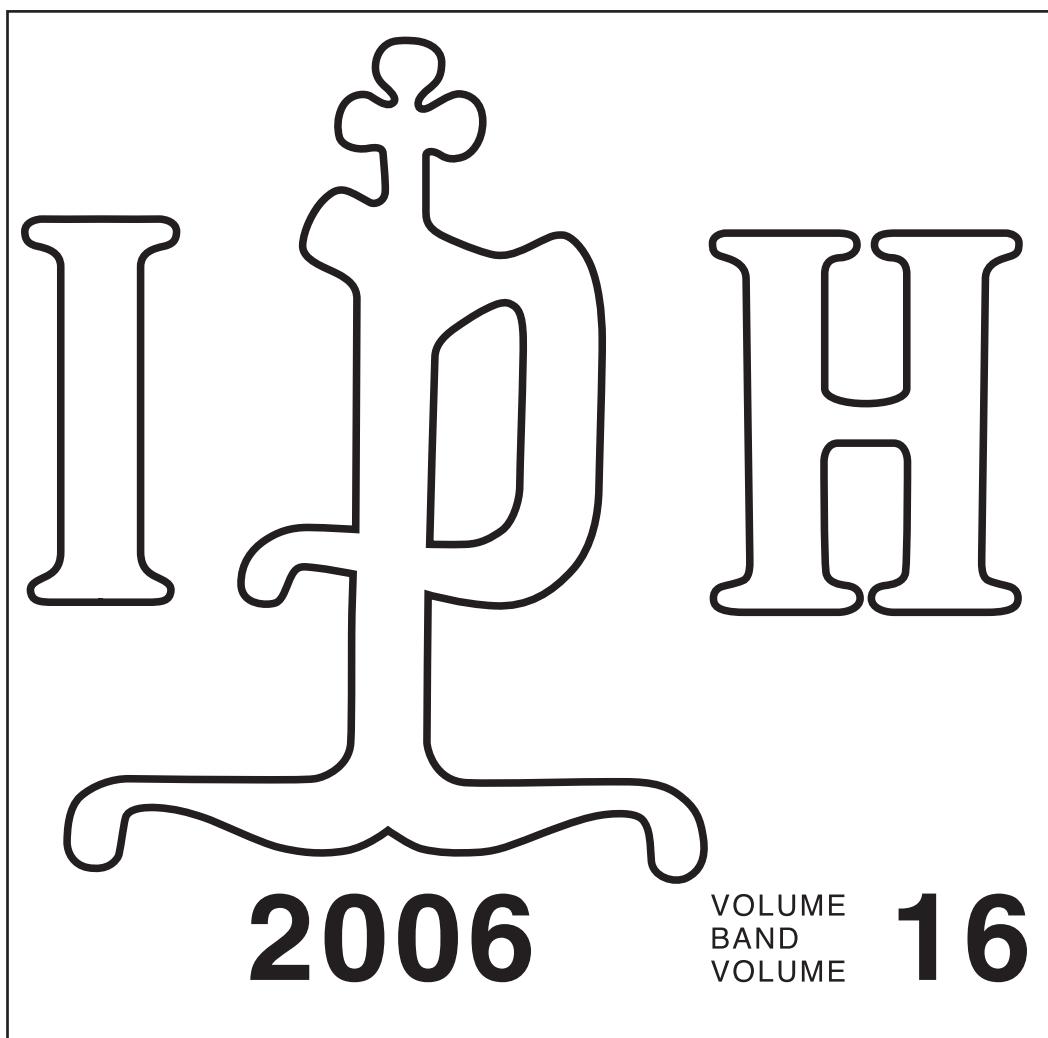


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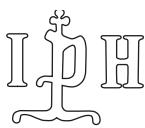
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Errata

Dear Reader

This offprint is publishing in order to point out and correct some errors that were introduced during publication of the minute book of the 28th IPH Congress. Please note an error in page 195: the letter “r” is missing from the title: the correct version is *Henk Voorn (1921-2008) his paper-historical habitat*. Next you will find the paper by Dr. Józef Dąbrowski *Remarks on the invention of true paper by Cai Lun*, which in the minutes contained various errors, especially in the transcription of words from Polish. Finally, you will find the paper by T. Espejo Arias, A. Durán Benito, A. López Montes, R. Blanc García, *Aplicación de tecnologías de análisis para el estudio de los soportes de papel en manuscritos Hispano-Árabes. Un modelo de transición en la Granada del siglo XV*, which does not appear in the minute book.

Our apologies to the authors of the cited texts and also to the readers for any inconvenience caused.

Józef Dąbrowski

Remarks on the invention of true paper by Cai Lun

“Where shall I begin, please your Majesty?” he asked.
“Begin at the beginning,” the King said gravely,
“and go on till you come to the end: then stop.”
Lewis Carroll (1832-89), *Alice in Wonderland*

To Suzanne Ackerson-Addor, my dear friend at the IPH

Summary

Different approaches to the invention of paper in ancient China are thoroughly discussed, together with aspects of technology in the manufacture of both bark cloth (*tapa*) and paper. In the author's opinion, the history of true paper begins with the Paper of Marquis Cai.

Zusammenfassung

Verschiedene Ansichten über die Erfindung von Papier im altertümlichen China werden eingehend diskutiert, zusammen mit Aspekten der Technologie bei der Herstellung von Rindenbaststoffen (*Tapa*) und Papier. Nach Meinung des Autors beginnt die Geschichte des echten Papier mit dem Papier von Marquis Cai.

Résumé

Les approches différents à l'invention du papier en Chine ancienne sont examinées à fond ainsi que les aspects du technologie du manufacture du tissu d'écorce (*tapa*) et papier. C'est l'opinion du l'auteur que l'histoire du papier vrai commence avec le Papier du Marquis Cai.

According to Ling, the beginning of paper-making in ancient China is closely associated with the manufacture of bark cloth. In his 1961 essay [1], Ling stated:

In every probability, the Chinese invention of the art of paper-making and of printing could be attributed to the influence of the bark cloth culture, which had been in existence in China since time immemorial. [...] It is universally known that the art of paper-making was created by Ts'ai Lun in the year 105 A.D. But, as a matter of fact, two kinds of paper had been used for writing previous to the time of Ts'ai Lun: one was silk paper, made of the refuse silk of animal fibres; the other, made of bark cloth, was called *heh-ti* paper or *nieh-ti* paper. What Ts'ai Lun actually invented was the ‘true paper’, as called by Hunter. He made it by means of employing the silk paper manufacturing process, but using plant fibres as raw material instead of the refuse animal filaments. [...] From long before the birth of Christ, bark cloth had been used not only for making clothes and hats, but for writing purposes as well.

In the opinion of Ling, the Malayo-Polynesian word for bark cloth, *tapa* or *kapa*, appears in ancient Chinese literary records in the forms of *t'a-pu*, *ta-pu*, *tu-pu*, *na-pu*, *ka-pu*, *ku-pu*. He recalled *Shih chi* (The Historical Memoirs) written by Ssu-ma Ch'ien in the second century BC, where (in volume 129) *t'a-pu* is mentioned. It was merchandise at that time. In *Shih chi*, the word *t'a* (in the term of *t'a-pu*) means ‘beat’ [2]. Ling remembered also Chinese records of the third century AD, describing *ku-pu* as bark cloth, as well as *ku-pu* paper, manufactured in the form of a long web, pure white and shining. In his opinion [3]: “This *ku-pu* paper can be compared in length to the

Polynesian-made *tapa* carpets, which were also generally several hundred feet long.” In accordance with Chinese records, bark cloth in ancient China was also used for making hats, headbands, raiment, screen curtains, etc., and the earliest record of such uses dates back to the third century BC [4]. While discussing the geographical distribution of bark cloth in southern China and other areas, Ling quoted remarks from ancient Chinese chronicles about the use of bark cloth and its manufacture by hard pounding of the bark of *ku* (paper mulberry). Written records of the Chinese bark cloth began to appear as early as the sixth century BC [5].

According to Ling, there had been *fan* paper, silk paper and *heh-ti* thin and tiny paper before Cai Lun [I am writing the surname of the inventor in the official Romanisation system known as *Pinyin*; the Chinese term means “transcription”. The older system was known as *Wade-Giles*]. Fine-weave silk strips were used as a writing substance; however, it was very difficult to write on them, because of their uneven surface. To overcome this difficulty, *fan* paper was developed. The manufacturing method of *fan* paper was described in AD 232, and is quoted by Ling [6] as follows: “The plain silk of old times could be cut into a piece of any size to accommodate the required text. A number of such pieces, forced together in the manner of fulling, was called *fan* paper.” However, the definition of paper quoted from *Shuo wén chieh tzü*, completed by Hsü Shên in the closing year of the first century AD, is evidence for Ling that the method of making true paper was known before the time of Cai Lun. In the English translation by Ling [7], the definition is as follows: “Paper is a sheet of intertwined fibres of refuse silk well beaten in the water and lifted out of the water in the form of a thin layer by the medium of a moulding mat.” Ling therefore recapitulated the issue as follows [8]:

It seems probable that Hunter was unaware of the historical data as referred to above, when he arrived at the conclusion that the paper-making art was originated by Ts'ai Lun. In truth, refuse silk made of animal fibres was used as raw material for making paper prior to Ts'ai Lun, so such paper was called the silk paper. On this same account, the Chinese word for paper, 紙 (*chih*), even in its earliest form, is composed of the radical 糸 (a root in the Chinese written language, meaning silk). Moreover, a character 紙 (*ti*) is found in Hsü Shên's *Shuo wén chieh tzü*, which differs slightly from the word 紙 in that it has an additional short

line at the bottom of the radical 糸, and it means “refuse silk”. However, these two characters have been used promiscuously and interchangeably in later times.

The two Chinese characters mentioned above by Ling are enlarged in Figure 1.



Fig. 1: Two Chinese characters; the first (A) denotes ‘paper’ and the second (B) denotes ‘refuse silk’; according to Ling (cf. note 1, p. 37)

In the opinion of Ling, such silk paper (made from ‘refuse silk’) was manufactured not only before Cai Lun, but also after the invention of paper by him. Ling quoted a record concerning rattan rind and cocoon paper written in Vol. 12 of *Kao pan yü shih* by Tu Lung (in the 16th century) of the Ming era, as well as records on the manufacture of silk paper in Korea and the Chinese province of Sin-Kiang even during the Ching Dynasty. However, *heh-ti* or *nieh-ti* and *ku-pu* (formerly mentioned) were (in his opinion) kinds of bark cloth paper, and not silk paper at all. Ling stated clearly [9]:

In reality, this type of cloth paper had been in manufacture since the Wei and Chin Dynasties, through the T'ang, Sung and Yüan dynasties and down to the Ming period, and it had also been used for making paper currency, paper armour, paper dress and paper screen curtains, etc., in addition to its popular use for writing purposes.

In his opinion [10], “Ts'ai Lun thought out the measure of making paper by employing the old refuse-silk paper manufacturing process, but using the inexpensive plant fibres as a raw material, which may as well be described as the utilisation of waste substance.”

In his discussion of the ‘Biography of Cai Lun’ compiled by Fan Yeh (398-445), Ling highlighted the influence of the bark-cloth culture on Cai Lun’s invention of paper [11]:

Ts'ai Lun's native place was in the district of Kueiyang, which presently belongs to the Department of Heng-chou, Hunan Province. In ancient times, Hunan was an important part of the State of Ch'u, and it had been famous for the production of bark cloth from the remotest time down to the Ming

Period. [...] It is noteworthy in this connection that Ts'ai Lun, the inventor of paper in 105 AD, was a native of Ch'u. [...] The language of Ch'u was close to the Tai tongue.

Ling believed that Cai Lun had made on-the-spot investigations in regard to the manufacture of bark cloth. He used only plant fibres for making paper, mainly the cheap bark of certain trees, with an admixture of such waste articles as hemp waste, old rags, and fishing nets. However [12]: "The old rags he utilised might possibly have been some sort of bark cloth." Ling recalled that the new character denoting paper had been introduced after Cai Lun's invention, with the 'cloth' radical replacing the former 'silk' radical [13]: "However, it is the one with the silk radical that has survived and is in common use today."

The highly interesting contribution by Ling has remained almost unknown to paper historians, and needs to be brought to wider attention. Ling's contribution presents the main aspects of Cai Lun's invention in a condensed form, namely those aspects which are characteristic of the approach to the issue in China where true paper was born. First and foremost, 'paper' meant different materials before Cai Lun's time; either woven silk fabric or such fabric transformed into *fan* paper, as well as bark cloth paper, such as *ku-pu* paper and *heh-ti* or *nieh-ti* paper. The same name was applied to the new product invented by Cai Lun, though its structure was basically different from former 'papers'. For us only the material invented by Cai Lun is true paper, and the other examples mentioned above should in our opinion be preceded by an additional statement such as 'so-called', for example, 'the so-called' *fan* paper. Nonetheless, this was not the case in ancient China before Cai Lun's time, when sheets of various materials of fibrous nature – with a good writing surface – were called 'paper', sometimes with additional information, such as 'the *fan* paper'. Similar conclusions may be drawn from discussions of the issue by Chang [14], and from original texts on Chinese paper history, which have been carefully edited in English by Tschudin [15].

Chang also recalled the definition of paper present in an etymological dictionary compiled around AD 100, in which paper was specified as a material of silk floss, according to Chang [16]; in the opinion of Ling, quoted above, refuse silk was used to manufacture such paper. This is another question linked to Cai Lun's invention. Both Ling and Chang are convinced that such 'silk paper' was manufactured before Cai Lun's time, and in Ling's opinion, 'silk paper' conti-

nued to be manufactured after Cai Lun. This, in their common opinion, is why the Chinese character for paper has the radical meaning 'silk'. However, together with propagating the paper invented by Cai Lun and its manufacture in the West, this ancient definition of 'silk paper' was also propagated. In the opinion of Kâğıtçi [17], the Turkish word <kâğıt> and the Arabic and Persian words *el-Kagit* and *Kâgez* are derived from the old Turkic word <Kakat>, meaning 'dry sheet which was obtained from silk threads beaten with a mallet'. In Fabriano, where the genuinely European art of papermaking was developed, as well as in other locations in medieval Italy, paper was initially called 'silk paper', as it was found by Gasparinetti [18] in Latin documents: *carta banbaci-na*, *charta di bambacino*, or *carta bombycina*; and a master of this craft was accordingly called *magister cartarum bombycinis*, etc. The Latin word *bombyx* also denotes silk; nevertheless, it does not mean that silk paper was actually manufactured in these places.

After his investigation Ling came to the correct and highly interesting conclusion that Cai Lun's invention of the papermaking art was affected by the manufacture of bark cloth. Ling recalled a few scholars (none from China) who had earlier proposed this hypothesis alone; however, Ling's contribution presented the results he had discovered in his arduous research, together with his efforts at verification. Nonetheless, he was deeply convinced that the silk paper was really produced before Cai Lun's time, and so he believed that Cai Lun had employed the old refuse-silk paper manufacturing process to manufacture true paper from inexpensive plant fibres, mainly the bark of certain trees known to Cai Lun as having been utilised in the manufacture of bark cloth. Nevertheless, Ling's idea highlighted the importance of inventing true paper derived from bark cloth manufacture, which involved hard pounding of the inner bark, i.e. the bast layer, as it was practised in southern China from time immemorial. In fact, the making of bark cloth materials (*tapa*) was widespread in a belt running along the equator, as shown in Figure 2, according to Loeber [19].

The bark cloth is made directly from the bast fibres, without being spun into yarn or any subsequent weaving. Strips of the inner bark (the bast layer) from trees belonging to the family of *Moraceae* are the raw material for making *tapa*. Such strips are boiled over a slow fire in a cauldron containing water and wood ash, or they are fermented or treated with lime. After such treatment, the strips are thoroughly rinsed in water. Next, the fibrous strips are intensively beaten with hand-held mallets, or with other tools, to a cloth-

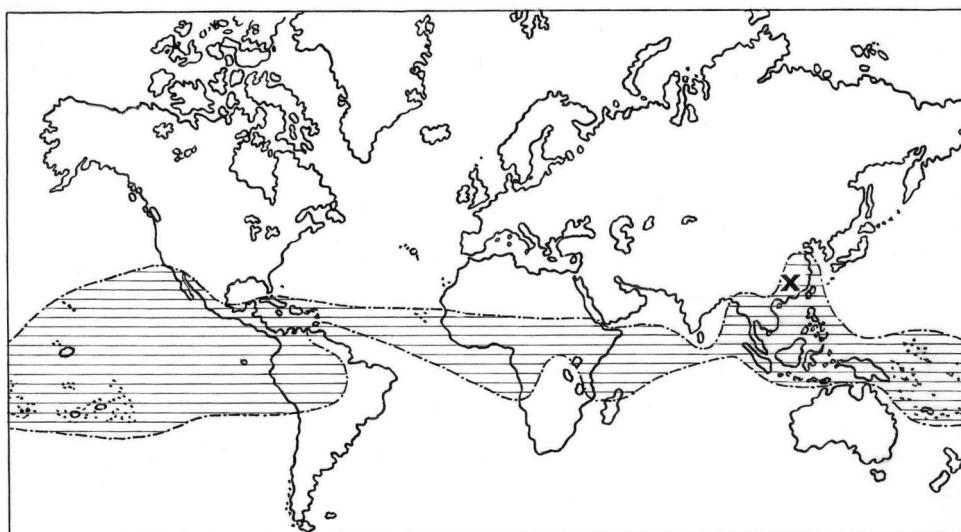


Fig. 2: Zone of bark cloth (tapa) manufacture, originating in the region (X) in which much later (c. AD 62) Cai Lun was born, according to Loeber (cf. note 19)

like product with gradual addition of additional strips, uniting them into a sheet or web, which are left to dry. Glazing could have completed the manufacturing process. Details were published by Hunter [20], and examples of other publications devoted to the manufacture of bark cloth (tapa) in various parts of the world are given below [21]. There is a strong resemblance in appearance between tapa and paper; nonetheless, the latter is formed upon mould from separated fibres dispersed in water, and therefore characteristic differences are perceived in the structural appearance of both materials when they are observed in an enlargement. Usually, however, a small sample is taken from the historical objects for fibre-furnish analysis, using different techniques and modern optical systems in microscopic examination, as well as undergoing examination in polarised light [22]. This requires breaking the fibrous substance into a fine suspension of individual fibres, and therefore the characteristic differences between tapa and paper, which are visible in their structural appearance, are lost. However, these structural differences are clearly perceived while comparing the look-through of both fibrous substances. To that end, it is possible to delaminate tapa for comparing the pattern visible in the look-through of the thin layer of tapa and of the thin paper formed upon the floating mould (see Figure 3 [23]).

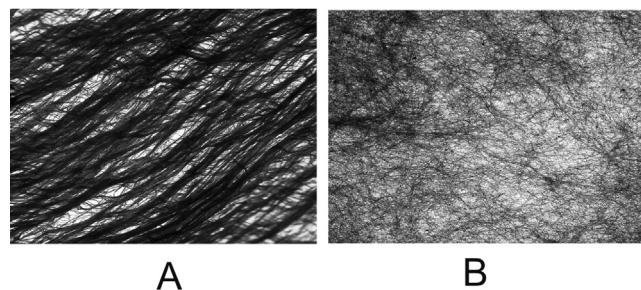


Fig. 3: Look-through of tapa (A) and of paper formed upon the floating mould (B). Both samples were manufactured in the 1960s, the tapa in Tonga Islands, and the paper in Nepal. Photographs by the author (cf. note 23; however, both photographs reproduced here were originally made at a higher magnification, 10x.)

Moreover, these differences are visible not only when viewed in the look-through under diffuse, transmitted light, but can also be perceived in the surface appearance of tapa and paper, when observed in enlargement under reflected light. The ability to recognise differences between bark cloth (tapa) and paper, without however delaminating the tapa, is of significance to the non-destructive investigations into historical samples of fibrous substances; see the photographs presented in Figure 4 in a black & white computer-contrasted version.

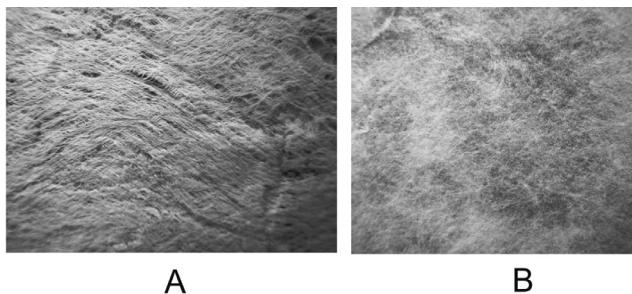


Fig. 4: Surface appearance of tapa (A) and of paper formed upon the floating mould (B). Photographs by the author of the same samples as in Fig. 3, but in reflected light

Nevertheless, Ling's contribution has been rather neglected in China. For example, Pan does not mention that Cai Lun knew bark cloth (tapa); in the opinion of Pan, Cai Lun improved the art of making hemp paper, and also developed his papermaking method by utilising tree bark as the starting material. Bearing in mind archaeological discoveries in Baqiao (Pa-ch'iao) and other places, Pan wrote [24]: "On the basis of these facts, it is now obvious that the art of paper making was invented one to two hundred years before the arrival of Ts'ai Lun – some time during the Earlier Han dynasty – by the working people." In his further publication [25], Pan presents his results gained in microscopic analyses of unearthed fibrous samples, among them the so-called 'Baqiao paper', discovered in 1957 at the Baqiao building site near the city of Xian (in north-western Shaanxi). This was the oldest one, as its manufacture was assessed as no later than 140-87 BC. Both the 'Baqiao paper' and other investigated historical samples contained hemp fibres, according to Pan, who wrote: "However, after we had done a microscopic analysis of the Baqiao paper in 1964, we found to our surprise that it was not made of silk, but hemp fibre." Once again, the belief in using silk fibres for making the earliest papers manifested itself. Nonetheless, it should be recalled that the dating of the so-called 'Baqiao paper' was criticised from the very beginning. In his 1959 article, Chang [26] also writes about the so-called 'Baqiao paper' excavated in 1957:

It has been held by some scholars that, judging from the bronze dagger, mirror and cash coins, the carved stone tiger, and pottery figurines and wares exhumed, the grave could not be later than the reign of Han Emperor Wu (140-87 BC). From this, they deduced that paper was invented much earlier than the Han Dynasty. But none of the bronze and other objects are dated, and it is not possible to establish a definite date for the grave. We feel that until it can be proved that the grave was from the

Former Han Dynasty, it would be premature to conclude that the fragments of paper found in it were made some two or three hundred years before Ts'ai Lun.

The history of paper and printing in China elaborated by Tsien [27] is highly recommended to paper historians. We owe a debt of gratitude to Tsien, who presented many aspects of these topics in his extensive (almost five hundred pages) and magnificent work, which is a pleasure to read. However, there is a lack of written records about the very beginning of paper-making in China, and therefore the remarks presented by Tsien about this issue are sometimes no more than his own suggestions. Regarding the ancient definition of paper (AD 100), Tsien understands it differently than Ling and Chang, as "a mat of refuse fibres" which were obtained from rags or from boiling cocoons [28]. Concerning a possible use of silk fibres for making paper in ancient China, Tsien wrote [29]:

Mention of the use of silk fibres is based primarily upon philological speculation without sufficient evidence. It was thought that since the character of *chih* for paper bears the silk radical at its left, *chih* before Cai Lun's time must have been made of silk fibre. [...] At present, no actual paper made of pure silk fibres is known to exist, nor is their use documented in literature.

According to Tsien [30]: "It has been suggested that the manufacture of paper in China originated from the process of pounding and stirring rags in water, after which the wadded fibres were collected on a mat. [...] It is very likely that an accidental placing and drying of refuse fibres on a mat suggested the idea of making a thin sheet of paper." In his opinion [31]:

Tshai Lun was a native of Lei-yang in what is now Hunan province, and it was here that the bark was made into cloth by beating and then into bark paper after maceration. Since, then, the maceration process of turning rags into pulp was already known in China, it was very likely that the people in the south of the country were the first to convert paper mulberry bark into a pulp for papermaking.

However, the processes of turning rags into pulp and its further preparation for making paper are not easy, and such comments from Tsien suggest a not uncommon lack of knowledge about the technical aspects of making paper by hand. In Europe, for example, small pieces of rags were fermented over eleven days, were next de-fibred in a water-powered stamper for twelve hours, and finally beaten in another water stamper for twenty-four hours, with an admixture of lime, which

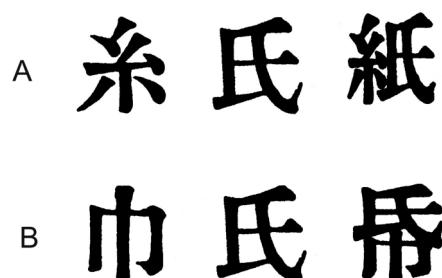
is rather a strong base [32]. Washing clothes and pounding & stirring of rags were carried out in ancient China, as in other ancient countries, under much milder conditions. But the labour required in the beating of bast fibres for bark cloth is tremendous, and therefore the people of central China could have learned for themselves how to beat bast fibres from the people of southern China who had practised that process since immemorial times, as well as for making fine kinds of bark cloth, known as bark cloth paper. Moreover, treating the bast strips with chemicals and/or their fermentation, as is done in the technology of tapa, could (when prolonged) weaken the bonds between fibres in the bast strips, resulting in the bast strips dividing during their intensive beating into ultimate bast fibres. The pulp for making true paper could have been prepared in such a way. The accidental drying of refuse fibres, which could have suggested the idea of making a thin sheet of paper, as imagined by Tsien, may also be an argument for initiating the papermaking art in the manufacture of tapa.

However, the number of paper specimens from the second century BC onwards discovered in China is, in Tsien's opinion, the main argument for starting the manufacture of paper from the process of pounding and stirring rags in water. Tsien repeats without any criticism the information about the 'Pa-chhiao paper' and other ancient fibrous specimens [33]. Nonetheless, he writes: "The existence of paper before Tshai Lun does not necessarily contradict the story of his contribution as recorded in the official history. It is possible that he was an innovator who used new raw materials in papermaking." Tsien [34] quoted the contribution by Ling only in this context. In addition, 'paper' *chih* (now *zhi*, in Pinyin) is mentioned before Cai Lun's time in several places in the ancient literature, and such examples (from 93 BC onwards) are presented by Tsien in his book as an argument against attributing the invention of paper to Cai Lun. After so many arguments by Tsien against the priority of Cai Lun, the historic information about the invention of paper by Cai Lun (present in his biography) seems to be of lesser significance. In the English translation by Tsien [35], this information is presented as follows:

In ancient times writings and inscriptions were generally made on tablets of bamboo or on pieces of silk called *chih*. But silk being costly and bamboo heavy, they were not convenient to use. Tshai Lun then initiated the idea of making paper from the bark of trees, remnants of hemp, rags of cloth, and fishing nets. He submitted the process to the emperor in the first year of Yüan-Hsing [+105] and received praise for his ability. From this time,

paper has been in use everywhere and is universally called 'the paper of Marquis Tshai'.

However, it was not only these pieces of silk used for writing which were called *chih*. The new writing material invented by Cai Lun was also called *chih*; however, it was the '*chih* of Marquis Cai'. Later, two different Chinese characters were used to denote 'paper'. Hunter points out that two prominent Chinese characters, of ancient origin, embody the meanings of both silk and cloth (see Figure 5 [36]). In the most common character for 'paper' (at the right of the A row) we find the radical meaning 'silk' (at the left of the A row), and the other, less common character for 'paper' (at the right of the B row) embodies the radical meaning 'cloth' (at the left of the B row). The remaining parts of these two characters, in the centre of both rows (A) and (B), are made up of the same phonetic radical (*zhi*) meaning a surname.



*Fig. 5: Two Chinese characters for 'paper' (*zhi* formerly *chih*), the most common (A) and less common (B); according to Hunter (cf. note 36)*

One should recall the opinion about these two Chinese characters which was published by Zhong [37] in 1985, when the book by Tsien had been edited:

In ancient China, wood and bamboo strips were the principal writing materials; only the privileged used materials woven from cocoon silk. In West Han days, such silk materials were named *zhi*, with the left half of the character representing silk. Definitely this *zhi* (paper) referred to silk woven writing material, and should be understood as ancient paper.

After the announcement of Tsai Lun's invention, another Chinese character also pronounced *zhi*, but written differently and specified by a Chinese character with the symbol for cloth written underneath it, came into existence. As years went by, both of these characters were taken to mean the same thing; gradually the former character with 'silk' at the left side took the predominate position. But it

is important that the word *zhi* (paper) with silk on its left half found in historical records before Tsai Lun's days stood exclusively for silk materials made for writing purposes. On the other hand, *zhi* (paper) whether with a left-half silk or a symbol for cloth, found after Tsai Lun refers to plant-fiber writing materials, or 'true paper'.

It should be noted that the character *zhi* (paper) with cloth written underneath cannot be found in any historical recordings before the days of Tsai Lun. To imply that the word paper (to be more exact, *zhi* with a left half silk) appeared in historical recordings before East Han, and to come to the conclusion that paper was invented during the West Han period, is unconvincing.

This means that the 'silk paper' mentioned by Ling and by Chang was not manufactured before Cai Lun's time, and therefore Cai Lun could not employ the old refuse-silk paper manufacturing process to manufacture true paper from plant fibres, as suggested by Ling. The silk woven writing material was that 'silk paper' before Cai Lun, and at that time it was represented by the character with 'silk' at the left side. Zhong [38] showed a commonly written version of these two Chinese characters denoting 'paper' (Figure 6).



Fig. 6: Two Chinese characters *zhi* denoting 'paper', with a left half silk (A) and with the symbol for cloth written underneath it (B); according to Zhong (cf. note 38)

Zhong recalled that the biography of Cai Lun had been selected and entered into Fan Yeh's writings from the "History of East Han Compiled in the East Temple" (*Dong Guan Han Ji*). He highlights the fact that the biography of Cai Lun was originally written by Cao Shou, Yan Du and others as early as in 151, i.e. thirty years after Cai Lun's death. The entries about his work should therefore be reliable [39]. The earliest translation of the biography of Cai Lun into a European language was published in French by Edouard Chavannes in 1905, according to Tschudin, who published a German version of this document with many notes and explanations in 1954 [40]. Forty years later, Tschudin [41] published new translations of the biography of Cai Lun into IPH languages (English, German, and French).

However, such a multiplication of the doubts regarding the priority of Cai Lun by some Chinese scholars seemed to weaken the significance of a biography of Cai Lun. Visibly, such a strange conception of inventing paper from 'nothing', by sheer accident during the washing of cloth and rags, was stronger than the idea that making paper was derived from the manufacture of bark cloth (tapa). This was accompanied by the discoveries of a growing number of ancient papers, or paper-like structures, which had been recognised as papers manufactured before Cai Lun. After investigations into the so-called 'Baqiao paper', Pan [42] wrote: "Since then the excavation of ancient paper has been paid much attention to by Chinese archaeologists. Earlier paper made before Cai Lun's time has appeared gradually in various places; wonderful discoveries were made one by one." There was a lack of any initiatives in China aimed at continuing the investigations started by Ling directed to studying the associations between the invention of the art of paper-making and the manufacture of bark cloth (tapa), resembling paper. This fibrous material required very intensive beating of the strips of bast fibres during its manufacture, and later the beating process became of utmost significance in the papermaking art. In addition, refined versions of bark cloth were used in China as writing materials before Cai Lun.

Therefore the question is: what kind of new writing material did Cai Lun show the Emperor in AD 105? True paper or a modified version of bark cloth (tapa)? Fortunately, it is possible to answer this question. Tsien [43] wrote:

...Tung Pa of the early +3rd century said that 'The Eastern Capital (Loyang) has the paper of Marquis Tshai, which was the paper made by Tshai Lun; that made of used hemp is called hemp paper; that of tree bark *ku chih* (paper mulberry paper); and that of used nets net paper.'

Tschudin [44] published the same information, although drawn from another Chinese historical source:

In the *Dongbaji* it is written: "In the eastern capital there was 'Master Cai paper', i.e. from [Cai] Lun. Paper made with old hemp was called 'hemp paper', that made from tree bark 'gu paper', that made from old fishing nets 'net paper'."

This means that Cai Lun was able to manufacture his new writing material from each raw material mentioned in his biography. However, the manufacture of bark cloth (tapa) from hemp waste or from old fishing nets is not possible, although each of these raw materials could be used separately to make true paper. So

this information from these ancient Chinese historical sources about the ‘hemp paper’ and ‘net paper’ made by Cai Lun is trustworthy evidence that Cai Lun showed the Emperor samples of true paper, and not just an improved version of bark cloth. Nevertheless, these historical sources do not mention the ‘rag paper’ (!) Cai Lun made. Most likely, Ling is right to suggest that Cai Lun used worn bark cloth (*tapa*) to make his paper, which Cai Lun’s biography described as ‘rags of cloth’. Together with a fresh bark of paper mulberry, the main raw material for Cai Lun (and formerly the main raw material in the manufacture of *tapa*), he used rags of this unwoven fabric to manufacture a paper called *ku chih* or ‘gu paper’. It would be hard to explain in any other way why Cai Lun employed four different fibrous raw materials (the bark of tree, remnants of hemp, rags of cloth, and fishing nets) and why, despite being able to manufacture paper from each one, he finally prepared only three kinds of paper, not four. It should be emphasised that the bark of tree and the rags of bark cloth (i.e. *tapa*) are, from the technological point of view, sources of the same fibres. Therefore the above-quoted information, which has been discussed in two different Chinese historical sources, is also convincing evidence that in his invention Cai Lun had nothing in common with typical rags, such as those from the woven fabric of hempen (or any other) threads, or with any possible technique of making pulp for paper-making, such as those which originated in central China from the process of pounding and stirring such rags in water, as imagined by Tsien and others – even if such techniques had existed before the time of Cai Lun’s invention.

Having prepared the fibrous slurry for making paper, there was a need for a papermaking mould, the most essential tool in making paper by hand. Chinese sources are silent about the constructions of the mould in ancient times, and Tsien therefore recalls the results obtained by Hunter in his field investigations of traditional papermaking in China and in other Far Eastern countries, according to which the floating or ‘wove’ type of mould could be the earliest form employed by the ancient Chinese [45]. In his book, Hunter [46] clearly states:

In my own numerous experiments in an endeavour to arrive at the methods employed by the actual inventor of paper, I have come to the conclusion that the ‘wove’ mould must have been the earliest form used, and that the beaten fibres were poured upon the mould and the moist sheet left to dry upon it. [...]

In Kwangtung Province, China, at the present

time, the ‘wove’ style of mould, upon which the fibre is poured and allowed to dry, is in use (Figure 46). There is no record as to the number of years this type of mould, or the method employed, has been used, but it is interesting to note that the locality where these ‘wove’ moulds are found is not more than two hundred miles from Lei-yang, near Henschow, Hunan Province, the seat of the invention of paper-making by Ts’ai Lun about A.D. 105.

However, the earliest mould employed in making paper is not under general dispute. An origin of the idea how to prepare the pulp for paper-making is still in dispute, though, and two options have been proposed, from the manufacture of bark cloth (*tapa*), or from the washing of cloth & rags. The latter technique is however not oriented towards the manufacture of any kind of material. Moreover, according to the latter concept, which neglects the influence of the manufacture of bark cloth (*tapa*) on the invention of paper, and diminishes the significance of the biography of Cai Lun, paper could also have been invented outside China, even in such countries where the process of making bark cloth (*tapa*) was not developed, but where a highly developed civilisation required a new writing material. Gosavi [47] published his suggestions about a possible invention of paper in India, much earlier than in China. In his opinion, some sources indicate that papermaking was well-known to Indians even as far back as the fourth century BC, and Indians used to make the paper pulp from beating cotton fabrics. However, the troublesome manufacturing process prevented paper from gaining popularity in India, and along with the Buddhist religion, the art of papermaking went from India to China (eastwards) and to Turkestan (westwards); nevertheless, this art came back to India with the Muslims in the tenth century AD [48]. McGovern [49], as a scientific paper-maker, expressed his criticism of these suggestions by Gosavi; in addition, Tschudin [50] (as a paper historian) reported an error by Gosavi in his translation of the text by Megasthenes. However, immediately after these publications by Gosavi, many Chinese authors neglected the former doubts, and recognised Cai Lun as the inventor of paper, trying to highlight that paper was invented in China and not India [51].

Paradoxically, these suggestions by Gosavi also promoted scientific explanations of some questions associated with the invention of paper. Critical analyses began in China to verify the fibrous samples from excavations and the dates assigned to them; by Chen and Li [52] from the historical & archaeological point of view, as well as by Wang [53] from the paper-tech-

nology point of view. The results showed that so far no samples of true paper had been found which could be dated before Cai Lun in AD 105. Some remarks on the so-called ‘Baqiao paper’ are briefly recalled here as an example of the results gained in these investigations. In 1957, information came to light about small fragments of ancient paper found in an old grave at Baqiao; however, Chen and Li wrote [54]:

Unearthed ancient bronze mirror, iron lamp, pottery pot in square, lead bar, copper coins, etc... (including paperlike objects) was bulldozed during building the Baqiao Brick Factory in Xian City in 1957. The driver of the bulldozer had not found any tomb, coffin or remains; someone thought that the unearthed historical relics belong to the tomb.

In the opinion of Chen and Li, the paperlike object was a hempen mat of fibre bundle for another application; however, a young archaeologist had recognised it as paper because its appearance was similar, and its dating had been estimated without any research. They stated:

A young archaeologist reported the “Baqiao Paperlike Objects” to be a paper dating from the West Han Dynasty, not later than 10 days after the “Baqiao Paperlike Objects” had been unearthed. It was only a piece of news without any scientific appraisal. When some readers asked him how it was that the paperlike objects were dated from the West Han Dynasty, he used as supporting evidence some relics unearthed on the same spot, which were similar to others dated from the West Han Dynasty, such as bronze mirrors, copper coins and pottery square mouthed wine vessels, shown in figure 1 [55].

64 Banling copper coins were collected in a pottery pot covered by hempen mat when unearthed in Baqiao. A worker tore the hempen mat to pieces when he took it out. Later on, the pieces of hempen mat were clamped between two glasses by a young archaeologist, and these hempen mats became several pieces of hempen slice (and called paper dating from the West Han Dynasty) [56].

Therefore those other unearthed relics were carefully examined from the archaeological point of view by Chen and Li, who finally concluded that the ‘Baqiao Paperlike Objects’ had incorrectly been dated by the other relics as coming from the West Han Dynasty, without enough evidence, reliable analyses or studies [57]. In addition, according to the results gained by Wang [58], the hemp fibres in the ‘Baqiao paperlike sheet’ had neither been pounded nor beaten. In her

opinion, the paperlike sheet was not made by formation, but separated from the pile of hemp. Some fibre bundles were found lying across the ‘paper’ surface and breaking at the edge of the sheet; the longest of them was about 7 cm. This means that the fibres have never been subjected to the shearing or cutting necessary for papermaking. The individual fibres appeared to be rather stiff and their fibre walls remained intact, without any signs of fibrillation. A Scanning Electron Microscope/Energy Dispersion X-ray Analyser (SEM/EDAXA) was used to examine both the ‘Baqiao paperlike sheet’ and the market hemp. The market hemp contained quantities of calcium similar to those detected in fibres of the ‘Baqiao paperlike sheet’. This was evidence that the fibres present in the ‘Baqiao paperlike sheet’ had not been subjected to a special treatment with lime to improve their paper-making ability. In Wang’s opinion, the ‘Baqiao paperlike sheet’ is not a paper but a mat of waste hemp fibres.

These investigations, carefully carried out by Chen & Lin and also by Wang, have revealed two important aspects of the latest discoveries in China (before their investigations) of ancient paper or paper-like objects. The first of them is very positive, showing a high level of scientific standards in China in both a historical & archaeological approach, as well as with respect to the examination of such specimens from the paper-technology point of view. The second aspect, however, is rather unusual, showing a lack of any careful analysis before an official announcement of the new discoveries of specimens of ancient paper or paperlike object. Such unreliable announcements (lacking appropriate scientific investigations) of having discovered “paper samples made before Cai Lun’s time” are later propagated worldwide, and are finally quoted in scientific publications, as in the book by Tsien and in other accounts, thus suggesting a scientific basis for these announcements. Many efforts of this kind to sort out the priority of Cai Lun meant that the great anniversary in the year 2005, marking the 1900th anniversary of paper, was not celebrated [59].

Paper historians in China are still divided into two separate views with regard to the time when paper originated in China. In April 1999, an expedition of International Association of Paper Historians (IPH) to China was undertaken. The expedition was led by Elaine Koretsky, director of the Research Institute of Paper History & Technology at Brookline (Boston), USA; but Albert Elen, President of the IPH at that time, played a dominant role during formal meetings between the IPH and Chinese scholars & officials.

The Research Institute of Paper History & Technology explores and carefully documents traditional techniques of papermaking around the world [60], and the close contacts of the Institute with Chinese paper historians made the IPH's expedition to China possible. Its participants, a group of 16 Europeans and Americans, also attended a Congress held in Xian on the origin of paper in China, where a sharp division between two groups of Chinese scholars manifested itself in heated discussions among the members of these groups. One group attributed the origin of paper to Cai Lun; an opposing group attributed the origin of paper to a time approximately two centuries earlier, during the Western Han Dynasty [61]. This is documented on the available video focused on the Congress held in Xian [62].

The latest announcement of the discovery of "a paper sample made before Cai Lun's time" was propagated worldwide in August 2006. Macartney published some remarks about this event in her short article [63]:

A scrap of paper made from linen fibre was found by archaeologists picking through an ancient rubbish tip at the Yumen Pass, the gate between China and Central Asia. Measuring just 1.6 square inches, it is believed to have been made in 8 BC, or 113 years earlier than the first known paper. Fu Licheng, the curator of the nearby Dunhuang Museum, said: "This is very important evidence to show that paper was invented in China."

In curator Fu's opinion, the discovery of paper-like material made from silk in northwest China and other parts of the country has fuelled debate in recent years as to whether paper could have been invented two centuries before Cai Lun. According to curator Fu, the paper found at the Yumen Pass was a more developed material than the disputed silk-based substance. Archaeologists had found several pieces of paper while carrying out restoration work on a garrison in use during the Western Han (206 BC – AD 25). However, only one scrap contained writing; Macartney presented a colour photograph of it. According to curator Fu, more than 20 characters on the paper had been identified. In his opinion, more time is needed to make out the meaning of the note. In his opinion, more time is needed to make out the meaning of the note. In this announcement, China has not given even the least information about the scientific institutions involved in detailed analyses of the fibrous substance found at the Yumen Pass, regarding its fibrous composition, its structure (bark cloth, paper, or something else), and – first and foremost – its dating. The Chinese interlocutor has mentioned

restorative work on a garrison in use during the Western Han dynasty, and that making out the note's meaning needs more time; nevertheless, "it is believed to have been made in 8 BC" (!). This resembles previous Chinese statements about, for example, the so-called 'Baqiao paper', "which was only a piece of news without any scientific appraisal", as was quoted above (after Chen and Li). This sensational news about the find in a rubbish tip at the Yumen Pass is additional evidence of a strong tendency in China to prove that paper originated in China not from the bark cloth (tapa), but 'out of thin air'; as well as to 'move' the invention of paper in China far to the north of the southern provinces, where the bark cloth (tapa) had been manufactured since immemorial times.

This tendency is probably linked to the traditional Chinese conception of history. Larre, a French Sinologist, in his essay on the empirical apperception of time and the conception of history in Chinese thought [64], has specified seven special features of the Chinese conception of history, commenting as follows:

In speaking of the 'special features of the Chinese conception of history', I have in mind a number of traits distinguishing the Chinese historiographers' conception of history, but have no wish to imply that the same features may not be found elsewhere.

Larre highlighted the following features: (1) the breadth of the historical panorama, (2) the central position given to the Han, (3) an inward-looking approach, (4) the dominant rural note, (5) the spirit of democracy, (6) a communal type of life, exemplified in the clan and the extended family; and (7) formalism in thought and expression. Two of them are quoted below from this essay by Larre:

The central position given to the Han. No one who has lived in China can fail to be aware of the persistent rivalries between the ethnic groups making up the Chinese nation today. History gives special prominence to the Han, a race of eastern origin established far to the north of the Yang tze Kiang, and the fame of the huge areas around Shanghai (the ancient kingdom of Wu) and north of Canton (kingdom of Yueh) has undoubtedly suffered as a result.

The inward-looking approach. What is more serious - and accounted for partly by the isolation of the Chinese territories from other parts of Asia, and partly by the relatively late development of maritime communications – Chinese history was written on the assumption that human life was essentially what went on in central China, China

itself being the centre of the world, washed by four seas and casting its brilliant light over the less fortunate and inhospitable regions inhabited by barbarians on the borders of earth and heaven.

In summary, we may describe the matter in the following terms:

Cai Lun, as a native of Ch'u, was acquainted with the manufacture of bark cloth (tapa). Employing subsequent steps of this manufacturing process, he was successful in his attempts to develop a new writing material, mainly from an inner bark (the bast layer) of paper mulberry, the raw material in the manufacture of tapa, with a possible admixture of other raw materials from recycling, such as remnants of hemp, rags of cloth, and fishing nets. Cai Lun was able to manufacture this new writing material from each of these raw materials, according to the information in Chinese historical sources about the various kinds of paper made by Cai Lun. This is trustworthy evidence that Cai Lun developed true paper, and not merely an improved version of bark cloth (tapa), because the manufacture of bark cloth (tapa) from remnants of hemp or from old fishing nets is not possible, but the fibrous slurry prepared from them could be processed into true paper when poured upon the mould.

These historical sources do not mention any ‘rag paper’ having been made by Cai Lun. This means that Cai Lun used a worn bark cloth (‘rags of cloth’, i.e. tapa, an unwoven fabric) together with a fresh bark of paper mulberry to manufacture paper from the bast fibres of paper mulberry (*ku chih* or ‘gu paper’). Cai Lun did not employ typical rags, from the woven fabric of hempen (or any other) threads, in his new substance.

It showed great promise as a writing material, and a new form of the Chinese character *zhi* was introduced

to distinguish the ‘*zhi* of Marquis Cai’ from former kinds of *zhi*. However, the older form of the character *zhi* (with the silk radical) has survived, and this form is in common use today to denote true paper in Chinese.

Chinese civilisation, which badly needed a new writing material at Cai Lun’s time, was of utmost significance for Cai Lun’s invention of paper, as ‘necessity is the mother of invention’.

The invention of paper in China by Cai Lun (AD 105) is documented in the biography of Cai Lun compiled by Fan Yeh (398-445); however, the biography of Cai Lun as entered into Fan Yeh’s writings was originally written as early as the year 151, i.e. thirty years after the death of Cai Lun.

In my opinion, the attempts to separate the invention of paper from the manufacture of bark cloth (tapa), made mainly in China, but also in India – are bound to fail, and the history of true paper does indeed begin from the Paper of Marquis Cai : 蔡侯紙 .

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Application of analytical technologies in the study of paper media in Hispano-Arabic manuscripts. A model of transition in 15TH century Granada

The heritage bequeathed to the history of science by the Arabic world stems from the innovations that it introduced both in paper manufacture and also in the making of manuscripts. The Arabic world is known as the guardian of an entire cultural legacy in which the tradition of manuscript-making has played a key role.

The study of codicological structure, which has been carried out for some years on collections of Arabic manuscripts from Andalucía, is enabling us to determine inherent characteristics and structural models, such as establishing its influence and impact on current approaches, both in nearby Arabic countries and in comparable Western documents.

Therefore this work draws on the study of paper as the medium used in a series of manuscripts which share some specific characteristics and which lead us to speculate on the possible existence of a typology of codicological structure peculiar to the transition from the Arabic to the Christian book en Al-Andalus. The selected books belong to the collection of the Provincial Historical Archive of Malaga, the Historical Archive of the Sacromonte Abbey in Granada, and, also in Granada, the School of Arabic Studies and the library of P.P. Escalapio.

The physical study of paper, regarded as an additional aspect of the research, will be undertaken using advanced analytical techniques. The results of our research will enable identification, dating and evolution of the media.

As well as microscopic observation (whether optical or electronic of the longitudinal section and cross-section of the fibre, as a component of paper), spectroscopic methods are also being used in our research, enabling us to pinpoint different types of cellulose, protein and synthetic fibre. This is possible because there are certain absorption bands that can be assigned to specific components, such as cellulose, hemicellulose, pectin and lignin.

The fibres have also been sorted by calculating the relationship between bands, at 2900cm (organic material), 1595cm (lignina) and 1105cm (cellulose). Finally, two relationships between the intensities of these absorption bands were calculated and it was verified that this was a suitable method to distinguish between the different types of fibre.

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Aplicación de tecnologías de análisis para el estudio de los soportes de papel en manuscritos Hispano-Árabes. Un modelo de transición en la Granada del siglo XV

La herencia que el mundo árabe ha dejado en la historia de las ciencias está directamente relacionada con las innovaciones introducidas tanto en la fabricación del papel como en la ejecución de sus códices, guardianes de todo un legado cultural. El estudio de los materiales que los constituyen ayudará en la ampliación de conocimientos sobre una manera propia de hacer y sentará las bases para, desde el punto de vista de conservadores y restauradores, determinar los criterios y tratamientos más apropiados para combatir los daños y garantizar la conservación.

El conocimiento de la estructura codicológica de este legado y de los diferentes elementos que lo constituyen facilita la datación y la identificación, y ayuda en el estudio de la evolución de la técnica empleada por calígrafos, copistas y encuadernadores.

Ampliar el conocimiento sobre los manuscritos árabes de Al-Andalus a partir del análisis científico de los materiales que lo constituyen y del uso de los medios tecnológicos más avanzados es nuestro principal objetivo así como una de las líneas de investigación que la Universidad de Granada, en colaboración con el Instituto de Ciencia de los Materiales del CSIC de Sevilla, y con diversas instituciones encargadas de la salvaguarda y custodia del Patrimonio Documental¹, vienen desarrollando. El proyecto de investigación² en el que se enmarca este estudio cuenta, además, con la colaboración de archiveros, arabistas, químicos, conservadores-restauradores y empresas del sector. Gracias a ello, estamos logrando determinar características y modelos estructurales propios

así como establecer su influencia y repercusión en los modos de ejecución actuales tanto en los países árabes vecinos como en los documentos occidentales coetáneos.

El papel Árabe

Los procedimientos de fabricación del papel árabe no han sido demasiado difundidos. Las fuentes, además de no ser muy numerosas, nos presentan procesos de elaboración que, aunque similares, difieren entre sí según el marco cronológico y geográfico donde se localizan.

De modo genérico, para hacer el papel árabe se preparaba una pasta haciendo fermentar y blanqueando en cal restos de cuerdas o trapos previamente batidos y desfibrados. La pasta era depositada sobre un tamiz o forma que servía de molde para la fabricación de la hoja. Los papeles orientales se distinguen de los occidentales por su aspecto más liso. Mientras que en Occidente eran encolados con gelatina animal, en el mundo árabe se utilizaba el almidón de arroz, de trigo o de maíz, lo que favorecía su conservación y brillantez. Posteriormente, el papel era raspado y pulido, aplicándose, finalmente, un apresto con pincel. De este modo, los papeles, además de adquirir un aspecto translúcido, eran preparados para recibir la escritura sin absorber la tinta. El tamaño de la hoja, salvo excepciones, estaba en relación con la capacidad del artesano para manipular solo la forma, por lo que no solían superar los 45 x 65 cms.

1. Colaboran: Archivo Histórico Provincial de Granada, Archivo de la Real Chancillería de Granada y Archivo Histórico de la Diputación de Granada.

2. "Nuevas Tecnologías de análisis para el conocimiento de los materiales y técnicas de ejecución en manuscritos árabes en Al-andalus". Proyecto de Investigación y Desarrollo Tecnológico, ref. CTQ2005-07717. Ministerio de Educación y Ciencia. 2005-2008.

En los manuscritos islámicos, los cuadernillos, cosidos juntos para formar el volumen, estaban formados por numerosos bifolios preparados previamente plegando hojas de papel o encolando dos folios en la zona de plegado del lomo. El número de folios por cuadernillo era variable y solía presentar numerosas anomalías. Así podemos encontrar desde folios sueltos hasta cuadernillos formados por 12 hojas o más. El estudio de la estructura de los cuadernillos y de su montaje no es, sin embargo, objeto de este estudio.

La selección de los documentos

Teniendo en cuenta las diferencias probadas en el uso del papel en los documentos árabes y en los occidentales en cuanto a su composición, el grado de refinado, la ausencia o presencia de filigranas, etc. y la posibilidad de la adopción de elementos característicos de los procesos de fabricación cristianos en un momento en el que en la Península convivían ambas culturas y donde, lógicamente, existía el intercambio de información, este trabajo recoge el estudio del papel como soporte de una serie de manuscritos que comparten unas características singulares y que nos hacen sospechar acerca de la existencia de una tipología de estructura codicológica propia de transición entre el libro árabe y el cristiano en Al-Andalus. Los libros seleccionados pertenecen a las colecciones del Archivo Histórico Provincial de Málaga, el archivo de la Abadía del Sacromonte de Granada y, también de esta ciudad, la Escuela de Estudios Árabes y la biblioteca de la Comunidad de los P.P. Escolapios.

Los datos obtenidos a partir del examen visual y el estudio de las características físicas y codicológicas de cada uno de los documentos en relación con el papel empleado como soporte de escritura en el cuerpo del libro y en las tapas, son los que, a continuación, se detallan:

Libro I. Colección de manuscritos árabes. Archivo Histórico Provincial de Málaga. (Ref. Ms1)

Según la investigación realizada por M^a Luisa Calero³, el Libro I es un *libro de oficio*, perteneciente al alfaquí Muhammad b. ,Ali b. Muhammad al-Yayyar al-Ansari, imán de la mezquita de la alquería

3. CALERO SECALL, M.I.; Los manuscritos árabes de Málaga: los libros de un alfaquí de Cútar del siglo XV. Actas del Congreso Los manuscritos árabes en España y Marruecos. Fundación El legado Andalusí y Consejería de Cultura de la Junta de Andalucía. Granada 30 mayo – 2 de junio 2005. P.151-174.

de Cútar en plena época mudéjar de la zona. Se trata de un códice misceláneo que incluye fragmentos de formularios notariales, de la ciencia de las herencias, de matemáticas, de tradiciones del Profeta y de cuestiones jurídicas sobre el matrimonio. Está escrito en árabe clásico, vocalizado en gran parte, y con errores, en ocasiones, en rojo sobre letra negra.

La encuadernación es de cartera con revestimiento de pergamino rígido y manuscrito en su cara interior, con tapas de papelón manuscrito y forro de tela teñida en azul *pastel*. El papel es utilizado como soporte de escritura, como material de refuerzo en el lomo y como elemento constitutivo de las tapas del libro.

El cuerpo del libro es de papel y está compuesto por 111 folios. Las medidas de las hojas son de 205 x 164 mm. La observación con luz transmitida permite visualizar las marcas de la forma utilizada en su manufactura. El primer folio difiere en características con el resto de las hojas; en él se aprecia la verjura del papel siendo evidente la presencia de 2 corondeles y de 23 puntizones en 20 mm y su espesor es de 0,20 mm. En el resto del manuscrito no se aprecian marcas de corondeles o líneas de cadeneta aunque sí es evidente la impronta de la forma. En ningún caso se ha encontrado filigrana. Debido al estado de deterioro del manuscrito, no podemos determinar ni el número de cuadernillos ni la cantidad de folios constitutivos de cada uno de ellos.

Libro 16 y libro 20. Colección de manuscritos árabes de la Abadía del Sacromonte de Granada (Espejo y Arias, 2005).

Nº reg. 16: (Ref. Ms2)

Gramática de *Ibn al-Fajjar al-Bayri, Sarh al-Ŷumal fi l-nahwi*. La encuadernación es de cartera en piel de oveja o cordero, marrón y gofrada. Su decoración es geométrica destacando una rueda central y una greca que bordea todo el perímetro. El revestimiento interior es una sarga de 18x18 hilos/cm² de densidad, tejida a partir de fibras de cáñamo y teñida de azul índigo.

El cuerpo del libro se compone de 245 folios agrupados en 26 cuadernillos de 10 folios cada uno, aunque han sido localizados 2 de 6 y, el último, que aparece incompleto, es de 3. Cada página, de 294 x 21,5 mm, posee 25 líneas de texto en letra magrebí sin vocales.

El tipo de papel empleado es de trapos y verjurado. Posee cinco corondeles separados entre 35 y 39 mm. unos de otros y paralelos al lomo. La medida para 20 puntizones es de 16 mm.. Se aprecia una filigrana que, con ligeras variaciones a lo largo del documento, representa la mano o el guante extendido y rematado por una flor o la estrella de seis puntas. Su espesor es irregular variando según el folio y la zona de medida, oscilando entre 0,19 y 0,27 mm.

Nº reg. 20: (Ref. Ms3)

Medicina de al-'Aynazarbi, *Kitāb al-kāfi fi-l-tibb min al-qarn ilà l-qadam* manuscrito que se localiza en el año 702 de la hégira o 1302 de nuestra era. La encuadernación es de cartera en piel marrón gofrada que vuelve por el interior abrazando la contratapa que, igual que en el documento anterior, está cubierta por un tejido de cáñamo teñido, en este caso, de color amarillo y cuya densidad es 15x16 hilos/cm². La decoración se limita a una triple línea que encuadra un motivo geométrico central.

El cuerpo del libro se compone de 48 folios agrupados en cuadernillos aunque su estado de deterioro impide determinar el dato relativo al número de folios por cuadernillo al haberse perdido parte del soporte en la zona del lomo. Las páginas, de 305 x 470 mm., poseen 31 líneas de texto escritas, igual que en documento anterior, en letra magrebí sin vocales.

El tipo de papel empleado es de trapos y verjurado. Aunque no se observan ni corondeles ni filigrana, sí se observan puntizones perpendiculares al lomo, y cuya medida para 20 puntizones es de 30 mm. Su espesor es irregular y varía según el folio y la zona de medida oscilando entre 0,26 mm. de mínima y 0,30 mm de máxima.

Gramática de Al-Zubaydi. Escuela de Estudios Árabes. (Ref. Ms4)

Kitab al-Wadih de Abu Bakú Muhammad B Hasan Al-Zubaydi, aparece recogido en la catalogación que C. Castillo hace de la colección de manuscritos árabes de la Escuela de Estudios Árabes de Granada situando su procedencia en la Universidad de Granada y aportando como únicos datos codicológicos que se trata de una “encuadernación en cuero repujado marrón muy deteriorada. Papel grueso. Letra magrebí clara y vocalizada, de tamaño mediano. Tinta negra con mociones y epígrafes en rojo. Estos últimos con letra más grande. Sin foliación. (...) Faltan hojas al final. Conservación defectuosa en las cuatro últimas hojas. Tamaño: 200 (170) / 140 (90). 20 líneas por folio y algunas palabras al margen” (Castillo, 1984).

Una primera aproximación a su estudio nos indica que posee una estructura codicológica que podría considerarse transición entre la encuadernación árabe y la mudéjar por presentar elementos característicos de la encuadernación occidental unidos a elementos propios de las encuadernaciones árabes. Así, combina la estructura de cartera con la presencia de nervios marcados por una triple línea, muy característicos del s.XVI, o posee el revestimiento textil común al modelo de encuadernación que nos ocupa además de pasadas de nervios a los cartones de las tapas o diferentes refuerzos en papel o pergamino apoyando la estructura del montaje.

Las tapas, igual que en los documentos anteriores, son de papelón compuesto por varias capas de papel muy fragmentado; los recubrimientos de pergamino y tejido de sarga sin teñir forman una estructura compleja que se une al cuerpo a partir del cosido de los nervios de piel.

El cuerpo mide 200 x 140 x 20 mm y está constituido 90 folios agrupados en 10 cuadernillos que varían en número de folios así encontramos cuadernillos de 10, de 12, de 8 y de 6 folios y alguna hoja suelta.

Son evidentes al menos tres tipos diferentes de papel, todos verjurados, con los corondeles dispuestos perpendicularmente al lomo y cuyo espesor oscila entre 0,17 y 0,25 mm. El primero constituye el grueso del cuerpo del libro (del folio 1 al 80), posee 5 corondeles separados irregularmente y se aprecian 10 puntizones en 20 mm. Posee una filigrana en el centro del bifolio que nos recuerda a una letra china (ver fig.1) Del folio 81 al 88

los dos tipos de papel que se observan son similares al anterior, cada uno corresponde a un bifolio y se alternan. El primero, posee filigrana aunque resulta difícil de identificar por encontrarse muy fragmentada, tiene 6 corondeles y 15 puntizones en 20mm. El siguiente tiene 5 corondeles, 16 puntizones para idéntica medida y está desprovisto de marca al agua. Finalmente, el folio 90 corresponde a la mitad de un bifolio, presenta 5 corondeles, 13 puntizones en 20 mm y parte de una filigrana que debió representar un círculo y en cuyo interior se intuye la presencia de algún elemento que, dada la mutilación, no acertamos a definir.

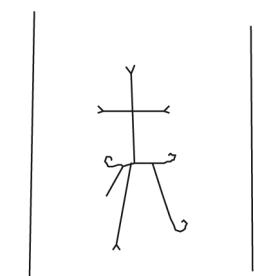


fig.1

El Corán de los Escolapios. Comunidad de los P.P. Escolapios de Granada. (Ref. Ms5). (Espejo, 2005)

Se trata de un Corán morisco cuya encuadernación es de cartera en piel de oveja o cordero con curtición vegetal de taninos, marrón y gofrada. Su decoración se limita a una triple línea con realce geométrico en las esquinas que enmarcan la cubierta y en cuyo espacio interior se recoge un motivo central con forma romboidal. Como característica principal, igual que sucede en los manuscritos del Sacromonte, resaltar que el revestimiento interior es una sarga tejida a partir de fibras de cáñamo, sobre el que se estructura el montaje del libro y que aparece cosido al cuerpo por medio de las cabezadas. La cubierta de piel ha sido montada posteriormente, abrazando este tejido y dejando visible las cejas interiores que aparecen también decoradas con una línea marcada con hierros en frío.

Originariamente, debió constar de tres volúmenes de los cuales sólo se conserva el tercero que comprende desde la azora XXXVIII hasta la CXIV y última, completas y sin lagunas. El nombre del copista, la fecha y el lugar de ejecución no se han encontrado posiblemente por localizarse en el primer volumen, hoy perdido. Las características técnicas y estilísticas y algunos datos cronológicos encontrados en el cartón de las tapas lo sitúan hacia la mitad del s.XV. Su escritura es magrebí, de traza andalusí y de tipo mabsut, muy clara y cuidada en la puntuación, con vocalización en rojo y títulos en letra cífica, simple e irregular, de color ocre sin puntuar ni vocalizar.

El cuerpo del libro se compone de 108 folios, de esquinas redondeadas y manuscritas por ambas caras, con excepción del primer folio que inicia el texto en la página 2 y del último que aparece sin escritura, que se agrupan formando 11 cuadernillos compuestos por 10 folios y uno, el último, que sólo tiene 8. Las páginas, de 191 x 245 mm., poseen 13 líneas de texto en el interior de una caja de escritura de 125 x 170 mm.

El tipo de papel empleado responde a una única tipología. Como materia prima se han utilizado los trapos cuya presencia es evidente a simple vista en determinadas zonas. En algunos folios son visibles hasta 5 marcas de cadena o corondeles perpendiculares al lomo, mientras que en otros sólo se intuye una en la parte inferior. Se han contabilizado 10 puntizones en 20 mm. Y no se ha encontrado filigrana. Su espesor es variable en función del folio y de la zona oscilando entre los 0,24 mm. y los 0,40 mm.

La identificación de las fibras

Son muy poco numerosos los estudios que sobre la identificación y el estudio del papel se han realizado, limitándose, con cierta mayoría, a determinar su composición a partir únicamente del examen visual. Esto ha dado lugar a importantes errores, máxime si tenemos en cuenta que una de las principales alteraciones que el exceso de humedad origina sobre estos papeles radica en la disolución de los aprestos y colas lo que hace que, debido a sus características de fabricación, se exfolie y presente un aspecto algodonoso. El examen físico de todo manuscrito debe completarse con el estudio científico de los materiales que lo constituyen.

El análisis y determinación del componente vegetal de los papeles empleados en los documentos seleccionados forma parte de una investigación más amplia en la que se pretende desarrollar el conocimiento que actualmente se tiene en relación con el estudio e identificación de cada uno de los materiales constitutivos de los manuscritos árabes. Para ello se están utilizando nuevas tecnologías de análisis, adoptadas desde la química analítica, que nos permiten la separación, identificación y cuantificación de las sustancias a analizar. De este modo, con una única muestra y un solo análisis, se puede conseguir, por ejemplo, la determinación de la gran mayoría de las sustancias presentes en aglutinantes y tintas reduciendo considerablemente los mapas de toma de muestra.

Por ello, además de la observación microscópica, ya sea óptica o electrónica del corte longitudinal y transversal de la fibra, estamos utilizando métodos espectroscópicos que nos han permitido distinguir distintas clases de fibras celulósicas, proteínicas y sintéticas, puesto que hay ciertas bandas de absorción que pueden ser asignadas a los diferentes componentes específicos de las fibras como son celulosa, hemcelulosa, pectina y lignina (Gal et al., 1991) (Lang et al., 1986) (Howell y Davies, 1991) (Perry, 1985).

Las fibras se han caracterizado además por cálculos de las relaciones entre las bandas a 2900 cm⁻¹ (materia orgánica), 1595 cm⁻¹ (lignina) y 1105 cm⁻¹ (celulosa) y las dos relaciones ($R_1=I_{1595}/I_{1105}$) y ($R_2=I_{1595}/I_{2900}$) entre las intensidades de estas bandas de absorción, comprobándose que era un buen método para distinguir entre los diferentes tipos de fibras (Garside y Wyeth, 2000 y 2003) (Durán, 2006).

Fase experimental

El presente artículo reúne los resultados de los análisis efectuados en 1995 por el Dr. Enrique Parra⁴, y Dña. Carmen Martín de Hijas⁵, con motivo de la restauración que sobre el Corán Morisco de la Biblioteca de los P.P. Escolapios de Granada se llevó a cabo. Por su parte, en el Instituto de Ciencias de Materiales de Sevilla se realizaron los análisis y estudio de un total de 24 muestras tomadas del resto de los documentos seleccionados para el desarrollo de este trabajo, de las cuales 3 corresponden al Libro I, perteneciente al Archivo Histórico Provincial de Málaga, 10 a la Gramática de Al-Zubaidy de la Escuela de Estudios Árabes del CSIC de Granada, 6 al manuscrito 20 de la colección del Archivo de la Abadía del Sacromonte y, finalmente, 5 al manuscrito 16 de la misma colección. En la relación anterior, se han incluido, además de muestras de papel, otras tomadas de los tejidos que han servido de refuerzo de la estructura del libro y del cosido.

Teniendo en cuenta que este tipo de análisis es destructivo, para la toma de las micro muestras se han buscado aquellas zonas estratégicas del libro que, sin dañar el documento, nos aportarán la máxima información sobre la composición de los soportes de papel y textil.

El reconocimiento de las fibras textiles componentes del papel se ha realizado por observación microscópica del corte longitudinal y transversal de la fibra. Antes de proceder a la identificación, es conveniente eliminar los restos de cola, barniz o apresto que pueda tener el tejido, para lo que se sumerge en agua destilada o disolución acuosa de sulfato sódico y se lleva a ebullición. (Durán, 2006)

La microscopía óptica para la investigación llevada a cabo con motivo de la restauración del Corán Morisco de la Biblioteca de los P.P. Escolapios de Granada fue realizada en un microscopio Olympus BX-50 por reflexión para el estudio de los pigmentos, y por transmisión para el estudio de fibras vegetales. Fueron primero lavadas con hidróxido sódico al 5 % (p/v) en agua, observadas al microscopio y atacadas con una disolución de cuprietilendiamina al 20 % (p/v) en hidróxido sódico al 5 % (p/v) para la diferenciación entre lino y cáñamo. Los análisis por microscopía electrónica de barrido/energía dispersiva de rayos X realizados sobre las muestras de este manus-

crito, fueron realizados en un microscopio Philips XL30 con analizador EDX PV9900 con detector de Si(Li).

En el Instituto de Ciencia de Materiales, los estudios por microscopía óptica fueron realizados en un microscopio Nikon HOPTIPHOT con objetivos x25, x50, x100 y x200 y los análisis por microscopía electrónica de barrido/energía dispersiva de rayos X (SEM/EDX) se realizaron con un microscopio JEOL JSM 5400 con sistema de dispersión de rayos X LINK ISIS incorporado.

Los métodos espectroscópicos han sido usados en este trabajo para distinguir distintas clases de fibras. Para estos estudios se empleó un espectrómetro Nicolet 510 (Fuente: Globar, Detector: DTGS/KBr). Se realizaron un total de 200 scans con una resolución instrumental de 4 cm⁻¹ para cada espectro, con rango espectral 4000-400 cm⁻¹. Para el procesado y análisis de datos se usaron los programas comerciales OMNIC y PEAK FIT.

Resultados

Las fibras del manuscrito y del papel de las páginas del Corán fueron analizadas y se determinaron como lino o cáñamo por su morfología microscópica (Greaves y Saville, 1995).

Las dos primeras muestras (1 – tela de la contratapa; 2 – papel del papelón) del libro I del Archivo Histórico Provincial de Málaga muestran un comportamiento similar, si bien en la segunda de las mismas se observa una clara coloración de tono rojizo. En ambos casos, las fibras halladas son lino y algodón (esta segunda en menor proporción). En la muestra número 3 (papel del cuerpo del libro) se identifica lino como única fibra constituyente.

Las muestras procedentes de Al-Zubaidy (Escuela de Estudios Árabes, CSIC, Granada) son bastante heterogéneas: en algunas de ellas la composición de la fibra es claramente a base de lino y muy poco o nada de algodón. En este grupo se encuentran las muestras 1 (papel del cuerpo del libro), 2 (papel del papelón tapa principal), 3 (papel del papelón tapa posterior), 7 (hilo natural –urdimbre- forro contratapa) y 8 (hilo natural –trama- forro contratapa). Aunque se observan algunos hilos de algodón y los retorcimientos propios de este tipo de fibra, éstas son

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consideradas como derivaciones de la fibra de lino que podemos designar con el nombre de lino algodonizado (Hall y Davies, 1968). Esta presencia es debida a la falta de desarrollo de la fibra o por la separación de las últimas fibras de lino por medio de un tratamiento a base de álcali, y sin hilar o tratar totalmente. En cualquier caso, se trata de lino.

El resto de muestras: 4 (papel del forro de las contratapas), 5 (hilo azul –urdimbre- refuerzo del lomo), 6 (hilo azul –trama- refuerzo del lomo), 9 (hilo natural cabezada) y 10 (hilo natural costura de la piel de la cubierta), muestran la presencia de lino y algodón. La visión morfológica se reafirma por el análisis espectroscópico y los valores más bajos de R^1 y R^2 calculados en comparación con el otro grupo de muestras, lo que nos indica la presencia de ambos tipos de fibras (ver figura).

Por otra parte, hay gran presencia de actividad orgánica, principalmente en las muestras 1, 2 y 3, y la coloración azul (5 y 6) y rojiza (2 y 3) detectada en algunas de las muestras.

Las notas indicadas anteriormente en cuanto al reconocimiento de lino algodonizado y los valores de R_1 y R_2 también sirven para la serie de muestras del Sacromonte.

Se observa actividad orgánica en las muestras 1 L20 (papel del cuerpo del libro), 4 L20 (papel del

papelón), 1 L16 (papel del cuerpo) y 2 L16 (papel del papelón). Están coloreadas con tono rojizo amarillento las muestras 1 L20, 2 L20 (papel del cuerpo del libro), 4 L20, 5 L20 (hilo amarillo del forro –urdimbre-), 6 L20 (hilo amarillo del forro –trama-), y en tonos azulados la 4 L16 (tejido azul –urdimbre-) y la 5 L16 (tejido azul –trama-).

En esta última serie, se observa algodón junto al lino en las muestras 1 L20, 2 L20, 4 L20, 5 L20, 6 L20, 2 L16, 4 L16 y 5 L16. En el resto, no se ha detectado la presencia abundante de algodón.

Tabla 1: La tabla 1 expone las intensidades correspondientes a las bandas características de algunos de los componentes de las fibras. La banda a 1595 cm^{-1} se asigna a dobles enlaces C=C correspondientes a la lignina, la banda a 1105 cm^{-1} a las vibraciones C-O-C glicosídicas de los componentes polisacáridos, y la banda a 2900 cm^{-1} se toma como una medida del contenido en materia orgánica.

Las intensidades halladas servirán posteriormente para encuadrar cada una de las muestras de fibra estudiadas en zonas características del diagrama $R_1 \perp R_2$. Se define R_1 como la relación entre las intensidades a 1595 cm^{-1} y 1105 cm^{-1} , y R_2 como la definida entre las bandas a 1595 cm^{-1} y 2900 cm^{-1} (Garside y Wyeth, 2000 y 2003) (Durán, 2006).

<u>LIBROS</u>	<u>I_{1595}</u>	<u>I_{1105}</u>	<u>I_{2900}</u>	<u>R_1</u>	<u>R_2</u>
<u>Málaga 1</u>	0.024	0.10	0.069	0.24	0.35
<u>Málaga 2</u>	0.052	0.204	0.135	0.25	0.38
<u>Málaga 3</u>	0.028	0.062	0.057	0.45	0.49
<u>Al-Zubaidy 1</u>	0.041	0.070	0.058	0.58	0.71
<u>Al-Zubaidy 2</u>	0.059	0.098	0.07	0.60	0.84
<u>Al-Zubaidy 3</u>	0.029	0.056	0.043	0.51	0.67
<u>Al-Zubaidy 4</u>	0.026	0.143	0.093	0.18	0.28
<u>Al-Zubaidy 5</u>	0.025	0.12	0.083	0.21	0.30
<u>Al-Zubiady 6</u>	0.015	0.052	0.046	0.29	0.33
<u>Al-Zubaidy 7</u>	0.021	0.041	0.032	0.5	0.64
<u>Al-Zubaidy 8</u>	0.015	0.022	0.020	0.68	0.73
<u>Al-Zubaidy 9</u>	0.026	0.133	0.084	0.19	0.31
<u>Al-Zubaidy 10</u>	0.035	0.155	0.108	0.23	0.32
<u>Sacromonte 20 1</u>	0.031	0.135	0.076	0.23	0.41
<u>Sacromonte 20 2</u>	0.021	0.088	0.042	0.24	0.5
<u>Sacromonte 20 3</u>	0.033	0.039	0.034	0.84	0.98

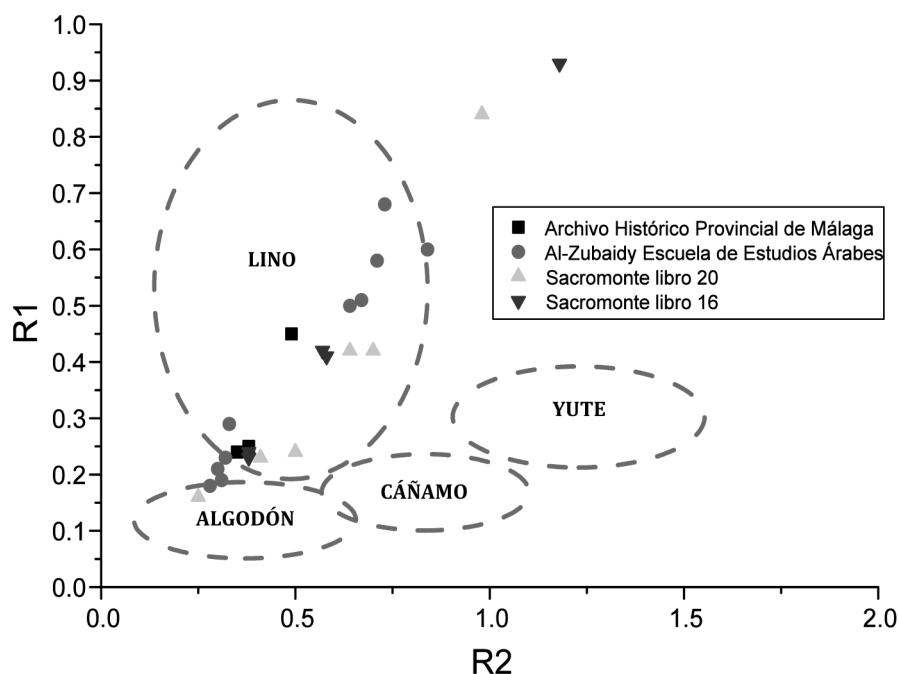
<u>Sacromonte 20 4</u>	0.039	0.093	0.056	0.42	0.70
<u>Sacromonte 20 5</u>	0.046	0.108	0.072	0.42	0.64
<u>Sacromonte 20 6</u>	0.052	0.316	0.205	0.16	0.25
<u>Sacromonte 16 1</u>	0.040	0.043	0.034	0.93	1.18
<u>Sacromonte 16 2</u>	0.033	0.142	0.088	0.23	0.38
<u>Sacromonte 16 3</u>	0.027	0.11	0.07	0.24	0.38
<u>Sacromonte 16 4</u>	0.022	0.053	0.038	0.41	0.58
<u>Sacromonte 16 5</u>	0.021	0.050	0.037	0.42	0.57

Figura:

En el estudio de las fibras hay un comportamiento general que indica mayores valores de las relaciones R1 y R2 para los materiales lignificados y que coincide con bastante verosimilitud con los datos de valores porcentuales teóricos.

Tanto los datos porcentuales de celulosa, hemicelulosa, pectina y lignina en la composición de algodón, lino, cáñamo y yute, como las magnitudes R1 y R2 relacionadas, definen teóricamente una serie de

zonas en el diagrama R1?R2 que corresponden con los diferentes tipos de fibras. En la figura se observan las diferentes zonas definidas anteriormente mediante modelos teóricos comparados con muestras patrones experimentales y la posición dónde se sitúan las muestras estudiadas en este trabajo en función de sus valores de R1 y R2. Se comprobó que era un buen método para distinguir entre los diferentes tipos de fibras.



Conclusiones

De los documentos seleccionados, el libro I del Archivo Hco. de Málaga y el N° 16 de la Abadía del Sacromonte están fechados a mediados del s.XV, el N° 20 parece localizarse en el s.XIV aunque por las características de su encuadernación se corresponden

con los modelos establecidos en el s.XV, tal y como sucede con el Corán de los P.P. Escolapios. La gramática de Al-zubaydi, sin embargo presenta unas características propias del s. XVI, mostrando características propias de las encuadernaciones mudéjares.

	(Ref.Ms1)	(Ref.Ms2)	(Ref.Ms3)	(Ref.Ms4)	(Ref.Ms5)
Siglo	XV	XV	XIV	XVI	XV-XVI
	848h./1445d.C	890h./1484d.C	702h./1302d.C	? ?	? ?
Folio (mm)	200 x 150	295 x 215	305 x 235	210 x 140	235 x185
Espesor (mm)	0,300,19 - 0,27	0,26 – 0,30	0,17-0,25	0,24 – 0,40	
Nº folios	170245	48	90	108	
Nº cuadernillos	s/determinar	26	s/determinar	10	11
Folios/cuadernillo	s/determinar	4 - 6 – 10	s/determinar	6 – 8 – 10 – 12	8 -10
Marca de la forma	Si Si	Si	Si	Si	
Puntizones	Si Si	Si	Si	Si	
Corondeles	No Si	No	Si	Si	
Filigrama	No Si	No	Si	No	
Fibra papel	Lino	Lino y algodón	Lino y algodón	Lin-godonizado	Lino-cañamo?
Fibra tapa	Lino y algodón	Lino y algodón	Lino y algodón	Lin-godonizado	Lino-cáñamo?
Fibra contratapa	Lino y algodón	Lino y algodón	Lino y algodón	Lin-godonizado	Cáñamo

En todos los casos, se aprecia la marca de la forma sobre la superficie del papel, están ligeramente satinados y el grado de refino es relativo.

Entre todos los documentos estudiados, destaca la presencia de algodón en las fibras que componen el papel del Manuscrito 20 de la Colección de la Abadía del Sacromonte (ref.Ms.2); dada la fecha de ejecución del manuscrito, podemos pensar que, ya en el s.XIV en Al-Andalus, se había incorporado esta materia prima en los procesos de manufactura del papel. La presencia de filigrana en el Manuscrito 16, de esta misma colección, ratifica el hecho de que las innovaciones en los procesos de elaboración del papel italiano no eran perfectamente conocidos y eran utilizados en la producción del papel árabe en el sur de la Península desde antes de la conquista cristiana.

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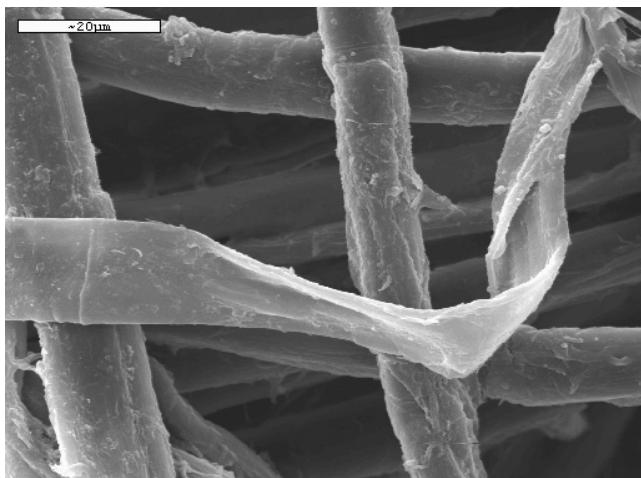
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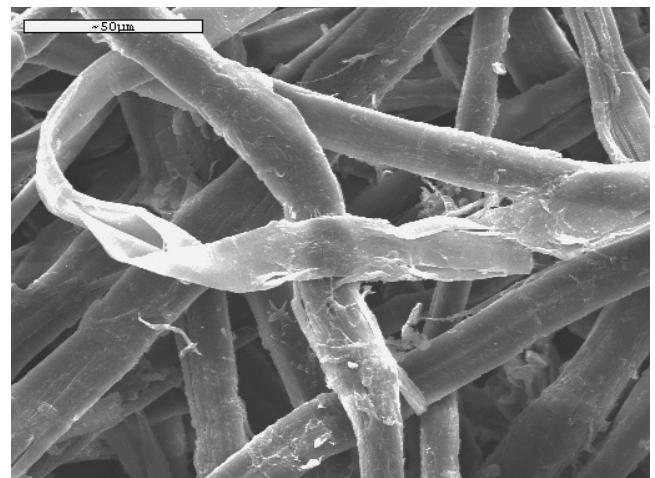
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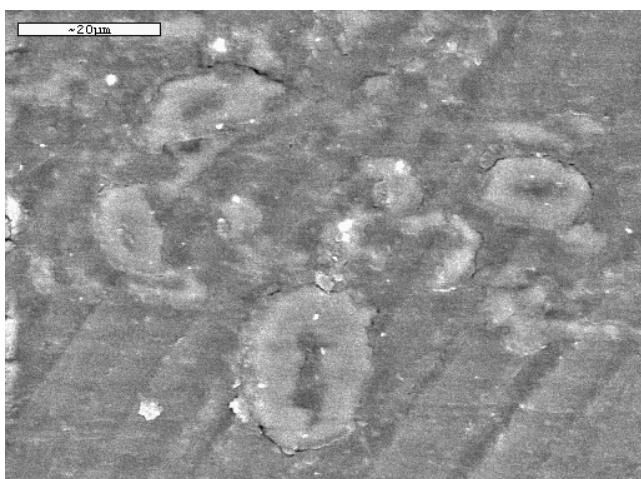
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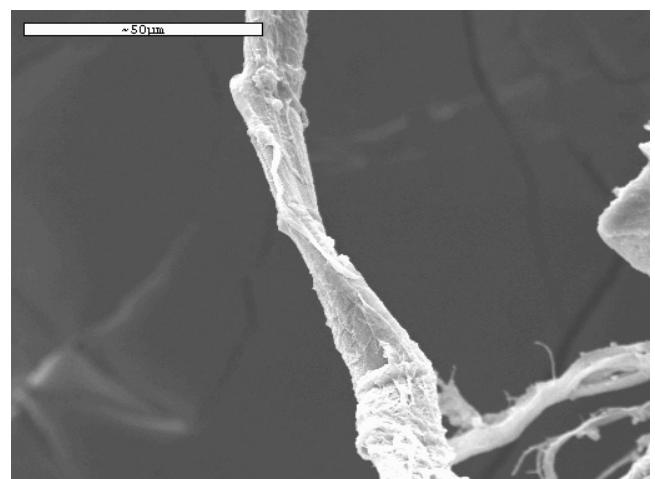
F.1 Imagen SEM, lino. Libro I. Archivo Histórico Provincial de Málaga.



F.2 Imagen SEM. Lino y algodón. Ms 16, Colección de manuscritos árabes, Abadía del Sacromonte de Granada.



F.3 Imagen SEM. Algodón. Ms 20, Colección de manuscritos árabes, Abadía del Sacromonte de Granada.



F.4 Imagen SEM: lino algodonizado. Gramática de Alzubaidy. Escuela de Estudios Árabes, Granada.



F.5 Microfotografía a 200 X. Lino o cáñamo. Corán. Col. PP. Escolapios, Granada.