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Paper in Dongba Manuscripts from the Weltmuseum in Vienna

Abstract: This article presents the results of analyses of paper and fibre in sixteen Naxi manuscripts from the Weltmuseum in Vienna in the context of paper production in the northwestern part of China's Yunnan province, where the Naxi communities live. Understanding the material aspects of these manuscripts requires knowledge about the provenance of the paper, the technology of papermaking, and the raw materials that are used. Examination of paper samples with both digital and optical microscopes has revealed the papermaking techniques and raw materials that were involved. Identification of the raw materials and the way they correspond to the distribution of local plants and cultural habits provide clues to the possible regional origins of the paper.

1 Introduction: Paper and papermaking in the Naxi area

The Naxi are one of China's 55 officially recognised minorities, primarily inhabiting the highlands of today's Lijiang Naxi Autonomous Region in the northwestern part of Yunnan Province, China (Fig. 1).¹ The Naxi region located along the Jinsha river including its commercial centre of Lijiang is situated along the 'Southwest Silk Road', the traditional network of trade routes connecting China, Southeast Asia, Tibet and India.² As suggested by Chinese semi-official websites nowadays 'Dongba paper' has become part of tourism industry, presented as unique material, produced from special plants by craftsmen, who inherit their skills patrilineally over generations.³ While this would suggest a long tradition,

1 For the state of the art of research on languages of the Naxi subgroup of Sino-Tibetan in Chinese scholarship see Michaud, He and Zhong 2015; for the history of the study of Dongba manuscripts see the contribution of Michael Friedrich in this volume.

2 For the study of trade routes and exchange of goods including paper see Yang 2004.

3 This can be exemplified by 'The paper making of Dai and Naxi people' (2009), China Daily http://en.chinaculture.org/focus/focus/2010expo_en/2010-04/17/content_376648.htm (accessed on 3 May 2022).

numerous studies clearly show a loss of cultural practices and deprivation of natural resources due to both the turbulent history and rapid expansion of roads, markets, tourism and other infrastructure developments.⁴ It is why many questions remain as to just what kinds of raw materials and techniques were used before the Chinese Revolution of 1949, as well as how these various papermaking traditions have historically been absorbed into Naxi papermaking in a region with a complex history of interaction between various ethnic groups. This study seeks to address some of these questions through an examination of the actual makeup of paper from manuscripts in the Weltmuseum of Vienna.



Fig. 1: The location of Naxi area inhabiting the highlands of the Lijiang Naxi Autonomous Region in Yunnan Province, China.

⁴ After being listed as a World Heritage in 1997 Lijiang has become one of the most popular tourist destinations in China, and its heritage (including papermaking) has been commercialized for the purpose of maximizing benefits. In effect of this it is difficult to say how much of original papermaking tradition is preserved nowadays. For more on this topic see for example: Zhu 2016, 78–79, 85–87, 90–92; Yang et al. 2011, 334–342.

There are many hypotheses concerning the origins and development of papermaking in Naxi communities,⁵ as well as dating of manuscripts.⁶ It seems (based on the date of the earliest extant manuscripts) that papermaking has existed for at least three hundred years. This is also attested by records of family-run workshops making local paper which are known to have existed as early as the 1700s and expanded in the early nineteenth century.⁷ Despite uncertainty over whether these families of papermakers today are Naxi, it does imply the flourishing of local production at some point.⁸ Majority of Dongba manuscripts preserved had strong links to the religious tradition and rituals of the Naxi communities, while the papermaking tradition that is present today has been revived after a lapse from 1949 to the 1990s. Considering that, until recently, Naxi paper has not received much attention and since the Naxi people were not allowed to practice their religion after 1949, the main purpose of producing Naxi paper ceased to be valid. This suggests that whatever technology and skills have survived to this day may not be a continuation of the original Naxi papermaking tradition but rather a new adaptation to the tourist market.

Besides all above, papermaking being a seasonal activity, has not been only the occupation of the Naxi, but also that of other people seeking to make a living.⁹ This became especially apparent when papermaking was commercialised after 1949.¹⁰ In some remote villages located in mountainous areas, such as Kenbeigu Village (Daju Township, Lijiang City, Yunnan Province), villagers made paper in order to exchange it for food, money and other necessities, since Naxi paper sold

5 Li and Zhu 1999, 6; Chen 2004, 76.

6 The dating of the Naxi manuscripts remains questionable. Joseph Rock dated the earliest Naxi manuscript in his own collection to 1573 (Rock 1963, 44–45). This dating however was later contested by Anthony Jackson (see Jackson 1979, 52–57). Li Lincan refers to the manuscript dated to 1668 (presently in the collection of the Library of Congress) (Li 1984, 138). According to the catalogues of Naxi manuscripts preserved in the collections of the Beijing Library, Chinese History Museum, Museum of Minzu University of China and Museums of Yunnan Province these manuscripts have been dated to 1668 (Yan and Lin 2015, 129). Mueggler states that only a few Naxi books can be firmly dated with textual evidence, most of them to the nineteenth century. The earliest date on a manuscript about which scholars can roughly agree is 1703, see Mueggler 2011, 91. For the dating of Naxi manuscripts see also Michael Friedrich contribution to this volume.

7 Li 2003, 73.

8 As soon as traditional Naxi paper was promoted as a traditional craft and an attraction for tourists, more people, not necessarily of Naxi origin, began to produce it in the region. However, in many cases, the shift of papermaking from a sacred ritual to a livelihood activity has been accompanied by a loss of cultural meaning and symbolism of Dongba paper (Yang et al. 2011, 337).

9 Yang et al. 2011, 337.

10 Yang et al. 2011, 337.

better than other types of handmade paper.¹¹ In the early days of the People's Republic of China (around 1949), the Naxi religion was pushed underground, so papermaking was prohibited and all such activity was halted in Lijiang. Cultural restrictions continued until 1990s. Around 1991 Naxi papermaking was resumed,¹² but its revival was slow due to the introduction of machine-made paper which could be produced more quickly and at lower cost.

The reports referring to papermaking tradition before 1990s, as one by Ge Agan who is Dongba himself, are very rare, and it is why especially valuable.¹³ Ge reports that on 9 September 1990, while visiting Baidi 白地 (the 'holy' place of the Dongbas), he met the old Dongba Zhiben 治本 who told him that he had started to make paper again yesterday. Ge writes that according to his knowledge Zhiben was the first Dongba to make paper again after more than thirty years. The tools used by Zhiben (and reported by Ge) suggest that he produced laid type of paper using the mould with movable bamboo sieve.¹⁴ Zhiben used a tree bark called *adan'r* 阿丹儿, after having peeled it off, he would cook it for c. three hours. Then he would produce the pulp using a wooden hammer or a goose-egg stone and pour it into the vault, then spread it evenly within the bamboo sieve frame, then placed on the drying boards. He said that he could produce twenty sheets a day (c. 25 × 65 cm), but since he was busy with other agricultural work would make more than five sheets a day in average.

There are different kinds of paper that can be found in the area: 'Naxi paper' made of *Wikstroemia* plants from the Thymelaeaceae botanical family, and paper made from *Broussonetia papyrifera* (paper mulberry) belonging to the Moraceae botanical family.¹⁵ Paper mulberry is readily accessible at an altitude below 2500m on plains, hills and mountains across China,¹⁶ while most *Wikstroemia* plants are found mainly south of the Yangtze River and in southwest China (Fig. 2).¹⁷

¹¹ Yang et al. 2003, 88, Luo 2017, 146.

¹² Chen 2004, 72; Li 2003, 71.

¹³ On Dongba paper before 1990s, see: Ge 2008, 70. We are grateful to Michael Friedrich for bringing Ge Agan works to our attention, as well as for help with translation into English.

¹⁴ Zhiben used the following tools (Naxi terms in brackets, written with Chinese characters): *mucao* 木槽: wooden vat (*du* 督); *zhulianzi* 竹帘子: bamboo sieve [?, lit. curtain] (*dan'r* 丹儿); *lianzike* 帘子壳 bamboo papermaking mould [lit. bamboo sieve frame] (*dan'rzuo* 丹儿箬); *lianban* 晾版: drying boards (*seshiduo* 色士多); *muchui* 木槌: wooden hammer (*kedui* 课堆).

¹⁵ Interestingly, Yang et al. list paper mulberry, *Wikstroemia* and hemp as raw materials used for papermaking in southwestern China practiced by Naxi, Bai, Dai, Tibetan and Yi, but only *Wikstroemia* plants as traditional Naxi papermaking plants. See: Yang et al. 2011, 334–335.

¹⁶ He 2001, 122; Liu 2007, 88.

¹⁷ The locations marked in different colours are determined by the decimal latitude and longitude referring to the counties. The data on the areas where *Wikstroemia delavayi*



Fig. 2: Distribution of *Wikstroemia delavayi* (in blue), *Wikstroemia lichiangensis* (in yellow) and paper mulberry (in green) in China.

The rarest plants used for the production of Naxi paper are those from the *Wikstroemia* genus, specifically *Wikstroemia delavayi* and *Wikstroemia lichiangensis*, which are found only in Yunnan, Sichuan, and Tibet in China (Fig. 2).¹⁸ The bast of these plants is robust and the paper made from them has an eminently suitable surface for writing with hard bamboo pens. They are, moreover, poisonous.¹⁹ The

is to be found come from https://www.gbif.org/occurrence/search?basis_of_record=LIVING_SPECIMEN&basis_of_record=PRESERVED_SPECIMEN&country=CN&taxon_key=5523166, where *Wikstroemia lichiangensis* is to be found come from https://www.gbif.org/occurrence/search?basis_of_record=LIVING_SPECIMEN&basis_of_record=PRESERVED_SPECIMEN&country=CN&taxon_key=5524588 and where *Broussonetia papyrifera* is to be found come from https://www.gbif.org/occurrence/search?basis_of_record=LIVING_SPECIMEN&basis_of_record=PRESERVED_SPECIMEN&country=CN&taxon_key=5361944 (retrieved on 12 January 2019).

¹⁸ On *Wikstroemia delavayi* and its use for Dongba handmade paper see Yang et al 2007, 17, 21–24.

¹⁹ In fact, most species of the Thymelaeaceae family are poisonous and some are valuable ingredients for medicine. Touching the roots and barks of these plants may produce allergic reactions in people, but the paper made from them may contain little poison (the toxins are reduced during the papermaking process) and does no harm to people, although it remains resistant to insects.

paper is therefore more resistant to insect infestation and microbial destruction than many other types of paper, and it is also more durable.

Paper of the traditionally Naxi area is still mainly made in family-run workshops in the villages of Baidi²⁰ and Kenbeigu.²¹ The paper from Baidi (or ‘Baidi paper’) is made exclusively from *W. delavayi*, while additional materials such as hemp and *Gerbera delavayi* are added in the process of papermaking in Kenbeigu, with the proportion of *W. delavayi*, hemp and *Gerbera delavayi* being 32:2:1.²² In the town of Dayan (under the administration of Lijiang City, Yunnan Province), papermakers also use paper mulberry and bamboo as raw materials, and in the village of Zhonghe (in Yulong Naxi Autonomous County, Yunnan Province), paper mulberry, hemp and *Wikstroemia* plants are used in the papermaking process, the proportion being 7:2:1.

Nowadays the papermaking technique of the Naxi uniquely combines the movable-sieve (known for instance from the papermaking traditions of Han and Bai communities) with the floating-mould technique (known from traditional Tibetan papermaking). However, there remain the questions of 1) if this is indeed the case in older manuscripts and 2) if so, how these techniques came to be integrated historically, and how (i.e. in terms of raw materials, techniques/moulds). This article seeks to address these questions and is structured in the following way: material analyses; materials and methods; measurements; fibre analysis; techniques; fibre composition; and conclusion.

2 Material analysis of Naxi paper

Few tests concerning the material aspects of particular Naxi manuscripts have been conducted to date. The earliest microscopic examination of paper used in Naxi manuscripts was carried out in 1963 in Germany by M. Harders-Steinhäuser and G. Jayme.²³ The analysis included the visual features and fibre analyses of

20 Baidi village (Sanba Naxi Nationality Township, Shangri-La City, Deqing Prefecture) is located in 27° 30' N to 27° 28' N and 100° 01' E to 100° 05' E, the Northwest of Yunnan Province, roughly between the two cities Lijiang and Diqing.

21 Kenbeigu village (a highland Naxi community in the Baimai administrative village of Daju Township, Yulong Naxi Autonomous County, Lijiang City, Northwest Yunnan Province) is situated at 27°18.78' N and 100°18.21' E at an altitude of 2645 m in a temperate montane forest.

22 Chen 2004, 72; Li 2003, 72.

23 Harders-Steinhäuser and Jayme 1963. We thank Dan Petersen for bringing this article to our attention.

paper from eight manuscripts from Westdeutsche Bibliothek, Marburg, made from a variety of plants such as *Wikstroemia*, paper mulberry, and bamboo identified in the title page of manuscript 8466 (Hs. or. 1517).²⁴ In general, the paper varied in thickness, sometimes consisting of several layers glued together. The surfaces of the paper also ranged from rough to smooth (after being polished with stones). Seven manuscripts used woven paper, while laid lines were observed in paper from manuscript 8239 (Hs. or. 544), indicating that bamboo sieves were used. According to M. Harders-Steinhäuser and G. Jayme, the Naxi mainly used the traditional floating-mould with cotton sieves. They also explained that paper mulberry had sap in its bark and that this natural glue may have given the paper optimum absorbency for ink, in contrast to paper made from *Wikstroemia*, which needed to be sized with starch or other substances before being written on in order for the ink to be retained.²⁵ Although this may not actually be the case, and still needs to be confirmed, the study provides a sound reference for us to conduct paper and fibre analyses on our samples.

Another related study was carried out in 2009 by Wang and Tan on paper samples from five manuscripts,²⁶ four of which were allegedly produced in the Qing dynasty (1644–1912). The fifth sample was of modern paper made in the town of Daju, Lijiang. This study identified *Edgeworthia*, which had not previously been mentioned in the literature, as one of the raw materials for Naxi paper, and *Wikstroemia*, as well as paper mulberry in the modern paper from Daju. All five samples of paper were made using the floating mould with movable bamboo sieves. The old paper was either calendered,²⁷ or powder was applied to the surface after it had been smoothed with stones, so that a smooth writing surface for hard bamboo pens was produced. No powder was applied to the modern paper.

Just as in the case of our predecessors, our research here, based on paper and fibre analyses, focuses on the material characteristic of Naxi manuscripts and, in a longer perspective, attempts to find out about the particular material aspects of Naxi manuscripts that may be associated with specific social, historical and geographical contexts before the mid-twentieth century.

²⁴ In fact, *Wikstroemia* fibres are undistinguishable under the microscope from *Daphne* and *Edgeworthia*, also of the Thymelaeaceae family, but the researchers considered the species of the Thymelaeaceae plant they examined to be *Wikstroemia* because the bast of *Wikstroemia* was used locally to make paper.

²⁵ Harders-Steinhäuser and Jayme 1963.

²⁶ Wang and Tan 2009, 572–574.

²⁷ Calendering is a process in which cloth, paper, or the like, is smoothed, often by pressing between rotating cylinders, or in traditional production in Asia by wooden roll.

2.1 Materials and methods

Our sample of Naxi manuscripts comprises sixteen manuscripts currently housed in the Weltmuseum, Vienna (Fig. 3). They were donated to the museum by K. Anton Gebauer,²⁸ Heinrich Handel-Mazzetti,²⁹ Joseph Francis Charles Rock³⁰ and René de Nebesky-Wojkowitz³¹ between 1920 and 1961. Fifteen manuscripts belong to the East Asia collection curated by Dr Bettina Zorn and one belongs to the South Asia collection curated by Dr Christian Schicklgruber.

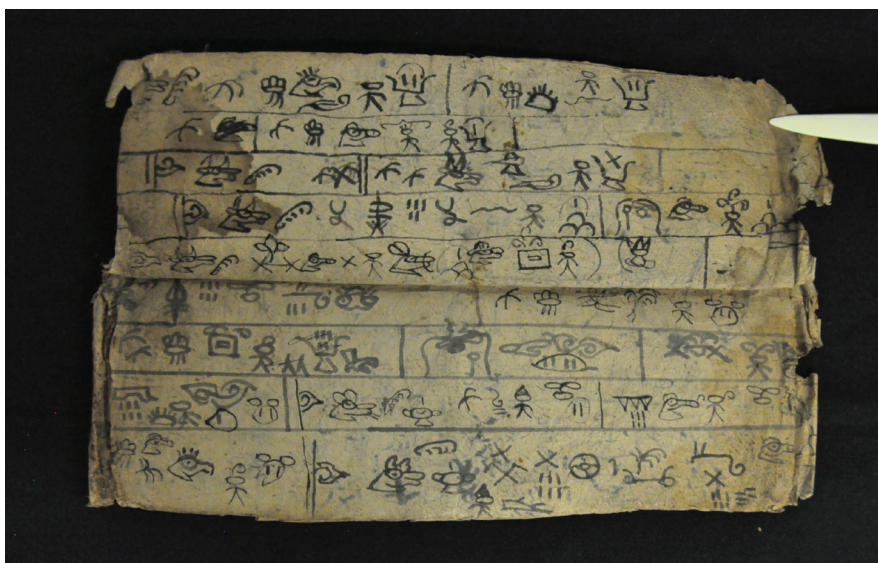


Fig. 3: Naxi manuscript 101508 in the collection of Weltmuseum.

Visual assessment was conducted during a three-day trip (23–25 January 2019) to the museum. General information and physical conditions of preservation, as well as visual and technological features of the manuscripts were recorded in

28 There are ten manuscripts in total. The inventory numbers are 101502, 101503, 101504, 101505, 101506, 101507, 101508, 101509, 101510, 101511.

29 There are four manuscripts in total. The inventory numbers are 117910, 117920, 117921, 128548.

30 There is one manuscript. The inventory number is 132264.

31 There is one manuscript. The inventory number is 140869. It was a gift from Joseph Francis Charles Rock.

documentation sheets, and samples of paper were collected for later fibre analysis.³²

2.1.1 Measurements *in situ*

The aspects of the manuscripts that were studied first are their technological and visual features. Consent was obtained from the conservator for where micro-samples were to be taken for fibre analysis, and these locations were then documented. As listed below, all possible measurements were conducted *in situ*. Information recorded for each manuscript consists of:

1. General information, such as their shelfmarks, date received, provenance, and the size and format of the manuscript.
2. The condition of the paper and the ink.
3. The scripts used and the colour of the ink.
4. The type and the thickness of the paper. Thickness was measured in five different places per sheet.
5. The type of sieve print of the paper, e.g. woven or laid. Measurements of laid lines in 3 cm and chain line intervals were taken where visible. The measurement of chain line intervals was taken only for distances that it was possible to measure, i.e. where chain lines were clearly visible.
6. The fibre distribution within the sheet and the texture of the paper.
7. Sampling for fibre identification.

2.1.2 Fibre analysis by microscope

The fibre analysis of Naxi manuscripts was conducted at the Centre for the Study of Manuscript Culture at the University of Hamburg. An Olympus BX51 Transmitted-Reflected light microscope with polarised light was used for fibre identification. An Olympus UC30 camera and Olympus Stream Software were used for photographic documentation and image analysis separately. A range of magnification from 50× to 500× with both plain and polarised light was used.

The paper samples were immersed in distilled water in a small beaker and boiled for between 10 to 15 minutes. The water was decanted and the samples were drained. About 0.2g of paper pulp was placed on a microscopic slide and separated into a fine suspension of individual fibres. The fibres were then observed

³² On methods see Helman-Wazny 2016b, 131–132.

with water solution using polarised light. The selected samples were then stained with 2 drops of Herzberg staining reagents (zinc-chlorine-iodide) and observed through an optical microscope. The colour of the resulting stain depends on the lignin content of the fibre and helps to distinguish the species and morphological characteristics of the fibres, as well as other cells and elements in the paper pulp. The results were compared to reference samples collected earlier by the author and to available atlases.

The most important atlases we have used are *Fibre Atlas: Identification of Papermaking Fibres* by Marja-Sisko Ilvessalo-Pfäffli, published in 1995, and *Zhongguo zaozhi yuanliao xianwei texing ji xianwei tupu* [Papermaking Raw Materials of China: An Atlas of Micrographs and the Characteristics of Fibres] by Juhua Wang, published in 1999.³³ We also used the online database Khartasia,³⁴ which includes historical and technological information on raw materials and paper-making techniques used in the production of the books from Asia and Western artefacts made from Asian paper. General information about plants, such as botanical classification, distribution, cultivation and use, fibre dimensions, characteristics of the fibre morphology, etc. are contained in all three resources, while each has its strengths and deficiencies.

Ilvessalo-Pfäffli's descriptions of plants and fibres are the most accessible and are accompanied by a wealth of illustrations, but some plants, such as *Daphne* and *Stellera*, are not included in the book, and some are mixed (for example, *Wikstroemia canescens* is described together with *Edgeworthia papyrifera*, perhaps because of their similarity). Neither are there descriptions of the colours of stains left on the fibre by staining reagents, so the identification is focused solely on the fibre morphology of fresh plants rather than historical fibres from old books, which nevertheless serves as a sound reference for microscopic analyses with polarised light or digital microscope. Wang's book can be regarded as the earliest and most systematic fibre atlas of plant materials found in China, despite its main focus on machine-made paper and the lack of clarity in its descriptions of handmade paper. The research practice at the time the book was written mean that Wang only described the distribution of different species of plants within the PRC, and in places it is incorrect. For example, *Daphne* is missing from the book. Although *Edgeworthia papyrifera* and *Wikstroemia sikokiana* are illustrated separately, no comparison is made between them and they are not distinguished from each other. In the case of *Stellera chamaejasme* (spelt incorrectly in the book), the distinguishing features of the fibre are unclear.

³³ Ilvessalo-Pfäffli 1995 and Wang 1999.

³⁴ <http://khartasia-crcc.mnhn.fr/en>.

The database Khartasia provided us with a great deal of additional information on the plants and fibres, including illustrations of plants, their vernacular names in Chinese, English, Japanese, Korean and French, the areas where they were used for papermaking, and the processes and techniques involved. The fibre descriptions, however, are simple; there is usually only one image of each kind of fibre. The identification features and fibre images are sometimes missing, such as for *Daphne odora*. While the database provides general information about plants, it offers limited help in fibre identification.

Finally, we should note that the majority of fibre images in the three resources are from reference samples (laboratory-made pulp from identified plants), which illustrated different fibre morphology in samples made through boiling, beating and pounding. The deterioration over time would, however, also change the fibre morphology. In this case, samples collected earlier by Helman-Ważny, which were made through traditional papermaking processes, as well as fibre descriptions and images included in Harders-Steinhäuser and Jayme's study and Jasper Trier's *Ancient Paper of Nepal* study prove to be of great assistance.³⁵ We should, however, continue to be critical, since there may also be mistakes in past studies. Harders-Steinhäuser and Jayme,³⁶ for example, observed curved hair and vessel cells in paper mulberry pulp from the title page of one manuscript, neither of which has ever been reported in paper mulberry pulp according to fibre atlases.

3 Results and discussion

3.1 Papermaking techniques

Generally, as mentioned in the introduction, there are two types of mould used in papermaking: the dipping mould and the floating mould. The floating mould is placed on the surface of the water and paper pulp is poured onto the sieve within the frame of the mould. With the dipping mould, however, the pulp is mixed with water before the mould is dipped into it. As a result, paper made with a floating mould is usually thicker, and the fibres are more unevenly distributed in the sheet of paper compared to paper made with a dipping mould. This is an important distinguishing feature between the different methods of papermaking.³⁷ In addition,

³⁵ Trier 1972; Harders-Steinhäuser and Jayme 1963.

³⁶ Harders-Steinhäuser and Jayme 1963, 55.

³⁷ For more on papermaking technology see Hunter 1978; Pan 1979; Pan 1998; Tsien 1985.

a fixed sieve made of woven cotton, hemp or flax textile is often attached to the floating mould, while a movable sieve, made from bamboo, reed or another kind of grass, is attached to the dipping mould. The different sieves leave clearly different imprints on the paper. A textile sieve leaves woven patterns and a movable sieve leaves a pattern of laid lines (bamboo sieves leave regular laid lines; reed or other grass sieves leave irregular laid lines). The chain lines, being the impressions of stitches that tie the strips of bamboo, reed or other grass together, are sometimes visibly perpendicular to the laid lines.³⁸

Historically, however, the techniques used by the Naxi combines the floating mould (used widely by Tibetan communities and all across the Himalayas) with movable sieves (used for example by Han and Bai communities). Traditionally papermakers used floating type of mould; however instead of a thin wooden frame, wider planks were used for such papermaking moulds, resembling a box floating on water. This ‘box’ was then equipped with a movable sieve made of bamboo, which left the laid print preserved in the structure of paper, as we can see in some of the manuscripts examined. In such cases it is clear that we are dealing with a laid type of paper, but it is not always clear if the floating or dipping technique was used. If the sheet of paper is large enough it is possible to observe traces of pulp distribution and thereby to obtain further clues about technology used.

Table 1 (in appendix) (in appendix) shows a summary of paper features gleaned from the manuscripts examined in this study, including through microscopic examination. Observation of paper structure against the light showed that fibre was unevenly distributed in all the paper samples. This is probably the reason why the thickness measured at five points on a single sheet of paper varied so greatly, especially in manuscript 101510. It is clear that all the paper studied was made with a floating mould.

The sieve imprints sealed in the paper structure reveal that fifteen of the manuscripts used woven paper (Fig. 4). Manuscript 101507 was the only manuscript whose paper showed regular laid lines from a bamboo sieve, but there are no visible chain lines (Fig. 5). This means that paper in the majority of the manuscripts was made using a floating mould with fixed textile sieves, and only paper from 101507 was made using a floating mould with movable bamboo sieves.

³⁸ Helman-Ważny 2016b, 129–130.

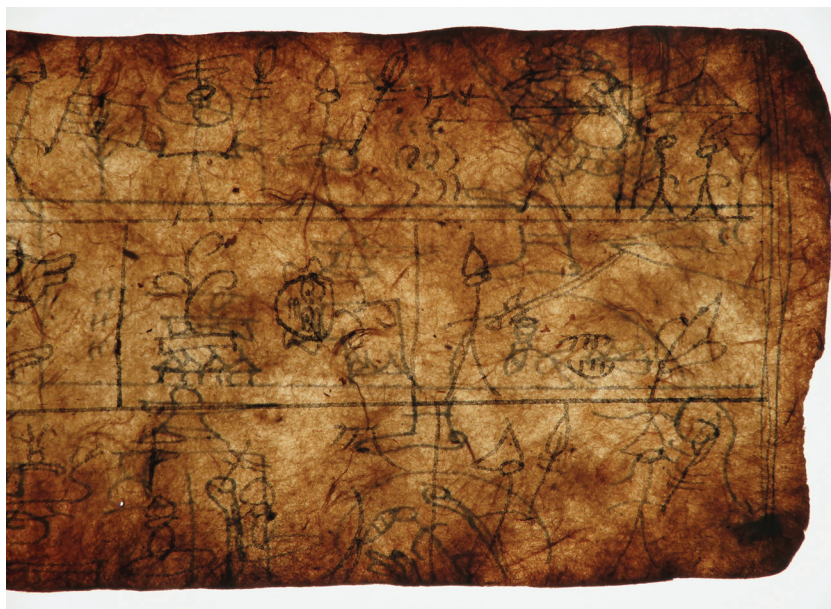


Fig. 4: Example of woven paper in manuscript 117920 when observed against light.



Fig. 5: Regular laid lines on the surface of the paper of Naxi manuscript 101507 are visible on the light table.

Our results indicate that the most of manuscripts from our sample were made with the use of traditional floating moulds with fixed sieves. This suggests that the floating-mould technique was used more often in the past, unless further paper analysis proves otherwise. Considering that the floating-mould technique with fixed sieves is the most primitive method of papermaking and that the dipping-mould technique with movable sieves is commonly perceived to have developed later, it would be unusual if the Naxi had first learned the dipping-mould technique, but chose to retain use of the floating mould, which was also a slower technique. It is uncertain whether the current floating mould with movable bamboo sieve of Naxi papermaking in fact represents an intermediate stage of development between the floating-mould technique and the dipping-mould technique, as proposed by Fan and Zhang;³⁹ it could be that the Naxi kept the original floating-mould technique to make their paper, and at some point exchanged the fixed textile-made sieves for movable sieves made of bamboo in order to increase productivity. If the results of our preliminary research are confirmed by further investigations it may therefore be more likely that the floating-mould technique used in traditional Tibetan papermaking was learnt by the Naxi before the dipping-mould technique.

3.2 Preparation for writing

Table 1 (in appendix) (in appendix) shows that fourteen manuscripts used paper comprising more than one glued layer. This is sometimes indicated by split edges. The exceptions are manuscripts 101505 and 117910, which used single-layered paper. The writing implements are also examined. More than half of the sixteen manuscripts are written with a brush, rather than the bamboo pen known to have been traditionally used by the Naxi.⁴⁰

Tibetan paper, which also has uneven thickness and a rough surface from the use of the floating mould, often also consists of multiple layers. In order to obtain a relatively smooth surface, Tibetan papermakers would glue several layers of paper together and finish the surface with additional substances, such as wheat or barley powder.⁴¹ On the other hand, hard and wide-cut bamboo pens were utilised in Tibetan areas and the thicker paper is less susceptible to abrasion

³⁹ Fan and Zhang 2009, 64.

⁴⁰ Scripts written with a bamboo pen are found in manuscripts 101502, 101506, 101508, 101509, 101510, 117920, 128548.

⁴¹ Helman-Ważny 2006, 8.

during writing. The same may be said of Naxi paper because the seven manuscripts which were probably written with point-cut bamboo pens all used multiple-layered paper, and the two manuscripts with single-layered paper, 101505 and 117910, were more likely written with a soft brush. Manuscript 101507, although it had three layers, has less thick paper (thickness of inner page: 0.16–0.25 mm), and there the brush was utilised instead of the bamboo pen.

Unlike Tibetan paper, whose surfaces are polished and sometimes treated with varying kinds of powder, Naxi paper is sometimes calendered or polished using wooden sticks or stones before it is written on. Although the signs of polishing are not clearly visible, the comparatively smooth surfaces of manuscripts 101504, 101505, 101507, 101509, 101511, 128548 may be a result of this process.

3.3 Fibre composition

Fibre analysis shows that seven samples are made of mixed fibres,⁴² while nine are homogeneous.⁴³ One species of the main raw materials recognised has varying fibre width and irregular thickness of the fibre walls. The broad central portion shown in Fig. 6 from 101503 illustrates the most characteristic feature of this fibre, placing it in the Thymelaeaceae family (Fig. 6). The ends of the fibre found in the sample from 117910 are usually pointed, blunt, spatulate, scalloped, or of other irregular shapes (Fig. 7). Dislocations and cross-markings are sometimes less obvious, and remains of parenchyma cells are common in the pulp. Examination under the microscope with polarised light reveals the morphology of the fibre to be *Daphne* or *Wikstroemia*. These species are so similar that we were unable to distinguish them. In total, ten samples analysed contain *Daphne*/*Wikstroemia*⁴⁴ and four are composed of *Daphne*/*Wikstroemia* mixed with a few *Stellera* fibres.⁴⁵ *Stellera* also belongs to the Thymelaeaceae family. Despite its similar features, it can be distinguished by its flabby, ribbon-like shape (Fig. 8, arrowheads). Sometimes the wavy fibre walls and much more irregular lumens also helped us distinguish *Stellera* fibres from *Daphne* or *Wikstroemia*.

⁴² Inventory numbers: 101502, 101504, 101505, 101507, 101511, 117921, 132264. Mixed fibres were also reported by Harders-Steinhäuser (1963).

⁴³ Inventory numbers: 101503, 101506, 101508, 101509, 101510, 117910, 117920, 128548, 140869.

⁴⁴ Inventory numbers: 101502, 101503, 101504, 101505, 101508, 101511, 117910, 117921, 132264, 140869.

⁴⁵ Inventory numbers: 101502, 101505, 101511, 117921.

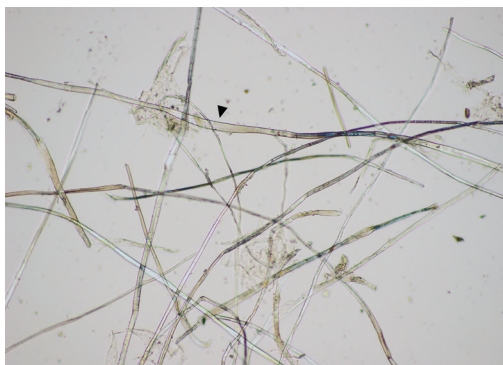


Fig. 6: *Daphne/Wikstroemia* fibres.



Fig. 7: *Daphne/Wikstroemia* fibres with the irregular shape of the fibre ends.



Fig. 8: *Stelleria* fibres with ribbon-like shape (arrowheads) from Naxi manuscript 101502.

Another major raw material is paper mulberry, which was identified in seven paper samples.⁴⁶ The fibres are often thick-walled, of varying width, but thin-walled, ribbon-like fibres (Fig. 9, arrowheads) have also been found in the samples. Frequent dislocations and cross-markings are visible and the fibre ends have various shapes, such as pointed, blunt, spatulate and forked. The most characteristic element of paper mulberry is the transparent membrane enveloping the whole fibre, which is clearly observed around the fibre ends from the sample of 117920 (Fig. 10). Parenchyma cells and square or diamond-shaped crystals have also been found.

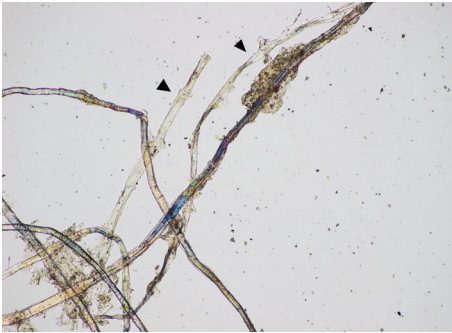


Fig. 9: Thin-walled, ribbon-like *Broussonetia* sp. (paper mulberry) fibres (arrowheads) and normal thick-walled fibres from Naxi manuscript 101510.

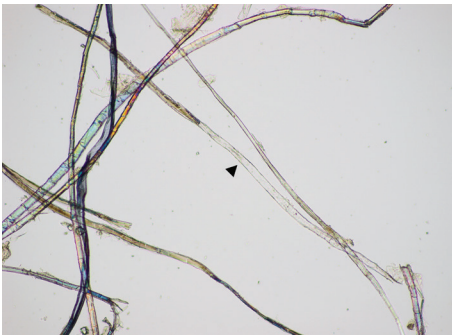


Fig. 10: *Broussonetia* sp. (paper mulberry) fibres with transparent membrane around the fibre ends (arrowheads) from Naxi manuscript 117920.

⁴⁶ Inventory numbers: 101504, 101506, 101507, 101509, 101510, 117920, 128548.

The above results confirm that *Daphne*/*Wikstroemia* plants and paper mulberry are the two main genera and species used as raw materials by the Naxi to make paper. Nine manuscripts mainly made of *Daphne*/*Wikstroemia* may have come from Baidi or Kenbeigu area, where *Wikstroemia* is the main raw material in papermaking, while six containing mainly paper mulberry may have come from other places where paper mulberry was used.

Wikstroemia, which belongs to the same family of plants as the main species of plants used in the Tibetan plateau such as *Stellera*, *Daphne* and *Edgeworthia*, was the primary raw material used by the Naxi. This plant was also widely distributed around the areas in Yunnan where the Naxi lived. Along with paper made from *Wikstroemia*, the Naxi utilised paper made from paper mulberry for the writing (the usage of this species of raw material was said to have been learnt from the Bai); this plant was found in seven samples. Despite hemp and *Gerbera delavayi* being mentioned by Chen Dengyu and Li Xiaocen as additional raw materials used by the Naxi in Kenbeigu and Zhonghe Village,⁴⁷ they have not been found in the samples from the sixteen manuscripts. Neither had *Stellera* been considered among the raw materials used by the Naxi in papermaking, but it is widely found in dry, sandy places at an altitude between 2600 and 4200 m in Yunnan Province.⁴⁸ It is a plant recognised for its properties in papermaking in Tibetan cultural regions, but possibly only used where other plant sources were unavailable, such as in regions on the Tibetan plateau. The Naxi might therefore have learned to use *Stellera* for papermaking through interaction with Tibetan peoples, while its distribution in Yunnan would provide the opportunity for using this plant for paper production. Only a small quantity of *Stellera* fibres, however, was found in each sample, suggesting that it was probably also used when the main raw materials were insufficient, as in areas of high altitude.

Of the sixteen manuscripts, the paper used in 132264 is different because a small quantity of wood fibres and associated cells were identified. The typical morphology of softwood fibres with some circle pits is shown in Fig. 11. The wide circle pits suggest that the paper was possibly made from pine pulp, but we were unsure of the exact species. It is also interesting that an associated element such as a vessel with a small tail was found, indicating that hardwood pulp might have been added (Fig. 12). It is therefore highly likely that the paper contained mixed wood pulp. The pulp seemed to have been highly processed because most of the

⁴⁷ Chen 2004, 72; Li 2003, 72.

⁴⁸ See Flora of China http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200014523 (accessed 28 March 2022). For more information on *Stellera chamaejasme* plant and its distribution see: Boesi and Helman-Ważny 2020, 105–108 or Helman-Ważny 2016a, 177–178.

wood fibres and associated cells were distinctly damaged or broken (Fig. 13). The extent of deterioration of the fibres and degree of pulping during the papermaking process are subjectively rated according to the morphology of the fibres and associated cells. We regard eight manuscripts⁴⁹ as showing a high degree of deterioration or pulping because it was more difficult to find unbroken fibre ends or parenchyma cells, and there was swelling or fracturing in the middle of the fibres more frequently than in other samples. Manuscript 132264 falls into this category.

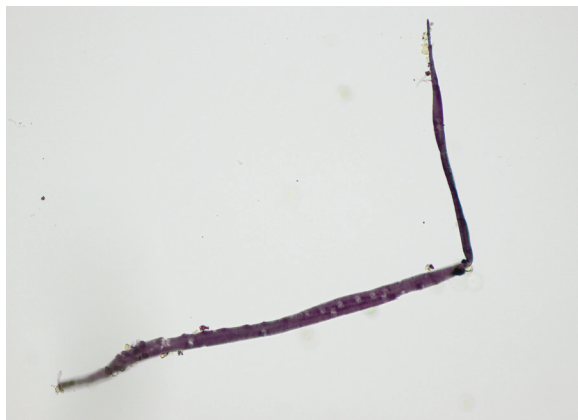


Fig. 11: Softwood fibre with small round pits stained with Herzberg from Naxi manuscript 132264 in 200× magnification observed in polarised light.

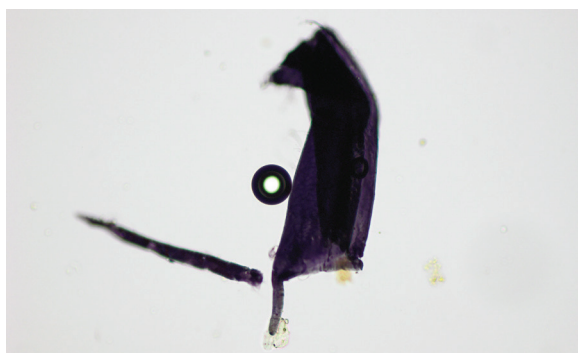


Fig. 12: Associated element like a vessel with a small tail from hardwood pulp from Naxi manuscript 132264 in 200× magnification.

⁴⁹ Inventory numbers: 101504, 101506, 101507, 101508, 101511, 117910, 132264, 140869.

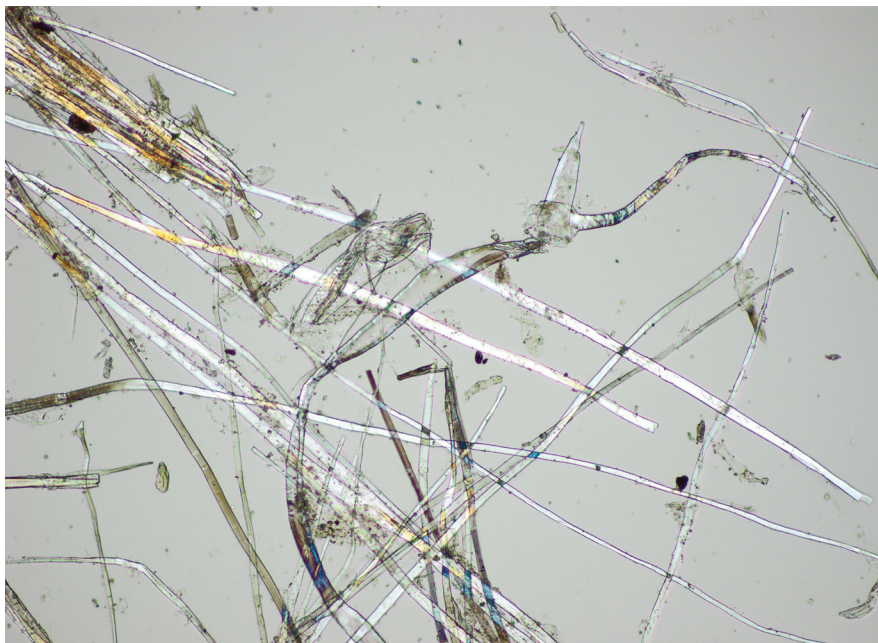


Fig. 13: Common broken fibres and associated cells from Naxi manuscript 132264 in 100× magnification observed in polarised light.

According to Hunter, wood pulp was not really used in papermaking in Europe until the mid-nineteenth century, but there are a few records regarding the introduction of wood pulp to China.⁵⁰ Wang conducted an analysis on the fibre in a piece of newspaper, *The Peking News*, dated to 1907, and identified the raw material as softwood.⁵¹ In her opinion, either the wood pulp or the paper was imported because wood pulp was not produced in China at that time. In the remote regions inhabited by the Naxi, where paper was produced on a small scale in family-run workshops, it may have been impossible for papermakers to use imported wood pulp at that time or to produce it themselves (which would have required sophisticated procedures); mixed wood pulp would be even less likely to have been used. Considering that the first foreigners came to the Naxi territory in the 1860s and after 1912 were quite common in Lijiang, the wood pulp could also have originated from recycled paper brought from overseas. Recycled paper pulp or pieces

⁵⁰ Hunter 1978, 315–376.

⁵¹ Wang 2006, 379.

of recycled paper containing both softwood and hardwood was therefore possibly mixed with *Daphne/Wikstroemia* during papermaking, which might have constituted a more economically viable method of papermaking for the Naxi. Since manuscript 132264 was donated to the museum by Rock after 1920, it could be produced contemporarily to Rock's presence in Naxi region.

4 Conclusion

Our samples reveal that fifteen manuscripts used paper made with the floating mould with fixed sieves; only one manuscript used paper made with the combined technique of the floating mould with moveable sieve. Thus, within our sample the former method, known to traditional Tibetan papermaking, was used more often. Paper from the majority of the manuscripts moreover comprised multiple layers glued together so as to achieve a relatively even, increased thickness suitable for writing with hard, point-cut bamboo pens. The same holds for Tibetan manuscripts, but the Tibetans usually used wide-cut bamboo pens to write. Six of the manuscripts also had a comparatively smooth surface, probably owing to the polishing or calendering.

The fibre analysis revealed that ten samples contained *Daphne/Wikstroemia* and seven contained *Broussonetia* (paper mulberry). The main raw materials might suggest the different geographical origins of the sixteen manuscripts. A presence of both *Wikstroemia* and *Broussonetia* suggests that both plants have been used by the Naxi, combining Tibetan papermaking techniques with local botanical resources (it belongs to the same family of plants as the raw materials used by the Tibetans), whereas using paper mulberry for papermaking is more likely to have been learned from other groups. Hemp and *Gerbera delavayi*, which are additional raw materials reported in present-day Kenbeigu and Zhonghe, have not been found in the samples. Some *Stellera* fibres, however, were mixed with *Daphne/Wikstroemia* in four samples. This species of plant has not been mentioned as being used by the Naxi in the scholarly literature. Naxi papermakers may have learned to use it from the Tibetans or used the recycled Tibetan paper as raw material. A small quantity of softwood fibres and hardwood vessel have also been identified in one sample. Considering the high cost and difficulty of access to mixed wood pulp, which was mostly imported at that time, as well as the extent of the deterioration of wood fibres or associated cells, it is highly likely that recycled paper pulp or pieces of recycled paper containing softwood and hardwood was added during the papermaking process. This remains to be confirmed by further investigation.

In this study, we have tried to analyse the material aspects of Naxi manuscripts from the perspectives of history, society and geography. On the basis of the results, we have discerned a variety of different raw materials and papermaking techniques, which may suggest connections and interactions between the papermaking traditions present in the Naxi region. Of course, the preliminary results of this article will need to be confirmed with further study. We hope that it will nevertheless provide a new perspective on the study of Naxi culture through the technologies and materials they used.

Acknowledgments

This research was carried out at the Cluster of Excellence ‘Understanding Written Artefacts: Material, Interaction and Transmission in Manuscript Cultures’, funded by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG), and within the scope of the Centre for the Study of Manuscript Cultures (CSMC) at Universität Hamburg. We also thank the curators and the conservators of the Weltmuseum for their permissions to study the collection, and their support during our research. We would especially like to acknowledge the help of Bettina Zorn and Christian Schicklgruber. We also thank Michael Friedrich, Zhenzhen Lu and Barend ter Haar for reading our manuscript and offering useful comments.

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Appendix: The characteristics of the paper in the Naxi manuscripts from the Weltmuseum in Vienna

Table 1: The characteristics of the paper in the Naxi manuscripts from the Weltmuseum in Vienna.

No.	Inventory number	Raw material	Degree of deterioration/ pulp [*]	Type of paper	Layers	Thickness (mm) ^{**} Cover	Inner page	Fibre distribution	Texture
1	101503	Homogeneous: Daphne/Wikstroemia	Medium	Woven	Ply	0.52-0.65	0.57-0.66	Uneven	Rough
2	101508	Homogeneous: Daphne/Wikstroemia	High	Woven	Ply	0.17-0.20	0.21-0.29	Uneven	Rough
3	117910	Homogeneous: Daphne/Wikstroemia	High	Woven	Single		0.17-0.21	Uneven	Rough
4	140869	Homogeneous: Daphne/Wikstroemia	High	Woven	Ply	0.28-0.35	0.24-0.30	Uneven	Rough
5	101506	Homogeneous: Paper mulberry	High	Woven	Ply	0.21-0.32	0.28-0.35	Uneven	Rough
6	101509	Homogeneous: Paper mulberry	Medium	Woven	Ply		0.31-0.46	Uneven	Smooth
7	101510	Homogeneous: Paper mulberry	Medium	Woven	Ply	0.65-1.02	0.63-1.02	Uneven	Rough
8	117920	Homogeneous: Paper mulberry	Medium	Woven	Ply	0.31-0.41	0.32-0.40	Uneven	Rough
9	128548	Homogeneous: Paper mulberry	Medium	Woven	Ply	0.32-0.44	0.36-0.54	Uneven	Smooth

Table 1 (continued).

No.	Inventory number	Raw material	Degree of deterioration/ pulp [*]	Type of paper	Layers	Thickness (mm)** Cover	Inner page	Fibre distribution	Texture
10	101502	Mixed: Daphne/Wikstroemia, Stellera	Medium	Woven	Ply	0.30-0.36	0.32-0.46	Uneven	Rough
11	101504	Mixed: Daphne/Wikstroemia, paper mulberry	High	Woven	Ply	0.44-0.52	0.26-0.39	Uneven	Smooth
12	101505	Mixed: Daphne/Wikstroemia, Stellera	Medium	Woven	Single		0.16-0.25	Uneven	Smooth
13	101511	Mixed: Daphne/Wikstroemia, Stellera	High	Woven	Ply	0.45-0.50	0.28-0.37	Uneven	Smooth
14	117921	Mixed: Daphne/Wikstroemia, Stellera	Low	Woven	Ply	0.28-0.34	0.33-0.49	Uneven	Rough
15	132264	Mixed: Daphne/Wikstroemia, softwood, hardwood	High	Woven	Ply	0.37-0.49	0.33-0.41	Uneven	Rough
16	101507	Mixed: Paper mulberry, grass	High	Laid: 20 laid lines in 3 cm	Ply: 3 layers		0.16-0.25	Uneven	Smooth

^{*} The degree of deterioration /pulp^{*} was evaluated subjectively according to the frequency of occurrence of undamaged fibre ends and parenchyma cells remained as well as the swelling or fractures in the middle of fibres.

^{**} Thicknesses were measured in five different places within one sheet and only the minimum and maximum values were given here.