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"Laylā visiting Majnūn in the desert", watercolour, gouache and gold on paper. Central Deccan, 1780—1800. Miniature in Album (*Muraqqa'*) X 3 in the Fabergé collection at the St. Petersburg Branch of the Institute of Oriental Studies, fol. 8b, 13.6×17.1 cm.

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Plate 1. *'Unwān* from *Khamsa* ("Pentateuch") by Abū Muḥammad Ilyās b. Yūsuf b. Mu'ayyad Niẓāmī Ganjawī. Manuscript C 1674 in the Fabergé collection at the St. Petersburg Branch of the Institute of Oriental Studies, Heart, *ca.* 1480—1490, fol. 1b, 13.0×21.4 cm.

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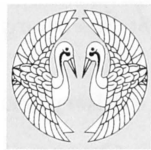
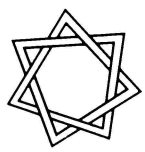
RUSSIAN ACADEMY OF SCIENCES



Manuscripta Orientalia

International Journal for Oriental Manuscript Research

Vol. **8** No. **3** September 2002



THESA
St. Petersburg

CONSERVATION PROBLEMS

Anna-Grethe Rischel

THE DANISH COLLECTION OF DUNHUANG MANUSCRIPTS: PRELIMINARY ANALYSIS

The Royal Library in Copenhagen received a minor collection of Dunhuang manuscripts nearly 80 years ago. The donator, Arthur Bollerup Sørensen, was chief telegraphist in Shanghai in the Great Northern Telegraph Company. In 1915, during his second voyage from China to Central Asia, he acquired 15 Buddhist manuscripts and 1 Daoist scripture in Dunhuang, just a few months after the departure of the Russian expedition headed by Sergei Oldenburg. Information about this minor collection of Dunhuang manuscripts in Denmark may be of interest for the International Dunhuang Project. The 200 sheets of handmade paper can provide important data on the early Chinese paper technology which deserves special investigation. The following notes are the preliminary results of the analysis of the paper of the Dunhuang manuscripts.

A small label on the manuscript box at the Royal Library in Copenhagen runs that 14 Chinese manuscript rolls from the Dunhuang monastery in Turkestan were donated by Mr. A. B. Sørensen on 29 November 1915, and that the manuscripts originate from the same library, hidden in a walled-up grotto, where huge manuscript collections were discovered by Sir Aurel Stein a few years before, in 1907, and then by Paul Pelliot in 1908.

Each roll in the Danish collection consists on average of 17 paper sheets with text in characters; the sheets are glued together at the short edges with tiny overlappings to a long roll. Paper of the same quality is mostly used for all sheets in individual manuscripts.

The macroscopic and microscopic analysis of the paper has been made, in a non-destructive way, similar to that presented in 1997 in London at the IDP workshop of forgeries of the Sven Hedin collection of Central Asian paper from Stockholm. The macroscopic part of the analysis was an observation of the paper with the naked eye. The microscopic analysis has required a combination of three types of microscopes to conduct it, using a limited test material of fibres removed from the backside or edges of the document.

The first part of the present article gives a preliminary description of characteristics of each manuscript's material, and the material's variations. The results of this investigation are found in the second part of the article, in a general description of the features of the whole collection. The third part provides a description of the Danish Dunhuang collection paper as compared with similar Central Asian paper material of the same provenance from the Sven Hedin collection. The results of these investigations can give new information not only about early paper technology and preservation of the ancient fibre material but also necessary data to indicate possible forgeries in the Danish collection.

1. Preliminary description

Three examples of macroscopic and microscopic observations are presented here:

Manuscript 1, roll 1

Yellowish paper colour
Very even fibre sorting
Very even fibre distribution
Glazed paper on recto

Thin paper quality in good condition, but the traces of earlier fungal attack in the upper part of the manuscript are visible.

17 sheets, measuring 45.2—45.7×25.2—25.5 cm
Inscriptions in black and red Indian ink
The upper margin — 2.7 cm, the lower margin — 2.6 cm
Mould: inside measurement — at least 45.7×25.5 cm with 5—6 supporting ribs with a distance of 8.5—9.5 cm
Screen: no visible impressions of chain-lines; regular laid lines: 23.0—24/3 cm
Scanning Electron Microscope (SEM) analysis: semi-open structure of smooth, uniform fibres with slightly varying width — 0.010, 0.011, 0.020 mm
Ground element present: silicium, aluminium, sulphur, calcium, chloride, potassium, magnesium, sodium
Differential Interference Contrast Microscope (DIC) analysis: raw fibres with several rhombic crystals, star-shaped crystals, amorphous substance, limited fibrillation, long fibres with rounded fibre tips and frayed fibre tips, decentral lumen visible sporadically, both varying and uniform fibre width.

Manuscript 2 a, roll 2

Sandgrey paper colour
Uniform fibre sorting
Cloudy fibre distribution
Smooth and glazed paper on both sides
Heavy paper quality in good condition
5 sheets, measuring 15.5—48.0×26.8—27.0 cm
Inscription in black Indian ink
The upper margin — 3.4—3.5 cm, the lower margin — 3.4—3.5 cm
Mould: inside measurement — at least 48.0×26.8 cm with no visible supporting ribs.
Screen: no visible impressions of chain-lines; irregular laid lines 11/3 cm.

Manuscript 2 b, roll 2

Sandgrey paper colour
Uneven fibre sorting with rough fibres present
Cloudy fibre distribution
Smooth and glazed paper on both sides
Heavy paper quality in good condition
4 sheets, measuring 17.0—48.5×26.8—26.9 cm
Inscription black Indian ink
The upper margin — 3.2 cm, the lower margin — 3.3 cm
Mould: inside measurement — at least 48.5×26.9 cm with no visible supporting ribs
Screen: no visible chain-lines, irregular laid lines 11—13/3 cm
SEM-microscope analysis: closed structure with smooth thin fibres and thick fibrillated fibres, fibre width — 0.005, 0.008, 0.010, 0.013, 0.018, 0.020 mm
Ground element present: aluminium, silicium, chloride, barium, sulphur, calcium, sodium, iron
DIC-microscope analysis: raw fibres and recycled fibres, starch grains, varying fibre width, central lumen, loose primary wall, thin fibres with rounded fibre tips, fibrils, debris.

Manuscript 4, roll 4 (in 2 parts)

Sandgrey paper colour (first part of the manuscript), yellow brown paper colour (the second part)
Uniform fibre sorting
Uniform, slightly cloudy, fibre distribution in the first part of the manuscript, uneven and slightly cloudy in the second part
Less glazed surface on the back of the paper
Heavy (rattling) paper quality in good condition
15 sheets, measuring 45.5—46.5×27.0—27.4 cm
Inscriptions in black Indian ink
The upper margin — 3.2—3.6 cm, the lower margin — 3.2—3.9 cm
Mould: inside measurement — at least 46.5×27.4 cm with no visible supporting ribs
Screen: 5 chain-lines with a distance of 5.0—6.0 cm, irregular laid lines 11—13/cm
SEM-microscope analysis: closed fibrillated structure with frayed fibre tips and more smooth fibres, fibre width — 0.005, 0.009, 0.010, 0.012, 0.013, 0.018, 0.020 mm
Ground elements: calcium, sulphur among similar elements as mentioned above.
DIC-microscope analysis: starch grains, loose primary wall, fibrils, varying fibre width, frayed debris.

2. General description and characterization of the collection

The manuscripts can be divided into two main groups depending on paper quality as presented in the Danish collection. Characteristics of the major group of rather heavy and stiff paper are the impressions of irregular laid lines, the result of employing the reed screen, with 11—13 laid lines per 3 cm density; sometimes visible chain-lines; the lack of impressions made by the supporting ribs of the mould; a slightly uneven and cloudy fibre distribution and the presence of not sorted course fibres.

Table 1

MAJOR GROUP	
Chain-lines 5, distance 5—6 cm	Manuscript 4, roll 4
Chain-lines 7—8, distance 5—7 cm	Manuscript 3, roll 3
	Manuscript 10, roll 8
	Manuscript 12, roll 10
	Manuscript 13, roll 11
	Manuscript 16, roll 14
Chain-lines 7—11, distance 5 cm	Manuscript 7, roll 5
Chain-lines 9—12	Manuscript 11, roll 9
	Manuscript 14, roll 12
	Manuscript 15, roll 13
Laid lines 11 per 3 cm	Manuscript 2a, roll 2
	Manuscript 3, roll 3
Laid lines 11—13 per 3 cm	Manuscript 2b, roll 2
	Manuscript 4, roll 4
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 8, roll 6

Continuation of ***Table 1***

Laid lines 11—13 per 3 cm	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 11, roll 9
	Manuscript 12, roll 10
	Manuscript 13, roll 11
	Manuscript 16, roll 14
Laid lines 16 per 3 cm	Manuscript 14, roll 12
	Manuscript 15, roll 13

The laid lines in the minor group (manuscript 1, roll 1, manuscript 7, roll 5 and manuscript 14, roll 12) of thinner and sometimes soft paper are very regular with a density of 23—24 laid lines per 3 cm; chain-lines, if the impressions of the bamboo screen are visible at all. The fibre distribution is very uniform as well as the fibre sorting.

Table 2

MINOR GROUP	
Laid lines 23—24 per 3 cm	Manuscript 1, roll 1
	Manuscript 7, roll 5
	Manuscript 14, roll 12
FIBRE SORTING	
Even sorting	Manuscript 1, roll 1
	Manuscript 2a, roll 2
	Manuscript 2c, roll 2
	Manuscript 4, roll 4
	Manuscript 7, roll 5
	Manuscript 8, roll 6
	Manuscript 11, roll 9
	Manuscript 14, roll 12
	Manuscript 15, roll 13
Uneven sorting with coarse fibres	Manuscript 2b, roll 2
	Manuscript 3, roll 3
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 12, roll 10
	Manuscript 13, roll 11
	Manuscript 16, roll 14
FIBRE DISTRIBUTION	
Even	Manuscript 1, roll 1
	Manuscript 3, roll 3
	Manuscript 7, roll 5
	Manuscript 11, roll 9
	Manuscript 14, roll 12
	Manuscript 15, roll 13
Cloudy	Manuscript 2a, roll 2
	Manuscript 2b, roll 2
	Manuscript 2c, roll 2
	Manuscript 4, roll 4
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 8, roll 6
	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 12, roll 10
	Manuscript 13, roll 11
	Manuscript 16, roll 14

In comparison with the minor group, the major one is distinguished by more primitive paper of uneven fibre sorting and uneven and cloudy fibre distribution. Common for both groups, however, are the paper colour variations, from light sandgrey, yellow brown, yellowish to curry yellow, as well as the presence of the paper polishing or glazing.

Table 3

PAPER COLOUR	
Yellowish paper	Manuscript 1, roll 1
	Manuscript 9, roll 7
	Manuscript 14, roll 12
Curry yellow	Manuscript 3, roll 3
	Manuscript 7, roll 5
	Manuscript 15, roll 13
Yellow brown	Manuscript 5, roll 5
	Manuscript 6, roll 5
Light yellow brown	Manuscript 10, roll 8
	Manuscript 11, roll 9
Sandgrey	Manuscript 2a, roll 2
	Manuscript 2b, roll 2
	Manuscript 2c, roll 2
	Manuscript 4, roll 4
	Manuscript 8, roll 6
	Manuscript 12, roll 10
Dark sandgrey	Manuscript 13, roll 11
	Manuscript 16, roll 14
PAPER SURFACE	
Glazed recto	Manuscript 1, roll 1
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 7, roll 5
	Manuscript 8, roll 6
	Manuscript 12, roll 10
	Manuscript 14, roll 12
	Manuscript 15, roll 13
	Manuscript 16, roll 14

The preliminary analysis of the test material with the aid of SEM reveals the presence in both groups of calcium and sulphur (gypsum) as a filling, combined with aluminium, barium, chlorine, iron, magnesium, phosphate, potassium, silicon, sodium and titanium. Unboiled starch grains are also added, either as a sheet formation aid or as a later sizing agent combined with the glazing.

In most cases the paper surface is smooth and hard pressed, together as a result of the glazing or polishing process, and well fit for writing, so the characters in ink are deep black and well discernable; the ink are not running. Smudging of ink can be seen only on a single sheet. The same type of paper quality was normally used for all sheets in an individual manuscript, and the same reed screen with characteristic irregularities was also employed for a number of sheets.

Only small variations in size of the trimmed sheets glued together have been noticed as well as in a number of lines of characters per sheet and a number of characters per line.

Table 4

DIMENSION OF SHEETS	
Length 39.0—43.0 cm	Manuscript 1, roll 1
	Manuscript 14, roll 12
Length 43.1—47.0 cm	Manuscript 4, roll 4
	Manuscript 7, roll 5
	Manuscript 10, roll 8
	Manuscript 11, roll 9
Length 47.1—48.5 cm	Manuscript 2a, roll 2
	Manuscript 2b, roll 2
	Manuscript 3, roll 3
	Manuscript 5, roll 5

Continuation of ***Table 4***

Length 47.1—48.5 cm	Manuscript 6, roll 5
	Manuscript 8, roll 6
	Manuscript 9, roll 7
	Manuscript 12, roll 10
	Manuscript 13, roll 11
	Manuscript 16, roll 14
Length 48.6—51.5 cm	Manuscript 15, roll 13
Height 24.3—25.5 cm	Manuscript 1, roll 1
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 7, roll 5
	Manuscript 11, roll 9
	Manuscript 14, roll 12
Height 25.6—27.0 cm	Manuscript 2a, roll 2
	Manuscript 2b, roll 2
	Manuscript 3, roll 3
	Manuscript 8, roll 6
	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 13, roll 11
	Manuscript 15, roll 13
Height 27.1—29.0 cm	Manuscript 4, roll 4
	Manuscript 12, roll 10
	Manuscript 16, roll 14
NUMBER OF LINES OF CHARACTERS	
Lines 26	Manuscript 2b, roll 2
	Manuscript 4, roll 4
	Manuscript 12, roll 10
Lines 27	Manuscript 6, roll 5
Lines 28	Manuscript 1, roll 1
	Manuscript 2a, roll 2
	Manuscript 3, roll 3
	Manuscript 4, roll 4
	Manuscript 5, roll 5
	Manuscript 7, roll 5
	Manuscript 8, roll 6
	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 11, roll 9
	Manuscript 13, roll 11
	Manuscript 14, roll 12
	Manuscript 15, roll 13
Lines 36	Manuscript 16, roll 14
NUMBER OF CHARACTERS PER LINE	
Characters 17	Manuscript 1, roll 1
	Manuscript 2a, roll 2
	Manuscript 2b, roll 2
	Manuscript 3, roll 3
	Manuscript 4, roll 4
	Manuscript 5, roll 5
	Manuscript 6, roll 5
	Manuscript 7, roll 5
	Manuscript 8, roll 6
	Manuscript 9, roll 7
	Manuscript 10, roll 8
	Manuscript 11, roll 9
	Manuscript 12, roll 10

Continuation of ***Table 4***

Characters 17	Manuscript 13, roll 11
	Manuscript 14, roll 12
	Manuscript 15, roll 13
Characters 17—20	Manuscript 7, roll 5
	Manuscript 11, roll 9
	Manuscript 14, roll 12
Characters 30	Manuscript 16, roll 14

3. Paper analysis: genuine manuscripts and suspected forgeries

The results of the preliminary analysis of the major group of the Danish Dunhuang manuscripts are mostly similar to the results of an earlier analysis of genuine Central Asian Saka manuscripts from the Sven Hedin collection. Heavy fibrillated fibres mixed with less fibrillated or not fibrillated bast fibres are typical of both collections, as typical of them is a sizing with unboiled starch grains. However, there is a difference between the surface treatment of the Dunhuang manuscripts paper and the Saka manuscripts paper. The fibres in the Dunhuang manuscripts are polished and pressed together, producing a closed structure of a smooth layer in contrast to the more open three-dimensional fibre structure in the Saka paper. The same type and dimension of mould with a screen of reeds seems to have been used by the paper makers in the sheet formation process for a long period along the Silk Road, and the density of the reed screen of 11—13 laid lines per 3 cm is usual density of handmade paper produced using a reed screen even today.

The paper of the minor group of the Dunhuang manuscripts differs from the paper of the Sven Hedin collection. The paper of this minor group is of such a high quality, with regard to fibre sorting and distribution, that it bears great resemblance to modern machine-made paper or the best handmade Japanese paper, especially the Dunhuang sheets of paper with no visible laid lines and chain-lines.

The microscopic analysis, however, shows the same type of bastfibres and fibrillation, with the presence of crystals, starch grains and particles of fillings, as in other Dunhuang manuscripts, and the same type of surface treatment. The employment of two different types of screens and the different degree of fibre sorting and distribution of the same kind of bast material had the result that we have paper of rather different quality, and both types of screens seem to have been used at the same time.

Heavy paper with impression of a reed screen, which is characteristic of the Danish Dunhuang collection, is predominant. Investigation of other collections might be of help in describing and dating the stages of the development of a bamboo screen and the production of thin, uniform paper; it would be also of use for determining the time when a reed screen was replaced by a bamboo screen.

As the paper investigation shows, in all Dunhuang manuscripts of the Danish collection handmade paper of a mixture of bastfibres with varying degree of fibrillation was used. The preliminary analysis reveals a great variety of the paper in many small details which produce individual combinations in individual sheets. The investigation demonstrates quite traditional paper technology known to scholars, and this technology employed in the paper production testifies to the authenticity of the collection's manuscripts.