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## Paper Analyses of Tocharian manuscripts of the Pelliot Collection stored in the National Library of France (*Bibliothèque nationale de France*)

“One day in my office, a heated discussion was raging about the material that the Chinese use for making paper. Their paper is far better than ours because the raw material is better; and a good deal was said about this thin, light Chinese paper, for it is light and thin, the texture is smooth, and there are no transparent patches”.

Honoré de Balzac, *Lost illusions*

**Abstract:** This paper describes the preliminary results of my PhD research within the ERC project “HisTochText”. The aim is to perform macroscopic analyses of archaeological papers from the Pelliot Collection. They are stored in the National Library of France (*Bibliothèque nationale de France*). Most were discovered in the oasis kingdom of Kucha, inscribed in an ancient Indian writing, *brāhmī*. The language was unknown in France. Kucha was a meeting place for many influences both western and eastern, insofar as paper analysis seeks to determine technological influences and local adaptations. Macroscopic analyses rely on traces found in the material of the paper which may be the result of the many stages in the life of the document: the raw material, the manufacturing process, the conditions of use and the storage conditions, both ancient and modern. To this day 350 fragments have been observed. Little is known about papermaking in Central Asia. As a consequence, every shred of information must be examined in order to determine the differences from and similarities to paper manufacturing in Xinjiang.

**Key words:** Central Asia, Xinjiang, Papermaking technology, Macroscopic analyses, Paul Pelliot, *Bibliothèque nationale de France*.

„Z Badań nad Książką i Księgozbiorami Historycznymi” – Udział zagranicznych recenzentów w ocenie publikacji; Stworzenie anglojęzycznej wersji wydawniczej publikacji; Digitalizacja tomów archiwalnych rocznika w celu zapewnienia otwartego dostępu do nich przez Internet oraz wdrożenie i utrzymanie cyfrowej platformy redakcyjnej – zadanie finansowane w ramach umowy nr 653/P-DUN/2019 ze środków Ministra Nauki i Szkolnictwa Wyższego przeznaczonych na działalność upowszechniającą naukę.

## Introduction

The “HisTochText” project, “History of the Tocharian Texts of the Pelliot Collection”<sup>1</sup>, aims at rendering the written Buddhist culture during the first millennium of our era. A multidisciplinary team<sup>2</sup> is examining manuscripts excavated in the Kucha region. So far the language and contents of these documents have been studied, but not their materiality. Little is known about papermaking in the Tarim basin<sup>3</sup>, and it is why macroscopic and microscopic analyses of papers were carried out in order to determine the raw materials and the manufacturing process used.

The historical context of the Pelliot collection creation at the National Library of France (*Bibliothèque nationale de France* (BnF))<sup>4</sup>

The documents studied as part of this doctoral work were discovered by Paul Pelliot. They are currently stored in the department of manuscripts in the National Library of France. The collection dates back to the early twentieth century. At that time France was beginning to organise geographical and scientific expeditions in many Asian regions. Over time these missions attracted local interest. Politics was also a major stimulus. That epoch is characterised

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<sup>1</sup> The project has a five-year sponsorship from the European Research Council (action number 788205) which began on 1<sup>st</sup> October 2018, principal investigator Georges-Jean Pinault (EPHE, PSL). This study forms part of my PhD thesis (cotutelle EPHE, Paris and CSMC, Hamburg) prepared within the “HisTochText” project under the supervision of Georges-Jean Pinault and Agnieszka Helman-Ważny.

<sup>2</sup> Codicological, philological, linguistic, technological and material studies.

<sup>3</sup> Julius von Wiesner was the first, as early as 1902, to describe and analyse fragments from Kucha (J. Wiesner, *Mikroskopische Untersuchung alter Ostturkestanischer und anderer Asiatischer Papiere nebst histologischen Beiträgen zur mikroskopischen Papieruntersuchung*, Wien 1902). Scholars such as Kazuyuki Enami, Anna-Grethe Rischel and Agnieszka Helman-Ważny have analysed papers found in Central Asia. (K Enami et al, ‘Origin of the difference in papermaking technologies between those transferred to the East and the West from the motherland China’, *Journal of the International Association of Paper Historians*, vol.14, Issue 2, 2010, pp. 11-22, A.-G. Rischel, *Analysis of papermakers choice of fibrous materials and technology along the paper road*, [in:] *Paper as a Medium of Cultural Heritage. Archaeology and Conservation*, 26<sup>th</sup> Congress – International Association of Paper Historians, edited by R. Graziaplena, Rome, 2006, pp. 202-208, A.-G. Rischel and S.-C. Raschmann, *Old Turkish fragments from the Berlin Turfan collection, Paper analysis of 62 manuscripts and block prints*, [in:] *Alt türkische Handschriften*, Teil.18, Franz Steiner Verlag, Stuttgart, 2012, pp. 265-311, A. Helman-Ważny, *More than meets the eye: Fibre and Paper Analysis of the Chinese Manuscripts from the Silk Roads*, “STAR: Science & Technology of Archaeological Research” 2016, vol. 2, no. 2, pp. 127-140, R. Nöller, A. Helman-Ważny, *The Materials of Turfan and Dunhuang Manuscripts: Analysis of Paper, Pigments and Dyes*, “International Dunhuang Project News” 2013, no. 41, pp. 6-7.

<sup>4</sup> The Collection was named after P. Pelliot (1878-1945), French explorer, philologist and linguist. For his career and his work, see J.-P. Drège, G.-J. Pinault, *Paul Pelliot: de l'histoire à la légende*, eds. G.-J. Pinault, M. Zink, Paris 2013.

by the spirit of competition between European powers for discoveries and archaeological trophies. France was felt to be late in this, which is the reason Sylvain Lévi wrote in 1910: “Obliged by its glorious oriental traditions and by its Asian interests, France was obliged to play a part in this unearthing of an ancient past”<sup>5</sup>.

In this context the French decided to take on other nations<sup>6</sup> in order to establish a presence in Asia<sup>7</sup>. At the beginning of 1905 a committee formed to organise a mission in Central Asia and in 1906 a second expedition set out for Turkestan on the initiative of the *Archaeological Survey of India*<sup>8</sup>. It was led by Aurel Stein.

Paul Pelliot was member of the EFEO, student of the sinologist Edouard Chavannes and of Sylvain Lévi. He was chosen for that mission because of his excellent understanding of both ancient and modern Chinese, but he also spoke many languages, such as Turkish, Uighur, Mongolian, Tibetan, as well as knowing Sanskrit. He carried out excavations in Central Asia between 1906 and 1908 after a long and perilous journey, worthy of the ancient caravans, crossing northern Central Asia on horseback. He reached the oasis of Kucha on 2<sup>nd</sup> January 1907. He favoured studying isolated and little-explored sites<sup>9</sup>, such as the monastic complex of Duldur-Akhur, which supplied the first manuscripts written in brāhmī. He went on to explore Kumtura and Subashi<sup>10</sup>, bringing to light new languages, such as Sogdian and Tocharian. He also discovered some two hundred fragments written in Chinese<sup>11</sup>. The site of Subashi yielded

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<sup>5</sup> S. Lévi, *La mission Pelliot en Asie centrale*, “Annales de Géographie” 1910, vol. 19, no. 105, pp. 274-276.

S. Lévi (1863-1935) is a French Indianist, Professor at the Collège de France, honorary member of the École Française d’Extrême Orient (EFEO). He was one of the first to take an interest in the Tocharian language. He participated in the deciphering of it and the identification of the Buddhist texts. For details about that aspect of his work, see G.-J. Pinault, *Sylvain Lévi déchiffreur et lecteur des textes des frontières*, [in:] *Sylvain Lévi (1863-1935). Études indiennes, histoire sociale Actes du colloque tenu à Paris les 8-10 octobre 2003*, eds. L. Bansat-Boudon, R. Lardinois, Turnhout 2007, pp. 111-144.

<sup>6</sup> England, Russia, Germany and Japan.

<sup>7</sup> In 1894 Sven Hedin became the first explorer to traverse these territories. Four years later the Academy of Science in Saint Petersburg sent a team lead by Dimitri Klementz in order to explore the Turfan region. England assigned A. Stein to Kashgar and Khotan between 1900 and 1902. Stein subsequently ran two later missions. His last expedition lasted from 1906 to 1908 and ended at Dunhuang. Germany organised Albert Grünwedel’s expedition to Turfan in 1902 and 1903. There followed two missions directed by Albert von Le Coq in 1903 and 1904 and 1905 and 1907.

<sup>8</sup> The Archaeological Survey of India (ASI) is an agency of the Indian government attached to the Ministry of Culture. It was established in 1861 with responsibility for archaeological research and heritage conservation.

<sup>9</sup> S. Lévi described those sites as Hindu-Chinese “Pompeii”, buried in central Asian sands.

<sup>10</sup> The Duldur-Akhur monastery is located to the West of Kucha, beyond the River Muzart. The city of Subashi is located to the North and straddles the River Kucha.

<sup>11</sup> They constitute the Pelliot Chinois Douldour-Âqour collection of the BnF.

a set of poplar wood strips and fragments with an *Udānavarga*<sup>12</sup> text written in Sanskrit and some manuscripts bore texts written in several languages.

At the end of 1909 Pelliot undertook a brief inventory of manuscripts written in Chinese, the majority of which came from the Library Cave of Dunhuang. The results of his findings were shared among various institutions and books, manuscripts and sheets were deposited at the National Library of France. Other findings, such as statues, frescoes, artefacts, paintings and banners, were stored largely at the Louvre, but some were offered to Émile Guimet. Between 1945 and 1946 works preserved in the Louvre were relocated to the Guimet Museum (*Musée Guimet*) and the Natural History Museum in Paris (*Museum d'Histoire naturelle*) received every specimen of an herbarium containing eight hundred plants, two hundred birds, mammals, insects and geological samples<sup>13</sup>.

### The oasis kingdom of Kucha, a flourishing multicultural town along the silk road

The number of fragments found and the many high-quality artefacts and wall paintings show that the ancient oasis-town of Kucha was a flourishing kingdom. In addition to its manifold natural resources<sup>14</sup>, its location was commercially strategic (Fig. 1).

The town lies in the northern Tarim basin in the modern Xinjiang region. Its territory expanded beyond the city ramparts to spread along the Silk Road, which borders the Taklamakan desert. The phrase “*Silk Road*” (*Seidenstrasse* in German) was coined in 1877 by the traveller and geographer Baron Ferdinand von Richthofen. It designates trade networks from China through central Asia and Persia, as far as modern Syria and beyond to the Mediterranean Sea. These roads were originally referred to as “The Road to Samarkand” or to any other significant city along the route<sup>15</sup>. This network was a set of roads leading to a number of oasis-towns in desert areas. In the case of the Tarim basin, sites

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<sup>12</sup> Part of the Pelliot Sanskrit collection of the BnF, the *Udānavarga*, is a compilation of stanzas credited to Buddha. That is the equivalent of the *Dhammapada* in the *Pāli* Canon. This is one of the most widespread texts in Central Asia. It is also known thanks to several paper manuscripts written in Sanskrit but also with translations into other Buddhist languages.

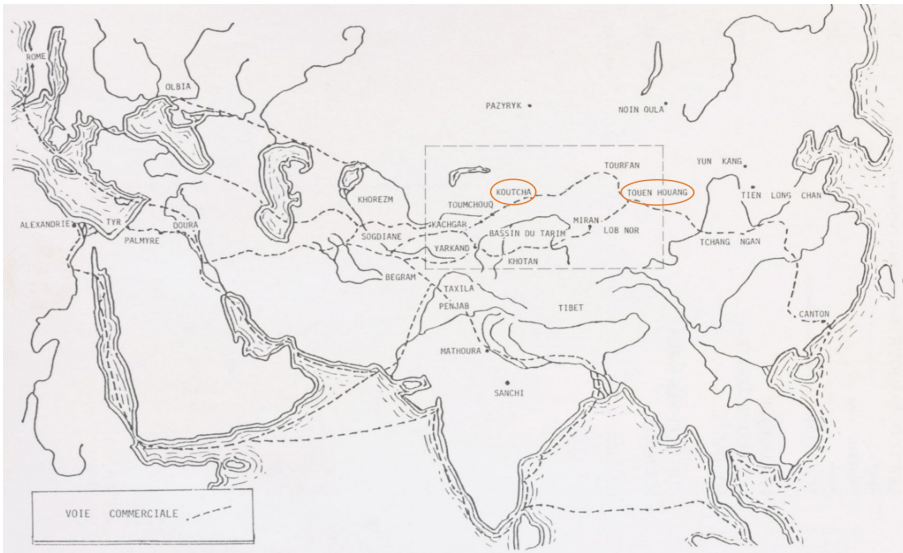
<sup>13</sup> For further details about the collection's history and the way it was shared among collections of French institutions, see: N. Monnet, *Paul Pelliot et la Bibliothèque nationale*, [in:] *Paul Pelliot de l'histoire à la légende*, eds. J.-P. Drège and M. Zink, Colloque international organisé par Jean-Pierre Drège, Georges-Jean Pinault, Christina Scherrer-Schaub et Pierre-Etienne Will au Collège de France et à l'Académie des Belles-Lettres (Palais de l'Institut), 2-3 octobre 2008, Paris, Académie des Inscriptions et des Belles-Lettres, 2013.

<sup>14</sup> Minerals and metals, such as jade, copper, iron and brass; products such as leather and its by-products (boots and saddles); sugar, spices and herbs. See V. Hansen, *The Silk Road, a new story*, New York 2012, p. 237.

<sup>15</sup> *Ibidem*, p. 7.

were located around towns and, specifically in the case of Kucha, in what were huge monastic complexes. They were established either on plains, or in caves<sup>16</sup>. The prevailing local religion was Buddhism and this permeated the every aspect of life. Unearthed leaves tend to be from Buddhist books, but they are largely fragments or scattered sheets. The original and most common form of book is *poṭhī* (or *pustaka*<sup>17</sup>). Some paper manuscripts are gathered in the form of scrolls, imitating Chinese manuscripts type (Fig. 2). These different forms partly correspond to the type of text, but some secular texts were written on paper scrolls or sheets. They consist of economic or administrative documents and texts not strictly Buddhist, but drawn from Indian culture, such as medical texts<sup>18</sup>.

Fig. 1. Main trade routes in Central Asia. Map by Vaillant

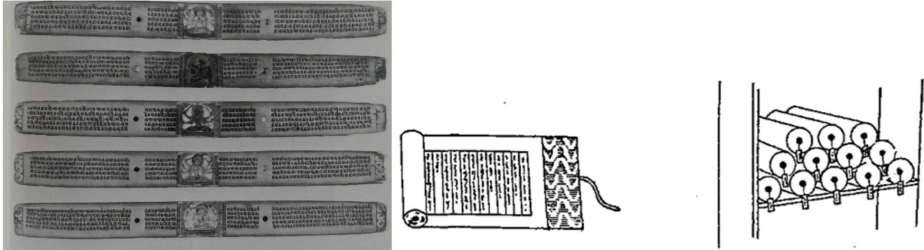


<sup>16</sup> Duldur-Akhur, Qumtura, Subashi, Hiçar and Khitai bazar.

<sup>17</sup> The *poṭhī* format, (the word means book in Punjabi and is related to the Sanskrit term *pustaka*) hails from India, where palm leaves were used as writing support. The oblong shape of the leaves determines the shape and dimension of the books' sheets. These latter are bound together with a thread through a hole drilled into the folio. This shape was then replicated in Asia for Buddhist books, while paper was adopted as support. See: A. Helman-Ważny, *The archeology of Tibetan book*, Leiden, Boston, Brill, 2014, p. 49.

<sup>18</sup> The inventory of the Pelliot Koutchéen collection was made in the 1980s and published by G.-J. Pinault, *Concordance des manuscrits tochariens du fonds Pelliot*, [in:] *Instrumenta Tocharica*, ed. M. Malzahn, Heidelberg 2007, pp. 162-219. The ensemble is divided in several series and sub-series, cited later: *ancienne série* [old series], *nouvelle série* [new series], DAM.M.507 [monastery account], *lettres commerciales* [business letters], *bois* [caravan passes and administrative documents written on wooden strips].

Fig. 2. Left: pothī (pustaka) format © Pratapaditya 2002 Right: scroll format.  
Illustration based on Tsuen-Hsuiin 1985



## Manuscripts

The fragments analysed come from Buddhist manuscripts, monastery ledgers and drafts of ledgers, trade contracts and administrative letters written by the Chinese administration<sup>19</sup>. Palaeographic dating<sup>20</sup> puts all these documents between the 6<sup>th</sup> and 9<sup>th</sup> centuries. During the excavation Pelliot briefly described the leaves. He records in his diary expressions such as “paper manuscript”, “Chinese paper” and “Indian paper”. It is likely that he saw no need to be more specific. The history of paper and the development of papermaking has been little studied. He specified that “[in] the inner courtyard of Duldur-Akhur, we excavated an important batch of manuscripts written in *brāhmī*”<sup>21</sup>.

Many of these documents were written neither in Sanskrit nor any Persian language, but in an Indo-Iranian language unknown at the time, one deciphered in 1908 by two German Indologists, Emil Sieg and Wilhem Siegling, on the basis of manuscripts discovered during the Turfan expeditions. From 1910 this work was continued by Lévi with manuscripts found during the Pelliot mission<sup>22</sup>. The name “Tocharian” covers in fact two languages: Tocharian A and Tocharian B. These terms were coined by German researchers according to

<sup>19</sup> For an accurate description of manuscripts contents, read C. Chao-Jung, *Secular documents in Tocharian : Buddhist economy and society in the Kucha region*, Doctoral thesis directed by Georges-Jean Pinault, presented in 2010, École Pratique des Hautes Études, Paris and É. Trombert, 2000

<sup>20</sup> The study was carried out as part of Athanaric Huard’s PhD thesis at the École pratique des hautes études, EPHE, PSL. For dating of the Tocharian documents on the basis of script, see M. Malzahn, *The most archaic manuscripts of Tocharian B and the varieties of Tocharian B language*, [in:] *Instrumenta Tocharica*, op. cit., pp. 255-297.

<sup>21</sup> *Brāhmī* is a writing system which emerged in India some time before *Asoka* inscriptions, i.e. in the middle of the third century BCE.

<sup>22</sup> M. Cohen, *La mission Paul Pelliot en Asie Centrale*, [online] <https://archivesetmanuscripts.bnf.fr/ark:/12148/cc4395j> [accessed 24.01.2019]; G.-J. Pinault, *Concordance des manuscrits...*, op. cit.



a false identification with the assumed language of a people named *Tochari* in Latin, which refers to the Kushan people.

The majority of texts from the Pelliot collection are written in “Tocharian B”. Lévi proposed the name *kutchean*<sup>23</sup>, but the language gradually died out when the Uighurs invaded the region in the 9<sup>th</sup> century, and the first Uighur Buddhist period in the 11<sup>th</sup> century in the Turfan region. The Turfan region is characterised by a strong Tocharian influence, but the language did not survive the disappearance of Buddhist culture due to the proliferation of Islam in the region. Both Tocharian languages (A and B) discovered so far are understood due to their use in translating Buddhist texts into Sanskrit. The most ancient manuscripts written in Tocharian B were dated to the late fourth or early fifth century. The early centuries of CE are characterised by the influx of Buddhist monks who crossed the region from oasis to oasis doing missionary work. The characters of both these Indo-European languages is closely related with a writing borrowed by north-western India. It reached the Tarim basin with Buddhist missionaries from the West, the region that corresponds to modern Pakistan and Afghanistan, the centre of which was Gandhara<sup>24</sup>. Broadly speaking, influences came to the kingdom of Kucha from both West and East at an early stage. There was as a result of Alexander the Great conquered Gandhara in 327 BCE and left a Greek settlement there, but in the second century BCE, during the Xiongnu Empire (209 BCE- 93 (156) CE) the nomadic tribes of Yuezhi and Xiongnu<sup>25</sup> invaded. During the Tibetan Empire (618-842 CE) Tibet invaded and then the Chinese seized control over the territory<sup>26</sup>. As a consequence, the oasis town was a meeting point for migrants involved in trade, the military, the arts and religion. The importance of the Indo-Buddhist culture of Gandhara and other Persian civilisations, i.e. Bactria or Sogdia, should be highlighted. It was spread by missionaries from Parthia and Sogdia in the first place before India, but also by merchants trading in the region.

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<sup>23</sup> Hence the current title of the collection “fonds Pelliot Koutchéen”, which is a part of the Pelliot collection stored at the National Library of France by “fonds Pelliot Sanskrit”, “fonds Pelliot chinois”.

<sup>24</sup> O. von Hinüber, *Expansion to the North: Afghanistan and Central Asia*, [in:] *The World of Buddhism*, eds. H. Bechert, R. Gombrich, London 1991, pp. 99-107; R. Salomon, *The Buddhist literature of ancient Gandhara: an introduction with selected translation*, Sommerville, MA 2018 (*The world of Gandharan Buddhism*, pp. 11-49).

In a narrow sense Gandhara corresponds to the region of Peshawar (the north-western province of Pakistan) and areas along the River Kabul; in a broad sense it includes a part of western and northern Afghanistan (Swat valley, Bactria) and the western Punjab (Taxila).

<sup>25</sup> The Xiongnu people comprise a confederation of a number of tribes. For further information, see N. Di Cosmo, *Ancient China and Its Enemies, the Rise of Nomadic Power in East Asian History*, Cambridge University Press, Cambridge, 2002.

<sup>26</sup> For an overview see J.P. Mallory, V.H. Mair, *The Tarim mummies*, London 2000, pp. 34-63.

From the east there was the Chinese influx from the beginning of the Tang dynasty (618-907)<sup>27</sup>. This influence is seen in crafts and arts, such as wall paintings and architecture<sup>28</sup>.

The history of the Gandhara is punctuated by its more or less belligerent relations with its numerous neighbours<sup>29</sup>. The Kings were regularly compelled to fight for the country's independence<sup>30</sup>. The year 658 was particularly significant, since Kucha, ruled at the time by the Tang Dynasty, became the headquarters of one of the four Anxi garrisons<sup>31</sup>. The Chinese administration then took control over the region, although the local king maintained his power<sup>32</sup>. Within that multicultural context the technical analysis of paper may help to determine the way papermaking spread and its possible local uses.

### Macroscopic analysis of documents: preliminary results

A macroscopic analysis of paper fragments mostly relies on observation and interpretation of traces printed on the material. These traces reflect not only the stages of papermaking but also the stages of a document's life. The nature of raw materials, the manufacturing processes and the shape of the sheet influence the properties of the sheet of paper such as colour, resistance, appearance, and texture.

Within the Tarim Basin and during earlier periods, two types of raw materials were used for pulp: recycled materials such as old rags, ropes, fishing nets and used papers, and plant materials such as grasses and specific barks, mainly mulberry. These materials would be subjected to several processes, chemical and mechanical, in order to reduce them to fibres. They would firstly be allowed to rot before being boiled in a caustic lye. They would finally be pounded and formed into dough.

The pulp, made of fibres diffused in a small amount of water, is spread evenly over a cloth pinned across a wooden frame. The sheet of paper is shaped

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<sup>27</sup> M. Hallade, S. Gaulier, *Mission Pelliot, Soubachi et Douldou-âqour*, vol. 4, Recherche sur les civilisations, Paris 1982, p. 30.

<sup>28</sup> Traces of this new style were observed on buildings located in Duldur-Akhur and Subashi.

<sup>29</sup> S. Lévy, *Le 'Tokharien B', langue de Koutcha*, "Journal Asiatique, XI<sup>e</sup> série" 1913, vol. 2, pp. 311-380: This article describes the many conflicts between Kutcha and the other oasis kingdoms as well as China and Tibet.

<sup>30</sup> V. Hansen, *op. cit.*, p. 66.

<sup>31</sup> É. Trombert, *Les manuscrits chinois de Koutcha, Fonds Pelliot de la Bibliothèque nationale de France*, Paris 2000. Four garrisons of the Chinese army were established between 648 and 658. Besides Kutcha, the towns of Khotan, Kashgar and Karashar were also headquarters of Chinese military bases. The Protectorate General to Pacify the West (Anxi Grand Protectorate) was a protectorate (640 – c. 790 CE) established by the Tang dynasty in 640 and above mentioned garrisons were supposed to monitor the area. The Chinese intention was to pacify and control the Tarim Basin.

<sup>32</sup> See translation of Chinese documents found in Kucha in É. Trombert, *op. cit.*



by allowing it to dry under the sun. The dipping mould brought technical improvement, in which the papermaking sieve no longer forms part of the rigid frame. This innovation enabled papermakers to remove sheets as soon as they were shaped. As a consequence, paper making production increased significantly. Wet sheets would be piled on top of each other and pressed in order to drain the water before drying them stretched out on a flat surface.

During the period we are dealing with, both kinds of moulds were used. As a consequence, raw materials and manufacturing processes may determine certain features that may be observed in the paper. The presence of threads (coloured or plain) or cloth, for example, may indicate the use of rags. The sheet shaping method (Fig. 3) and the drying method (Fig. 4) likewise leave specific traces in the structure of the paper. The finishing stages, i.e. polishing, calendaring and coating, are also detectable.

Figs 3 A-D. The two main sheet shaping processes. Top A and B: Floating mould, pulp is spread manually (left) or by means of a tool (right). Bottom C and D: Dipping mould from Japan (left) and China (right). Photographs A by Trier, B by Josh Summers, bottom C and D [www.cnnews.com](http://www.cnnews.com)



Figs 4 A-C. A. Drying support: Left on a wall. Photograph courtesy of Claude Laroque; B. Top: on a mould. Photograph by Jesper Trier; C. Bottom: On a wooden plank. Photograph after Dard Hunter

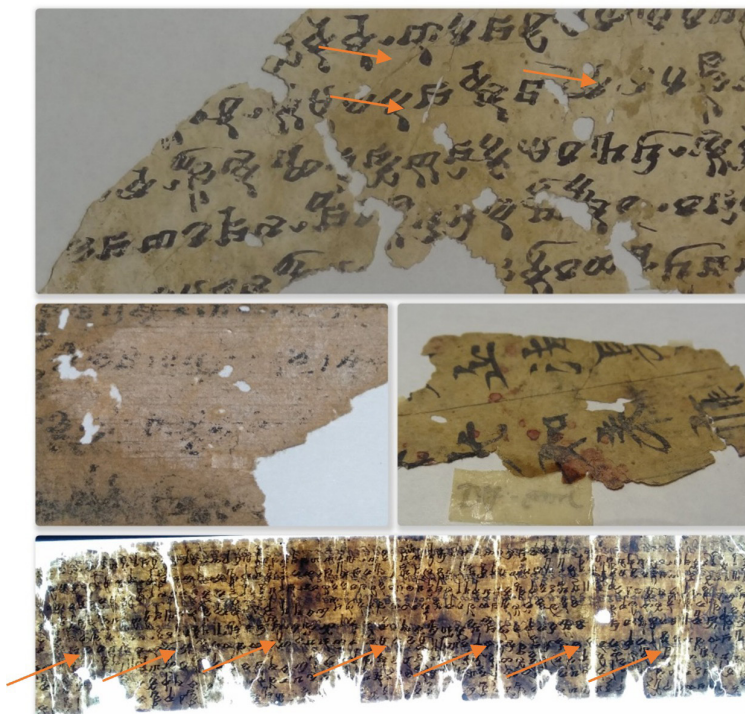


Macroscopic analysis also enables the detection of some practices and some uses of documents. Certain leaves show numerous folds which look deliberate. Other documents show vertical traces due to being stored rolled (Fig. 5). Some fragments bear little holes. These would be magical texts of a medical nature. They would be pinned to the sick<sup>33</sup>. Some other manuscripts show coloured stains (white, purple, pink or red) the composition and origin of which have yet to be determined<sup>34</sup>.

<sup>33</sup> Communication with prof. G.-J. Pinault.

<sup>34</sup> They may be stains resulting from degradation (moulds), accidental stains or even intentional stains resulting from a document's usage. The BnF Laboratory needs to analyse these stains.

Figs 5 A-D A. Top: folds B-C. Middle: coloured stains D. Bottom: regular folds due to being stored rolled. Photographs by Emilie Arnaud-Nguyen



Storage conditions on the site of the find have an impact on the paper (Fig. 6). Besides common paper degradation<sup>35</sup>, sheets of paper are marked by the extreme conditions in which they have been stored for many centuries. Some sites were ransacked and burnt, the papers left in the open and subjected to bad weather. Conditions in which documents were transported also affected their condition (Fig. 6). Documents would be placed in wooden crates, manhandled onto horse carts and buffeted and battered, as they shuddered and juddered across the rough terrain. Temperature changes and bad weather also took their toll<sup>36</sup>.

<sup>35</sup> Yellowing, dust, folds, tears and losses of paper.

<sup>36</sup> Pelliot's diaries illustrate severe winters and blistering summers which characterise the climate of the Tarim basin, located between the Taklamakan desert and the mountain ranges of the Tianshan. For greater accuracy regarding the climate of the region, read the book by L. Golomb, *Die Bodenkultur in Ost-Turkestan. Oasenwirtschaft und Nomadentum*, Freiburg 1959.

Figs 6 A-D Top: A. A convoy heading for Kutcha (left), B. “Manuscripts house” in Khitai Bazar (right) Bottom: C. The road to Qumtura (left) D. Et Hiçar excavation (right). Photographs by Nouette



A pad of manuscript leaves has been kept untouched. It consists of fragments of paper and agglomerated mud, which illustrates storage conditions on the site where it was found.

To this day 350 leaves and fragments have been viewed under natural light, low-angled light and transmitted light. They have been photographed and measured (height, length and width). Documents are inspected with the naked eye before using a digital Dino-Lite microscope<sup>37</sup> to focus on details. General characteristics may already be identified. They are more or less clear depending on the dimensions of the fragment, its state of conservation<sup>38</sup> and whether there was a coating.

Colour is the first feature of paper observed (Fig. 7). Conclusion may not, however, be drawn from the colour. There are many causes of colour

<sup>37</sup> Dino-Lite FC OC 1.

<sup>38</sup> In fact, a small size lowers the possibility to identify some features. Likewise, a poor state of conservation may change the paper inner structure. It gets impossible to note typical manufacturing features.



changes: raw materials, fibres, sizing, coating, the way the paper had been used, the length of time it was cooked, whether an alkaline product was used and the length of time it was beaten. External factors, such as temperature, humidity, light, contact with pollutants or substances that hasten the natural aging process of paper, also have an impact. Black traces may be visible on calcinated edges, for example; the presence of dirt (dust, silica) may be due to the site it was discovered, as described by Pelliot<sup>39</sup>.

It makes sense, therefore, to describe the colour of the paper in order to facilitate comparison between items of the same manufacture and composition. Colour evaluation also depends on the observer and observing conditions, in particular the light source and the surface aspect<sup>40</sup>.

Figs 7 A-D. Shades of paper colours (Pelliot Koutchéen Lettre Commerciale XXXVI, Pelliot Koutchéen Nouvelle Série 400, Pelliot Sanskrit Udānavarga 1.21, Pelliot Koutchéen Ancienne Série 5). Photographs by Emilie Arnaud-Nguyen



<sup>39</sup> P. Pelliot, *Carnets de route, 1906-1908*, Paris 2008, p. 120: “Thursday 18<sup>th</sup> October 1907 «We found some rather large page fragments on birch bark, and especially some fragments in Sanskrit and Chinese on paper. The Chinese fragments are largely accounts. The whole thing was found mostly in piles of rubbish, mingled with dung, seeds, apricot kernels, walnut shells». [“Jeudi 18 octobre 1907 «Nous avons quelques fragments assez grands de feuillettes sur écorce de bouleau et surtout des fragments sanscrits et chinois sur papier. Les fragments chinois appartiennent surtout à des comptes; le tout est généralement trouvé dans des tas de déchets, mêlés à du fumier, des graines, des noyaux d’abricots, des cosses de noix»”].

<sup>40</sup> Light reflexion differs between a smooth and a rough surface. This modifies the perception of colour.

Terminology used to describe paper colour remains subjective and somewhat lacking in accuracy<sup>41</sup>. Instruments are not necessarily any more accurate because the use of an absolute white standard, used in industrial paper mills is sometimes unsuitable for uneven surfaces.

The absolute white standard was nonetheless considered suitable for the Pelliot collection, as long as documents were compared with each other. Broadly speaking, paper colour ranges from creamy white through beige to brown<sup>42</sup>. When the coating is in good condition, the surface of the paper is white, smooth and glossy (Fig. 8). That indicates the care and the quality of the finishing process afforded some manuscripts. The coating consists of a thick gypsum-based substance. Papers with a coated surface display an even surface making it possible to write on it with a wooden stick. In the case of non-coated paper, ink would also not bleed through the paper. It may be thus assumed that paper was sized. Micro-sample analyses alone, however, is able to confirm this and specify the nature of the sizing. Ink analyses identified a carbon ink that sometimes contained metallic elements such as copper<sup>43</sup>. Copper would commonly be used to liquefy it and stabilise the colour<sup>44</sup>. It is uncertain, however, whether the presence of copper was accidental or intentional. The region was known for its copper mines and archaeological digs have revealed a number of ovens used in the extraction of metal (Fig. 9). Copper may nonetheless have been a common ingredient in carbon ink in Central Asia<sup>45</sup>.

<sup>41</sup> A range from white to dark brown is used.

<sup>42</sup> For more about Chinese paper colour read J.-P. Drège, *Le papier dans la Chine impériale : Origine, fabrication, usage. Textes présentés, annotés et traduits*, Paris 2017, and also the article *Note sur les couleurs des papiers des manuscrits de Dunhuang*, “Cahiers d’Asie” 1987, vol. 3, pp. 147-150. Still, it seems more or less impossible to transpose Chinese paper colour typology of Tang Dynasty manuscripts and apply to comparative study of those written in Sanskrit and Tocharian. To better understand the problem, however, V. Bunting’s article, *The prints and the papers: Whistler’s Venice sets at the Freer Gallery of art*, [in:] *Looking at Paper*, ed. J. Slavin, Ottawa 1999, pp. 53-62.

<sup>43</sup> Numerous analyses were performed *in situ*:

Coating: Gypsum was identified by total reflection X-ray fluorescence spectroscopy (equipped with an X-Ray tube containing a rhodium tube. It worked with a voltage value equal to 40kV and an intensity of 100 mA) and by use of a reflectance spectrometer (spectral range analysed from 350 to 2500 nm with a halogen source). Analyses performed by Kilian Laclavetine (EPHE/ CRC) and Anne Michelin (CRC).

Sizing: Analysed by Fourier Transform InfraRed Spectrometry (FTIR) (Specular reflection spectral range analysed from 350 to 4000 cm<sup>-1</sup>) and et Raman (red laser at minimal 700 μW). Analyses performed by Ludovic Bellot-Gurlet and Céline Paris (MONARIS, Sorbonne Université Campus Pierre et Marie Curie), Kilian Laclavetine and Anne Michelin.

Ink: Carbon was identified through Raman spectroscopy. Copper was identified with reflection X-ray fluorescence spectroscopy. Analyses were carried out by Ludovic Bellot-Gurlet, Céline Paris, Kilian Laclavetine and Anne Michelin.

<sup>44</sup> S. van Schaik, A. Helman-Ważny, R. Nöller, *Writing, painting and sketching at Dunhuang: assessing the materiality and function of early Tibetan manuscripts and ritual items*, “Journal of Archaeological Science” 2015, pp. 110-132.

<sup>45</sup> R. Nöller, O. Hahn, *Illuminated manuscripts from Turfan: Tracing Silk Road glamour by analyzing pigments*, “STAR: Science & Technology of Archaeological Research” 2015, vol. 1, no. 2, pp. 50-59.



Fig. 8. Burnished, glossy surface (Pelliot Koutchéen Nouvelle Série 112).  
Photograph by Emilie Arnaud-Nguyen



Fig. 9. Copper mining ovens in Kutcha. Photograph by Nouette



Manuscripts were little restored. Back in France Pelliot oversaw the restoration of the leaves once they had been deposited at the National Library of France in 1910. He was opposed to certain treatments; dry cleaning was one such treatment<sup>46</sup>. This was intended to preserve documents as they were together with their component parts<sup>47</sup> and debris from the place they were discovered<sup>48</sup>. As was mentioned above, on-site storage conditions left traces on the great majority of documents. Burn marks, paper losses such as holes and tears, abrasions from insects and scratches from rodents all feature here (Fig. 10).

A calliper<sup>49</sup> was used to measure paper thickness. Whenever sample sizes permitted it, the four edges were measured. That informs us about the evenness of the paper thickness, thus revealing the papermakers' expertise. It assesses two main skills: the papermakers' ability to form thin sheets and make them even. This last characteristic is relevant when dimensions of paper analysed is significant.

The average thickness fluctuates between 0.10 mm and 0.20 mm<sup>50</sup> with little variation in one sheet. One may therefore conclude that papermakers had acquired a mastery of their craft. We may conclude then that papermaking was not in its infancy. This raises questions as to whether these papers were imported, whether skilled papermakers had migrated to the region and whether the paper had been manufactured in the region before the time of writing of the manuscripts studied.

There remains uncertainty regarding layered paper. Some paper delaminates, but this may be the result of two sheets being glued together or the natural degradation of paper. We can infer many stages of the papermaking process from the structure of the paper. In one case the brush strokes from the application of the white coating revealed a hair from the brush used<sup>51</sup>. Some straight traces can also be observed on paper surface, sometimes also within paper structure (Fig. 11). They may result from a polishing or even a calendaring stage. The present state of our knowledge does not enable to favour one process in particular (Fig. 12).

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<sup>46</sup> For more information on the various methods for treating and packaging manuscripts from their excavation up until today read Nathalie Silvie's master's thesis *Problèmes de traitement et de reconditionnement des documents de la collection Pelliot de la Bibliothèque nationale dégradés par le Rhodoïd*, Université Paris I, Paris 1995, not published.

<sup>47</sup> As an example, some conservation treatments, such as lining irreversibly introduce extraneous material. Cleaning with water may likewise eliminate specific components, no longer observable, such as mica. This occurs naturally in soil and is readily visible on the surface of paper. In the case of too invasive a treatment it may disappear without trace.

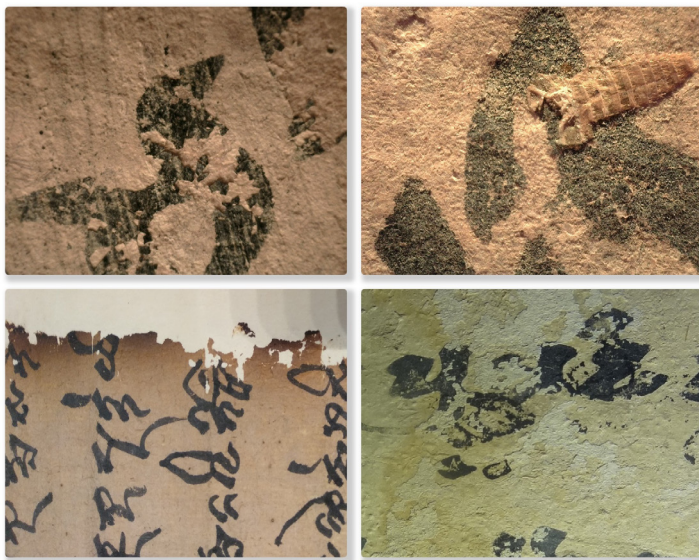
<sup>48</sup> This remark must be relativised, as former storage and conservation decisions will have modified some aspects of paper and some of its properties.

<sup>49</sup> The calliper used is Mitutoyo PK-0505APX.

<sup>50</sup> Two extreme thicknesses were measured: 0.06 mm and 0.30 mm. The thinnest is a document written in a Persian language (Pelliot Douldour Aqour\_Divers K\_M\_914\_1).

<sup>51</sup> A strand of hair was found embedded in the coating. The animal to which it belongs is so far unidentified.

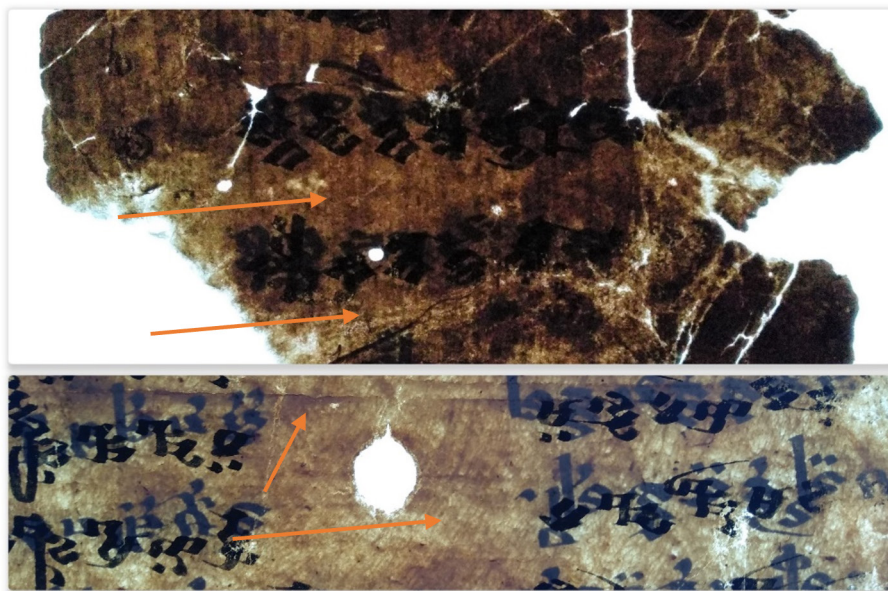
Figs 1 A-D Top: A. Scratches (left); B. Insect remains (right); Bottom: C. Burn marks (left); D. Coating patches (right). Photographs by Emilie Arnaud-Nguyen



Figs 2 A-C Right top and bottom: A and B. Straight traces on paper surface Left bottom: C. Brush strokes. Photographs by Emilie Arnaud-Nguyen



Figs 12 A-B Top: A. Longitudinal traces observable under ranking and transmitted light; Bottom: B. Brush strokes observable under transmitted light. Photographs by Emilie Arnaud-Nguyen



Among the 350 manuscripts observed, 64 retained their oblong shape. The most common dimension is  $8\text{ cm} \times 20\text{ cm}$ <sup>52</sup>. Almost two-thirds of the papers show no traces betraying the mould used, as many of the fragments are tiny or opaque. A partial transparency, however, enables us to observe the distribution of fibres (Fig. 13). A formation aid may have been added to the vat to disperse the fibres evenly. Papermakers would have been unlikely to use this, as it resulted in a cloudy distribution of fibres along the sheet. This is particularly the case when the pulp is coarse. Laid lines appear sporadically along the sheet. This results from a modified sieve, on which a cloth would have been sewn (Fig. 14). This is a practice that continues in some papermaking workshops in Nepal, in Himalayan regions and in eastern Asia. This method handily slows down the dripping of the water which allows the papermaker more time to spread the fibres evenly and produce an even thickness.

<sup>52</sup> The *pustaka* manuscripts are found in three sizes:

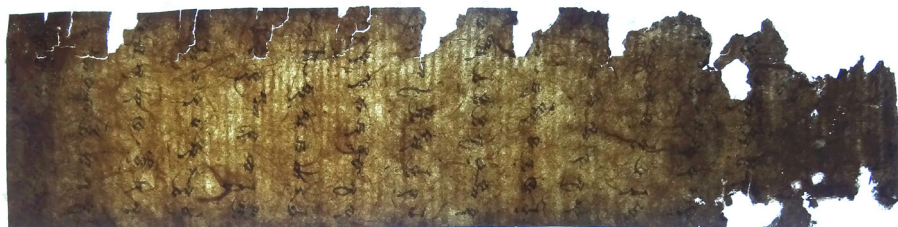
Size 1:  $8\text{ cm} \times 20\text{ cm}$  (18 manuscripts) /  $8\text{ cm} \times 30\text{ cm}$  (15 manuscripts) /  $8\text{ cm} \times 40\text{ cm}$  (2 manuscripts) /  $8\text{ cm} \times 10\text{ cm}$  (1 manuscript);

Size 2:  $9\text{ cm} \times 20\text{ cm}$  (2 manuscripts) /  $9\text{ cm} \times 30\text{ cm}$  (9 manuscripts);

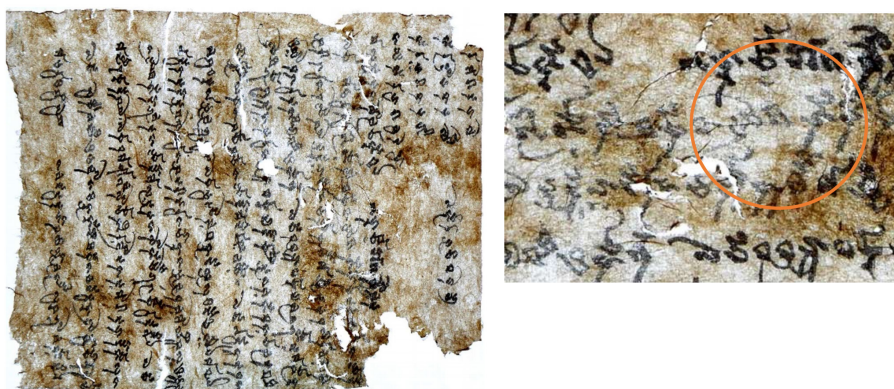
Size 3:  $7\text{ cm} \times 20\text{ cm}$  (6 manuscripts) /  $7\text{ cm} \times 30\text{ cm}$  (2 manuscripts) /  $7\text{ cm} \times 40\text{ cm}$  (4 manuscripts).



Fig. 13. Cloudy distribution of fibres (Pelliot Koutchéen Lettre Commerciale X).  
Photograph by Emilie Arnaud-Nguyen



Figs 14 A-B Traces of a modified dipping mould (PK DAM 507 32).  
Photographs by Emilie Arnaud-Nguyen



Many questions remain unanswered. The long period of transition of the method manufacturing the sheet of paper must be taken into consideration. There was a changeover from the so-called archaic<sup>53</sup> papermaking technology marked by the use of a stationary floating mould to a more sophisticated, efficient process using a dipping mould equipped with movable sieve. The paper produced by the latter mould is characterised by chain and laid lines visible in its structure. Laid lines were found on 93 fragments<sup>54</sup>. There are between

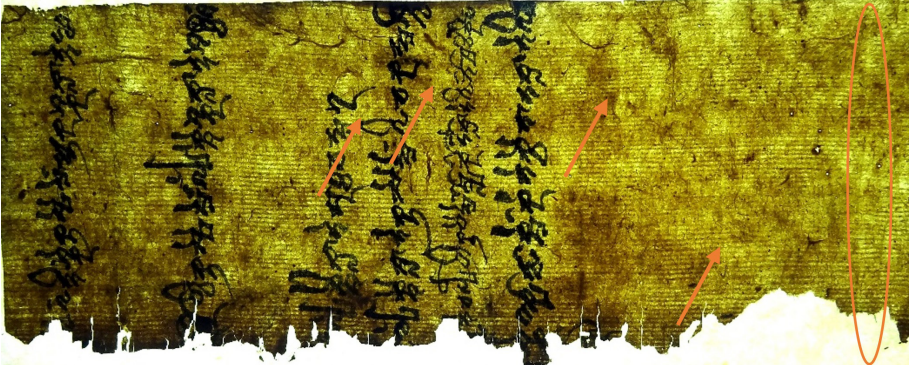
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<sup>53</sup> The chronology used to describe the evolution of papermaking technology was highlighted by D. Hunter in his book *Papermaking: the history and techniques of an ancient craft*, London, 1957. It was thereafter questioned, as both processes were practiced simultaneously. The dipping mould, nonetheless, offers a higher performance and efficiency which probably tempted papermakers. Its economic benefit is even more evident when craftsmen would have to produce more paper and maintain the quality.

<sup>54</sup> This was observed in 13 fragments of the Pelliot Koutchéen Ancienne Série, 39 scrolls of the Pelliot Koutchéen DAM 507 collection (of which 16 also show chain lines), 10 of the Pelliot Koutchéen Lettre Commerciale collection, 19 of the Pelliot Koutchéen Nouvelle Série, 4 of the Pelliot Chinois Douldour-Âqour collection, 3 of the Pelliot Douldour-Âqour Divers collection, 3 of the

6 and 7 per centimetre. Only a small number of papers show chain lines. When regular, they are 5 centimetres apart (Fig. 15). Sometimes, transversal or thicker chain lines bear witness to the sieve having been repaired (Fig. 15).

Fig. 15. Chain and laid lines, lacking in regularity (PK DAM 507 9).  
Photograph by Emilie Arnaud-Nguyen



Papermakers' skill may also be judged by the defects in the paper such as folds, skinned areas and water droplets (Fig. 16). The first two imperfections occur during the drying stage, when the wet sheet is brushed onto a flat surface and then detached from it. Droplets of water occur when the papermaker is careless when draining the wet sheet. A minority of fragments in the Pelliot collection displays these defects because of their small size and opacity.

The use of a Dino-Lite digital microscope enables us to observe the presence of bundles of fibres, threads (whether coloured or not), pieces of silk cloth and a good many impurities from plant matter, straw, grass, bark, wood and even cereal spikelets (Figs 17 and 18). Larger threads were observed in scrolls, so these documents were written on low-quality paper. Pulp was partly made from raw fibres with variable quantities of recycled material. This was confirmed by analysis under a microscope<sup>55</sup>. Bundles of fibres are caused by low separated fibrils. The pulping process is, however, adapted to the raw material in question. Whether it may be concluded that either the cooking stage or the beating stage were shortened is a moot point.

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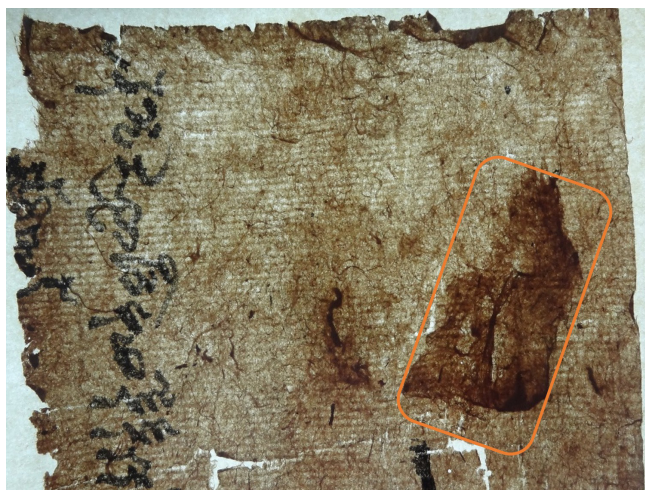
Godfrey collection and 2 of the Pelliot Sanskrit Udānavarga collection.

<sup>55</sup> Identification of the fibres was performed *in situ* by Lucas Llopis (EPHE / CRC) and Léon-Bavi Vilmont (CRC) without sampling thanks to the digital microscope Keyence VHX 6000 equipped with VH-Z 1000 R focus. Transmitted and low-angled lightning were used. The surface of the sheet was scanned with a  $\times 100$  magnification. Magnification between  $\times 200$  and  $\times 500$  enables us to observe and identify coarse elements such as thread or bundles of fibres, but a  $\times 1000$  magnification was used to identify the fibres.

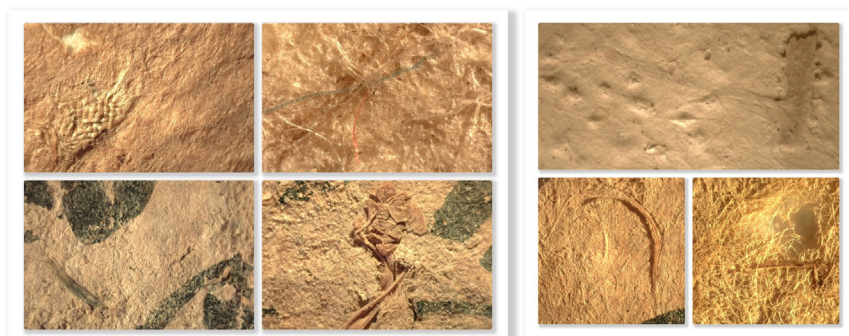


Microscopic analysis reveals that, whatever the material used, recycled or raw, the same fibres are present: hemp and linen<sup>56</sup>, hemp mixed with ramie or mulberry<sup>57</sup>, or even a combination of the three fibres.

Fig. 16. A piece of another sheet of paper: this defect occurred when the sheet of paper was split before the drying stage or when they were detached from their drying support (PK DAM 507 4). Photograph by Emilie Arnaud-Nguyen



Figs 17 A-B Top: A. A piece of cloth, coloured fibres, bundles of fibres and impurities Bottom: B. Blue thread, impurities, bundle of fibres.  
Photographs by Emilie Arnaud-Nguyen



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<sup>56</sup> These plants share similar features, which makes them difficult to distinguish from one another.

<sup>57</sup> It was impossible to determine which species of the Moraceae family was used: *Morus alba* L. or *Broussonetia papyrifera* (L.) l'Hér. Ex Vent. Both genera are mulberry used to make paper. The former was initially used in the breeding of silkworms. The latter is the paper mulberry, used exclusively in the manufacture of paper.

It was impossible to determine whether cereal spikelets came from wheat or barley (Fig. 18). These spikelets show that papers were likely to be manufactured in an agricultural environment. A good deal of the paper also contained tiny wood pieces, suggesting that the paper was produced in a wooded area. In such an environment, papermakers would make use of coarser materials in the vicinity of the workshop. Adding cheap material proved an economical way of increasing the quantity of the pulp and thus enabled them to meet the increasing demand for paper. Some elements suggest that there was a lack of raw material. As common corrections and repairs, some leaves were composed of several sheets coarsely joined to form a *pustaka* format. This was not always done with the requisite attention to detail, showing that some workers, be they merchants or monks, depending on the nature of the place the binding was made, varied in their diligence or skill (Fig. 19).

Corrections were made by applying a layer of coating over the text or erasing the text. In the case of repairs, a strip of paper might have been glued to cover a tear, or the document might even have been sewn together. In this last case, the holes through which the thread passed may be observed along the tear (Fig. 20). We may therefore assume that there would have been a high demand for paper, since repairing leaves was favoured to writing new ones. In the Buddhist world, where copying religious texts represented an act of merit, making a new manuscript to replace a degraded manuscript would have been preferred.

Fig. 18. Spikelet of cereal on the surface of paper.  
Photograph by Emilie Arnaud-Nguyen





## Conclusion

Macroscopic analyses of papers from the Pelliot collection found in Kucha reveal a certain manufacturing homogeneity with similar general features, such as the presence of impurities and bundles of fibres. They attest to an imperfect pulping process, whereas the sheet shaping seems fully mastered. The increasing demand for paper may have given rise to a fast and abundant production which in turn may have been the reason for the low-quality of the pulp. We can assess the practice of at least two papermaking technologies: the dipping mould and a modified mould. The finishing process on religious manuscripts was skilfully carried out, giving a smooth, white, glossy surface. The addition of coarser material, resulting in an uneven surface, was thus corrected. The thinness and even the thickness of paper, and the almost systematic finishing process used on religious texts show that papermakers were highly skilled craftsmen. Paper production was thus not in its infancy in the Xinjiang of the 7<sup>th</sup> century. The question of whether the paper would have been imported or produced locally remains to be resolved. Less than a third of papers analysed showed laid lines and this may be explained on the one hand by the diminutive size of documents, and on the other hand by the use of a number of papermaking technologies in the same place during the same period. Other questions, such as coloured stains or the presence of particular folds on some religious documents remain to be answered. These remarks should be correlated with observations of papers found in the Xinjiang region, dated to the same period in order to create a typology of the materials, tools and papermaking processes in the same region.

I wish to express my thanks to Claude Laroque and Georges Pinault for their valuable advice in the writing of this article and their careful rereading of it.

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