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"DIGITAL AND SCIENTIFIC APPROACHES TO ORIENTAL MANUSCRIPT STUDIES"
mavzusidagi

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**THEME: DIGITAL AND SCIENTIFIC APPROACHES TO ORIENTAL MANUSCRIPT STUDIES**

**PLAN**

## INTRODUCTION

Peer reviewing was a major asset of the network. Besides undergoing the obligatory mid-term and final evaluations by the European Science Foundation, the Digital and scientific approaches to oriental manuscript studies program continuously subjected itself to an internal review process. It is now time to face a more crucial trial, namely the verdict of our readers as to whether the cooperative and comparative approach is indeed so sound, fruitful and useful that it might set standards for future research. What is certain even now is that many people who have taken part in Digital and scientific approaches to oriental manuscript studies share the feeling that the scholarly and human experience acquired during this project will last a long time. Some explanation is due to the larger community of all those who have participated in Digital and scientific approaches to oriental manuscript studies activities in the last few years on how the work was actually conducted. We may certainly state that neither the Steering Committee nor the Editorial Board have ever reduced 'formalities' in the technical sense to 'simple formalities'. In projects such as COMSt, formalities are matters of substance indeed, and they were approached accordingly. Every application for a workshop or a travel grant, report, minutes, every draft submitted for the present volume, all were openly and thoroughly discussed, without any pre-determined result. There may be projects where any question is settled in a two-minute discussion or even without any discussion at all. In the case of COMSt, this was never the case – even if in some cases this might have caused some inconvenience. True collegiality – sharing responsibilities, the search for unanimity wherever possible or at least for widely shared compromises, without concealing divergences and open questions – has always been the leading work principle in COMSt.

The community of scholars that cooperated in the Comparative Oriental Manuscript Studies Research Networking Programme was inspired right from the beginning by the common expectation that an agreed approach can provide a

significant contribution to progress in manuscript research, both on a general, interdisciplinary level and with regard to the individual disciplines of manuscript book culture; this community has therefore volunteered to accomplish a common task deemed important and urgent. The academic backgrounds of the COMSt members are different but, along with their respective differences and various ideas and attitudes, they have shared some basic convictions, which in some cases were challenged or looked upon in a new or different light in the course of these years. The intensive activity of exchanging ideas, experiences and points of view has eventually served to create a common language and to focus on the topics that were selected as relevant and crucial in the comparative perspective. The many core-points where the practice of the COMSt activity and interchange deployed its fruitful results with regard to achievements and contents, reveal themselves in the chapters of the present manual.

**The aim** is to analyze the existent problems in COMSt activity and interchange and find the ways out of this problem by suggesting a series of exercises that can be useful in classroom activities.

Thus, according to the set aim we are to solve the following **tasks** :

- to determine the aim Comparative Oriental Manuscript Studies Research Networking Programme;
- to open the essence of
- to describe the Comparative Oriental Manuscript Studies Research Networking Programme;
- to describe different approaches to COMSt;
- to work out new technologies in COMSt;

**The scientific novelty** : few would dispute the claim that comprehension is necessary in order for language acquisition to occur. In order to communicate effectively, learners must understand what is being said. To function successfully with a target COMSt, learners depend upon their ability to comprehend the manuscripts.

Empirical studies have identified a positive relationship between language acquisitions as well as between reading ability and language acquisition.

**The theoretical and practical value** of the research work consist in the material that was used during the investigation work which may be used in further researches and be helpful in lectures on methodology of the Comparative Oriental Manuscript Studies Research Networking Programme as well as to teachers and students in their practical lessons.

Material under analysis is the literature on the theme of the work.

# I CHAPTER. DIGITAL APPROACHES TO ORIENTAL MANUSCRIPT STUDIES

## 1.1. The representation of oriental scripts and the encoding of characters

With the spread of personal computers in the 1980s and early 1990s, studies concerning manuscripts and their contents started to change in both their aims and their methods, and the 'digital turn' has meanwhile embraced nearly all relevant fields. It seems therefore appropriate first to outline the essentials of digital approaches to oriental manuscript studies here; more detailed treatments will be found in the individual chapters following. The present survey focuses on questions of the representation of different scripts (original and transcriptional) and the encoding of characters; the conception of electronic texts, their structuring and their processing; the arrangement of databases, their layout and their handling; and the basics of digital imaging including special relevant methods of photography.

In the early times of the digital age, attempts to store and process data in oriental languages were for many years hampered dramatically by the fact that computers were not yet able to deal with scripts other than Latin, and even the correct treatment of extra characters such as the 'umlaut vowels' of German or the accented letters of French was anything but guaranteed. The reason was that in a digital environment, the encoding of written text must be based on a given set of correspondences of characters with numerical values, every character being represented by one unique value. To encode the two times 26 letters (lower and upper case) of the Latin alphabet plus the digits from 0 to 9, the punctuation marks, parentheses, and the like, a set of less than 100 unique values is necessary, and this is why the 'stone age' mainframe computers of the 1960s to 1970s were based on a so-called 7-bit encoding: with 7 bits, $2^7 = 128$ characters can be encoded uniquely. The most popular standard developed on this basis is the so-called ASCII standard ('American Standard Code for Information Interchange', see Table 0.2.1), which prevailed in the first personal computers.

It is clear that on the basis of this encoding scheme, English texts could easily be digitized, but German, French, or Spanish texts could not, let alone Greek, Russian, or Arabic texts in their original scripts. This does not mean, however, that it was impossible then to process texts in more 'exotic' languages. What was necessary was the invention of encoding schemes that used more than one 'code point' to represent certain characters. One such scheme, the so-called 'BETA-Code', was applied to encode the ancient Greek texts that are comprised in the 'Thesaurus Linguae Graecae' (TLG), a huge database attempting to cover the complete textual heritage from Homer down to the Middle Ages. Cf. Table 0.2.2 which shows the 7-bit adaptation of the beginning of Hesiod's *Theogony*, contrasted with the 'traditional' rendering in Greek script. It is clear that the 7-bit encoding had at least two disadvantages: it was hardly possible to visualize the text as it should be on a computer screen, and the encoding was not transparent (or 'self-explaining') in the sense that the individual items (letters, diacritics, accent marks) could be easily determined by people who were not involved in the encoding process themselves. It is true that this encoding met the condition of being consistent in that a given sequence of codes always represented the same character, and this is why these texts can be used and analysed even today (and the TLG website still supports it); however, it will be clear that it remains clumsy and hard to handle.

With the extension of the ASCII encoding basis to 8 bits, this problem was at least partially overcome. On an 8-bit (= 1-byte) basis, 28 = 256 characters can be encoded uniquely, and since the early 1980s, many 8-bit encoding schemes were developed and applied, adding 'special' characters such as those representing German *ä*, *ö*, *ü*, the accented vowels *é*, *à*, *ô*, etc. of French, or the Spanish palatal nasal *ñ* to the inventory. Unfortunately, this was not done in an equal, 'standardized' way right from the beginning; instead, several leading computer companies developed their own individual schemes, which resulted in serious terms used in IBM/DOS computers, Mac computers, and MS-Windows—only the latter one is more or less identical with

the 8-bit standard used in many applications up till now, the ANSI standard (‘American National Standards Institute’) also known as ISO standard no. 8859-1 (the special MS-Windows characters are displayed on a grey background within Table 0.2.5). Still, these encoding systems were not sufficient for the immediate encoding of other scripts such as Greek, Cyrillic, or Chinese. This is why from the middle of the 1980s on, so-called ‘code pages’ were developed for 8-bit based computers, in which, just as in the examples shown above, the ‘upper’ area exceeding the basic ASCII plain (values above 128) was used to encode various other character sets. Some of these code pages have been standardized within the ISO standard 8859 (see, for example, Table 0.2.6 contrasting the Cyrillic code page ISO 8859-5 with the ANSI standard, ISO 8859-1), and some of them are still used in web pages. Apart from these ‘official’ extensions, an unknown amount of local or even personal 8-bit encoding systems were developed in the 1980s and 1990s to meet the needs of philologists dealing with oriental languages. As a matter of fact, whenever someone developed and applied a certain font, the encoding of which did not match one of the standardized code pages, a new encoding system was created from scratch.

Applying the method of ‘font mapping’, one could thus meet, for example, the requirements of Ancient (‘Polytonic’) Greek to be noted in original characters as well as Iranian languages to be rendered in a scholarly Latin transcription.

Table 0.2.6 Standardized 8-bit mapping: ISO 8859-1 vs. ISO 8859-5

**ISO 8859-1**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | | ! | " | # | $ | % | & | ' | ( | ) | * | + | , | - | . | / | 47 |
| 48 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? | 63 |
| 64 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | 79 |
| 80 | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | _ | 95 |
| 96 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | 111 |
| 112 | p | q | r | s | t | u | v | w | x | y | z | { | \| | } | ~ | | 127 |
| 160 | | ¡ | ¢ | £ | ¤ | ¥ | ¦ | § | ¨ | © | ª | « | ¬ | | ® | ¯ | 175 |
| 176 | ° | ± | ² | ³ | ´ | µ | ¶ | · | ¸ | ¹ | º | » | ¼ | ½ | ¾ | ¿ | 191 |
| 192 | À | Á | Â | Ã | Ä | Å | Æ | Ç | È | É | Ê | Ë | Ì | Í | Î | Ï | 207 |
| 208 | Ð | Ñ | Ò | Ó | Ô | Õ | Ö | × | Ø | Ù | Ú | Û | Ü | Ý | Þ | ß | 223 |
| 224 | à | á | â | ã | ä | å | æ | ç | è | é | ê | ë | ì | í | î | ï | 239 |
| 240 | ð | ñ | ò | ó | ô | õ | ö | ÷ | ø | ù | ú | û | ü | ý | þ | ÿ | 255 |

**ISO 8859-5**

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | | ! | " | # | $ | % | & | ' | ( | ) | * | + | , | - | . | / | 47 |
| 48 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? | 63 |
| 64 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | 79 |
| 80 | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | _ | 95 |
| 96 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | 111 |
| 112 | p | q | r | s | t | u | v | w | x | y | z | { | \| | } | ~ | | 127 |
| 160 | | Ё | Ђ | Ѓ | Є | S | I | Ї | J | Љ | Њ | Ћ | Ќ | · | Ў | Џ | 175 |
| 176 | А | Б | В | Г | Д | Е | Ж | З | И | Й | К | Л | М | Н | О | П | 191 |
| 192 | Р | С | Т | У | Ф | Х | Ц | Ч | Ш | Щ | Ъ | Ы | Ь | Э | Ю | Я | 207 |
| 208 | а | б | в | г | д | е | ж | з | и | й | к | л | м | н | о | п | 223 |
| 224 | р | с | т | у | ф | х | ц | ч | ш | щ | ъ | ы | ь | э | ю | я | 239 |
| 240 | № | ё | ђ | ѓ | є | s | i | ї | j | љ | њ | ћ | ќ | § | ў | џ | 255 |

The problem about all this is that whenever ‘font mapping’ is applied, the basic requirements of consistent encoding, namely the recoverability and exchangeability of data, cannot be guaranteed as there is no unique one-to-one-relation between a character to be encoded and a given digitized value. If, for example, we applied the Greek 8-bit font illustrated in Table 0.2.7, the value of 231 would represent a Greek lower case letter matching the standard codepage ISO 8859-5, and it would represent a Latin *c* with cedilla (*ç*) if we used the plain ANSI standard. This means that whenever an 8-bit encoding was applied in the encoding of textual materials, additional information had to be stored as to what code page or font encoding was valid for a given character. This information, however, was not encodable as such in a standardized way, being dependent on the idiosyncrasies of word processing programs such as Microsoft Word, and it was lost all too easily when data were transferred across systems. This is all the more true so for scripts with right-to-left direction such as Arabic, which required special encoding solutions in all cases. This

is why many textual materials in oriental languages stored electronically in the twentieth century (sometimes even later) in transcribing manuscripts or editing their contents are no longer usable today—or at least hard to process.

To be able uniquely to encode all characters that have been used in writing down human languages including both 'original' scripts and alphabets and linguistic 'transcriptions', the basis of encoding had to be extended far beyond the 1-byte (8-bit) standard. This is exactly what has been undertaken since the early 1990s when the so-called 'Unicode' standard was created: based on 16 bits (or 2 bytes), this standard comprises 216 = 65536 basic 'code points' used for the 'unique' encoding of characters. Considering that for the Chinese script alone, far more than 65,000 different characters have been used throughout history, it is clear that even this standard is not yet sufficient to cover all characters used by mankind at all times.

This is why a further extension has been conceived, in the 32-bit standard ISO 10646 which provides a total of (232 =) 4,294,967,296 code points; as a matter of fact, the Unicode standard is but one subset of this near to 'infinite' inventory, just as the ANSI standard (ISO 8859-1) is a subset of Unicode, and the ASCII standard a subset of ANSI (see fig. 0.2.1). Along with the expansion of the World Wide Web, Unicode encoding has become more and more prominent since the late 1990s, and it is the encoding basis of practically all up-to-date operating systems and word processors today. There can be no doubt that this is a huge advantage for the purposes of oriental manuscript studies. Cf., for example, Table 0.2.9 which shows a few of the 'blocks' of Unicode characters: the distinction of a Cyrillic and Latin c with cedilla (ç) is now guaranteed by their different code points (hexadecimal number 0447 = decimal 1095 vs. hexadecimal 00E7 = decimal 231), and various Latin-based characters used in transcription systems can now as well be encoded as characters of the Greek, Coptic, or Georgian scripts. In addition, the Unicode standard even comprises information on the directionality of a given character so that Hebrew, Arabic, or Syriac texts can be encoded (and exchanged!) without further

programming—provided the system used has implemented the relevant 'blocks' and the rules pertaining to them. However, even Unicode encoding is not without problems. First of all, it builds upon the so-called character/glyph distinction. According to the definition provided by the Unicode Consortium, a 'glyph is a particular image which represents a character or part of a character', and it 'may have very different shapes' as illustrated by the set of six 'sample glyphs' for the Latin 'character' a in Table 0.2.10 (modeled after the diagram in General introduction § 2.1 at <http://www.unicode.org/reports/tr17/tr17-3.html>, accessed March 2014). It will be clear from the example that a 'character', which is what is to be encoded, is an abstraction of all the possible actual forms of a 'letter' that may appear in handwritten or printed form, while every single appearance of the letter is regarded as a 'glyph variant'. This distinction, then, is crucial indeed for manuscript studies, as the assignment of individual 'letter shapes' occurring in handwritten sources to 'abstract' character values may always be a matter of dispute, especially in a diachronic perspective: we may think, for example, of the emergence of minuscules from majuscules over time, or of 'new letters' from former ligatures. As a matter of fact, the decision of the Unicode Consortium to treat the 'minuscule' a as a character in its own right, with a unique code point, and not to treat all the 'minuscule' variants of a as glyphs of the one ('majuscule') character A, which has another code point, may be justified for practical (and traditional) reasons, but it may be problematical indeed for manuscript studies concerning the first millennium. It may be even more problematical when it comes to scripts that are less 'fixed' than Latin.

To be sure, the problem of assigning letter forms as appearing in a handwritten context to 'abstract' units is not intrinsically determined by digitization, and it is by no means confined to it: just like a scholar of today, who has to decide by what code point he would represent the glyph he 'reads' in a manuscript, a scholar using pen or pencil in transcribing a manuscript would have had to decide for an 'abstract' character, too, at least when handing his transcript over to a typesetter. There is

indeed an important difference, however, in that the purpose of typesetting was limited to a reproduction in print, whereas a digital encoding can be used for other purposes such as automatic indexation as well; here, the consistency of the encoding becomes crucial indeed (cf. below). Another difference concerns the way restrictions could be overcome when necessary, those of a typesetter's letter case of old and those of an encoding standard of today: the typesetter may have resorted to the production of new types if this was deemed unavoidable (cf. the approaches summarized in the case study on the edition of the Berlin Turfan manuscripts, Ch. 3 § 3.9), and the 'digital' scholar, to the tedious process of convincing the Unicode Consortium that a character (not a glyph!) is missing in their standard (cf. the problem of a 'different letter for q and initial y' in Indian and Iranian manuscripts of the Avesta, thematized in case study.

Be that as it may, the problem of distinguishing abstract 'characters' from 'glyphs' as their 'representations' is actually one of the history of scripts, their analysis and their usage in general, not of digitization. The development of the Unicode standard has contributed a lot to this question by enforcing thorough investigation, and many of us have been involved in the process of its extension. However, it is a pity that this has often not been determined and shortcomings that we still have to cope with. One such inconsistency lies in the fact that the encoding facilities Unicode provides are not always 'unique'. This is especially true for the huge amount of combinations of (Latin, Greek, Cyrillic etc.) characters with diacritics it intends to cover, many of which can be encoded 'as such', that is as so-called 'precomposed characters', or as combinations of the respective 'basic character' and the diacritic(s) it carries. For example, the German *ä* can be encoded as the Unicode character no. 226 (U+00E4) or as a sequence of *a* = no. 97 (U+0061) and the 'umlaut' diacritic ('diaeresis', U+0308); in a similar way, *r* with a macron above and a dot below (*ṟ*) can be encoded as such as no. 7773 (U+1E5D) or as a sequence of *r* (U+0072), macron above (U+0304), and dot below (U+0323), or even as a sequence

of *r* with a dot below ( U+1E5B) and a macron above (U+0304). It is true that the different ways of encoding the same 'composed character' are essentially equivalent according to the definition of the standard—with the 'precomposed' units being considered as the first choice—and should be treated as such by Unicode-based systems; however, users cannot rely upon this in all cases yet, depending on system or software peculiarities. A similar problem is posed, for example, by Arabic characters, given that Unicode provides code points for both the different 'surface' forms they may appear in within words (isolated, final, initial, character (identical in shape with the 'isolated' variant) which is meant to be adapted automatically to the sensually equivalent according to the definition of the standard, with the 'idealized' representations to be used preferably wherever possible.

Another problem that may be crucial in the application of Unicode is the persistence of at least one area that is designed for font mapping. This is the so-called 'Private Use Area' (PUA), which comprises 6144 code points for non-predefined characters (in the blocks U+E000–EFFF and F000–F7FF). This area can be assigned *ad libitum* by companies, user groups, or individuals, with the result that additional information is again necessary to distinguish the characters 'encoded' in it. Table 0.2.11 shows what can happen when different fonts are applied to visualize PUA encoded characters; in the worst case, the intended information will again be lost. The use of the 'Private Use Area' should therefore be avoided wherever possible.

Table 0.2.9 16-bit encoding: Unicode blocks Latin and Cyrillic

**Latin**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 000 | | | | | | | | | | | | | | | | |
| 001 | | | | | | | | | | | | | | | | |
| 002 | ? | ! | “ | # | $ | % | & | ' | ( | ) | * | + | , | - | . | / |
| 003 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? |
| 004 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| 005 | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | _ |
| 006 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| 007 | p | q | r | s | t | u | v | w | x | y | z | { | \| | } | ~ | |
| 008 | | | | | | | | | | | | | | | | |
| 009 | | | | | | | | | | | | | | | | |
| 00A | | ¡ | ¢ | £ | ¤ | ¥ | ¦ | § | ¨ | © | ª | « | ¬ | | ® | ¯ |
| 00B | ° | ± | ² | ³ | ´ | µ | ¶ | · | ¸ | ¹ | º | » | ¼ | ½ | ¾ | ¿ |
| 00C | À | Á | Â | Ã | Ä | Å | Æ | Ç | È | É | Ê | Ë | Ì | Í | Î | Ï |
| 00D | Ð | Ñ | Ò | Ó | Ô | Õ | Ö | × | Ø | Ù | Ú | Û | Ü | Ý | Þ | ß |
| 00E | à | á | â | ã | ä | å | æ | ç | è | é | ê | ë | ì | í | î | ï |
| 00F | ð | ñ | ò | ó | ô | õ | ö | ÷ | ø | ù | ú | û | ü | ý | þ | ÿ |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |

**Cyrillic**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 040 | Ѐ | Ё | Ђ | Ѓ | Є | Ѕ | І | Ї | Ј | Љ | Њ | Ћ | Ќ | Ѝ | Ў | Џ |
| 041 | А | Б | В | Г | Д | Е | Ж | З | И | Й | К | Л | М | Н | О | П |
| 042 | Р | С | Т | У | Ф | Х | Ц | Ч | Ш | Щ | Ъ | Ы | Ь | Э | Ю | Я |
| 043 | а | б | в | г | д | е | ж | з | и | й | к | л | м | н | о | п |
| 044 | р | с | т | у | ф | х | ц | ч | ш | щ | ъ | ы | ь | э | ю | я |
| 045 | ѐ | ё | ђ | ѓ | є | ѕ | і | ї | ј | љ | њ | ћ | ќ | ѝ | ў | џ |
| 046 | Ѡ | ѡ | Ѣ | ѣ | Ю | ю | Ѧ | ѧ | Ѩ | ѩ | Ѫ | ѫ | Ѭ | ѭ | Ѯ | ѯ |
| 047 | Ѱ | ѱ | Ѳ | ѳ | Ѵ | ѵ | Ѷ | ѷ | Ѹ | ѹ | Ѻ | ѻ | Ѽ | ѽ | Ѿ | ѿ |
| 048 | Ҁ | ҁ | ҂ | ҃ | ҄ | ҅ | ҆ | ҇ | ҈ | ҉ | Ҋ | ҋ | Ь | ь | Ҏ | ҏ |
| 049 | Ґ | ґ | Ғ | ғ | Ҕ | ҕ | Ж | ж | Ҙ | ҙ | Қ | қ | Ҝ | ҝ | Ҟ | ҟ |
| 04A | Ҡ | ҡ | Ң | ң | Ҥ | ҥ | Ҧ | ҧ | Ҩ | ҩ | Ҫ | ҫ | Ҭ | ҭ | Ү | ү |
| 04B | Ұ | ұ | Ҳ | ҳ | Ҵ | ҵ | Ҷ | ҷ | Ҹ | ҹ | Һ | һ | Ҽ | ҽ | Ҿ | ҿ |
| 04C | І | Ӂ | ӂ | Ӄ | ӄ | Ӆ | ӆ | Ӈ | ӈ | Ӊ | ӊ | Ӌ | ӌ | Ӎ | ӎ | Ӏ |
| 04D | Ӑ | ӑ | Ӓ | ӓ | Ӕ | ӕ | Ӗ | ӗ | Ә | ә | Ӛ | ӛ | Ӝ | ӝ | Ӟ | ӟ |
| 04E | Ӡ | ӡ | Ӣ | ӣ | Ӥ | ӥ | Ӧ | ӧ | Ө | ө | Ӫ | ӫ | Ӭ | ӭ | Ӯ | ӯ |
| 04F | Ӱ | ӱ | Ӳ | ӳ | Ӵ | ӵ | Ӷ | ӷ | Ӹ | ӹ | Ӻ | ӻ | Ӽ | ӽ | Ӿ | ӿ |
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |

Table 0.2.10 Example of the character/glyph distinction in Unicode

| **Character** | **Sample glyphs** | | | | | |
|---|---|---|---|---|---|---|
| a |  |  |  |  |  |  |

### 1.2. Instrumental analysis in manuscript studies

Physico-chemical analyses of writing materials offer insight into various questions associated with historical, cultural and conservation aspects of manuscript studies. The catalogue of questions includes authenticity, dating, or attribution of various parts of the text to different scribes, relation between primary and secondary texts, and so on. Similarly, preservation of the manuscripts requires knowledge of the composition of the original materials vs. old repairs, identification of damage, as well as recognition of natural ageing and degradation processes. The material sciences can contribute data about the chemical compositions of the writing materials, elucidation of the techniques of their production and the absolute age of organic components, as well as characterization of corrosion effects, evaluation of conservation treatment, and monitoring of the preservation state. It is probably impossible now to pinpoint the first analytical studies of objects of historical interest.

It seems, however, that metal studies of pre-historic finds in the 1870s belong to the earliest documented chemical investigations. In 1888 the first chemical laboratory, today known as Rathgen Research Laboratory, was opened in Berlin to assist conservation. Within the following fifty years scientific studies in archaeology and conservation became established mostly within the frame of Egyptology, as witnessed by numerous editions of the standard textbook Ancient Egyptian Materials and Industries first published by Alfred Lucas in 1926 (19624).

In 1946 Willard Libby published the first paper on the decay of radiocarbon, which can be viewed as a revolution in the studies of organic artefacts: he showed that organic matter carries an internal clock and, therefore, can be dated within the range of approximately fifty thousand years. It took some forty years to improve the measurements methods that allow for reduction of the material tested, to standardize and to calibrate this technique (<http://www.c14dating.com/>). Despite the fact that it is an inherently destructive analysis, it is universally accepted in the studies of manuscripts. In the 1990s another scientific breakthrough—DNA sequencing—

looked very promising not only for identification of the precursor species for parchment but for a range of historical questions such as relation between the species and their geographical origin. This technique is, however, still under refinement and is not routinely employed in the field of manuscript studies (Bower et al. 2010). Recently, researches from the department of archaeology at the University of York developed a radically new method that requires only minute amounts of collagen to determine the species of animal used in parchment production (Fiddyment et al. 2014). We hope that this technique will find a broad application in the field of cultural heritage. One of the great shortcomings of the radiocarbon and DNA methods is their sensitivity to contaminations.

Radiocarbon analysis of a contaminated sample can easily result in an error of hundreds of years. Therefore, both techniques should be coupled with non-destructive material analysis to reduce the chance of sampling contaminated material. Over the last two decades, the impact of material studies has increased enormously with the industry driven development of so-called 'non-destructive technology' (NDT) that does not require extracting samples for testing. Further technological developments have led to the invention of NDT methods using extremely small measurement spots. Alongside their advantages, however, these methods have obvious limitations when deployed to analyse objects whose composition displays heterogeneity of the same order of magnitude as the measurement spot. Therefore their application as a random single-shot measurement should be avoided. Since protocols for routine measurements pertaining to X-ray intensity, measurement time and minimal signal-to-noise ratio similar to those current in the medical sciences have yet to be established, presently available results must be interpreted with extreme caution. Denker et al. (2006) offer a good introduction to relevant technical investigations in the field of arts and cultural heritage.

The most popular non-destructive techniques can be roughly subdivided into optical and vibration of elemental composition. Other techniques such as electron

microscopy to study surface morphology and X-ray diffraction (XRD) to identify pigments are traditionally used when extracting samples is allowed. Optical properties reflect the interaction of a material with light from ultraviolet (UV), visible (VIS), and infrared (IR) regions of the electromagnetic spectrum. IR reflectography has been traditionally used to study soot-based pigments or carbon inks: the colour of soot inks is independent of the illumination wavelength in the range 300–1,700 nm; plant inks lose opacity between 750 and 1,000 nm, whereas iron-gall inks become transparent only at a wavelength > 1,000 nm. Similarly, multispectral imaging for the visualization of palimpsests can allow one to differentiate between soot-based and tannin-based inks, since only the latter become transparent in the infrared region of the spectrum. A conventional multispectral imaging set-up employs LED illumination with up to thirteen different wavelengths ranging from UV to near IR region (Christens-Barry et al. 2011). To incorporate ink differentiation into routine manuscript digitization workflows, one could adopt a simplified 2- or 3-wavelength reflectography, since the main goal is to investigate the opacity in the spectral range 700–1000 nm. An easy way to add such functionality to the routine inspection of manuscripts by scholars is to use a hand-held USB microscope equipped with a 940 nm light source, or a pocket multispectral camera. It should be stressed, however, that pure soot inks can be unambiguously identified by reflectography at a wavelength 1,000 nm. It is distinguishing between plant and iron-gall inks that is challenging and requires additional tests in the range 750–1000 nm. It has become customary to refer to this range as ‘near infrared’ since commonly used digital cameras are equipped with silicon detectors that lose sensitivity around 1,000 nm.

Vibration spectroscopy (IR and Raman) allows identification of molecules and their structure by supplying specific information on vibrations of atoms in the molecules and is therefore routinely applied in order to screen unknown materials. In the first technique, a molecule absorbs a portion of the irradiated infrared light, hence its name, IR spectroscopy.

Soot, plant, and iron-gall inks form different typological classes of historical black writing materials used in manuscript production. Soot ink is a fine dispersion of carbon pigments in a water-soluble binding agent; plant-based ink consists of tree bark (tannin) solution; iron-gall ink, produced by mixing iron(II) sulphate with a tannin extract from gall nuts, presents a boundary case between soot and plant ink – a water soluble preliminary stage (similar to inks from the second group) oxidizes and evolves into a black, insoluble material (similar to the carbon pigments of the first group) when the writing is exposed to air. Each ink class has distinct properties that would readily permit their easy differentiation, if only the inks used throughout history always belonged to just one of these classes. Carbon inks do not penetrate the substrate (whether papyrus, parchment or paper) and stay well localized on the surface. In contrast, plant inks and iron-gall inks are absorbed by the substrate, and the degree of their absorption depends to a great extent on the nature of the substrate. Iron-gall inks are best studied by the means of the XRF technique. Natural vitriol, the main component of the historical iron-gall inks, consists of a mixture of metallic sulphates (iron sulphate, copper sulphate, manganese sulphate, and zinc sulphate) with relative weight contributions characteristic of the vitriol source or purification procedure (Krekel 1999). One uses this very property of the iron-gall inks to compare them and to distinguish among them. Specifically, the development of the fingerprint model based on the qualitative and quantitative detection of inorganic components of iron-gall inks allows their reliable classification (Hahn et al. 2004, 2008b).

In addition to inks of pure classes, mixed inks containing components of different classes are well known. In such cases, the ink usually has a type-defining component and ‘picture smearing’ additives. In this respect, a recipe from Dioscorides is remarkable among ancient Roman recipes for the production of soot inks. Along with soot (‘condensed smoke’) and gum, the recipe mentions a copper compound: chalcanthon (Zerdoun Bat-Yehouda 1983, 80). Indeed, PIXE studies of ancient Greek papyri from the Louvre collection identified copper in the inks. Without supporting

evidence from other analyses, these inks were classified as metal-gall ones (Delange et al. 1990). In contrast to iron, however, copper does not produce a black precipitate upon reaction with gallic acid. The term ‘metal-gall’ is therefore misleading; only ‘irongall’ should be used. PIXE and micro-X-Ray Fluorescence (μ-XRF) studies of the Dead Sea Scrolls revealed a number of documents written with inks containing large amounts of copper. In this case, however, the use of infrared reflectography unequivocally proved the soot nature of the inks and helped to avoid erroneous classification.

The difficulty and high costs of soot-ink production resulted in various attempts to replace them. We believe that the early appearance of the plant inks can be correlated with such attempts. In some cases, small quantities of soot were added to improve their colour. Some mediaeval Arabic and Jewish recipes for soot inks contain such additives as vitriol and tannins (Schopen 2006).

Even more gradual is the transition from the purely plant (that is tannin) inks to the iron-gall inks since a small addition of vitriol to a tannin ink would produce an imperfect iron-gall ink. Moreover, metals like iron and copper can occasionally be present in the tannin inks due to the water or tools used in the production process. Though a full elucidation of the composition of such inks requires the combination of XRF, Raman and IR reflectography (Rabin et al. 2012), the determination of the main components can be accomplished using their optical properties alone, i.e. their opacity in the spectral range 700–1000 nm.

## CHAPTER II. ETHICAL AND LEGAL ASPECTS OF MANUSCRIPT RESEARCH

### 2.1. Ethics in research and conservation of oriental manuscripts

The professional ethical standards of researchers of manuscripts, persons in charge of manuscript collections, and those responsible for the conservation are not a recent invention. For many years questions have been raised concerning the methods and technical choices allowed in historical research, and these apply also to the treatment of documents in archives, libraries and museums. At the end of the nineteenth century in France, the school derived inspiration from German historians (see Bourdeau 1888) and dictated the first rules for the positivistic approach to historiography: August Comte stated that a historian must study all facets of history. The same general principles were applied in the twentieth century by the *Annales* school. A historian must neither judge nor interpret the past, but take witnesses as they are. There must be a total separation between the historian and the historical fact. History exists in and of itself, and we can therefore arrive at a historical fact. The work of a historian is to find and re-assemble the verified facts in order to constitute a history that will organize itself. At the end of the nineteenth century a number of historians were also palaeographers working in archives, and their work influenced the library and archival economy.

In archives and libraries, there has been for years a discussion concerning ethical rules to be respected. In the domain of museums, it suffices to recall the questions of the theoreticians of restoration. The most emblematic case is certainly the polemic that took place during the eighteenth and most of nineteenth centuries surrounding the return of the Laocoon group, the famous sculpture discovered in 1506. Gotthold Ephraim Lessing's publications, and then the work of John Ruskin (1819–1900) who expressed his unfavourable opinion concerning the restitution of the Laocoon by Giovanni Antonio Montorsoli in 1523, are the principal witnesses. In the

twentieth century the need was felt to regulate and normalize these aspects at the heart of their respective international professional organizations.

Each country has developed a professional code of ethics used by researchers, but at an international level, this regulation emerges at the heart of the International Council for Science which was founded between the two wars, in 1931, as a non-governmental organization dedicated to the international cooperation for scientific progress. In matters of applied ethics, this organization presents, on its internet site, a chapter dedicated to the freedom and the responsibility of researchers. At a European level, the European Research Council, which depends on the European Union, does not seem to have worked on this aspect of regulation (apart from the Ethics Review that mostly regards natural sciences and sensitive personal data), even though the European Science Foundation (the carrier of the Research Networking Programme COMSt) has put a lot of work into this question.

The international professional organizations have not all launched a process for the regulation of ethics. The International Council of Museums (ICOM) adopted its code of ethics for museums in 1986 while the International Federation of Library Association (IFLA) and the International Council of Archives (ICA) do not seem to have adopted, to this day, any similar code.

For manuscripts in particular, one must look at the text by the IFLA (*The Principles of Conservation and Restoration of the Collections in the Libraries*, 1979), as first presented at a congress in Copenhagen. A revised version was edited in 2012 in the context of the Preservation and Conservation (PAO) plan. The text of 1979 reminds us already of the importance of necessary measures of preventive conservation. For aspects of restoration, the essential principles were outlined in the 1980s and they remain valid today, even if they are not always easy to apply. The three core principles are repeatedly recalled in Chapter 5: (1) the reversibility of the treatment; (2) the safety of the products and materials used and (3) the honesty of the intervention. In the case of oriental manuscripts, we deal in most cases with items that

are religious or are attached to a living religious practice. This creates additional issues for researchers, collection managers, and conservators. Thus, until recently there existed considerable religious reticence concerning the promotion of manuscripts. For example, a Druze community in Syria that venerates a manuscript (the complete book of the sacred book of the Druze) refused any exhibition, as for them, this manuscript cannot be seen by non-Druze (according to Eldin 2013). The same limits are also valid for digital copies: a few years ago, was proclaimed against the digitization of the diffusion in digital libraries. Today, mentalities have evolved, and the religious authorities usually accept museum and/or digitization practices, and even encourage them. An awareness has equally evolved that, by recording a manuscript in a database and making the information or a reproduction accessible to the general public, not only do we promote research but also protect the objects from a possible theft: a secure identification is created, and the object, if stolen, cannot be easily sold (Ipert 2005).

Restoration is another domain with religious connotations. For example, can one use alcohol to soften the parchment leaves of it following professional rules? On the Sabbath, must one disconnect the electricity of a freezer where flooded Tora scrolls are conserved? After documentation and restoration, must manuscripts from a *geniza* be re-buried? Can a Christian liturgical book continue to be used by a community of monks after having been restored, at the risk of future deterioration? The conservator is often at a loss when confronted with these questions. Whether for research, enhancing, or restoration of oriental manuscripts, it is sometimes difficult to follow the rules of ethics of the international professional organizations because these rules are most often conceived with a western perspective in mind. The only professional response is to explain well that researchers, museums and libraries cultivate scientific research, and, more specifically, that archives, libraries and museums are cultural institutions where all religions are respected, but that religions should not impose their rules.

Strictly speaking, manuscripts are not a legal category. However, a number of legal texts at national, international and European level do refer to manuscripts. The UNESCO Convention of 14 November 1970 defines as cultural property: 'rare manuscripts and incunabula, old books, documents and publications of special interest (historical, artistic, scientific, literary, etc.) singly or in collections', whereas the Hague Convention mentions 'manuscripts, books and other objects of artistic, historical or archaeological interest; as well … important collections of books or archives or of reproductions of the property defined above'. The UNESCO Memory of the World Programme focuses on the preservation and accessibility of documentary heritage, a broad concept that includes the books, manuscripts and archival collections listed in the Memory of the World Register provided that they are of international interest and universal value. Manuscripts are also covered by the legislation on intellectual property.

We can see that a manuscript is a complex object, a hybrid material valued for its content, for its precious character, singly or in a collection. This multiform reality must be expressed in the law. Firstly, a significant distinction is to be drawn. The physical medium of the manuscript is protected by a number of rules. These rules serve private as well as public interests. They are mostly related to the issue of ownership. Manuscripts are subject to ownership; they can belong to individuals or public entities, institutions, libraries, archives, and so forth. Other rules govern the conditions of use and access to the intellectual content. While in principle there may be a conflict between the legal protection of the physical object and the legal protection of the object's intellectual content, this rarely applies to manuscript studies, as in most cases intellectual rights expire within one or two generations after the death of the author and thus do not apply to manuscript content. We will discuss the legal status of manuscripts with respect to the great legal challenges they pose: material conservation, circulation, access, dissemination and valorization.

There are very few international texts specifically targeting manuscripts or books. Binding legal instruments (that impose obligations on the states signing and ratifying the conventions) concern more widely all the goods that are part of cultural heritage. Nevertheless, some soft law texts are worth mentioning, alongside the programs developed by UNESCO, in particular the Memory of the World Programme.

Within the general framework of cultural heritage preservation, few laws are likely to apply to manuscripts. In 1954, the first international convention to tackle the issue of protecting cultural objects (here, only in cases of armed conflicts) was passed; while providing a more inclusive understanding of cultural property, it expressly mentioned manuscripts. Under Article 4, the *Convention for the Protection of Cultural Property in the Event of Armed Conflict* of 14 May 1954 (Second Protocol, 26 March 1999) states that the parties must respect cultural property situated within their own territory as well as within the territory of other parties by 'refraining from any use of the property and its immediate surroundings or of the appliances in use for its protection for purposes which are likely to expose it to destruction or damage in the event of armed conflict; and by refraining from any act of hostility, directed against such property'. No derogation to this principle of respect for property is possible, unless military necessity imperatively requires it. In addition, the parties 'undertake to prohibit, prevent and, if necessary, put a stop to any form of theft, pillage or misappropriation of, and any acts of vandalism directed against, cultural property…'. In case of occupation, the occupant must 'as far as possible support the competent national authorities of the occupied country in safeguarding and preserving its cultural property'. The convention also provides for refuges to shelter movable cultural property; these refuges are placed under special protection and must be identifiable. Special protection is granted to cultural property by its entry in the 'International Register of Cultural Property under Special Protection'. The idea of the Convention is to ensure that each belligerent respects cultural property. To this aim, a

distinctive and internationally recognizable emblem must be placed on the cultural goods protected by the convention. Apart from this convention, there is no other binding instrument safeguarding movable cultural property as a whole.

There are soft law texts, however, that must be considered. In 2006, the Quebec archival community passed a Declaration on archives. It has been taken up at international level in 2011 when the International Council on Archives adopted the Universal Declaration on Archives which was very influenced by the Quebec declaration. Nevertheless, these declarations carry no legal weight. While recognizing the significance of archives for memory, it is advocated that: 'the management of archives is valued and is carried out fully in civil society, public bodies and businesses; archives are conserved in conditions that ensure their authenticity, integrity and intelligibility; archives are made accessible to everyone, while respecting the rights of individuals, creators, owners and users.'

The Memory of the World programmer is based on the principle 'that the world's documentary heritage belongs to all, should be fully preserved and protected for all and, with due recognition of cultural mores and practicalities, should be permanently accessible to all without hindrance', last accessed June 2014). In this view, the two prevailing objectives are preservation and access. As regards the first objective, the program aims at ensuring and facilitating the preservation of the world's documentary heritage by providing subsidies and disseminating advice and information. As regards the second objective, the legal requirements that protect private or public interests (property rights, intellectual property rights, archive rights, and so forth) can sometimes get in the way of access. The programme prescribes that these potential limitations must be recognized. It also recommends that 'indigenous communities' custodianship of their materials, and their guardianship of access' must be honoured.

Protective measures for documents, manuscripts and archives take multiple forms: some of them focus on the material preservation of the medium, and others set

out the conditions governing access to these documents or manuscripts. Generally speaking, there is no specific protection for manuscripts. Just like at international level, it is necessary to invoke either the general rules governing the preservation of tangible heritage, or public property rules. The heritage protection schemes set up by states often target cultural property as a whole. This allows ensuring the protection of documents and manuscripts. Laws on historical monuments (that generally include immovable as well as movable property), cultural property laws or cultural heritage laws have instituted protective measures that can be very restrictive. They oblige the owner to request an authorization for any activity that may alter the property: restoration work, modification, or any transformation that could impact the character of the property under protection. These measures are intended to protect property of artistic or historic interest, the creations belonging to cultural and intellectual heritage.

Manuscripts can be protected on this basis. A certain number of these protective measures apply to isolated items; for example when it is a matter of preserving a given building, manuscript or artwork. But there are different ways of considering a set; for instance, it could arise from the exceptional consistency of a fund or collection from a literary, artistic or historical standpoint. The consequences of such recognition vary according to the country, and it is not always possible to safeguard the whole set. In a number of states, publicly owned cultural property is relatively well protected. In some countries, cultural property becomes public property because it is thought to serve the public interest, which is why it is considered as inalienable, imprescriptible (it can be claimed without any limit in time) and cannot be seized. The character of inalienability means that the public owner cannot sell or even donate the property for as long as it remains under that special regime, that is to say as long as it serves the public interest. Such property can be found in museum collections, archival funds or libraries. This public nature is frequently used as an argument against restitution claims from other states. However, public property rules are not equally efficient among states. Customary property laws

may also be relevant. Conservation of manuscripts is sometimes ensured by private law instruments such as trusts, foundations, or in Muslim law (forms of collective properties), which entail some obligations. For the oriental manuscripts, a very significant amount is privately owned by families; many documents are held in religious institutions such as monasteries, churches, mosques, or synagogues.

### 2.2. Circulation of manuscripts and books

The circulation of manuscripts is another significant theme in cultural heritage law. Such protection has two functions: a preventive one and a repressive one. *Prevention: controls on the movements of artworks* Before studying the domestic principles governing the circulation of cultural property, it is important to consider these rules in a more global context, at international, European and national level. Again, as was the case in terms of protection, international rules come from general instruments concerning movable cultural property as a whole and not specifically manuscripts, books or archives. On an international level, from the beginning, the General Agreement on Tariffs and Trade (GATT, established in 1947, last updated in 1994) recognized that, to achieve the protection of national treasures, the circulation of cultural property could be subject to restrictions (for exportation or importation) in domestic legislations. Article XX: General Exceptions prescribes that 'Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures … (*f*) imposed for the protection of national treasures of artistic, historic or archaeological value.

In this view, states are not allowed to act totally freely. A measure not justified or a disguised restriction on international trade can be disputed. As of now, no case has been heard by the World Trade Organization (WTO). The rules governing the

circulation of cultural property at European level are more complex. Insofar as the European Union (EU), like the WTO, promotes trade liberalization, it also needs to reach a compromise between the free movement of goods and heritage protection. Article 36 of the TFEU also allows setting up prohibitions or restrictions on imports, exports or goods in transit justified on grounds of the protection of national treasures possessing artistic, historic or archaeological value. With the creation of the internal market on 1 January 1993, the EU member states' legislations regulating the circulation of cultural property and the prohibition of the most valuable cultural goods have been seriously undermined. To prevent or fight the unlawful removal of cultural property from a member state to another member state or outside the EU, two pieces of legislation have been passed. The first one creates a common control procedure to export towards third countries, whereas the second one regulates the return of the unlawfully removed national treasures that circulate within the Union. Manuscripts are mentioned among the categories listed in the annex to these texts. Finally, provided that they comply with WTO and EU rules, states establish their own legislations controlling the circulation of cultural property and, in that respect, the cultural objects under protection are not the same ones everywhere, and the techniques and methods for controlling their circulation vary as well.

Some states have developed broad definitions of cultural property, and they control significant cultural objects which are called in different ways (cultural heritage, cultural object, object of cultural significance, national treasure, and the like). Other states choose to list all the objects falling into a given category. Both methods are sometimes combined.

In the context of European policies on digitization and access to cultural heritage, we can speak today of a legal recognition of the right of libraries and archives to digitize manuscripts when it serves the purpose of conservation and accessibility of the manuscripts.

However, when approaching manuscripts from the legal point of view one should always regard them from two perspectives: (1) as containers of works that are sources of metadata and scholarly work and are subject to intellectual property rights (2) as material objects that are subject to material property rights, and are sources of images that can be produced from manuscripts.

Cataloguing of manuscripts (prior to exhibition or digitization) falls within the responsibilities and tasks of the library or archive where they are preserved. The resulting metadata is part of the digital library catalogues. It is recommended—as is already the case in many European countries—that the metadata should be integrated into national or international databases (hypercatalogues) that could be filtered by various parameters, including places of origin and historical periods.

The cataloguing entries themselves may also be subject to intellectual property rights, especially if they meet the originality criteria and involve scholarly analysis. When, as often happens in basic library catalogues, there is no real originality, the metadata should not be considered independently from the document the description identifies.

Libraries should be advised to specify on their Internet pages the conditions of use regarding these descriptive metadata, indicating that use is free provided the source is fully credited alongside the date of retrieval under an open license.

When manuscripts have been the subject of a study that identifies the date and shows their characteristics, such a study (a copyright protected object) may be very useful for those who consult the manuscript and should at least be referenced in the descriptive metadata. While it may be helpful if such studies are available with the manuscripts, they cannot, in principle, be reproduced or distributed without the permission of the authors. However, there are two relevant exceptions in intellectual property rights.

The first is citation, when certain elements of a study have been incorporated into another work. The citation must be appropriately short and justified by the

scientific content of the work in which it is incorporated; the name of the author and source must be clearly indicated.

In addition to studies that have gone out of copyright for time reasons, so-called orphan works (when we have lost track of the authors) may be reproduced by libraries or archives without permission under European law, provided the institutions can demonstrate that they have tried to locate copyright holders and that the search has been unsuccessful. Orphan works may be made accessible alongside the manuscript metadata provided full bibliographic reference is given.

In most European countries, if a manuscript is in a public collection, the institution that keeps it has no rights to the photographic images of this manuscript. However, in some member states of the European Union (e.g. Greece) the reproduction copyright belongs to the state, and therefore prior to any digitization action one should apply for, and receive, authorization. The local legal framework must thus always be clarified before any digitization campaign. If the owner is a private person, an authorization request is always required. Most museums allow amateur photography of works including manuscripts but the terms are defined by conservation and security demands. For example, the Musée du Louvre in Paris allows photographs without flash and without the use of tripods. Similarly, in France, professional photography can no longer be forbidden in public museums, as such a prohibition would violate the principle of freedom of trade and industry. Still, permission is strictly regulated. These examples show the importance of finding out beforehand what is allowed and under which conditions.

A separate question is whether the person who takes a photograph as an amateur may use it to illustrate a research work. While it may seem logical – since the photography itself is allowed – it is best to make sure, as using an image in a publication can be considered a commercial operation and thus adversely affect the rights of the owners. It is therefore recommended to take precautions and request permission.

Finally, photographers have intellectual property rights on the photographs they have created, and the reproduction or dissemination of manuscript images cannot be done without their permission. The rights, however, may not belong to the photographers themselves but to the person or institution who contracted them if their work has been part of a service or a project. When libraries create online photo galleries (which meet an important need for researchers), it is essential for each photograph to be accompanied by a statement not only about the subject photographed, but also about the status of the photograph (its author, date, conditions of reproduction, contact person, etc.).

## CHAPTER III. CONSERVATION: MAIN CONTEMPORARY TECHNIQUES AND PRACTICES

### 3.1. Basic principles of conservation

In order to understand the role of the conservator in the care of manuscripts, books, paper artefacts and archival material, it is necessary to follow how the evolution of the science of conservation has matured up to the present day. The philosophy around the multi-disciplinary field of conservation has evolved as the natural sciences and bibliographical studies have developed, providing the conservator with more options with regard to materials, equipment and techniques, as our understanding of the physical and chemical properties of the materials present in manuscript cultures deepens and at the same time as we learn from our past experiences and mistakes.

The same basic principles direct the conservator and his decisions on how best to preserve and conserve an object. The integrity of an object, the evidence of its history and its archaeological significance must be preserved above all. The conservator's role is to prolong the life of an object in its entirety, which in the case of manuscripts means that all parts of the object, not only the text or the text block but also its binding, its sewing, its boards and endbands, the covering materials and their decoration, are of equal importance and must be preserved.

A fundamental change in the concept of carrying out treatments on bound manuscripts over the last few decades has redefined what conservation is, with a shift from 'restoration' work, which aimed at remodelling and rebinding manuscripts entirely in order to create aesthetically pleasing results, towards a more moderate and reflective approach towards the history of the object, which conceives manuscripts also as archaeological objects. Thus the structural elements of books are respected and preserved. What is more, over the last three decades the science of conservation has experienced a gradual shift towards what is known as *minimal intervention* (or *minimal conservation*, see Ch. 5 § 1.2) giving more ground to the application of

preventive conservation measures. It is now widely perceived that minimizing intervention with a greater concern for the historical and archaeological aspects of collections is the most effective way to approach collections, and many institutions and conservation professionals are following entirely a minimal intervention policy.

The concept of minimal intervention since its first appearance relied greatly on the fundamental growth of preventive conservation science and the concept that conservation treatments must be fully reversible. Nevertheless, full reversibility of treatments is gradually re-evaluated as its feasibility is questioned, since most conservation treatments will inevitably alter even in the smallest amount the structural and physical properties of objects.

Minimal intervention is still a driving concept in the area of the conservation of manuscripts. However, there are limitations to its benefits, which relate to the requirements of the accessibility of manuscripts and the need to display them for exhibition purposes. What is more, minimal intervention may not deal with certain types of decay on specific objects which may require a more interventive approach to address immediate threats.

The decision on what should be the most appropriate conservation treatment depends on the conservator's critical thinking and his examination, evaluation and appreciation of the condition of the object and the requirements of the manuscript he is called upon to take care of. Interventive treatments may be deemed more necessary on certain occasions and, guided by professional principles and practices, the trained conservator must make intelligent and realistic decisions on each manuscript individually.

The conservator is also called upon to take decisions on what treatment is most appropriate for an object judging by the possible implications of his actions on the evidence of the object's history, the possibility that his interventions may interfere with parts of the structure that will be excessively disturbed, and the necessity to stop or delay any form of decay or damage that is a risk for the manuscript. Conservation

treatment may also be decided on for specific reasons. The display of manuscripts in exhibitions and their digitization may also dictate that specific treatments are required, while financial and time perspectives are also fundamental in the decision-making process, and different conservation plans and priorities are therefore formulated.

Treatments may thus generally be categorized as either minimal or interventive. This fact has significance for projections on the types of treatment that are considered acceptable and respectful for manuscripts in each case, as well as for the materials that conservators may apply to them. The materials that are selected for conservation work, particularly those materials that will be used and will become part of the object, must be as reversible as possible and should leave the smallest possible deposits, remnants and influence on the integrity of the manuscript, should they need to be removed in the future for any reason. The quality and availability of materials is a fundamental part in the equation to justify whether conservation treatments are possible. Inappropriate materials, such as acidic repair papers and acidic boards, synthetic adhesives and poor quality leathers are only some examples of materials that have been used in the repair process of oriental manuscripts primarily in areas where conservation standard materials are not always available, or due to inadequate understanding of their possible negative effects. It is vital to stress that introducing poor quality materials into manuscripts may be severely damaging and conservation treatments are best not executed unless good quality materials are available.

The conservator is equipped with the training to have an understanding of materials in manuscript cultures, the knowledge of the historical evidence contained in the structural features of bindings and the processes of degradation. His critical thinking and evaluation of what is the best way to approach a damaged manuscript on a case by case basis is the most effective way to address its problems. These constitute the principal guidelines for state-of-the-art conservation.

### 3.2. Conservation of text blocks

Mechanical damage to the leaves of the text block, flaking pigments of painted decoration and areas that present imminent threats of further mechanical damage are often types of damage that may be resolved by localized minimal treatments, with the aim of stabilizing them and preventing losses. The justification for their employment lies in the expected use of the manuscript, its possible digitization or display and the estimated benefits to the overall condition of the manuscript with localized stabilization.

**– Washing and deacidification**

The processes of washing and deacidification of paper text blocks have been practised extensively over the last decades, with the aim of reducing the discolouration and acidity of objects, and there are several studies to demonstrate both their disadvantages and advantages. In many cases, institutions have prompted the application of these treatments as a standardized practice of 'conservation', regardless of whether these treatments would be beneficial for the manuscripts in the long term, without looking at each manuscript and its problems individually and often without appropriate analytical testing. Washing and deacidification are not entirely inappropriate treatments, provided there is a good justification for their application, and there are certain cases where they might prove necessary. However, aqueous treatments require that text blocks are completely dismantled in order for them to be carried out, which is a severely destructive process, which interferes considerably with the historical integrity of the manuscripts and the archaeological evidence of bindings. In another respect, examinations and research on the effects of washing have shown that the primary objective of this treatment, which is to remove acidic products in the paper and to strengthen and return flexibility to the fibre matrix of the paper, is not always realistic or possible. The problems that washing aims to address may not always be possible to resolve, since it is vital to understand the source of acidity in the paper. Acidity may derive from products used in the paper-making

process, in which case the acidity will be entirely irreversible, regardless of any washing or deacidification treatment. In other cases, where acidity is the result of external materials adjacent to our objects, preventive measures may be deemed much more effective, realistic and sympathetic to the overall state of the manuscript.

It is important to weigh the consequences of such drastic treatments, when substantial results may be achieved by the correct housing of manuscripts, which would slow down the process of oxidization or hydrolysis of the cellulose polymer of paper. Overall, the damage-benefit aspect of these treatments is often not in favour of their execution and it is seldom justifiable to dismantle a manuscript with the sole purpose of carrying out these treatments.

– **Paper and parchment repairs**

The materials and techniques used for the repair of tears, lacunae and mechanical damage to paper have developed significantly during the last decades, relying considerably on a range of suitable, traditional Japanese papers that are still produced in adequate qualities and quantities for the conservation market. Japanese papers offer excellent options with which the reinforcement and infilling of damaged paper and parchment can be performed. Pulp repairs have also been used by conservators and institutions around the world; these offer very good aesthetic

results and can appear outstanding. Unfortunately, these pulp repairs have very low tensile strength and very short fibres, which result in weak repairs with low stability that are often in need of extra tissue lining or extra adhesive, so that it is debatable whether they will last in time. What is more, in order to carry out pulp repairs it is necessary to work on individual leaves and not on bound manuscripts; therefore these repairs cannot be performed unless manuscripts are disbound.

In comparison with Japanese paper repairs (using good quality, pH-neutral, long-fibre papers) pulp repairs may be easier and quicker to carry out, with good aesthetic results, but are significantly inferior in theirmechanical properties and more restricting in the conditions under which they can be performed. This is also the case with leafcasting (an apparatus used for infilling large areas of losses with paper pulp): although good aesthetic results can be produced, the unavoidable aqueous environment in which this treatment has to take place, along with the low tensile strength of the pulp fibres, have made leafcasting a less preferred method.

**– Ink corrosion treatments**

For many years it was believed that the cure for the problem of ink corrosion from iron-gall inks, a common problem for manuscripts across the oriental manuscript traditions, was a deacidification treatment where the acidity of the ink could be counterbalanced by an alkaline solution, thereby arresting corrosion. Recent research has raised doubts as to the efficacy of this approach. One of the main disadvantages of alkaline treatments is that they must be performed in aqueous solutions, otherwise the alkaline solutions would act only superficially and not on the whole matrix of the paper. Water, however, acts as a vector for the soluble ferrous irons, enhancing the corrosion process (Hahn et al. 2008a). The use of chelatingagents (such as EDTA) is considered equally unsatisfactory, since the iron-EDTA complex can still react with hydrogen peroxide and result in active free iron ions (Fe++) that will catalyse the oxidization process and lead to the degradation of the cellulose polymer. Alternative treatments such as the calcium phytate treatment in water-alcohol solutions (Neevel

1995, Botti et al. 2005) have shown better results in recent research; however the costs involved with these treatments are generally high, and for many institutions and conservation laboratories it may be a prohibiting factor. Low relative humidity (RH < 50%) slows down the oxidization process and is one of the most significant measures to take.

Parchment manuscripts on the other hand do not always present ink corrosion problems and are thus not equally in need of ink treatments. This is mainly related to the process of preparation of medieval parchment, which involved treatment with lime thus supplying an alkaline reserve.

**– Adhesives**

Numerous adhesives have traditionally been used in the restoration and conservation of manuscripts. Most frequently we encounter organic adhesives such as wheat starches, gelatin (animal glue or fish glue), isinglass (used for parchment repairs) and in the last few decades the laboratory-produced methyl cellulose.

Local variants, such as the bamia paste (a derivative of okra), found in Middle Eastern countries, are occasionally found and traditionally used but in most cases are not tested for their conservation quality properties. The most frequently encountered synthetic adhesives are PVA (polyvinyl acetate) and EVA(ethylene vinyl acetate).

Depending on the type of work to be carried out—whether paper repairs, leatherwork, parchment repairs or box-making—different adhesives may be selected and considered appropriate. The most significant recommendation that conservators can provide today is that synthetic adhesives, such as PVA and EVA, should never be used in direct contact with any part of the object, for two main reasons: a) they are irreversible, particularly as they lose their elasticity over time, b) off-gassing acetates produced from these adhesives are damaging to the manuscripts (see also Ch. 5 §§ 2.1 and 4.2).

It is therefore recommended to avoid using synthetic adhesives entirely,

Parchment; *c.*315 mm × 215 mm; 24 lines per page; script: Arabic: *ḥiǧāzī*-II; early eighth century; probably of Syrian provenance

| *Paris, BnF, Arabe 328e* | *Kuwait, LNS, 19CA*[ab] | *London, BL, Or. 2165* |
|---|---|---|
| 6 ff. | 2 ff. | 121 ff. |
| 5:7–65 (ff. 90–92)<br>6:39–6:112 (ff. 93–95) | 5:89–6:12 (2 ff.) | 7:42–9:95 (ff. 1–14)<br>10:9–39:47 (ff. 15–113)<br>40:61–43:71 (ff. 114–21) |



reserving them only for the production of boxes and containers for the safe-keeping of manuscripts, in which case EVA is preferable over PVA, and again it should be kept away from areas in contact with the manuscript as much as possible. There has been a long debate over the use of methyl cellulose versus wheat starch in the last decades, with equally strong arguments from both sides. Wheat starch is a traditional adhesive that has been used for centuries across most manuscript cultures and which has proved in time to have excellent propertiesand not to be harmful to objects in any way. Its strength may often be partly lost in time, depending on the quality of the wheat used and the manufacturing of the adhesive, but particularly for use on paper repairs It is an excellent opinion? With very good flexibility characteristics that work very well with paper. But on the other hand, wheat starches are believed to attract insects, even though there is no systematic research to demonstrate that they are more attractive than the paper, wood, leather or other organic materials or even other adhesives that constitute the manuscript itself. The same is believed of animal glue,

which was often used as a bookbinding adhesive in many oriental binding traditions, particularly at the spine and spine lining of bindings. The alleged insect-attracting properties of wheat starch and gelatin may perhaps originate in a confusion with the properties of the area in which they are most frequently applied. The spine of the book is an area most suitable for insects to lay their eggs and for the larvae to develop, as it is a dark, in damage. Methyl cellulose appeared as an alternative to wheat starch particularly for this reason, and it has indeed very good conservation properties. However, it is less strong than wheat starch, which makes it unsuitable for bookbinding purposes, but only adequate for paper repairs, and it is also less tested over time.

Its applications in other processes in conservation, such as adhesive removal, paper sizing and the making of pre-coated Japanese tissues, make methyl cellulose nonetheless a very useful adhesive. It is evident that wheat starches are counterbalanced by their supposed insect-attracting characteristics. Many conservators over the years preferred to use insect repellents and insecticides such as formaldehyde and bromide mixed with wheat starch or methyl cellulose to prevent insect damage. This approach is objectionable in several respects. Primarily, the protection of a manuscript from insect damage is a preservation measure that should be considered in a more holistic and effective way, by improving the environmental and storage/ housing conditions of an item, as there are several other parts of a book that are prone to insect damage besides the adhesives. What is more, the application of insecticides is severely damaging for the paper or parchment substrates, and they also entail considerable risks for the health of the conservators applying them.

Parchment repairs require stronger adhesives than wheat starch or methyl-cellulose. Tests and the experiences of conservators over the years have demonstrated that isinglass, gelatin, or a mixture of gelatin with wheat starch are strong, flexible and sympathetic to parchment.

As an alternative to using adhesives directly on water or humidity-sensitive media or substrates, such as certain pigments, iron gall inks or substrates such as papyrus, it is often advised to use Japanese tissues pre-coated with an adhesive, such as methyl-cellulose or wheat starch, which can be activated with minor umidity or solvents.

**– Adhesive tapes**

Repairs made with adhesive tapes are one of the most common and most damaging habits of book readers and librarians, and have been used throughout the twentieth century. Either as an easy repair method for torn and damaged leaves or as a means of labelling, they pose an immediate problem to manuscripts.

These adhesive tapes are composed of two parts: the paper or synthetic tape and the adhesive, the latter being the most difficult to remove and the tapes' most damaging part. There are numerous varieties of tape and the adhesives applied on them are equally numerous, depending on the different producers, but the vast majority have severely damaging effects on paper and parchment substrates, which escalate with time as the adhesive penetrates deeper into the manuscript substrate and becomes less flexible and soluble.

The most effective method to remove the adhesive and the tape is with the use of organic solvents, such as ethanol or acetone, but even so it is often inevitable that part of the adhesive will have crystallized and irreversibly penetrated the matrix of the substrate, and little can be done about it without disturbing the substrate too much. The presence of adhesive tapes is often flagged as an emergency risk for manuscripts and calls for the immediate attention of the conservator, since it is a type of damage that becomes more and more difficult to resolve with the passage of time.

**– Lamination of leaves**

The lamination of fragile manuscript leaves is a technique that was developed long ago and has been used for many decades, in order to improve the handling of these materials and stabilize them against further losses. In previous decades, particularly

between the 1950s and 1970s, many libraries and archives around the world embarked largely on lamination projects, looking for quick, cheap and effective methods for mass lamination of documents and book leaves. Soluble, machine or hand lamination with nylon and heat set tissues were the most common techniques adopted, but unfortunately the ageing properties of these materials and the impossibility of reversing them raised great concerns for conservators from early on. Nowadays, lamination of manuscript leaves is considered an inappropriate and destructive method: research now aims to find solutions to reverse the damage it has caused. Alternatives to lamination should be sought by conservators needing to reinforce a fragile manuscript, such as using a facing technique with pre-coated Japanese tissues with wheat starch paste or methyl cellulose, or making ordinary paper repairs and paper bridges.

### 3.3. Sewing

Broken or damaged sewing is most often a result of handling and mechanical damage, or pest damage when infestation occurs at the spine of the book. The failed sewing may result in bifolia or quires coming loose from the text block and weakened opening and mechanical properties of the structure are observed. The conservator is often called upon to repair damaged sewing structures to restore the mechanics and functionality of the book. The decision on if and how to repair the book's sewing may be deeply complicated, depending on how accessible the spine area of the book is, how much the book will be used, what disturbance will occur to other areas of the structure in order to repair the sewing, how feasible it is to achieve a stable sewing judging from the condition of the leaves of the text block and how beneficial the repair of the sewing will be for the structure overall.

*In situ* minimal repairs of sewing are a possibility depending on these factors, without the need to dismantle a manuscript; adequate sewing techniques have been developed that aid the conservator with this choice, which can be less invasive and more respectful to the object. Disbinding bound manuscripts is widely regarded as an

unnecessary procedure, except as a last resort. Inevitably, when dismantling a binding, much of the history of the structure and of the manuscript itself will be irreversibly lost.

In those cases where the conservator reaches the decision to re-sew a text block entirely, the style of the original structure, its history of repairs and the strength of the text block leaves are some of the variables that the conservator needs to consider in deciding what style and materials he will use, as well as how best to apply these to minimize the interference with the manuscript and to provide an aesthetic and functional result that will not be foreign to the earlier sewing.

Minimal or more interventive treatments may be employed on binding elements such as the end-leaves, the spine lining, the endbands and the boards, following the general concept of minimal intervention. The intention would be to consolidate, repair locally and in situ areas of damage that need to be secured before leading to further damage, which will help the manuscript to be used, digitized or displayed with greater safety. None of these treatments should have the sole goal of restoring the book to a perfect state and the utmost care should be taken of those elements of its history that are disturbed by the choices the conservator makes.

– Leather repairs and the choice of leather

The repair of broken, torn and damaged leather covers is a type of damage the conservator frequently faces. The conservator's task is not that of removing damaged covers and replacing them with stronger and better functioning ones; he must attempt to consolidate, repair and strengthen the original leather, in order to prevent further losses and damages and to stabilize it so as to return the book to a functional state, in case it needs to be used. This is done with little less than mechanical applications of either Japanese paper linings and/or infills, toned appropriately to the shades of the leather, or with the addition of new pieces of leather, which are used to fill in the missing parts, to strengthen and replace the functionality of the cover. One of the most important parts of this process—and most difficult to achieve, apart from having

sufficient manual dexterity to complete good infills and repairs, is the choice of the additional materials to be used: the leather and the adhesive. It is unfortunate that good-quality leather, prepared with a natural vegetable tanning process as it has been traditionally used for many centuries on bookbindings, is not easily acquired nowadays. Research has shown that chrome tanning, which has dominated the leather manufacturing process over the last century, should be avoided for use on historical objects due to its unfavourable ageing properties and the reduced durability of the grain (Barlee 2001). Archival-quality, vegetable-tanned (semi-aluminium) skins should be preferred. Chrome-tanned leather is also found to be less workable by bookbinders. Care should be taken also of the dyes that have been used to colour or tone the leather, which must not be colour-fast or water-soluble, and of finishing skin lubricants with unknown and aesthetically inappropriate properties. Such lubricants should be applied with great care, as they can affect the long-term condition of leather: their incorrect application will form a barrier that can trap humidity within the collagen of the skin, leading to the growth of microorganisms and preventing the skin from reaching an equilibrium with the surrounding environment.

*– Board attachment repairs and consolidation*

Like the sewing of a text block, board-attachments may be repaired either *in situ*, by reinforcing the damaged attachment or by introducing a new board-attachment system. In the latter case many considerations will need to be made to evaluate the implications on the other components of the binding that may be affected by this process and to avoid disturbing, removing or altering them as much as possible.

*– Old repairs*

Old repairs, either in the text block or in parts of the sewing and binding of a manuscript, offer valuable evidence on the history of the manuscript and its previous conditions, its past owners, and may lead to significant information about its provenance. The history of repairs in parallel to the history of bookbinding is at the

same time a topic for systematic research as it may contribute substantially to what we know about individual manuscripts and about book producing cultures as a whole. It is recognized however that certain repairs of the past often pose problems to the present conditions of manuscripts and are a cause of further damage. The conservator may be faced with a dilemma between removing historical evidence, which may nevertheless be jeopardizing the very safety of the original manuscript. Unless threatening to the object, these pieces of evidence should be regarded as part of the manuscript and not removed or disturbed. Decisions must be weighed, justified and most importantly documented meticulously to provide the historical evidence in the event that they have to be disturbed.

## CONCLUSION

The unrestricted use of written sources is often associated with the human right to freedom of information and opinion. The provision of digital data is a prerequisite, although it cannot replace the preservation of the originals. The originals – manuscripts, documents and archival material, artistic graphics and so forth – are likely analogous to master files, whose preservation is a top priority. In fact, some people erroneously think digital copies will totally replace protection of the originals, as if they virtually replaced the analogue object. Undoubtedly, digitization allows virtually worldwide access to much-demanded collection items. This allows a certain protection of vulnerable objects as the necessity of physical access seemingly decreases. In practice, however, it has been shown quite often that due to the digitization of certain codices these objects gain a popularity that leads to an increasing demand for consultation of the originals. This effect could already be observed before digitization with high-quality facsimile editions.

An important point is also the risk for the original, which arises in the digitization of sensitive objects. For this reason, digitization should be carried out only by trained staff and after a carefully coordinated workflow (see below). Even the best digital copy is only a copy of the surface of a document that contains possibly visible and invisible information. A digitized version preserves neither the material substance of the object nor its condition. Therefore, while satisfying certain conservation-based aspects, digitization is not a measure for the permanent preservation of cultural heritage.

The digitization workflow can be divided into the following main parts: first, transport of the book from the shelf to the photographer followed by autopsy and decision-making; the actual digitization followed by return transport; the creation of metadata, control and processing.

Presumably, codices spend 99% of their lifetime on the shelf. For the purpose of digitization, individual books are picked and must first undergo an assessment of

their suitability for risk-free digitization. After a survey of their physical condition (see also Ch. 5 § 5), books in a risky condition are labelled to warn the photographer against risk of damage. Photographers often act under time pressure and are also affected by the monotony of the work, which leads to a certain dullness in dealing with the objects. They should undergo some training in handling sensitive books,

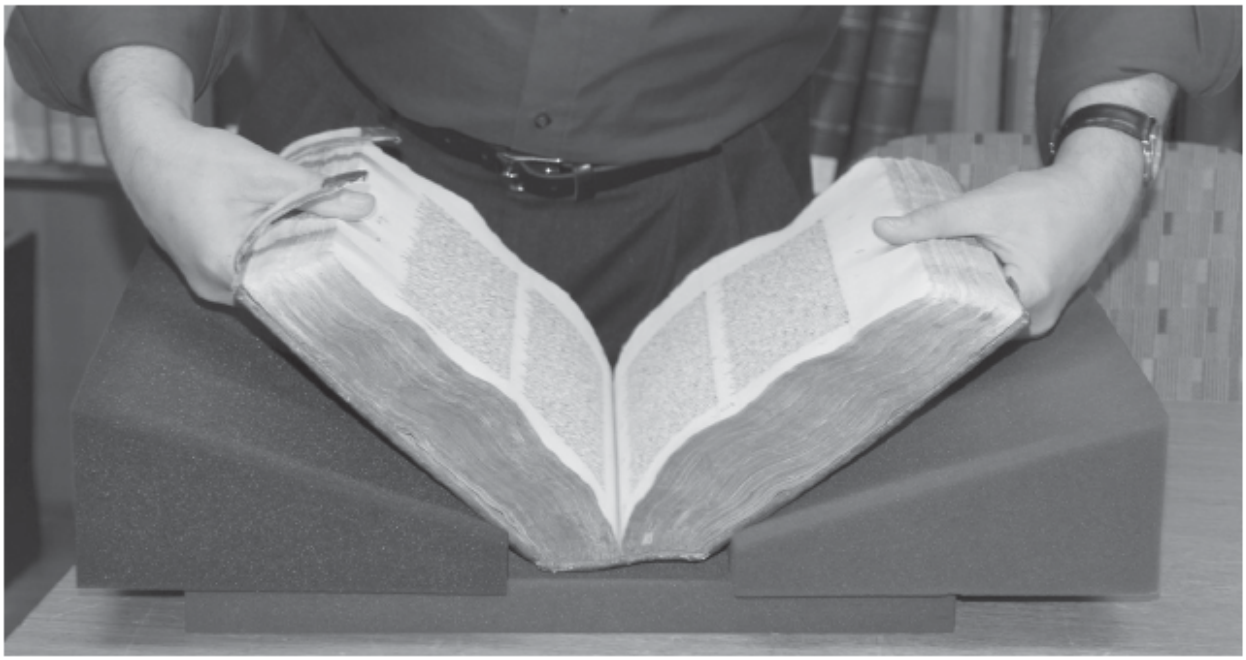

Fig. 5.7.1 Opening a manuscript on a support created from soft foam cushions, photograph by MMy.

preferably under the supervision of a conservator.

Ideally, photographers and conservators should work closely together. First, the condition of the binding is examined. The focus lies here on defining the degree at which the book can be opened without causing any harm or stress to the binding. To do this the book is placed on a v-shaped cradle (as described in Ch. 5 § 5.6; see there also for the discussion on the use of gloves). The text block must then be opened in the middle, carefully pressing the two halves of the book block apart while feeling and observing the resistance against opening (fig. 5.7.1). The book should be opened to an angle of 120°–140° without violence. Now the book rests in an open position on the cradle and one can browse forward and backward to consider if other areas allow

a violence-free opening of the book as well. During this process the book is also examined for damage to the pages of all kinds, particularly tears, looseor partially loose sheets, mould and inserted parts, slips, and similar

If irregularities of any kind are discovered, they must be documented in a condition report or survey protocol (see Ch. 5 § 5.7). In any case inserted loose slips or documents should be included in the digitization process based on their importance. Depending on the case, a decision will have to be made on whether the images of these documents are inserted into the sequence of the captured pages or stored in a separate file.

Depending on the results of the survey, one may have to consider a conservation process for damaged books before digitization. Only in the rarest cases will a complete restoration be carried out, as there is often a lack of human and financial resources. Interestingly, on the other hand, a weakened binding with a partly loose backing even promotes a digitization of the text block, since due to the open joint the text block opens wide without resistance (fig. 5.7.2).

The conservator or experienced photographer will decide from case to case if a scanning process can be carried out before conservation treatment. It is always recommended to remount loose sections or sheets before digitization. The risk of more detachment is too great, and confusion is likely to occur when re-inserting the loose parts. Cracked or torn pages run a risk of further tearing, often during the process of turning the pages. A temporary fixing must precede the digitization. If mould is

discovered, consultation from a professional conservator is mandatory in order not to endanger the health of the photographers. Books with mould growth should be isolated in order not to infest other books. If microbiological attack or dust, moisture, or similar damage is registered, a special treatment should be started, not only to ensure protection of the staff (recommended: use masks, gloves, disinfectant liquids), but also to enhance the quality of the images. Treatment can involve the mechanical cleaning of pages, and unfolding of corners or curled edges. The importance of such more or less ‘cosmetic’ treatment also depends on the importance of the original and the aim of the reproducing process.

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