2, and 4Q418 7–10 cast in the layout of 4Q418a, Columns IX–XII. The continuous text parallels fragments from both wads D and E. Arabic numerals designate fragment numbers; Roman numerals designate column numbers.

to its exceptional size and the large amount of nearly uninterrupted text, this fragment is the main anchor of the textual reconstruction, in relation to which other fragments are placed (see images: B-496201, B-499639, B-499640).[12]

Two fragments from wad D find parallels in 4Q416 2. Fragment 19 (layer 5) overlaps with 4Q416 2 ii 14–16 and 4Q417 2 ii 18–21. Strugnell and Harrington suggest a second overlap between frag. 18 (layer 4) and 4Q416 2 iv 3–7. Although column iv of 4Q416 2 is preserved in a fragmentary shape, and the overlap is limited, the text of both copies fits well, and there are no attested variants between them. The editors' suggestion was accepted by both Tigchelaar and Qimron (both offering slightly different reconstructions of the missing text).[13] If they are correct, it means that the upper layers (which came from the inner parts of the scroll), belong to a later part of the composition. This is the indication that 4Q418a was rolled in the normal way, with its end inside. The parallel text reveals the number of letters in the columns to which fragments 18 and 19 belong (40–50 letters per line, a rather large variation), and hence their width and the distance between layers. Below we will explain Tigchelaar's use of this parallel for reconstructing the height of the column.

12 For a textual reconstruction of the composite text of this fragment including several 4Q417 and 4Q418 fragments see Qimron, *Dead Sea Scrolls*, 2.152–57.

13 Strugnell and Harrington, DJD XXXIV, 490–91; Tigchelaar, *Increase Learning*, 133; Qimron, *Dead Sea Scrolls*, 2.157.

Another important parallel within wad D is that of frag. 15 (layer 1) to 4Q415 11 3–4 and 4Q418 167b 3–4 (see figure 101 below).[14] This parallel fills 11 additional lines in the textual reconstruction, determines the width of column XIV of our reconstruction, and affects the width of other columns around it.

2.2 *Wad C (fragments 13, 14, 14a; PAM 41.410, 41.972, 43.687; IAA Plate 511, fragment 13)*[15]

Fragment 13 (layer 1) overlaps 4Q418 167a 5. Since frag. 15 (wad D, layer 1) was shown above to overlap with the same parallels, it results that frags. 13 and 15 are distant joins. Fragment 13 contains a bottom margin, hence both wads C and D belong to the bottom of the scroll. Consequently, frag. 14 (layer 2) should also be joined to the bottom of frag. 16 (wad D, layer 2).[16] As explained in chapter 15, by checking the verso of fragment 14 and filtering the new IR image provided by the LLDSSDL, we were able to detect two additional layers

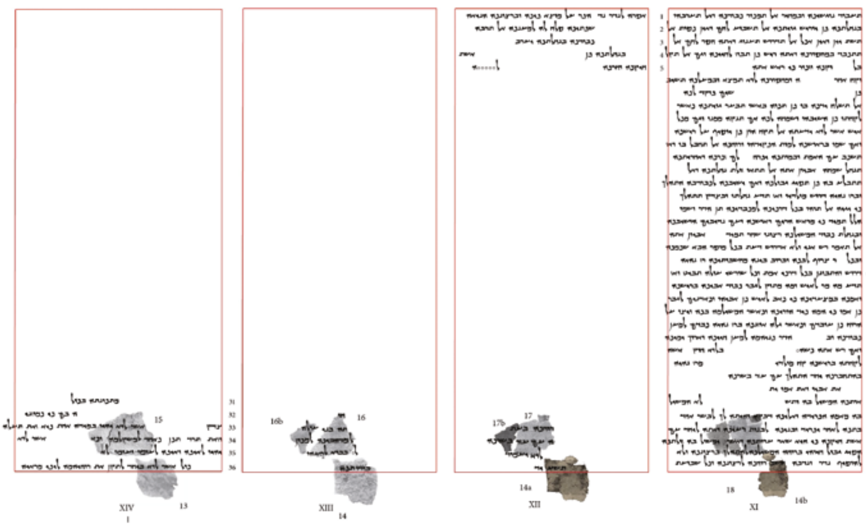

FIGURE 101 Fragments 15+13, 16+14, 17+14a, and 18+14b, columns XI–XIV
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14 For the overlaps between 4Q415 11, 4Q418 167a+b, and 4Q418a 15+13, See Strugnell and Harrington, DJD XXXIV, 488; Tigchelaar, *Increase Learning*, 136; Qimron, *Dead Sea Scrolls*, 2.160.

15 Fragment 13 is lost, its only attestation being PAM 41.410.

16 Strugnell and Harrington, DJD XXXIV, 488; Tigchelaar, *Increase Learning*, 135.

(14a and 14b).[17] 14a should be joined to the bottom of frag. 17, while 14b should be joined to the bottom of frag. 18. Indeed, the text of 14b matches the text known from 4Q416 2 iv that should precede frag. 18.

2.3 *Wad E (fragments 22, 22a, 22b, 22c; PAM 42.247, 43.687; IAA Plate 511, fragment 19)*

Our examination of the images of fragment 22 discovered that more fragments are attached underneath it, constituting a fifth wad (E). This wad contains four layers. Unfortunately, according to the professional estimation of the conservation team of the Israel Antiquity Authority (IAA), it is impossible to peel the layers of wad E since it would completely ruin the upper layer and perhaps also the following ones. The peeling would have allowed us to read the text on each fragment, confirming the exact number of layers. At the present, a thorough examination of the images reveals a few letters on two additional layers as well as a left margin on the second layer of this wad, underneath frag. 22.[18] The left margin served as an anchor for placing frag. 22a and for the entire reconstruction (see below).

Fragment 22 is similar in shape to wad D, indicating that they were once piled together. It also overlaps 4Q416 2 i 7–10 and 4Q417 2 i 12–17. As Tigchelaar correctly calculates based on these parallels, 32–33 lines of text are missing, both between frag. 18 and 19 and between frag. 19 and 22. Tigchelaar concludes that "this number together with the 4 lines of the fragments, suggests we are dealing with a manuscript with a column height of either ca. 36–37 lines or ca. 18 lines." The first option pertains if there was one column between each of these respective fragments, while the second indicates two intervening columns. Eventually Tigchelaar prefers the former, because frags. 9, 10, and 11 (wad B, layers 1–3), coming from an outer part of the scroll, all contain right margins and are thus one column apart (see below).[19] Our digital reconstruction supports Tigchelaar's call. The attempt to digitally create a two-column gap between two layers generated a too-wide distance between the fragments. Tigchelaar was uncertain whether an additional layer was missing between frag. 19 and 22. After determining the height of the columns, our trial and error of the material reconstruction did not permit an additional layer.

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17 We thank Eibert Tigchelaar for pointing out to us additional letters on the verso of frag. 14. He also spotted two more letters at the bottom of the verso of frag. 16, belonging to frag. 17.

18 Ratzon, "New Data," 25–38.

19 Tigchelaar, *Increase Learning*, 129–31.

2.4 *Wad B (fragments 9–12; PAM 41.410, 41.965, 41.972, 41.997, 43.687; IAA Plate 511, fragments 5, 10–12)*

4Q418a frag. 11 (layer 3) overlaps with 4Q417 1 i, which in its turn parallels 4Q418 43+44+45 i–ii (figure 103).[20] This is a very important overlap, because 4Q417 1 is considered to be part of the prologue of the entire composition.[21] The overlap places wad B at the beginning of the scroll.[22] Since the fragments of wad B contain bottom margins, it is evident that wad B originates from the same horizontal height as wad D+C. The similarity in the shape of the boundaries and cracks between frag. 11 and frag. 22 shows that wad B and E were indeed part of the same pile, and that wad B should be placed before wad E. This idea was raised by Tigchelaar, who proposes that all fragments of 4Q418a come from the same pile. Although he thinks that the evidence from the similarity of the boundaries and cracks of wad B is inconclusive, we support this evidence by means of the digital presentation (figure 102).[23]

Even stronger support is achieved by two previously unkown fragments that are visible on top of the wad in PAM 41.410. We name them fragments 9a and 9b. These fragments can be joined to the bottom of fragments 22c and 20+21 respectively.

20 Fragment 4Q418 45 ii does not find parallel in any of the other copies. Since its text carries on to the consecutive column, it must be reconstructed in column IV, although its exact position and layout depend on the unknown width of both columns 4Q418 45 ii and 4Q417 1 ii. The text of 4Q418 45 ii is not attested in Qimron's edition.

21 4Q417 1 was originally designated fragment 2 by Strugnell (Strugnell and Harrington, DJD XXXIV, 151, 169, 192). Elgvin, based on material considerations, claims that the original designation was correct, and that 4Q417 1 should be placed after 4Q417 2. See Elgvin, "The Reconstruction of Sapiential Work A," 568–69; Elgvin, "An Analysis of 4QInstruction," 12–18. However, Steudel and Lucassen (quoted in DJD XXXIV, 19) arrived at the opposite conclusion also on material grounds. The conclusion of the DJD editors is primarily based on the contents of 4Q417 1, which is more suitable for an introduction to the composition. Further, its content is similar to 4Q416 1; the latter fragment contains a wide right margin, suggesting it is the first column of a scroll. See also Tigchelaar, *Increase Learning*, 155–59. Material support for placing 4Q417 1 at the beginning of the scroll will be published as part of the edition of 4Q417.

22 In addition, Tigchelaar, *Increase Learning*, 54, proposes that 4Q417 1 ii parallels 4Q418 103 i, also bearing implications for 4Q418a frag 11. However, this parallel is based on a joined fragment to 4Q418 103 i that we do not accept.

23 Tigchelaar, *Increase Learning*, 129–30.

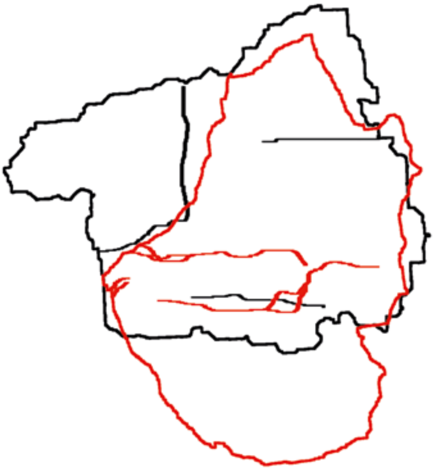

FIGURE 102
Black: borders and cracks of frag. 22;
Red: borders and cracks of frag. 11

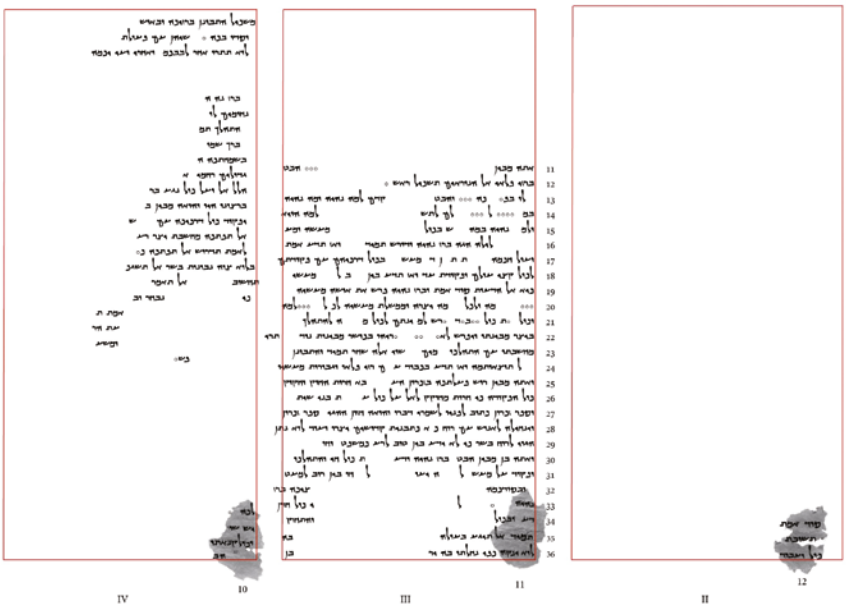

FIGURE 103 Wad B. The text of 4Q417 1 and 4Q418 43+44+45+108 presented in the layout of 4Q418a

2.5 *Wad A (fragments 1–8; PAM 41.973, 41.997, 43.687; Plate 511, fragments 1–4, 6–9)*

As explained in chapter 15, the earliest image of wad A already shows it at the stage after its separation into two piles. We were able to confirm that they both originated from the same wad in the documented order, with the exception of frags. 7 and 8, whose order should be reversed. In addition, remains of the upper part of frag. 6 are still attached underneath frag. 5. Our reconstruction anticipated an additional layer between wad D and wad A. This layer may still exist underneath frag. 7 (which we believe was the last layer of wad A). The ink from the recto of frag. 7 bled through the skin, but parts of it seem to be covered by the other layer (figure 104). Moreover, two separate layers seem to be visible on the bottom left edge of the verso (figure 105).

As Tigchelaar notes, frags. 6–8 (layers 6–8) are nearly identical in shape with frag. 15 (wad D, layer 1). This indicates that wad A and D had once been part of the same pile. Because of the similarity to the first layer of wad D, Tigchelaar places wad A after wad D.[24]

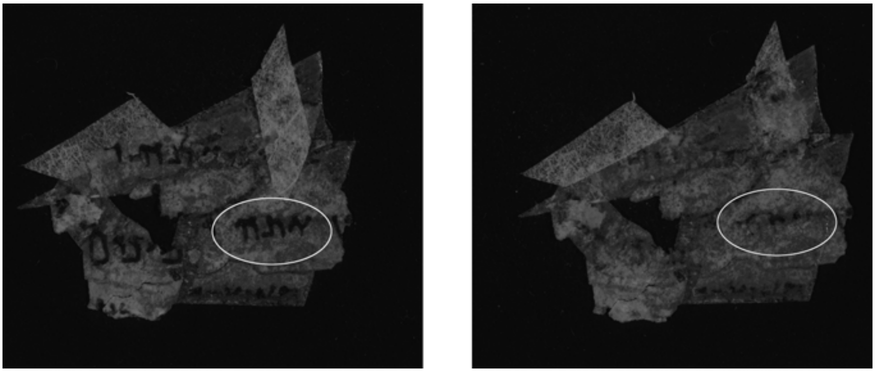

FIGURE 104 Left: IR image of 4Q418a 7 recto; Right: IR image of 4Q418a 7 verso, flipped and enhanced. The same word is circled in white both on the recto and on the verso. The horns of the א and the roof of the ת and ה are visible on the verso image, but the bottom parts of these letters are covered by another layer. © IAA, LLDSSDL, SHAI HALEVI

24 Tigchelaar, *Increase Learning*, 129. In fact, frags. 6–8 are also similar to frag. 22. This similarity may theoretically indicate that wad A should be placed between wads B and D, but for frags. 6–8 to be in proximity to frag. 22, one should assume that frags. 6–8 were placed above frags. 1–5, in an inner turn of the scroll. This can be ruled out, because as shown in the previous chapter, part of frag. 6 was torn away and is still attached to the verso of frag. 5, thus proving the documented order.

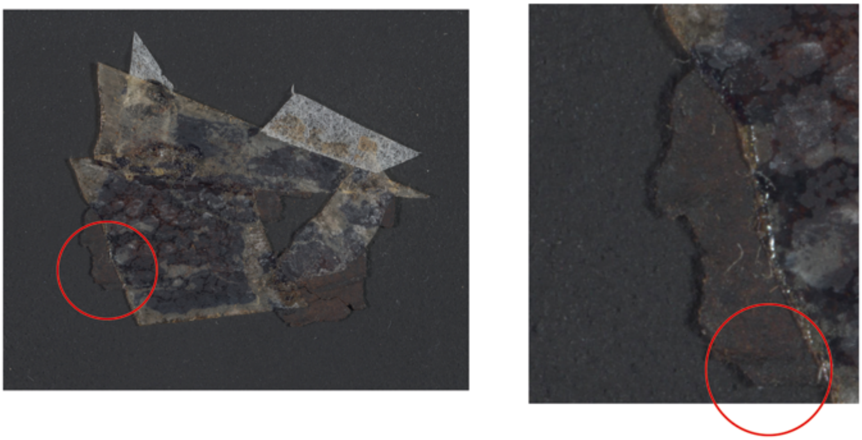

FIGURE 105 Multispectral image of 4Q418a 7 verso. The area in the red circle is enlarged in the right image, showing two separate layers one on top of the other.
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Fragment 3 overlaps 4Q423 5. This parallel adds two more lines to the textual reconstruction below frag. 3 (layer 3), and eight lines to the top of the next column. Fragment 7 (layer 7) overlaps 4Q415 6. This overlap is significant for the reconstruction of 4Q415, as 4Q415 11 contains also a parallel to 4Q418a 15.[25]

2.6 *Fragment 20+21 (Plate 511, Frag. 20+22; PAM 41.375, 42.760, 43.687)*

Fragment 20+21 is the only single-layered fragment in 4Q418a. Its earliest image in PAM 41.375 clearly shows one fragment, which, having been broken during the 1950s, received two different numbers.[26] The text on this fragment does not overlap with any known text from elsewhere in *Instruction*. Its shape was the first indication for its location. The borders of fragment 20+21 resemble the cracks of fragment 22.[27] They are also as narrow as fragments 10–12 from wad B. Hence, a location between wad B and wad E seems like the best

25 Strugnell and Harrington (DJD XXXIV, 480–81) proposed that 4Q418 103 ii is an overlap for frag. 4 (layer 4). Their proposal was accepted by Tigchelaar, *Increase Learning*, 137 and Qimron, *Dead Sea Scrolls*, 2.169. However, their claim that "the text of line 2 coincides almost exactly with that of 4Q418 103 4" is more of an overstatement, see chapter 15. For the implications of the present reconstruction on the reconstruction of 4Q415 see Dayfani, "Material Reconstruction."

26 According to DJD XXXIV, 492, it once belonged to a wad, but this is probably a mistake, as discussed above. See Tigchelaar, *Increase Learning*, 138–39.

27 Tigchelaar, *Increase Learning*, 129.

option. The borders of the previously unknown fragment 9b physically join fragment 20+21, which also confirms its position.

3 Reconstruction of 4Q418a

After discussing each wad separately, it is time to return to the order of the reconstruction procedure as described in the first part of the present book.

Placing all the fragments on the canvas. All fragments were prepared according to the methodology described in chapters 3–9. This task includes applying filters, examining the verso of each fragment, choosing the best image, enhancing it if necessary, scaling, removing the background, digitally restoring the fragments, and reading them. When each fragment is ready, it can be placed on the canvas for the reconstruction of the entire scroll.

Creating a custom-made font. Due to the degraded shape of the fragments we were unable to choose suitable letters from the fragments of 4Q418a. Instead we used letters taken from 4Q418, whose paleography is nearly identical to that of 4Q418a. After creating the basic font, we measured all the spaces between words in the existing fragments of 4Q418a, calculated their average, and applied it to the space glyph in the custom font.

The text preserved on the fragments was then typed as discrete text layers, and placed in the foreground in order to be seen above the fragments in the electronic display. We tried to fit every letter to its corresponding letter in the image without interfering with the space between letters or letter width. We then collected pairs of letters whose kerning required adjustment. The adjustment of kerning was done specifically for 4Q418a.

Recreating single columns based on fragments and parallels. After choosing the font size to adapt the printed text to the letters seen on the fragment, we continued to write the rest of the text in the same font size. For the current reconstruction, we used Qimron's edition for the text that was not preserved on 4Q418a. We did not include his reconstructions of the unpreserved text, and calculated these lacunae independently.[28] Fragments 18, 19, 22, and 22a are the key fragments for this reconstruction. Fragments 18, 19, and 22 overlap the large fragment 4Q416 2 (combined with the text of 4Q417 2). Although we know from the parallel copy the number of letters in each line of these three fragments, no right or left margin is preserved on any of them. Thus, theoretically each fragment can be placed anywhere within its column (near the right margin, in the

28 In some cases, the newly computed size of lacunae contradicts Qimron's reconstructions, but these cases will be published separately.

middle, or near the left margin). In practice, not every placement fits the alignment of the words as they were preserved on the fragment. Of note, frag. 19 was not easy to adapt. After ruling out several locations, the suggested reconstruction was the only one possible. For fragment 22a, however, we have no parallel text, but it does preserve a left margin, anchoring it at the end of column VIII. After all the trial and error, arranging the text of 4Q416 2 and 4Q417 2 in the layout and font of 4Q418a, reveals the following measurements:

– Column XI, attested in fragment 18, holds 44–48 letters per line, corresponding to an average width of 95.4 mm, which gives a density of 0.46–0.53 letters per mm.
– Column X, attested in fragment 19, holds 40–46 letters per line, corresponding to an average width of 88.6 mm, which gives a density of 0.45–0.51 letters per mm.
– Column IX, attested in fragment 22, holds 54–64 letters per line, corresponding to an average width of 120.4 mm, which gives a density of 0.45–0.53 letters per mm.

The experiment described above (chapter 10) for the use of a font in the procedure of reconstructing the width of a column, showed an expected error of approximately ±4%, which corresponds to 3.8, 3.5, and 4.8 mm respectively. This error should thus be assumed for columns IX–XI.

The height of the columns was established by adjusting the rest of the text of 4Q416 2 and 4Q417 2 into the layout of 4Q418a between the parallel fragments. The text fits into 36 lines between fragments 18 and 19, and 37 lines between fragments 19 and 22.[29] This difference falls within the margin of error for a font-assisted reconstruction of column height (see chapter 10). Consequently, we cannot be certain if it reflects the irregularity of the scribe's handwriting or a difference in the height of the two columns. If indeed there was such a difference, in most scrolls all columns begin at the same height, but sometimes a line is supplemented at the bottom of the column. We therefore added that additional line at the bottom of column IX under fragment 22.[30]

29 The space between lines in frag. 18 is uneven and narrower than the space between lines in frag. 19. We have noticed that the space between lines in frag. 18 grows narrower towards the bottom of the fragment, thus, it is likely that the spaces in the lines above were wider. Perhaps frag. 18 has shrunk near its bottom.

30 At this point, the fine-tuning of the experiment in chapter 10 proved significant. Before adjusting the space and the kerning to 4Q418a, the text between frags. 22 and 19 required only 36 lines, ignoring the 37th line required in column X. The right number was achieved only due to the accurate kerning, showing the significance of such adjustments for the reconstruction.

Damage patterns. The damage patterns in this scroll are in fact the wads, whose analysis was already recounted in great detail. To conclude, after establishing the order of wads and the order of fragments within each wad, we can now order the fragments of the entire scroll, as seen in figure 106:[31]

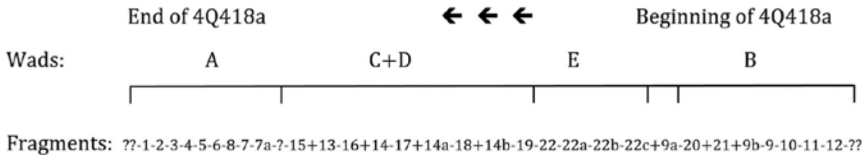

FIGURE 106 The suggested order of fragments in 4Q418a

Having established the order of the fragments, we can now proceed to calculate the distances between them.

4 Placing the Fragments on the Canvas Using the Stegemann Method

In order to ascertain the distance between these fragments, an additional datum is required: the width of the intercolumnar margins. As can be seen from other scrolls that preserve several consecutive columns, the width of columns and margins is not uniform throughout a scroll. Average margins are between 10–15 mm.[32] This variety within the same scroll allows some liberty in the reconstruction within certain limits, while at the same time calling for methodological prudence.

Two fragments preserve a large portion of margins: fragment 9 and fragment 5. The former also contains traces of stitches between sheets, and its width is 6 mm from the end of the line to the stitches. Unfortunately, neither of these fragments contains text from both sides of the margin, and therefore we lack their full width. The margin in frag. 5 is nearly 25 mm wide, a very wide margin compared to other scrolls,[33] but later in the reconstruction process this intercolumnar margin proved most probably to belong to a space between sheets, which explains its excessive width. Following the methodology of trial and error, we tested several possibilities for the width of the margins between the anchor columns of 4Q418a, many of which contradicted some of the data on

31 Fragment 20+21 is joined to fragment 9a from wad B, but was not preserved as part of wad B.

32 Tov, *Scribal Practices*, 103.

33 Tov, *Scribal Practices*, 103.

the preserved fragments. Eventually, the chosen width was set according to the restrictions of each column, as will be detailed below.

We set frag. 22a on the left margin of its column, and frag. 19 around the middle part of its column, the only possible place for it. The margin between columns VIII and IX was thus set to be 15.5 mm, and that between columns IX and X to 22.3 mm. The latter is wider since it lies between frags. 22 and 19, which belong to two different wads (E and D respectively). In this point we make the plausible assumption that the wads were separated in the places where the stitches used to be. The stitching eased the tightness of the roll and prevented the layers from attaching to each other. If indeed frags. 22 and 19 belong to two different sheets, one can expect the margins between sheets to be larger on average. Thus, the distance between frags. 19 and 22a, which includes the width of columns IX and X and the intercolumnar margins to their right is 211.5±10 mm.[34]

In order to place the rest of the fragments, we used the Stegemann method to calculate the incremental growth of distances between consecutive layers. The increase is dependent on the thickness of the skin and the tightness of the rolling. While we were unable to measure the thickness of the fragments, our examination in the IAA lab showed that their skin is thin compared to other scrolls. Since there is meager information about the thickness of the scrolls in general, we relied on the little available information in addition to crude estimations. According to Stegemann, the thickness of the *Temple Scroll*, which is one of the thinnest known scrolls, is 0.16 mm. He calculates its increase from one layer to another as about 1 mm, a rather tightly-rolled scroll. He describes the general picture as:

> The circumference of a layer may increase by rates varying from about 1 mm, as in the Temple Scroll, up to about 5 mm, as in one of the manuscripts of 4QAngelic Liturgy, partly published by J. Strugnell in 1959, or in 4Q504 (4QDibHam^{a}), published by M. Baillet in 1982. Most of the leather scrolls, however, have rates of increase of about 2 or 3 mm, as the quality of the leather was only of medium grade.[35]

The skin of 4Q418a is very thin. From the fact that the fragments were glued to each other in wads we conclude that the scroll was rolled tightly. We therefore

34 The error is composed of the uncorrelated errors of the width of columns IX, X, and their intercolumnar margins. The error for the intercolumnar margins was separately calculated for margins within sheets and those between sheets, using the average and standard deviation of each type. It is thus calculated: $\sqrt{3.5^2 + 4.8^2 + 8^2 + 2.5^2} \approx 10$.

35 Stegemann, "Methods for the Reconstruction," 195.

used an increase rate of 1.5 mm. Based on Ratzon and Dershowitz's examination of scrolls that were preserved comparatively intact, the error for the differences is 1 mm (see Appendix 3).[36] Thus, we placed frag. 22 between frags. 19 and 22a: 105±5 mm away from frag. 19, and 106.5±5 mm from frag. 22a.[37]

Choosing the points of recurring damage from which to measure the distances can affect the measured value. We examined the PAM images to decide which point of a certain layer was placed on the layer beneath it, also based on the similar cracks of consecutive fragments. In the few cases where this was not possible, we chose a point on the borders of the fragment in a place that seemed most similar to the borders of the other fragment. While the Adobe InDesign measuring tool gives a very high precision, the human factor gives a measurement error of approximately 0.5 mm.

Since frags. 19–22a served as the anchor for this reconstruction, we placed all the fragments to the left of frag. 19 in decreasing distances, and the fragments to the right of frag. 22a in increasing distances. The distance of each fragment from frags. 19 or 22a to the left and right respectively (S_n) may vary in a certain range because of the potential error, as explained in Appendix 3, and will be demonstrated in the following excursus.

5 Excursus: Calculating the Error for the Distance of Each Fragment from the Anchor Fragments and from Its Consecutive Fragment

The error for the distance of each fragment is calculated by means of the following equation (Appendix 3):

$$\Delta S_n = \sqrt{(n\Delta a_1)^2 + \left(\frac{n(n-1)\Delta d}{2}\right)^2 + \left\{\left[a_1 + d\left(n - \frac{1}{2}\right)\right]\Delta n\right\}^2}$$

The error for the distance between two consecutive fragments is:

$$\Delta a_n = \sqrt{\Delta a_1^2 + [(n-1)\Delta d]^2 + (d\Delta n)^2}$$

In this expression, n is the number of fragments from frags. 19 or 22a to the left or right respectively.

36 Ratzon and Dershowitz, "The Length of a Scroll."

37 The error for the distance between frag. 22 and frags. 19 and 22a depends on the errors for the distance between frags. 19 and 22a, and the error for the increase of the distances between layers (d). The latter, however, is negligible, and we were thus able to divide the error equally between the two distances.

a_1 is the distance between frags. 19 and 22 for the computation of the fragments to the left (105 mm), and the distance between frags. 22 and 22a for the computation of the fragments to the right (106.5 mm).

Δa_1 is the error for the above distances, which is 5 mm.

d is the difference (the increase or decrease) of the distances between consecutive fragments (1.5 mm).

Δd is the error for the difference (d), which is 1 mm.

Δn is the error for the number of layers. Within the same wad this error is zero, but when moving from wad to wad, we assume a potential error of 1 layer. Larger errors are less probable. Therefore, for fragments within wads D and E the error is 0 and for fragments from wad A the error is 1. As the position of wad B was confirmed by the join to wad E, the error for its fragments is also 0.

While it is possible to calculate up to several digits after the decimal point, this kind of precision is meaningless in the present case. The values should normally be rounded to 10% of the magnitude of the potential error. Nevertheless, as we set the fragments in an increasing/decreasing distance of 1.5 mm from each other, we keep that precision, in order to make our work clearer to the reader. We gave the possible range of each result in parenthesis in rounded numbers.

In the following tables we give the distances of each fragment from their consecutive fragment and from the anchor fragment (frag. 22) and the respective error:

TABLE 17 Positions of fragments to the left

Fragment	Wad and Layer	a_n–Distance from consecutive fragment (mm)	Δa_n–Theoretical margin of error (mm)	S_n–Distance from fragment 22 (mm)	ΔS_n–Theoretical margin of error (mm)	ΔS_n–Theoretical margin of error (%)
18+14b	Wad D, layer 4 + Wad C, layer 4	103.5 (98–109)	5.1	208.5 (198–219)	10.0	4.8
17+14a	Wad D, layer 3 + Wad C, layer 3	102 (97–107)	5.4	310.5 (295–326)	15.3	4.9

TABLE 17 Positions of fragments to the left (*cont.*)

Fragment	Wad and Layer	a_n–Distance from consecutive fragment (mm)	Δa_n–Theoretical margin of error (mm)	S_n–Distance from fragment 22 (mm)	ΔS_n–Theoretical margin of error (mm)	ΔS_n–Theoretical margin of error (%)
16+14	Wad D, layer 2 + Wad C, layer 2	100.5 (95–106)	5.8	411 (390–432)	20.9	5.1
15+13	Wad D, layer 1 + Wad C, layer 1	99 (93–105)	6.4	510 (483–537)	26.9	5.3
7a	Wad A, layer 9	97.5 (90–105)	7.2	607.5 (489–726)	118.1	19.4
7	Wad A, layer 8	96 (88–104)	8.0	703.5 (582–825)	121.8	17.3
8	Wad A, layer 7	94.5 (86–103)	8.7	798 (672–924)	126.1	15.8
6	Wad A, layer 6	93 (83–103)	9.6	891 (760–1022)	131.1	14.7
5	Wad A, layer 5	91.5 (81–102)	10.4	982.5 (846–1119)	136.9	13.9
4	Wad A, layer 4	90 (79–101)	11.3	1072.5 (929–1216)	143.6	13.4
3	Wad A, layer 3	88.5 (76–101)	12.2	1161 (1010–1312)	151.3	13.0
2	Wad A, layer 2	87 (74–100)	13.1	1248 (1088–1408)	160.1	12.8
1	Wad A, layer 1	85.5 (71–100)	14.0	1333.5 (1164–1503)	169.9	12.7

TABLE 18 Positions of fragments to the right

Fragment	**Wad and Layer**	**a_n–Distance from consecutive fragment (mm)**	**Δa_n–Theoretical margin of error (mm)**	**S_n–Distance from fragment 22 (mm)**	**ΔS_n–Theoretical margin of error (mm)**	**ΔS_n–Theoretical margin of error (%)**
22b	Wad E, layer 3	108 (103–113)	5.1	214.5 (204–225)	10.0	4.7
22c	Wad E, layer 4	109.5 (104–115)	5.4	324 (309–339)	15.3	4.7
20+21	Single layer	111 (105–117)	5.8	435 (414–456)	20.9	4.8
9	Wad B, layer 1	112.5 (106–119)	6.4	547.5 (521–574)	26.9	4.9
10	Wad B, layer 2	114 (107–121)	7.1	661.5 (628–695)	33.5	5.1
11	Wad B, layer 3	115.5 (108–123)	7.8	777 (736–818)	40.8	5.3
12	Wad B, layer 4	117 (108–126)	8.6	894 (845–943)	48.8	5.5

As seen in Tables 17 and 18, the computed length of the right part of the scroll from fragment 22 to fragment 12 is nearly one meter, and from fragment 22 to the left of the scroll until fragment 1 the length is over 1.3 meters. Thus, the entire preserved scroll between fragment 1 and 12 is over 2 meters long. Taking into account the possible error, the length of the preserved scroll is between 2–2.5 meters. The original scroll was probably longer, as it definitely contained at least one more column at its beginning and end. The potential error of the positions for each fragment varies between 4.7–19.4%. It is larger when the number of missing layers is not exactly known. Nevertheless, this error is considerably lower than the huge errors measured by Ratzon and Dershowitz for the reconstruction of the length of a scroll using the Stegemann method.[38] The reason for better certainty in this case is the knowledge we possess regarding the number of turns in the preserved part of the scroll, as each layer constitutes

38 Ratzon and Dershowitz, “The Length of a Scroll.”

one turn. Moreover, not every position within the potential range is possible, since some of them may lead to contradiction with other data, such as the existence of parallels and intercolumnar margins. In addition, one cannot simply change the position of one single fragment. The fragments' positions are co-dependent. This error is thus only a starting point, which will be reduced later in the process. Nevertheless, it may change the reconstruction to include one more or less column in every direction. It is important to be aware of these margins of error for future reconstructions of other copies of *Instruction*. The restrictions deduced from the data of other manuscripts are expected to further narrow down the range of possible reconstructions.

6 Columns and Margins

The positions of the fragments according to the table suggest the width of each column. Here the calculated measurement is affected by certain limitations found on the actual fragments, such as the existence of real (i.e., not calculated) margins and of a parallel text. The width of the columns and margins together with their potential errors and possible ranges are given in Table 19 and will be followed by detailed explanations. Note that the upper and lower limits of each value are not always equal, depending on the data preserved on each fragment. All numbers are rounded up to one millimeter.

TABLE 19 Columns and margins of 4Q418a

Columns and Margins	Layers/Fragments	Width	Error (mm)
Col. I	–	112 (101–123) mm	11
Margin I–II	–	13 (10–16) mm	2.5
Col. II	Wad B, layer 4 (= frag. 12)	112 (109–123) mm	+11 −3
Margin II–III	Wad B, layer 3 (= frag. 11)	15 (12–18) mm	2.5
Col. III	Wad B, layer 3 (= frag. 11)	105 (101–109) mm	4
Margin III–IV	Wad B, layer 2 (= frag. 10)	10 (7–13) mm	2.5
Col. IV	Wad B, layer 2 (= frag. 10)	105 (97–108) mm	+3 −8
Margin IV–V	Wad B, layer 1 (= frag. 9)	13 (10–21) mm	+8 −3
Col. V	Wad B, layer 1 (= frag. 9)	95 (84–102) mm	+7 −11
Margin V–VI	–	8 (5–11) mm	2.5

TABLE 19 Columns and margins of 4Q418a (*cont.*)

Columns and Margins	**Layers/Fragments**	**Width**	**Error (mm)**
Col. VI	frag. 20+21 Wad B, layer 1b (= frag. 9b)	117 (106–129) mm	+12 −11
Margin VI–VII	Wad E, layer 4 (= frag. 22c) Wad B, layer 1a (= frag. 9a)	9 (6–12) mm	2.5
Col. VII	Wad E, layer 4 (= frag. 22c), Wad E, layer 3 (= frag. 22b) Wad B, layer 1a (= frag. 9a)	117 (114–129) mm	+12 −2.5
Margin VII–VIII	Wad E, layer 3 (= frag. 22b)	9 (6–12) mm	2.5
Col. VIII	Wad E, layer 2 (= frag. 22a), Wad E, layer 3 (= frag. 22b)	108 mm	Very low
Margin VIII–IX	Wad E, layer 2 (= frag. 22a)	15 (12–18) mm	2.5
Col. IX	Wad E, layer 1 (= frag. 22)	120 (115–125) mm	5
Margin IX–X	–	22 (14–30) mm	8
Col. X	Wad D, layer 5 (= frag. 19)	89 (85–93) mm	4
Margin X–XI	–	9 (6–12) mm	2.5
Col. XI	Wad D, layer 5 (= frag. 18), Wad C, layer 4 (= frag. 14b)	95 (91–99) mm	4
Margin XI–XII	–	9 (6–12) mm	2.5
Col. XII	Wad D, layer 3 (= frag. 17), Wad C, layer 2 (= frag. 14a)	96 (80–112) mm	16
Margin XII–XIII	–	9 (6–12) mm	2.5
Col. XIII	Wad D, layer 2 (= frag. 16), Wad C, layer 2 = (frag. 14)	96 (80–112) mm	16
Margin XIII–XIV	–	9 (6–12) mm	2.5
Col. XIV	Wad D, layer 1 (= frag. 15), Wad C, layer 1 (= frag. 13)	102 (98–106) mm	4
Margin XIV–XV	–	28.5 (20–37) mm	8
Col. XV	Wad A, layer 9 (= frag. 7a), Wad A, layer 8 (= frag. 7)	128 (117–139) mm	11
Margin XV–XVI	–	10 (7–13) mm	2.5
Col. XVI	Wad A, layer 7 (= frag. 8)	118 (96–138) mm	+20 −22
Margin XVI–XVII	–	10 (7–13) mm	2.5
Col. XVII	Wad A, layer 6 (= frag. 6), Wad A, layer 5 (= frag. 5)	123 (113–137) mm	+14 −10.4
Margin XVII–XVIII	Wad A, layer 5 (= frag. 5)	30 (22–38) mm	8

TABLE 19 Columns and margins of 4Q418a (*cont.*)

Columns and Margins	Layers/Fragments	Width	Error (mm)
Col. XVIII	Wad A, layers 4 (= frag. 4)	93 (82–111) mm	+18 −11
Margin XVIII–XIX	–	9 (6–12) mm	2.5
Col. XIX	Wad A, layer 3 (= frag. 3)	101 (90–131) mm	+30 −11
Margin XIX–XX	–	13 (10–16) mm	2.5
Col. XX	Wad A, layer 2 (= frag. 2), Wad A, layer 1 (= frag. 1)	108 (87–142) mm	+34 −21

6.1 *Considerations Underlying the Data in Table 19*

The following section explains the reasoning for the width of the columns and margins, both to the right and to the left of columns IX–XI. The latter columns served as the anchor for the entire array of measurements, as explained above.

In the discussion below we explain the considerations for the width of every column. A separate paragraph will state the error that could be expected for that column and the factors that led to this calculation. We distinguish intercolumnar margins *within* sheets from those margins that stand *between* sheets. The average of each group is calculated separately. The standard deviation from that average is taken to be the margin of error for each group. For the width of the columns we had more information, and were hence able to give a better estimation for the error of their width. There is often more than one way to compute the margin of error, and some of our estimations might be judged differently by other scholars. The most important point to be taken from the below explanations is the order of magnitude of the errors and the kind of considerations accompanying them.

6.1.1 The Left Part of the Scroll

To the left of columns IX–XI, the anchor of our reconstruction, some of the fragments of wad D and all the fragments of wads A and C are placed. Several restrictions exist on the reconstruction of the left part of the scroll: the preservation of intercolumnar margins on fragments 5 and 1, and the fact that frags. 13 and 15 are paralleled in 4Q415 and 4Q418. This parallel determines the length of the lines of column XIV.[39]

39 Parallel texts exist also for fragments 7 and 3. However, in these cases there is no sufficient information to determine the width of the lines.

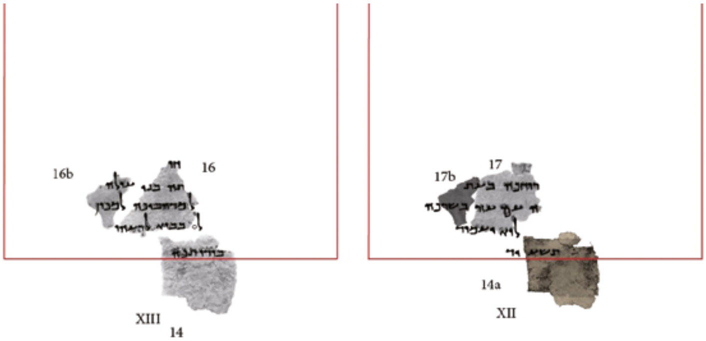

FIGURE 107 Columns XII and XIII

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

6.1.2 Columns XII–XIII

Since the preserved fragments 14, 14a, 16, and 17 do not provide any information on how to divide their columns, we set them to the same width as column XI, with equal margins to the margin between columns X and XI (figure 107). Evenly dividing the uninscribed length between fragments 15 and 18, which do have textual parallels to indicate their columns' width, gives the same result.[40] Support for this decision comes from the fact that it allowed an easy reconstruction of column XIV with the parallel text to frags. 13 and 15.

The error for the columns' width results from all the used data: the errors for the distance between fragments 15 and 18, the parts of columns XI and XIV contained within this distance, and the width of the three margins in that area (XI–XII, XII–XIII, XIII–XIV).[41]

6.1.3 Column XIV

Fragments 13 and 15 stand at the bottom of column XIV, with their text paralleling 4Q415 11 and 4Q418 167a+b. The combination of all three copies dictates the length of the lines in this column. The potential error derives only from the use of the font for the reconstruction of the text (figure 108).

40 $$\mathrm{L}_{\mathrm{XII}} = \mathrm{L}_{\mathrm{XIII}} = \frac{L_{15-18} - L_{XI} - L_{XIV} - L_{XI-XII} - L_{XII-XIII} - L_{XIII-XIV}}{2}$$

41 $$\Delta \mathrm{LXII} = \Delta \mathrm{LXIII} = \frac{\sqrt{\Delta L^2 + \Delta L_{XI}{}^2 + \Delta L_{XIV}{}^2 + \Delta L_{XI-XII}{}^2 + \Delta L_{XII-XIII}{}^2 + \Delta L_{XIII-XIV}{}^2}}{2}$$
$$= \frac{\sqrt{31.4^2 + \left(3.8\frac{45.5}{95.8}\right)^2 + \left(4.1\frac{38.5}{101.7}\right)^2 + 2.5^2 + 2.5^2 + 2.5^2}}{2} \approx 16$$

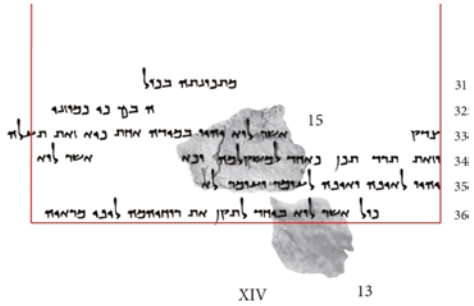

FIGURE 108
Column XIV
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6.1.4 Column XV

Col. XIV (frags. 13, 15) is the last column with fragments from wads C and D. The subsequent columns are represented by wad A, where frag. 7 represents the next known layer, whose text may overlap 4Q415 6, but it is not possible to infer a length of a line from these fragments. The width of column XV should thus be deduced by other means. We know that frag. 7 was not part of column XIV, because the text of the lower part of that column is known from parallel copies. We thus expect that the next two layers both belong to column XV. The problem is that the text of frags. 7 and 8 is hardly comprehensive. Their vocabulary is different, and while frag. 7 uses the second person singular, frag. 8 uses the third person plural. The only solution to the problem is that another layer is missing between wads A and D. In fact, this layer may be present in an additional fragment underneath frag. 7 which should be named 7a, as was shown above in the discussion on wad A. Theoretically, it is possible to add more than one fragment to the reconstruction. We examined the option that two fragments existed between wad A and wad D (fragments 7a and 7b), and it did not lead to a contradiction. However, we prefer to choose the minimalist option that requires the assumption of as fewest unpreserved fragments as possible. The fact that a larger number of fragments could not be ruled out means that the certainty of the reconstruction from this point onwards is reduced, and another column may have existed between fragments 15 and 7.

According to the current reconstruction, fragments 7 and 7a belong to column XV, while fragment 8 belongs to the subsequent column XVI. The inclusion of the two layers (7 and 7a) in the same column requires a very wide column in addition to a very wide intercolumnar margin between cols. XIV and XV (figure 109). The margin of 28.5 mm between these columns is similar to the wide margin between columns XVII and XVIII; both instances stand between sheets. In the lack of additional information, we must estimate the error for column XV statistically, based on the standard deviation of the width of the reconstructed columns in this scroll.

XV

FIGURE 109
Column XV
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6.1.5 Columns XVI and XVII

Fragment 5 contains a wide left margin, which means – when calculated in the larger framework of trial and error – that it must belong to the same column as frag. 6. Since the first letters on frag. 6 line 2 constitute the end of a word, a space should be assigned for the rest of the word and another word when placing the fragment, keeping the beginning of all lines aligned. Whether or not another fragment existed between wad D and A, exactly two columns must be reconstructed between the end of fragment 7 and the left margin of fragment 5, because, as explained above, fragments 7 and 8 cannot belong to the same column, and fragments 5 and 6 must belong to the same column (figure 110).

The minimum and maximum width of column XVII will be calculated separately. The minimum is between the margin on fragment 5 and two words away to the right of fragment 6. The uncertainty comes mainly from the possible range of the distance between the two fragments. The maximum can almost reach to fragment 8, leaving enough space in the previous column for the completion of the broken words appearing on the fragment, and subtracting the minimum width of the intercolumnar margin.[42] Note that the maximum width of the column exceeds any reconstructed column and assumes that column XVII is very narrow, thus the chances for a very wide column decrease with its growth.

We allocated the rest of the space between cols. XV and XVII to col. XVI and the margins around it. The exact division between them may change.[43] Thus, similarly to the method that was used for calculating the error of columns XII and XIII, here too the error takes into account the errors derived from the other known lengths: the distances between fragments 5 and 6 and fragments 6 and 8, the width of columns XV and XVII contained within this distance, and

42 $\Delta L_{XVII}(upper) = \sqrt{\Delta L_5^{\,2} + \Delta L_6^{\,2} + \Delta L_{XVI-XVII}^{\,2} + \Delta L_{XVI}^{\,2}} = \sqrt{10.4^2 + 9.6^2 + 2.5^2 + 0.04^2} \approx 14$

43 $L_{XVI} = L_{5-7} - L_{XV} - L_{XVII} - L_{XV-XVI} - L_{XVI-XVII}$

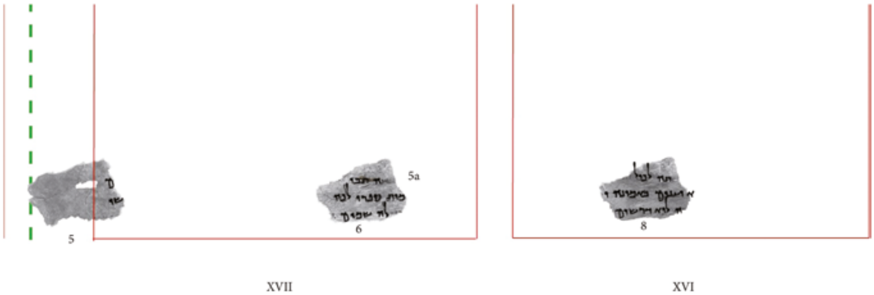

FIGURE 110 Columns XVI and XVII (fragment 5a is pasted on top of fragment 6).

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

the intercolumnar margins between columns LXV and LXVI and between columns XVI and XVII.[44]

6.1.6 Col. XVIII

In the lack of sufficient information for columns XVIII–XIX, we start the calculation in column XX where more information is available, and calculate backwards. The results are nonetheless presented sequentially. Column XVIII is very narrow, nearly the narrowest reconstructed column. Its maximum width is restricted by its right-hand intercolumnar space, showing on fragment 5 and by the reconstructed beginning of the parallel text to fragment 3 (see below).[45] There is no information regarding its minimal width. We therefore set it according to the standard deviation of the width of columns in this scroll (figure 111).

6.1.7 Column XIX

The text preserved on fragment 3 overlaps 4Q423 5. Since only the fragmentary line 34 is preserved on both copies, it cannot be used to reconstruct the width of the lines. Nevertheless, since at this point of the scroll the fragments stand

44 Again the upper and lower margins of error are not equal:

$$\Delta L_{XVI}(\text{lower}) = \sqrt{\Delta L_5^2 + \Delta L_6^2 + \Delta L_8^2 + \Delta L_{XV}^2 + \Delta L_{XVII}^2 + \Delta L_{XV-XVI}^2 + \Delta L_{XVI-XVII}^2} =$$
$$\sqrt{10.4^2 + 9.6^2 + 8.7^2 + 0.7^2 + 14^2 + 2.5^2 + 2.5^2} \approx 22$$
$$\Delta L_{XVI}(\text{upper}) = \sqrt{10.4^2 + 9.6^2 + 8.7^2 + 0.7^2 + 10.4^2 + 2.5^2 + 2.5^2} \approx 20$$

45 $$L_{XVIII} = L_{3-5} - L_{XIX} - L_{XVII} - L_{XVII-XVIII} - L_{XVIII-XIX}$$
$$\Delta L_{XVIII}(\text{upper}) = \sqrt{12.2^2 + 11.3^2 + \left(11\frac{58.5}{101}\right)^2 + 2.5^2 + 2.5^2} \approx 18$$

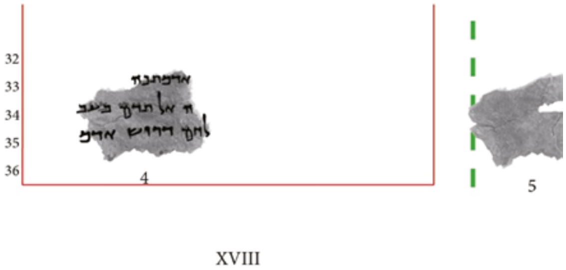

FIGURE 111
Column XVIII
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Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

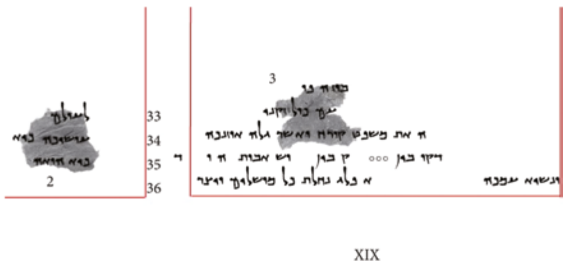

FIGURE 112
Column XIX
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Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

quite close to each other, the circumference of each turn being rather short, column XIX was limited from both sides by fragments 4 and 2, which determine its upper margin of error (figure 112).[46] There is no way to calculate the lower margin of error, hence we use the standard deviation.

6.1.8 Column XX

Column XX is the last extant column and is attested by frag. 1. This fragment merely contains traces of ink together with a left margin. The words on fragment 2 begin at the same vertical line, which may indicate the beginning of the column, but one more word is also possible. The size of such a possible word is approximately the same as the margin of error for the distance between fragments 1 and 2 (14 mm), and should be added to the calculation of the lower error.[47] The upper margin of error is based on the uncertainty of the distance between fragments 1 and 3, and the fact that the text of fragment 3 is not part of the same column as fragments 1 and 2.[48]

---

46 $\mathrm{L}_{\mathrm{XIX}} = L_{2-4} - L_{XX} - L_{XVIII} - L_{XVIII-XIX} - L_{XIX-XX}$

$\Delta\mathrm{L}_{\mathrm{XIX}}(\text{upper}) = \sqrt{13.1^2 + 12.2^2 + 21^2 + 10^2 + 2.5^2 + 2.5^2} \approx 30$

47 $\Delta L_{XX}(lower) = \sqrt{14^2 + 15^2} \approx 21$

48 $\Delta L_{XX}(upper) = \sqrt{\Delta L_{XIX-XX}{}^2 + \Delta L_{1-3}{}^2 + \Delta text^2} = \sqrt{14^2 + 13.1^2 + 27.5^2} \approx 34$

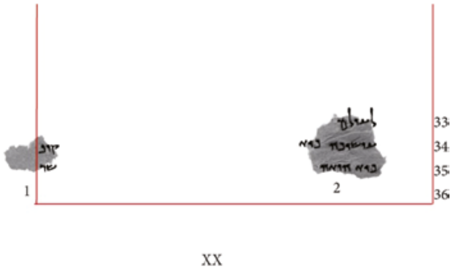

FIGURE 113
Column XX

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

6.1.9 The Right Part of the Scroll

Since the reconstruction of the entire scroll depends on the anchor columns IX–XI, we calculate the measurements of columns I–VIII backwards from column VIII to column I.

6.1.10 Column VIII

Fragment 22a is the second layer of wad E, but it is only partly visible as the bottom layer in the recto images of frag. 22. Inspection of these images shows the left end of a column on frag. 22a. A further layer of that wad, frag. 22b, is only visible on the verso images of frag. 22. A few letters are visible on new images of the verso provided to us by the IAA. However, most of the text of this layer is covered by a yet additional fourth layer (22c). Only in cases where 22c is broken, is the ink of 22b visible. The traces on 22b must be part of the same column of the letters visible on fragment 22a (figure 114). When placed in the reconstruction, the distance between the left end of the letters on fragment 22a and the right end of the letters on fragment 22b is 107.6 mm. The result is a rather wide column, albeit not the widest in 4Q418a (the widest is 128.2 mm in column XV). It is similar in width to column III, which is reconstructed based on a parallel text.

The only error for the width of this column is derived from the uncertainty of the distance between the fragments, but the placement of the fragments is supported by the join of fragments 9a and 9b with 22c and 20+21. The error is probably very low, and cannot be estimated.

FIGURE 114
Reconstructed borders of fragments 22a and b and the reconstructed distance between them.
Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

6.1.11 Columns VI–VII

Fragments 22c and 20+21 belong to two consecutive columns (figure 115). The joined frag. 20+21 shows the ends of several words, hence it is at least a few letters away from the left margin of column VI. From the right edge of column VIII to the approximate right edge of column VI we measure 252.5 mm. Since there is no additional information about the content of frag. 22c, we simply divide this width evenly between columns VI and VII.

After the reconstruction was performed, we discovered fragments 9a and 9b on top of wad B. The location of fragment 9a was calculated from the right according to its distance from fragment 9. It joins to fragment 22c. Luckily, the word preserved on fragment 9a begins exactly where we reconstructed the beginning of column VII, thus supporting the reconstruction, fixating the fragments of wad E to their place, and limiting the margin of error. Column VII can only be slightly narrower depending on the width of the margin between columns VII and VIII. Its maximum width depends also on the width of its right margin and the minimum width of column VI.[49]

Column VI includes fragment 20+21. The completion of broken words to its right demands at least a word or two to its right until the beginning of the column. Its minimum limit is affected by any addition to column VII and the margin between columns VI and VII. In the absence of more information regarding the possible addition to column VII, we set the minimum of column VI based on the standard deviation of column width in this scroll. Its maximum width is affected by the minimums of the margins around it and the minimum width of column V.[50]

In the proposed reconstruction, columns VI and VII are quite wide, whereas column V is very narrow. While the paucity of information created large errors that allowed even wider measurements for columns VI and VII at the expense of column V, we find these options to be less likely. The probability of the potential reconstructions will decrease with the increase of the disproportion between the columns.

6.1.12 Column V

The right margin preserved on fragment 9 determined the right end of column V (figure 116). It is narrower than its surrounding columns, but has approximately the same width as the known column XI. Fragment 9 preserves

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49 $\Delta L_{VII}(upper) = \sqrt{{\Delta L_{VI-VII}}^2 + {\Delta L_{VII-VIII}}^2 + {\Delta L_{VI}}^2} = \sqrt{2.5^2 + 2.5^2 + 11^2} \approx 12$

50 $\Delta L_{VI}(upper) = \sqrt{{\Delta L_{V-VI}}^2 + {\Delta L_{VI-VII}}^2 + {\Delta L_{V}}^2} = \sqrt{2.5 + 2.5^2 + 11^2} \approx 13$

FIGURE 115 Columns VI and VII with fragments 22c+9a and 20+21+9b

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

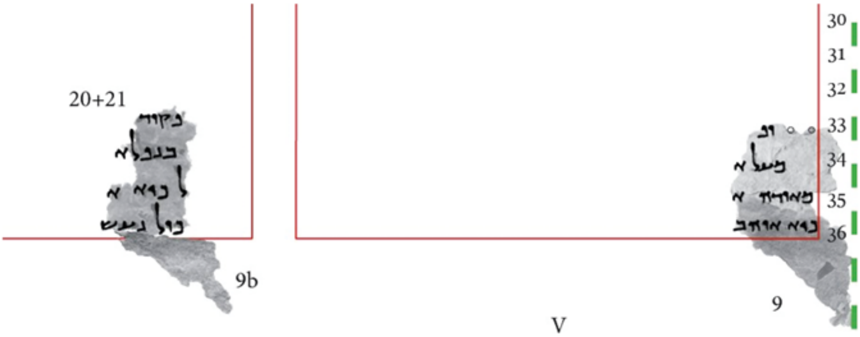


FIGURE 116 Column V with fragment 9

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

stitches. It is quite normal that the first and last columns in a sheet are narrower or wider than the rest of the columns in that sheet.

The maximum width of column V depends on the error of the distance between fragments 9 and 20+21 and the minimum size of the margin between their columns.[51] There is not enough information to set a minimum for this column. We thus use the standard deviation.

6.1.13 Column IV

Fragment 10 contains a right margin without stitches. The margin between columns IV and V contains stitches that connect two sheets, as fragment 9 indicates. The margin to the left of the stitches is 6.5 mm wide. We assumed that the margins on both sides of the stitches were equal (figure 117). Additionally,

51 $\Delta L_V(upper) = \sqrt{6.4^2 + 2.5^2} \approx 7$

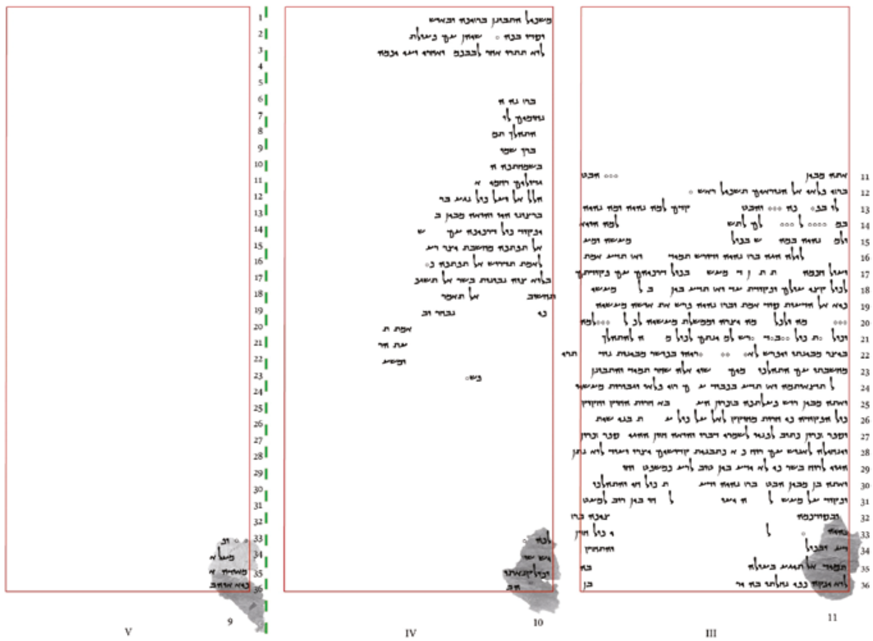


FIGURE 117 Columns III and IV

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

we equated the width of column IV to the known width of its preceding column (III). These assumptions are not always true, but in this case they fit well with the distances established by the overall reconstruction.

The error for the column's width derives only from the size of its left margin, whose upper margin of error was determined based on the standard deviation of the width of intercolumnar margins between sheets. The lower margin of error was set to be only 10 mm, as this intercolumnar margin is already the narrowest of its kind in this scroll.

6.1.14 Column III

Fragment 11 parallels 4Q417 1 i 21–24. Casting the text of 4Q417 in the layout of 4Q418a reveals that column III contains approximately 55–60 letters per line, reaching a width of about 105 mm, with an average intercolumnar margin of 10 mm. The size of this margin is close to the average in the DSS.

The error for the width of this column is derived from the error of using a font for the reconstruction. As the fragment contains a right margin, this error can only affect the margin between column III and IV. This outcome dovetails with the present reconstruction. Had the distance between frags. 10 and 11 turned out to be smaller, the text of column III would have intruded into column IV and overlapped frag. 10. Otherwise, had this distance turned out to be larger, the resulting margin would have been too wide to an unattested measure. Thus, the preservation of intercolumnar margins in several consecutive fragments and the parallel text from 4Q417 1 aggregate to constitute a crucial point for validating the entire reconstruction.

6.1.15 Column II

A small trace of ink on the right edge of line 3 of fragment 12 demonstrates that a space for at least one more word is missing to the right of the fragment before the right margin. This means that column II was comparatively wide (112.5 mm), but again not the widest one (figure 118). Within the current reconstruction, it is possible to narrow the margin between columns II and III, while widening column II and vice versa.

Regarding the error, there is not enough information to limit the highest potential width of the column, and we thus derive it from the standard deviation. The lowest possible width is based on the distance of fragment 12 from the preceding fragment 11. Since the distance between fragments 10 and 11 was confirmed by the join of fragments from wads B and E, the error for the distance to fragment 12 is only 1 mm. The most contributing factor to the lowest limit for the width of column II is based on the maximal possible width of the intercolumnar margin between columns II and III.

6.2 *The Beginning of the Scroll*

No fragment of 4Q418a overlaps the text of 4Q416 1, which is commonly considered to contain the beginning of *Instruction* (see chapter 14). The first fragment of 4Q418a, fragment 12, does not show any parallels in other copies either. Fragment 11 parallels 4Q417 1. In their unpublished reconstruction, Steudel and Lucassen suggested that 4Q417 1 was an alternative introduction

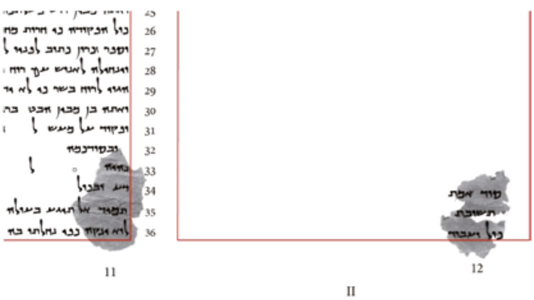


FIGURE 118
Column II

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940 to the composition instead of 4Q416 1, and that both introductions were joined in the copy 4Q418. The main basis for this proposal is the fact that 4Q417 1 contains stitches, and it is unlikely that only one column was included in the previous sheet. Tigchelaar adds some more literary arguments in favor of their proposal, but eventually concludes that it must remain a possible but unproved hypothesis.[52] Here we only address the material consideration, and demonstrate that materially the opposite hypothesis – that both introductory sections were included in both 4Q417 and 4Q418a – is also possible.

The main objection mentioned above is solved if we assume that more text was included before 4Q417 1, between it and the text of 4Q416 1. The first sheet of the scroll 4Q417 would then have contained more than one column. In addition, the verso of 4Q417 1 shows an imprint of the ink from a previous turn. This turn cannot have originated within this fragment despite its excessive width, and must have therefore originated in a previous sheet.[53]

Collating the evidence from 4Q417 and 4Q418a will present us with the size of the missing portion of text at the beginning of the composition before 4Q417 1. The procedure runs as follows:

We calculate the length of the text at the beginning of 4Q418a based on a comparison to 4Q417. This section parallels frag. 11 (the second preserved fragment of 4Q418a), and according to its content stems from the first few columns of the composition. We assume that the scribes of both 4Q417 and 4Q418a started copying *Instruction* at the top of the first column of their respective manuscripts, as usual in the DSS corpus. The preserved text of 4Q417 1 begins in the first line of the column, meaning that 4Q417 contained an additional number of whole columns from the beginning of the known text to the beginning of the scroll. This copy holds 28 lines per column. It thus lacks $28n$ lines, with n a positive integer (or, in other terms, a natural number). In 4Q418a, on the other hand, the known text begins in line 11 of what we now call column III. The number of lines in this copy is 36. Thus, 4Q418a contained an additional number of lines expressed by $36m + 10$ lines, with m also being a natural number, but unlikely the same one as n. While the number of letters per line in 4Q417 1 i and 4Q418a 11 is approximately the same, we cannot assume that this is true for all the rest of the columns, thus allowing the number of missing lines in both manuscripts to be close, but not necessarily exactly the same. Thus:

52 Tigchelaar, *Increased Learning*, 191–192, where he also summarizes Steudel and Lucassen's suggestion.

53 The details of this proof will be provided elsewhere with the full material reconstruction of 4Q417.

$$36m + 10 \approx 28n$$

Let us now run some iterations of this equation:

TABLE 20 Comparison of missing text at the beginning of 4Q418a and 4Q417

m	# of lines in 4Q418a	*n*	# of lines in 4Q417
0	10	1	28
1	46	1	28
1	46	2	56
2	82	3	84
3	118	4	112
4	154	5	140

If 4Q418a 12 would have stemmed from the first column of the manuscript, 4Q418a would lack 46 lines from the cast text of 4Q417 1 to the beginning of the scroll, while 4Q417 lacks either 28 or 56 lines. This configuration would mean that the beginning of the composition was of different lengths in these two copies. If, however, another column existed before frag. 12, 4Q418a would lack 82 lines, while 4Q417 would lack three columns, amounting to 84 lines. The difference of 2 lines is negligible compared to the margin of error, and may also result from unequal column width in both manuscripts. Three columns preceding that of 4Q418a 11 is also a possibility, but a less likely one, since the number of lines lacking in this case is 118, while in 4Q417 four lacking columns add to 112 lines. We thus choose to reconstruct one missing column before frag. 12, which equals three missing columns of 4Q417 before its first fragment. This is a normal size of a sheet, which shows that both introductory sections – 4Q416 1 and 4Q417 1 – could have been included in 4Q417.

No fragment was preserved from the first column of 4Q418a. Assuming that it belonged to the same sheet as columns II–IV, we set it to be of the same size as column II. Setting the margin between columns I and II is based on a similar estimate. We do not know where exactly to locate the text of the beginning of 4Q416 1 in the first column of 4Q418a. 4Q416 1 contains 18 out of 21 lines of the column. The first line of 4Q416 1 may have originally belonged to the first through the fourth line of its column, although the first is very unlikely, as its content does not seem like the opening line of the entire scroll. In the present reconstruction we began the text in line 3 of 4Q418a, but it may have been located one line higher or lower.[54] It is impossible to estimate the margin of error for the width of the first column, hence we use the standard deviation.

6.3 *Sheets*

Typically in the DSS, sheets contain 3–4 columns, but exceptional sheets may reach 1–7 columns.[55] The number of columns per sheet in the suggested reconstruction of 4Q418a is as follows:

TABLE 21 Number of columns per sheet in 4Q418a

Sheet	# of Columns
1	4
2	5
3	5
4	3
5	?

The sheets of 4Q418a are comparatively large, which is not surprising considering the height of the columns. The stitches between the first and second sheets were preserved on frag. 9. We assumed that there were stitches between wads D and E, which caused the roll to be looser and the layers to separate. Again we reconstructed stitches between wads D and A. Their existence also agrees with the large margin between cols. XIV and XV. Wad A is obviously too large to be contained in one sheet. The large margin preserved on frag. 5 may indicate the end of a sheet.

7 Conclusion

The digital and material methods for DSS reconstruction have been exemplified in this chapter. We have offered a reconstruction and visualization of 4Q418a. This digital reconstruction supports the suggestions of previous scholars, answers some of the remaining questions, and adds several new insights.

54 The widths of the first columns of 4Q416 and 4Q418a are approximately the same, thus the number of missing lines at the top of these columns should also be the same.

55 Tov, *Scribal Practices*, 75–76.

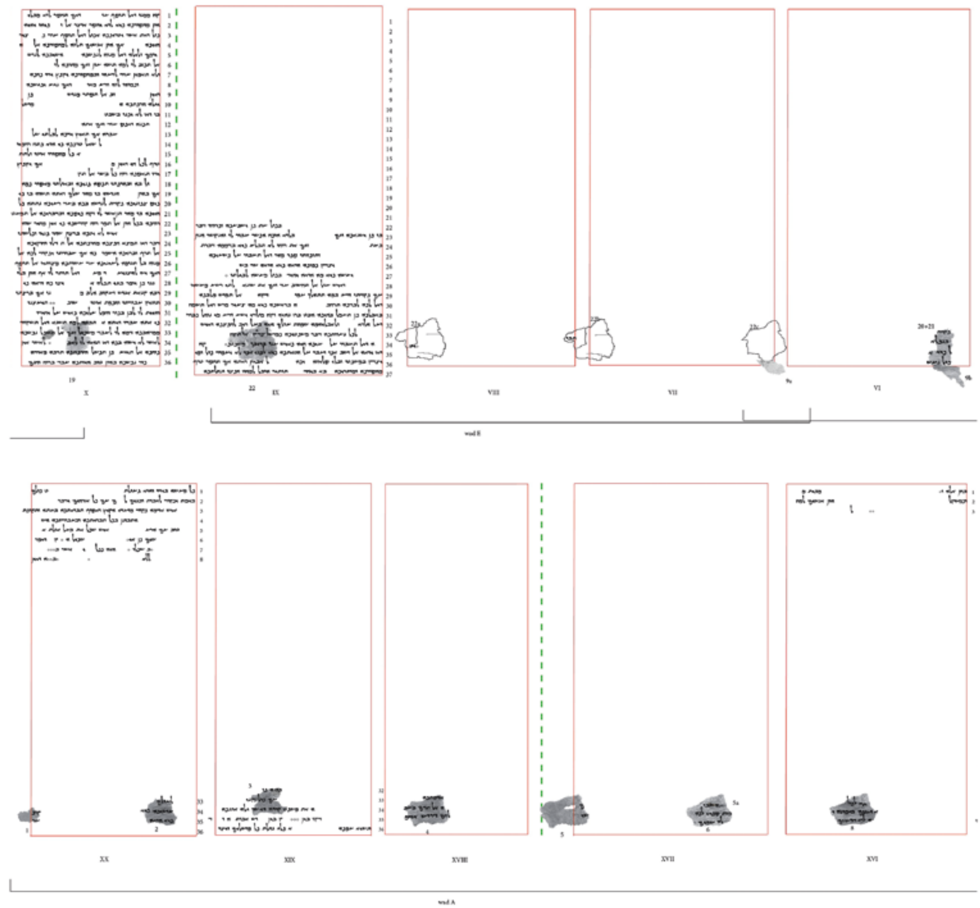
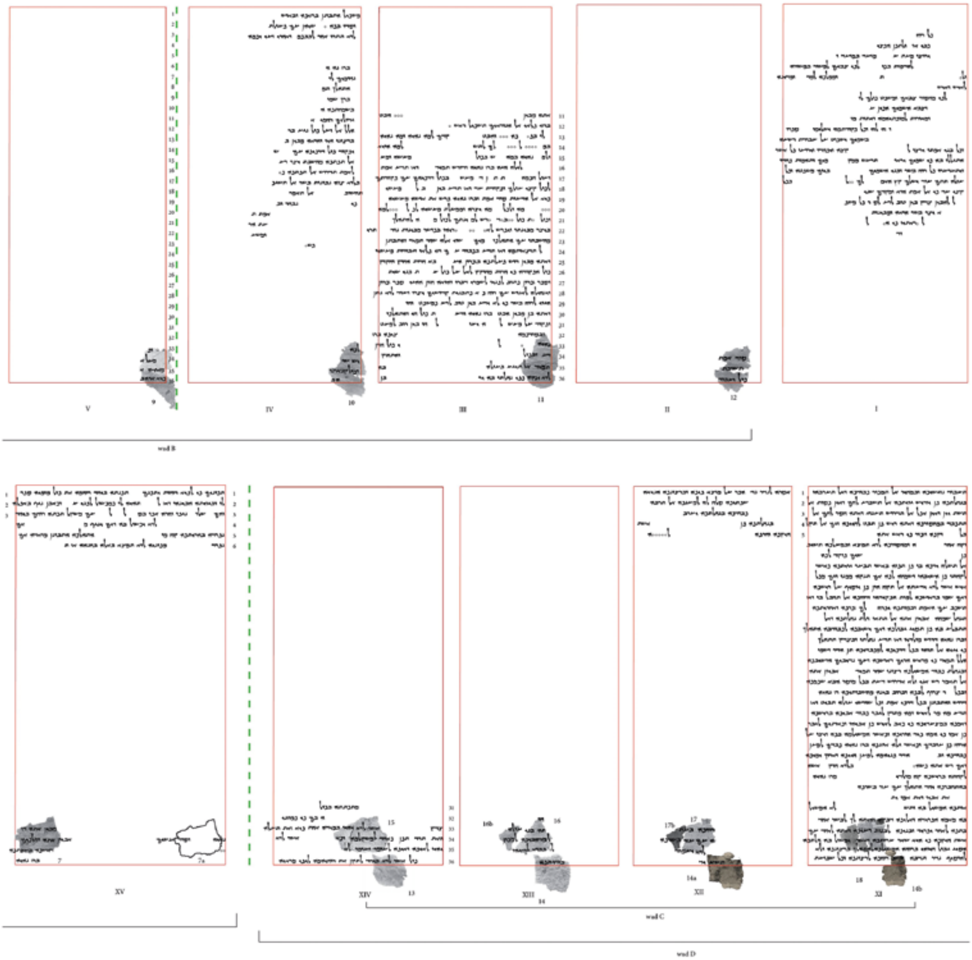


FIGURE 119 A visualization of columns I–XX attested in fragments 1–22c

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

We were able to identify previously unknown fragments and incorporate them in the general reconstruction; we rearranged some of the already known fragments; presented the text from parallel copies in the layout of 4Q418a; demonstrated the possibility for placing all the preserved fragments in 23 consecutive layers; and established the number and size of the missing columns from the beginning of the scroll. Despite the large theoretical margin of error, the control points in the left and right parts of the scroll allow a larger degree of certainty, buttressing the basic reconstruction. The length of the preserved part of the scroll is between 2–2.4 meters, including the beginning of the composition. Fragment 1, the last preserved fragment in the scroll, does not constitute the



end of the scroll. At least one more layer existed, indicated by the crumbles of skin attached to it (which we named fragment 0). The distance between frags. 1 and 2 indicates that there was enough space for more turns, but we cannot estimate how many. The methods presented in part 1 of this book also allowed us to improve the reading of 4Q418a in quite a few cases, discussed thoroughly in chapter 15. As it turns out, 4Q418a was a long scroll with exceptionally high columns. *Instruction* must have been highly cherished by the people supporting the production and penning of this scroll. The margin of error added to each stage of the reconstruction will allow scholars to correctly use this information for future reconstructions of other copies of *Instruction*.

CHAPTER 17

Conclusion: Movement towards a Comprehensive Reconstruction of *Instruction*

Part 1 of this book presented in detail the method for reconstruction, and part 2 exemplified how utilizing this method produces significant results in the reconstruction of a specific scroll, 4Q418a, a copy of *Instruction*. In this conclusion we survey what we consider to be the main achievements of the book. At the end of the chapter we take one step further, demonstrating the achievements such a method can carry for the entire *Instruction*.

The suggested method makes use of previously-used tools alongside some innovations, yet even the older tools discussed in this book are updated and sometimes critically examined. The method begins with meticulously recording and examining the entire material and photographic record for every fragment and wad, recto and verso (chapters 1, 6, 7). Beyond this basic practice, the main methodological innovations of this volume are as follows:

1. Calculating a potential margin of error for every reconstruction. The figures reached in the reconstruction must be considered as operating within a range rather than as absolute numbers. The factors impacting the error must be quantitatively assessed using the methods that are commonly used in the experimental sciences. After raising this issue in chapter 2, we offer for the first time a method for calculating the error. The method is recounted in the long appendices 1, 3, and 4. In addition, it is employed throughout the reconstruction of 4Q418a in chapter 16. The consistent application of the method to various stages in the procedure, each incurring its own potential error, yields a balanced result. On the one hand, multiple factors carry a larger potential error. On the other hand, the accumulation and cross-validation of various pieces of data checks this error and yields smaller, more reasonable figures.
2. Defining a policy for image manipulation and repair, as well as handy methods for removing the image background and scaling it (chapters 3, 4, 5).
3. Assessing the current methods for text demarcation (chapter 8).
4. Using a custom-made computer font for various scrolls in order to trace the sizes of individual columns and long stretches of text. The method for preparing and using such a font is described in chapter 10. A scientific experiment carried out in order to validate this method is recorded in

Appendix 1, and a tentative method for computerized automatic generation of fonts is described in Appendix 2.

5. Controlled use of the Stegemann method for material reconstruction in the newly-available digital environment. Ultimately, a canvas is created for each scroll encompassing all the various textual and material data (chapters 9, 11, 12).
6. Extrapolating the digital canvas of one scroll to other, parallel scrolls (chapter 13). This method is further exemplified in the present chapter.

When running this procedure for 4Q418a we carefully traced the wads of this scroll. We extracted the maximum information from them, both in terms of the scant text preserved in them and in terms of the material clues they suggest for analyzing the images of 4Q418a and arranging its layers. The information has led us to create a digital canvas of 4Q418a that concomitantly led, for the first time, to a comprehensive view of the entire *Instruction*. That is, the literary passages represented in 4Q418a are now placed not only in *relative* order to each other, but also in *absolute* order in one continuous sequence. Since some of the fragments of this copy parallel other, longer sections in other copies, we are able to place these sections on the canvas too, gaining an enhanced grasp of the layout of the entire composition. The text of the parallel sections was cast on the canvas of 4Q418a in the material format of this scroll.

The canvas of 4Q418a contains several new fragments that were discovered as we enacted the method delineated here. There are various kinds of new fragments, and together they give hope for "discovering" new fragments in other scrolls as well, not only in the caves but also at the laboratory using advanced equipment. Some of the new fragments belong to the previously unknown wad E, discovered under frag. 22 by means of a close scrutiny of the LLDSSDL images. Other fragments were found by mining the earlier log of PAM images. Yet others were "discovered" by the material reconstruction, that is, their existence was required by the calculation of the scroll's patterns of decay. The new fragments lend further checks to the material reconstruction and potentially buttress it. Finally, these small fragments add a small amount of new text, which could fit with the text of the known fragments and offer improved readings.

The reconstruction had initially been based on the sequence of PAM photos, the earliest of which was 41.909 taken in December 1955. We were fortunately able to verify our reconstruction by means of a chance discovery that turned out to be a providential accident. At a late stage of our work we discovered the earlier PAM 41.410 (taken December 1954), which contains an earlier record of wad B, earlier than the one known to Strugnell himself, and shows two more layers of this wad. This discovery could have had the potential of dismantling the entire edifice built in the digital canvas. In reality, however, not only did it not require any modifications in the canvas, but it has also perfectly matched our independently proposed reconstruction. The match pertains not only to the fully-extant fragment 22 but also to the “manufactured” fragment 22c and to the placement of that fragment next to frag. 20+21.

Moreover, bits and pieces of skin that stuck on subsequent layers of the wads, either on the verso or the recto of other fragments, joined the known readings to produce a meaningful text, as described in chapter 15. These considerations provide strong proof for the validity of the suggested canvas.

The canvas supports the initial proposal by Tigchelaar, who suggested the order of the wads of 4Q418a and accordingly arranged the entire work. This arrangement was embraced by Qimron and is endorsed in this book. Wad B contains the theological-apocalyptic portion, while frags. 18, 19, and 22 contain the practical advice found in 4Q417 2 and 4Q416 2. The change of focus between these two pericopae took place somewhere in the intervening fragments 9, 20+21, 22c, 22b, or 22a.

The reconstruction achieved here will serve as infrastructure for future work on other copies of *Instruction*, whose material layout can now be better understood. Once such work is achieved for all eight copies, the road will be open for the placement of additional text in the sequence of this enigmatic composition. Hundreds of fragments from other copies of *Instruction* are yet to be placed. We ultimately hope to pave the way for a better understanding of the content and flow of *Instruction*, which, despite the advance achieved so far, remains partial.

The digital canvas of 4Q418a provides important building blocks for the canvasses of other copies and for the structure of the entire composition. For example, we can now tell the absolute distance between the pragmatic instruction preserved in 4Q417 2 and 4Q416 2 to the general teaching of 4Q417 1. Had it been only dependent on 4Q417 we would not be able to ascertain this distance in the absence of unequivocal signs of material decay in that scroll. Using 4Q418a, this distance is anchored by means of a fragment of the latter scroll located in each of the separating columns, and thus verifying not only the mere existence of the columns but also their layout. This find, like all other finds in the present book, operates with a margin of error and thus in fact dictates a range of distances rather than exact figures. This range suffices, however, for a good overall sense of *Instruction*.

In the present chapter we draw several trajectories that can be developed on the basis of the hereby presented skeleton of 4Q418a. The ultimate result will be a fully-fledged score, a partiture as-it-were, of the eight copies of *Instruction*, alongside a continuous textual composition of its contents. All of these trajectories are followed in our current work, and some of them have been published. Those parts that have been peer-reviewed elsewhere will be summarized here, while other aspects, that have not been published yet, should be considered more tentative until fully substantiated.

1 The Length of the Introductory Section in 4Q416, 4Q417

The copies of *Instruction* attest to two main sections that may be considered introductory. One of them is preserved on 4Q416 1 (and parallels) and is commonly considered to be the opening of the entire composition, because the fragment shows a rather wide right margin and another piece protruding to the right.[1] A second and longer introductory section appears in 4Q417 1, at the right-hand column of the respective sheet. In earlier stages of research it was suggested that the introductions were not meant to operate together, and that the section presented in 4Q417 1 is the product of sectarian redaction of *Instruction*.[2] This view is no longer tenable, as proven in chapter 16. The two introductions seem to have co-existed, as our reconstruction also verifies.[3] In chapter 16 we also established the distance between them, i.e., the number of columns that separated the former from the latter. Figure 120 presents the text of these introductions in the layout of 4Q418a, based on the fragments of the latter scroll that have been placed along this textual sequence. The rightmost fragment of this scroll, frag. 12, does not reach as far as the text of 4Q416 1.

1 The introduction was sorted out and published by Tigchelaar, *Increase Learning*, 175–93; Tigchelaar, "Towards a Reconstruction," 99–126. We have recently cast doubt on the assignment of 4Q418 fragments to this section and suggested alternative layouts inducing a change of the unit's theme. See Jonathan Ben-Dov, "Family Relations and the Economic-Metaphysical Message of *Instruction*," *JSP* 30 (2020): 87–100; Asaf Gayer, "Measurements of Wisdom: The Measuring and Weighing Motif in the Wisdom Composition Instruction and in Second Temple Literature," (PhD diss, University of Haifa, 2021), 170–88.

2 Torleif Elgvin, "An Analysis of 4QInstruction," 54; Armin Lange, "Wisdom Literature from the Qumran Library," in *Outside the Bible: Ancient Jewish Writings Related to Scripture*, ed. Louis H. Feldman, James L. Kugel and Lawrence H. Schiffman (Philadelphia: JPS, 2013), 3.2399–443, here 2437.

3 Tigchelaar, *Increase Learning*, 191–92, remains ambiguous about this question. Qimron, *The Dead Sea Scrolls*, 2.147–48 places both passages in the running text of *Instruction*.

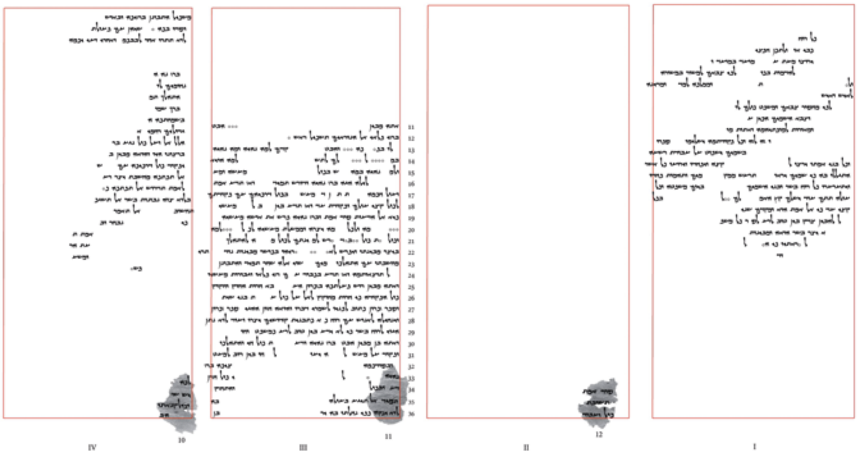


FIGURE 120 Columns I–IV of the canvas of 4Q418a. Column I contains the text of 4Q416 1, while columns III–IV contain the text of 4Q417 1.

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

2 The Layout of 4Q415

Wads C+D as well as wad A represent later parts of *Instruction*, where the long overlaps with 4Q416 and 4Q417 are no longer operative. This part of the scroll overlaps to some extent with the literary units on marriage and matchmaking preserved in the fragments of 4Q415. Specifically, the overlapping parts are 4Q415 11 // 4Q418a 15+13, and 4Q415 6 // 4Q418a 7. These units seem to have constituted a long section on these matters, in addition to the similar content of 4Q416 2 iv. However, the order and constitution of this unit in 4Q415 and 4Q418a remained vague. A material (Stegemann) reconstruction of 4Q415 produced several new joins of fragments as well as the traces of recurring damage patterns.[4] But the work could not have been completed without merging the outline already established for 4Q418a.

Hila Dayfani carried out the protocol described in chapter 13 to project data from the canvas of 4Q418a onto the canvas of 4Q415. Calculating the number of letters in a given sequence of columns led, first, to establishing the number of lines in 4Q415, which turned out to be smaller than that of 4Q418a. This datum

4 Damage patterns in 4Q415 were pointed out by Elgvin, "An Analysis of 4QInstruction," 26–27. Joins and initial material reconstruction were suggested by Gayer, "New Readings and Joins"; and incorporated in Dayfani, "Material Reconstruction."

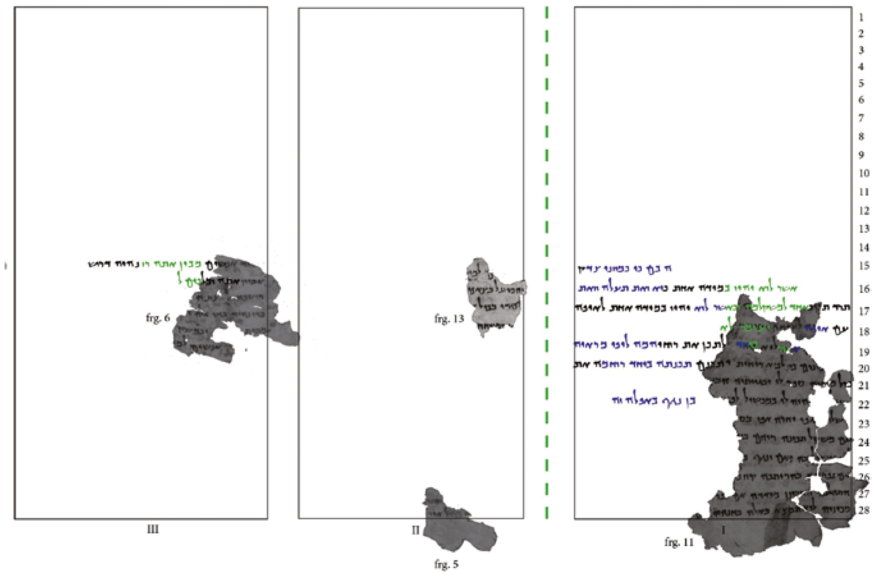


FIGURE 121 Section of the Canvas of 4Q415. The overlaps with 4Q418a, shown in green letters, provide the text outside the fragments. Graphics: Hila Dayfani

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

in turn led to establishing the width of lines in 4Q415. Being an opisthograph, this particular scroll presented a unique type of information, since its columns squarely overlap the columns of 4Q414 written on the verso. Combining these variegated pieces of data together, Dayfani was able to present a material reconstruction of 4Q415, spreading over seven columns and incorporating 13 fragments. This constitutes considerable improvement of our knowledge available on this scroll (see figure 121).

3 Extrapolation for Other Copies of *Instruction*

While other copies of *Instruction* do not lend themselves to long-scale material reconstruction like the former scrolls, quite a few insights can be achieved on a smaller scale. Most of these insights pertain to the copy 4Q418. This multi-fragment copy contains ca. 300 fragments, the great majority of which are rather small, holding a mere several words to several lines. Most of these fragments do not display deterioration patterns apparent enough to produce a full-scale material reconstruction. Stretches of the material of 4Q418 were

FIGURE 122 Section of the canvas of 4Q418 (fragments 81, 81a, 101, 102, 103, 122, 126, 137, 139)

Online version available at http://dx.doi.org/10.6084/m9.figshare.17032940

successfully reconstructed, however, by Asaf Gayer,[5] notably a sequence of four columns discussing "wisdom of the hands," i.e., practical advice to artisans and other manual laborers. This textual unit and other like it are placed on the canvas of 4Q418, whose contours were determined by the canvas of 4Q418a (figure 122).

Anna Shirav and Jonathan Ben-Dov used the canvas of 4Q418a for reconstructing the order of 4Q417. Joins were suggested by Shlomi Efrati for the scrolls 4Q423 and 1Q26, in sections relating to agriculture and priestly tithes. The text of these fragments seems to fit in the later part of *Instruction*, far beyond the end of the canvas of 4Q418a. Nevertheless, this canvas provides the framework for the later fragments as well. The method suggested here and the canvas developed on its basis thus provides a way to a reconstruction of *Instruction* that is more comprehensive than earlier work on this text.

The method presented here thus offers a promising path for future work on many other fragmentary scrolls. If adopted and properly operated, it could lead to a new wave of improvements of DSS editions. After having been read and published, the fragments still preserve a large amount of material that needs to be properly mined and efficiently put to use. Many of the scrolls that lie in the DJD volumes may find new reconstructions and provide new information. After seventy years of enormous achievements, we may shed yet more light on these precious fragments.

5 Asaf Gayer, "A New Reconstruction."

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