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Paper Analyses of Tocharian manuscripts of the Pelliot Collection stored in the *Bibliothèque nationale de France*

One day in my office, there was a hot discussion going on about the material that the Chinese use for making paper. Their paper is far better than our, 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 close, there are no transparent spots in it.

Honoré de Balzac, *Lost illusions*

Abstract:

This paper describes the preliminary results of my PhD in the frame of the ERC project « HisTochText ». The aim is to perform macroscopic

analyses of archaeological papers from the Pelliot Collection which are stored in the *Bibliothèque nationale de France*. They were mostly discovered in the kingdom oasis of Kucha, written in an ancient Indian writing, brāhmī. Once in France, the language was found to be unknown. The oasis was the meeting point of many western and eastern influences, in that context paper analysis tries to determine technological influences and local adaptations. Macroscopic analyses rely on traces found in the paper material which may result from many stages of the life of the document: the manufacturing process, the raw material, conditions of use and the storage conditions (ancient and modern). To this day, 350 fragments were observed. Little is known about papermaking in Central Asia. As a consequence, every information must be put through so to determine difference and similarities of paper manufacturing in Xinjiang.

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

Introduction

The “HisTochText” project, “History of the Tocharian Texts of the Pelliot Collection”¹, aims at rendering the written Buddhist culture during the first millennium of our era. A multidisciplinary team² is examining manuscripts excavated in the Kucha region. To date, the language and contents of these documents were studied, but not their

1 The project is borne by the European Research Council (action number 788205), for five years, from the 1st October 2018, principal investigator Georges-Jean Pinault (EPHE, PSL). This study is a part of author’s PhD thesis (cotutelle EPHE, Paris and CSMC, Hamburg) prepared within the « HisTochText » project under the supervision of Georges-Jean Pinault and Agnieszka Helman-Ważny.

2 Codicological, philological, linguistical, technological and material studies.

materiality. Little is known about papermaking in the Tarim basin³, therefore the author must carry out macroscopic and microscopic analyses of papers in order to determine raw materials used and manufacturing process performed.

Historical context of the Pelliot collection creation at the *Bibliothèque nationale de France*⁴

Documents studied as part of this doctoral work were discovered by Paul Pelliot. They are currently stored in the department of manuscripts of the National Library of France (*Bibliothèque nationale de France* – BnF). Creation of the collection dates back early

3 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). Henceforth, scholars such as Kaziyuki Enami, Anna-Grethe Rischel and Agnieszka Helman-Ważny have achieved analyses of papers found in Central Asia. (Enami K., 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, Rischel A-G., ‘Analysis of Papermaker’s choice of fibrous materials and Technology along the paper road’, in *Paper as a Medium of Cultural Heritage. Archaeology and Conservation*, 26th Congress – International Association of Paper Historians, edited by R. Graziaplana, Rome, 2006, pp. 202-208, Rischel and Raschmann S-C., ‘Old turkish fragments from the Berlin Turfan collection, Paper analysis of 62 manuscripts and block prints’, *Alttürkische Handschriften*, Teil.18, Franz Steiner Verlag, Stuttgart, 2012, pp.265-311, Helman-Ważny A., ‘More than meet the eye: Fibre and paper analysis of the Chinese manuscript of the Silk Road’, *STAR: Science & Technology of Archaeological Research*, August 2016, pp.1-14, Noeller, Renate and Agnieszka Ilona Helman-Ważny. “The Materials of Turfan and Dunhuang Manuscripts: Analysis of Paper, Pigments and Dyes.”, 2013.

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

20th century. At that time, France began to organise geographic and scientific expeditions in many Asian regions. Over time, these missions bore interests to local cultures. Politics was also a major stimulus. That epoch is characterised by a competition between European powers for discoveries and archaeological trophies. France felt to be late, which is why Sylvain Lévi wrote in 1910:

Obliged by its glorious orientalism traditions and by its Asian interests, France had to play part in this unearthing of an ancient past⁵

In this context, French have decided to confront other nations⁶ in order to enforce their presence in Asia⁷. At the beginning of 1905, a committee took shape to settle a mission in Central Asia while 1906 is marked by the implementation of a second expedition to Turkestan on

5 S. Lévi, *La mission Pelliot en Asie centrale*, “Annales de Géographie” 1910, Vol. 19, No. 105, pp. 274-276.

S. Lévi (1863-1983) is a French Indianist, Professor at the Collège de France, honorary member of the Ecole Française d'Extrême Orient (EFEO). He was one of the first interested in the Tocharian language. He participated in its deciphering and Buddhist texts identification. About that part of his huge 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.

6 England, Russia, Germany and Japan.

7 Since 1894, Sven Hedin was one the first explorer to cross 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 from 1900 to 1902. The latter subsequently ran two other missions. His last expedition lasted from 1906 to 1908 and ended at Dunhuang. Germany organised the expedition of Albert Grünwedel to Turfan between 1902-1903. Then followed two missions, directed by Albert von Le Coq between 1903-1904 and 1905-1907.

the initiative of the *Archaeological Survey of India*⁸. It was led by Aurel Stein.

P. Pelliot (**Fig. 1**), was member of the EFEO, student of the sinologist Edouard Chavannes and the last student of S. Lévi. He was chosen for that mission because of his excellent understanding of ancient and modern Chinese, and he also practiced many languages such as Turkish, Uighur, Mongolian, Tibetan and even Sanskrit. He carried out excavations in Central Asia between 1906 and 1908 after a long and perilous journey, which was worthy of the ancient caravans age, crossing northern Central Asia on horseback (**Fig. 2**). He reached the oasis of Kucha on the 2nd January 1907. He favoured studying isolated and little explored sites⁹ such as the monastic complex of Duldur-Akhur, which supplied the first manuscripts written in brāhmī. Then, he explored Kumtura and Subashi¹⁰. New languages emerged from the ground such as Sogdian or Tocharian. He also discovered some two hundred fragments written in Chinese¹¹. The site of Subashi delivered a set of poplar wood stripes and fragments with the

8 The Archaeological Survey of India (ASI) is an agency of the Indian government attached to the Ministry of Culture. It was created in 1861 and was responsible for the archaeological research and heritage conservation.

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

10 The Duldur-Akhur monastery is located on the West, beyond the Muzart river. The double religious city of Subashi is located on the North, on both shores of the Kucha river.

11 They constitute the Pelliot Chinois Douldour-Âqour collection of the BnF.

*Udānavarga*¹² text written in sanskrit. Some manuscripts bore texts written in several languages.

At the end of 1909, P. Pelliot undertook a brief inventory of manuscripts written in Chinese, the majority of which came from the grotto-library of Dunhuang. The result of his findings was spread between various institutions. Books, manuscripts and sheets were deposited at the National Library of France (*Bibliothèque nationale de France*). Other findings such statues, frescoes, artefacts, paintings and banners, were mostly stored at the Louvre. Finally, some were offered to Émile Guimet. Later, that is between 1945 and 1946, works preserved in the Louvre were relocated to the Guimet Museum (*Musée Guimet*). The Natural History Museum in Paris (*Museum d'Histoire naturelle*) received every specimen of which an herbarium containing eight hundred plants, two hundred birds, mammals, insects and geological samples¹³.

12 Part of the Pelliot sanskrit collection of the BnF, the *Udānavarga*, is a compilation of stanzas assigned to Buddha. That is the equivalent of the *Dhammapada* in the pāli cannon. This text is one of the most widespread in Central Asia. It is also known thanks to several paper manuscripts written in Sanskrit but also with translations into other Buddhist languages.

13 For further details about the collection history and how it joined collections of French institutions, see : Monnet Nathalie, “Paul Pelliot et la Bibliothèque nationale”, *Paul Pelliot de l’histoire à la légende*, J.-P. Drège and M. Zink (ed.), 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.

The Oasis Kingdom of Kucha, a flourishing multicultural town along the silk road

The significant number of fragments found added to the numerous high-quality artefacts and wall paintings prove that the ancient oasis-town of Kucha was a flourishing kingdom. Besides its manifold natural resources¹⁴, its location constituted a strategic trade asset (**Fig. 3**).

The town stands northern Tarim basin in the modern Xinjiang region. Its territory overflowed the city ramparts to expand along the silk road which borders the Taklamakan desert. The phrase “*silk road*” (*Seidenstrasse* in German) was created in 1877 by the baron Ferdinand von Richthofen, traveller and geographer. It designates trade routes networks departing from China, going through central Asia, Iranian countries, reaching modern Syria and beyond, that is the Mediterranean Sea. These roads were originally named “The road to Samarkand” or the name of any other significant city stage¹⁵. This network was a set of roads flooding to various oasis-towns along desert areas. In the case of the Tarim basin, finding places were located around towns and, specifically for Kucha, on sites which constituted huge monastic complexes. They were whether implemented on a flat area, or in caves¹⁶. The local prevailing religion was Buddhism which impregnated the

14 Mineral or metal extraction such as jade, copper, iron and brass; manufactured products as leather and its by-products (boots and saddles); production of sugar, spices and herbs. See V. Hansen, *The Silk Road, a new story*, New York 2012, p. 237.

15 V. Hansen, op. cit., p. 7.

16 Duldur-Akhur, Qumturâ, Subashi, Hiçar and Khitai bazar.

whole social life. Unearthed leaves mainly belong to Buddhist books, but it remains mostly fragments or scattered sheets. The original and most common book shape is named *poṭhī* (or *pustaka*¹⁷). Some paper manuscripts are gathered in the form of scrolls, imitating the Chinese manuscripts type (Fig. 4). These different shapes partly correspond to the type of text. Actually, some secular texts were written on paper scrolls or sheets. They consist in economic/administrative documents or texts that are not strictly Buddhist, though drawn from Indian culture, such as medical texts¹⁸.

Manuscripts

Analysed fragments originate from Buddhist manuscripts, monastery account books or drafts of account books, trade contracts and administrative letters written by the Chinese administration¹⁹. All these

17 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 leaves oblong shape imposes the shape and dimension of the book sheets. These latter are bound together with a thread going through a hole drilled into the folio. This shape is thereafter replicated in Asia for Buddhist books while paper is adopted as support (Information provided by Professor G.-J. Pinault). See: A. Helman-Ważny, *The archeology of Tibetan book*, Leiden, Boston, Brill, 2014, p. 49.

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

19 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, Ecole Pratique des Hautes Etudes, Paris and É. Trombert, 2000

documents dating, based on palaeography²⁰, ranges from the 6th to 9th century. Throughout their excavation, P. Pelliot briefly described leaves. He records in his diary expressions such as “paper manuscript”, “Chinese paper” or “Indian paper”. It is likely that he did not see the need of being more specific. Actually, paper history and evolution of its manufacture was little studied. He specified:

In the inner courtyard of Duldur-Akhur, we excavated a quite important batch of manuscripts written in brāhmi scripture²¹

A large number of these documents were not written in Sanskrit nor in an Iranian language but in an Indo-Iranian language unknown at this time which was 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 carried on by S. Lévi with the manuscripts found during the P. Pelliot mission²². The name “Tocharian” covers in fact two languages, that is Tocharian A and Tocharian B. This term was created by German decipherers according to a wrong identification with the assumed language of a people named *Tochari* in Latin which refers indeed to Kushan people.

20 The study was carried out as part of the project by Athanaric Huard, PhD student at the Ecole pratique des hautes études, EPHE, PSL. About the scripture phases dating of the Tocharian documents, see M. Malzahn, *The most archaic manuscripts of Tocharian B and the varieties of Tocharian B language*, [in:] *Instrumenta Tocharica*, op. cit., p. 255-297.

21 Brāhmī is a writing system which appeared in India at an uncertain date before Asoka inscriptions, that is in the middle of the 3rd century before our era.

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

The majority of texts from the Pelliot collection are written in “Tocharian B.” S. Lévi proposed to name it *kutchean*²³. That language slowly ceased when the Uighurs invaded the region, that is in the 9th century, and the first Uighur Buddhist period, that is until the 11th century in the Turfan region. That area is characterised by a strong Tocharian influence. That language did not survive the Buddhist culture disappearance due to Islam spread in the region. The understanding of both Tocharian languages is due to their use to translate Buddhist texts into Sanskrit. The most ancient manuscripts written in Tocharian B were dated of late 4th or early 5th century. First centuries of our era are characterised by the influx of Buddhist monks who crossed the region from oasis to oasis on proselyte purpose. Notation of these both Indo-European languages is closely related with a writing borrowed to north-western India. It has reached the Tarim basin with Buddhist missionaries coming from West, that is regions corresponding to modern Pakistan and Afghanistan which centre was Gandhara²⁴. Broadly speaking, the Kingdom of Kucha has been influenced from West and East at an early stage. Let’s mention Greek settlement in

23 Hence the present title of the collection “fonds Pelliot Koutchéen”, which is a part of the Pelliot collection stored at the BnF by “fonds Pelliot Sanskrit”, “fonds Pelliot chinois”, etc.

24 O. Hinüber von, *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 the narrow sense, Gandhara designates the Peshawar region (Pakistan north-western province) and nearest areas along the Kabul river; in the broad sense it includes a part of the western and northern Afghanistan (Swat valley, Bactria) and the western Punjab (Taxila).

Gandhara following Alexandre the Great invasion, raids of nomad tribes, particularly Xiongu tribes²⁵ and Yuezhi, Tibetan invasion and the Chinese control over the territory²⁶. As a consequence, the oasis town was the convergence point of many flows: migratory, trade, military, artistic or even religious. The importance of the Indo-Buddhist culture of the Gandhara and other Iranian countries, Bactrian, Sogdian, etc., must be highlighted. It was transmitted by missionaries (Parthians, Sogdians) who firstly arrived from these countries, and then from India but also by merchants furrowing the region.

There is also, on the eastern side, the Chinese inflow, from the beginning of the Tang dynasty (618-907)²⁷. It is found in crafts and arts such as wall paintings or architecture²⁸.

The history of the city is punctuated by its more or less belligerent relations with its numerous neighbours²⁹. Thus, the local royal power is regularly forced to struggle with the sole aim to maintain its independence³⁰. The year 658 shaped a particular importance since Kucha, which was dominated by the Tang at that period, became the headquarter of

25 Xiongnu people consist of a confederation of numerous 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

26 To have an overview, read J.P Mallory, V.H. Mair, *The Tarim mummies*, London 2000, pp. 34-63.

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

28 Traces of this new style were observed on building located in Duldur-Akhur and Subashi.

29 S. Lévy, “Le « Tokharien B », langue de Koutcha”, *Journal Asiatique*, XIe série, t.2, septembre – octobre 1913, p311-380 : This article describes the many conflicts between Kutcha and the other Oasis kingdom as well as China or Tibet.

30 V. Hansen, op. cit., p. 66.

one of the four Anxi garrisons³¹. From that moment the Chinese administration took control over the land management despite the power of the local king was maintained³². Within that multicultural context, the technical analysis of paper may help to determine how that craft spreads with its possible local adaptations.

Macroscopic analysis of documents: preliminary results

Macroscopic analysis of paper fragments mostly relies on observation and interpretation of traces printed within the material. These traces reflect not only papermaking stages but also documents stages of life. The nature of raw materials, the manufacturing processes and the sheet shaping confer the varying properties of the sheet of paper such as colour, resistance, appearance, surface, etc.

Within the geographical area of that research and for old periods, two types of raw materials were used for pulp. Raw material dumps such as rags, ropes, fishing nets and used papers but also grasses and specific barks, mainly mulberry. These materials undergo several processes, from chemical or mechanical nature, in order to reduce them into fibres. The latter is firstly put to rot then boiled in a caustic lye. They are finally pounded and reduced into the state of a dough.

31 É. Trombert, *Les manuscrits chinois de Koutcha, Fonds Pelliot de la Bibliothèque nationale de France*, Paris 2000. There are four garrisons of the Chinese army implemented between 648 and 658. Besides Kutcha, towns of Khotan, Kashgar and Karashar were also headquarters of Chinese military bases. Chinese secured monitoring and protection of the Anxi protectorate. They aim at pacifying and controlling the Tarim basin.

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

The pulp, made of fibres dispersed into a small amount of water, is evenly spread over a cloth pinned on a wooden frame. It is let to dry under the sun to shape a sheet of paper. A technical improvement was provided by using a dipping mould. The sieve is no longer part of the rigid frame. This innovation enables to remove sheets as soon as they are shaped. As a consequence, paper making production is significantly increased. Wet sheets are piled, pressed to drain water and finally dried under constrain on a flat surface.

For the period we are dealing with, the two kinds of moulds were used. As a consequence, raw materials and manufacturing processes may determine some features that can be observed within paper. As an example, the presence of threads (coloured or not) or cloth may indicate the use of rags. Likewise, the sheet shaping method (**Fig. 5**) and the drying method (**Fig. 6**) leave specific traces within paper structure. Finishing stages such as polishing, calendaring or coating (**Fig. 7**) are also noticeable.

Macroscopic analysis also enables to reveal some practices or uses of documents. Actually, certain leaves show numerous folds which do not look accidental but the result of a folding. Other documents show vertical traces due to their rolled storage condition (**Fig. 8**). Some fragments bear little holes: they are magical texts of a medical nature. They had to be pinned and carried on the ill one³³. Some other

33 Communication with prof. G.-J. Pinault.

manuscripts show coloured stains (white, purple, pink or red) which composition and origin have not been determined yet³⁴.

Storage conditions on the site of the find have an impact on paper (**Fig. 9**). Besides common paper degradations³⁵, sheets of paper are marked by their extreme storage conditions for many centuries. The various sites were ransacked and burnt, papers remained in open sky, submitted to bad weather. Conditions of carriage also had consequences (**Fig. 9**), documents were placed in wooden crates, buffeted in horse carts, thus submitted to vibrations of the rough terrain, temperature changes and bad weather³⁶.

A pad of sheets was kept unchanged, it consists in fragments of sheets and agglomerated mud. That illustrates storage condition on the find place (**Fig. 10**).

To this day, 350 leaves and fragments were observed under natural light, low-angled light and transmitted light. They were photographed and measured (height, length and width). Documents are firstly observed with the naked eye before using a Dino lite³⁷ to focus on tiny details. General characteristics can already be identified. They

34 They may be stains resulting of degradation (moulds) and/or accidental stains or even intentional due to documents usage. Analyses should be performed by the BnF Laboratory.

35 Yellowing, dust, folds, tears and losses.

36 P. Pelliot diaries perfectly illustrate severe winters and ardent summers which feature the climate of the Tarim basin, located between the Taklamakan desert and the mountain ranges of the Tianshan. For greater accuracy about the climate of the region, read the book of L. Golomb, *Die Bodenkultur in Ost-Turkestan. Oasenwirtschaft und Nomadentum*, Freiburg 1959.

37 Dino-Lite FC OC 1.

are more or less clear according to the fragment dimensions, its state of conservation³⁸ and the presence of a coating.

Paper colour is the first feature observed (**Fig. 11**). However, relevant conclusion can not be drawn from it. Actually, many causes result in colour changes: raw materials itself, fibres, sizing, coating, and how it is applied, the cooking time and the use of an alkaline product and finally the beating time. Exogenous factors also have an impact, temperature, humidity, light, contact with polluting materials or substances, hastening paper natural aging. As an example, black traces can be seen on calcinated edges; presence of dirt (dust, silica) can be explained by the finding place as described by P. Pelliot³⁹.

Therefore, colour description makes sense in the case of a paper collection which enables comparisons 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 aspect⁴⁰.

38 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.

39 P. Pelliot, *Carnets de route, 1906-1908*, Paris 2008, p. 120: “Thursday 18th October 1907 “We found some leaves fragments, they are quite big, on birch bark and especially fragments in Sanskrit and Chinese on paper. Chinese fragments mainly consist in account; the whole thing has been found mostly in waste piles, mingled with dung, seeds, apricot kernels, walnut shells” [“Jeudi 18 octobre 1907 «Nous avons quelques fragments assez grands de feuillets 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»”].

40 Light reflexion differs on a smooth and rough surface which modifies colour perception.

Terminology used to describe paper colour remains subjective and little accurate⁴¹. Using instruments is not necessarily more efficient because the use of an absolute white standard, dedicated to industrial paper mill, is not always relevant for uneven surfaces.

Nonetheless, that white feature was considered relevant for the Pelliot collection as long as documents were compared with each other. Broadly speaking, paper colour ranges from creamy white to brown including beige⁴². When the coating is in good condition, paper surface is white, smooth and glossy (**Fig. 12**). That shows the care and the quality of the finishing process dedicated to some manuscripts. The coating consists in a thick gypsum-based substance. The coated surface papers show an even surface enabling to write with a wooden stick. In the case of non-coated paper, ink did not bleed within paper, it can be assumed that paper was sized. However, micro-sample analyses only may confirm it and specify the sizing nature. Ink analyses identified a carbon ink which sometimes contains metallic elements such as copper⁴³. The latter was commonly used to fluidify it and stabilise

41 They cope with a range from white to dark brown.

42 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. Nonetheless, it looks little possible to transpose Chinese paper typology of the Tang manuscripts written in Sanskrit and Tocharian. However, to better understand reflection about that question, it may be interesting the article written by V. Bunting, *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.

43 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 reflectance spectrometry

colour⁴⁴. However, is the presence of copper accidental or intentional? The region was actually known for its copper mine, as a matter of fact archaeological digs unveiled numerous ovens dedicated to metal extraction (**Fig. 12**). Nonetheless, copper may be a common carbon ink ingredient in Central Asia⁴⁵.

It is important to note that manuscripts were little restored. Actually, P. Pelliot, once back in France, oversaw leaves restauration after their deposit at the BnF in 1910. He opposed many treatments of which dry cleaning⁴⁶. This approach aimed at preserving documents as they were with their component parts⁴⁷ and materials stemming from their place

(spectral range analysed from 350 to 2500 nm with an 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^{-1}) 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.

44 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.

45 R. Nöller, O. Hahn, "Illuminated manuscripts from Turfan. Tracing Silk Road glamour by analyzing pigments", *STAR : Science & Technology of Archaeological Research*, 2015, p 49-58

46 For more information on the various manuscripts treatments and packaging from their excavation until modern era, read the master's thesis of Nathalie Silvie, *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.

47 As an example, some conservation treatment such as lining have an irreversible impact introducing an outer material. Likewise, aqueous cleaning may eliminate specific components, thereafter non-longer observable such as mica. That element

of discovery⁴⁸. As previously mentioned, storage conditions on the finding place left marks on a large majority of documents. Examples of this are burn marks, losses or abrasions due to bugs, scratches caused by rodents (**Fig. 13**).

A calliper⁴⁹ was used to measure paper thickness. Whenever sample sizes permitted it, the four edges were measured. That informs about paper thickness evenness thus revealing papermakers know-how. In fact, that feature assesses two main skills, which are papermaker ability to shape thin sheets and their evenness. That last characteristic is, of course, relevant when analysed paper dimension is significant.

The average thickness oscillates between 0.10 mm to 0.20 mm⁵⁰ with little variation along one sheet. One may therefore conclude that papermakers had acquired a good mastery of their craft. As a consequence, this production was not at an early stage. Is it possible to deduct that papers were imported? Did skilled papermakers migrate in the region? Was paper manufactured in the region far before the writing time of the manuscripts studied?

The question of layered paper has not been solved yet. Actually, some paper delaminates but it may result wether from two sheets glued

occurs naturally in the soil and can be observed easily on paper surface. In the case of a too invasive conservation treatment, that material would have disappeared.

48 That remark must be relativized as former storage and conservation decisions modified some paper aspect and properties.

49 The calliper used is Mitutoyo PK-0505APX.

50 Two extreme thicknesses were measured: 0.06 mm and 0.30 mm. The thinnest is a document written in an Iranian language (Pelliot Douldour Aqour_Divers K_M_914_1).

together or natural paper degradation. Numerous traces, informing about papermaking stages, are noticeable within paper structure. That is the case, for instance, of brush strokes due to the white coating application⁵¹. Some straight traces can also be observed on paper surface, sometimes also within paper structure (Fig. 14). 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. 15).

Among the 350 manuscripts observed, 64 retained their oblong shape. The most common dimension is 8 x 20 cm⁵². Almost two-third of papers do not show traces revealing the mould used as many fragments are tiny or opaque. However, a partial transparency enables to observe fibres distribution (Fig. 16). Usually formation aid is added in the vat to spread fibres evenly. It is likely that papermakers did not use it which resulted in a cloudy fibres distribution along the sheet. This is particularly the case when pulp is coarse. Sometimes, laid lines appear sporadically along the sheet. It results from a modified sieve on which a cloth is sewn (Fig 17). That usage is still practiced in some papermaking workshops in Nepal, in Himalayan regions and in eastern Asia. This method is convenient to slow water dripping which allows

51 A strand of hair was found embedded within coating. The animal to which it belongs was not identified yet.

52 The *pustaka* manuscripts include three sizes:

Size 1: 8 × 20 cm (18 manuscripts) / 8 × 30 cm (15 manuscripts) / 8 × 40 cm (2 manuscripts) / 8 × 10 cm (1 manuscript);

Size 2: 9 × 20 cm (2 manuscripts) / 9 × 30 cm (9 manuscripts).

Size 3: 7 × 20 cm (6 manuscripts) / 7 × 30 cm (2 manuscripts) / 7 × 40 cm (4 manuscripts).

papermaker more time to spread fibres evenly and acquire an even thickness.

Many questions remain unsolved for the moment. The long transition period of the paper sheet manufacturing method must be considered. It consists of a changeover from a so-called archaic⁵³ papermaking technology marked by the use of a stationary floating mould to a more sophisticated, and efficient, process using a movable dipping one. The latest was possible thanks to many adaptations (the modified sieve may be one of them). Laid lines were observed on 93 fragments⁵⁴. They are numbered from 6 to 7 per centimetre. Only a small number of paper show chain lines. When they are regular, they are spaced 5 centimetres (**Fig. 18**). Sometimes, transversal or thicker chain lines witness that the sieve was repaired (**Figs 19 and 20**).

Papermakers know-how is also judged according to papermaking defects such as folds, skinned areas or water droplets (**Fig. 21**). The first two imperfections occur during the drying stage when the wet sheet is brushed on a flat surface and then detached from it.

53 That chronology used to describe the papermaking technology evolution was highlighted by D. Hunter in his book *Papermaking: the history and techniques of an ancient craft*, London, 1957. Thereafter, it was questioned as both processes were practiced simultaneously. Nonetheless, the dipping mould offers a higher performance and profitability which probably enticed papermakers. Its economic benefit is even more obvious when craftsmen must produce more upholding the quality.

54 That feature was observed in 13 fragments of the Pelliot Koutchéen Ancienne Série, 39 scrolls of the Pelliot Koutchéen DAM 507 (of which 16 also show chain lines) collection, 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 Godfrey collection, 2 of the Pelliot Sanskrit Udānavarga collection.

Droplets of water happen when papermaker carelessly drains the wet sheet. Let's remind further that within the Pelliot collection, a minority of fragments allow to detect these elements because of their small size and opacity.

The use of a Dino Lite enables to note the presence of bundles of fibres, threads (coloured or not), pieces of silk cloth and many impurities from vegetal elements, straw, grass, bark, wood and even cereals spikelet (**Fig. 22**). Bigger threads were observed in scrolls, so these documents were written on low-quality paper. Pulp was partly made from raw fibres with a variable quantity of recycled material. That hypothesis was confirmed by the microscopic analysis⁵⁵. Bundles of fibres are due to low separated fibrils. Yet the pulping process is adapted to the raw material. Is it possible to conclude that the cooking stage and/or the beating stage were shortened?

Anyhow, microscopic analysis reveals that whatever the material used, that is recycled or raw, the same fibres are present: hemp and/or linen⁵⁶, hemp mixed with ramie or mulberry tree⁵⁷, or even a combination of the three fibres.

55 Fibres identification was performed *in situ* by Lucas Llopis (EPHE / CRC) and Léon-Bavi Vilmont (CRC) without sampling thanks to a digital microscope Keyence VHX 6000 equipped with the focus VH-Z 1000 R. A transmitted and low-angled lightning were used. The sheet surface is scanned with a magnification $\times 100$. Then magnifications between $\times 200$ and $\times 500$ enable to observe and identify coarse elements such as thread or bundles of fibres, the magnification $\times 1000$ was used to identify fibres.

56 Both these plants show similar features what makes them hard to differentiate.

57 It was not possible to determine which specie of the Moraceae family was used: *Morus alba* L. ou *Broussonetia papyrifera* (L.) l'Hér. Ex Vent. Both genera are

It was not possible to determine if cereals spikelet come from wheat or barley (Fig. 23). These elements show that papers were likely to be manufactured in agricultural setting. Moreover, many papers contain tiny wood pieces, pointing that the writing support was crafted in a wooden area. In such an environment, papermakers disposed of plenty of various coarser materials beside the workshop. It was then a good way for them to increase the pulp quantity adding cheap material, which enabled them to meet an increasing demand for paper. Actually, some elements suggest that there was a lack of raw material. Besides common corrections and repairs, some leaves are composed of several sheets coarsely joined to shape the *pustaka* format. This task was not always meticulously achieved, which shows that some workers, merchants or monks (according to the place where that bonding was made) were more or less conscientious, or skilled, than others (Fig. 24).

Corrections were executed by applying a layer of coating over the text (Fig. 25) or the text can be erased. In the case of repairs, a strip of paper may be glued to stick a tear, or the document can even be sewn. In the latter case, thread passage holes can be observed along the tear (Figs 26 and 27). Thus, we may assume there was some specific tension with paper supply as repairing leaves was favoured to writing new ones. In the Buddhist world, where copying religious texts represent an act of

mulberry used to make paper. The first was initially dedicated to silkworms breeding. The second corresponds to the paper mulberry, used exclusively to manufacture paper.

merit, achieve a new manuscript to replace a degraded book should have been preferred (Fig. 28).

Conclusion

Macroscopic analyses of papers from the Pelliot collection found in Kucha reveal a certain manufacturing homogeneity with close general features such as the presence of impurities and bundles of fibres. They attest an imperfect pulping process whereas the sheet shaping is mastered. The increasing demand for paper, a fast and abundant production may be the reason for the pulp low-quality. We can assess the practice of at least two papermaking technologies: the use of a dipping mould and a modified one. The finishing process on religious manuscripts was nicely and skilfully performed providing for a white, smooth and glossy surface. As a consequence, the addition of coarser material, leading to an uneven surface, was overcome. As a matter of fact, paper thinness and even thickness, the almost systematic finishing process of religious texts show that papermakers were highly capable and skilled. Thus, paper production was not at its early stage in the modern Xinjiang at the 7th century. However, the question of paper import or local production remains to be answered. Less than a third of papers analysed show laid lines what may be explained on the one hand by the small size of documents, on the other hand by the practice of various papermaking technologies at the same place and the same period. Other questions are unexplained such as coloured stains or even the presence of particular folds on some religious documents. All these remarks should be correlated with observations of papers found in the

Xinjiang region, dated of the same period, that would help to create a typology of the materials, tools and papermaking processes within the same region.

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