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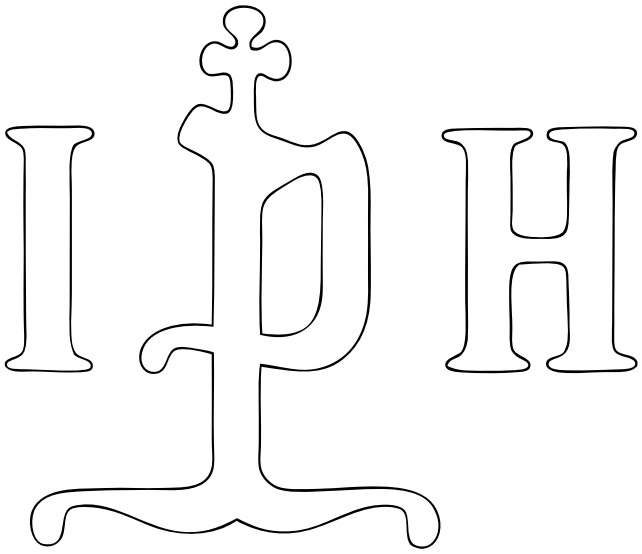

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Dear members of IPH

A year has gone by since people with interest in paper and paper history met each other in Italy at the memorable IPH Congress in Fabriano, Camerino and Amalfi. It was so perfectly organized in an inspiring atmosphere that the rich program and the speakers' presentation of their papers resulted in new ideas, discussions and positive critics from the vividly engaged audience. After the congress it is important that we remember to keep in touch with our new and old friends and use the updated Membership List. Check the website and send information about paper historical events, new publications etc. to our webmaster emanuel.wenger@oeaw.ac.at that cannot wait for publication in the spring and autumn issues of the IPH periodical Paper History.

This summer the establishment 625 years ago of the first documented paper mill north of the Alps was celebrated in many ways. At the gates of Nuremberg did the German merchant Ulman Stromer, assisted by Lombard artisans from Fabriano, start the production of paper at the renovated former fulling mill 24th of June in 1390. Johannes Gutenberg's invention 1445, only 55 years later, of a method of printing with movable types was especially fit for the new and much cheaper writing material; his genius art of printing resulted in spread of knowledge and information in a completely unexpected amount, in still rising demands for more paper and thus for development of the technology and later search for new fibre materials. The importance of Gutenberg's invention is described and discussed inTorbjörn Helle's article "Paper and the history of printing" in this issue of our periodical.

In Fabriano the time consuming editing of the manuscripts from the 2014 IPH Congress is taking place, but unfortunately a number of the final texts have not been received before the deadline of 31/12 2014 and that makes the editing unnecessarily complicated for the congress coordinators and delays the final publication of Volume 20 of the Congress Books. Simultaneously with this important work in Italy the planning of the next IPH Congress 2016 has already started in Spain. It is the third time that national and international paper historians are gathered at IPH Congresses in Spain, and hopefully it will happen as planned in Valencia, hosted by GENERALITAT VALENCIANA CULTUR ARTS IVCC+R, nearby the city of Xàtiva, where Arab paper makers 900 years ago started the art of papermaking in Europe. Please note that the Call for papers for the 2016 IPH Congress will be published as soon as possible on our web site with information about the subjects, program, date and deadlines for sending your suggestion for papers.

In the first week of June the annual Nordic paper historians NPH-meeting was organized by Kari Greve in Norway in the beautiful city of Bergen. Unfortunately I was not able to participate this time, because of my participation with the continued studies of the Khartasia data base project in Paris. During two fascinating weeks together with Claude Laroque, Agnieszka Helman-Wazny and members from CRC, Centre de Recherches sur les Collections, Muséum National d'Histoire Naturelle (MNHN), specimens were made of bast fibre materials from a selection of classical Asiatic paper making plants from Jardin des plantes in Paris and of artificially aged handmade new Chinese papers. With this material the Mulberry bast fibres could be observed and documented before the paper technological preparation and the difference noticed between Mulberry fibres from the plant and from the paper. One of the days in Paris Nina Jethwa from India presented an interesting lecture at CRC about the production of handmade pure cotton rag paper in Pondicherry in the Handmade Paper Dept. / Archives Dept. Sri Aurobindo Ashram. I am sure that the Indian papermaking project and its purpose, described in her article in this issue of the periodical, will be just as interesting for the readers of this periodical as it was for the audience in Paris.

Anna-Grethe Rischel

Liebe Mitglieder der IPH,

Es ist nun ein Jahr her, dass Papier- und Papiergeschichtsinteressierte sich in Italien bei dem denkwürdigen IPH-Kongress in Fabriano, Camerino und Amalfi getroffen haben. Er war so perfekt in einer anregenden Atmosphere organiziert, dass das reichhaltige Programm und die Präsentationen der Vortragenden in neue Ideen mündeten, sowie in Diskussionen und positive Kritik von den sehr engagierten Zuhörern. Nach dem Kongress ist es wichtig, dass wir daran denken, in Kontakt mit unseren neuen und alten Freunden zu bleiben, und die aktualisierte Mitgliederliste zu nutzen. Seht Euch die website an und sendet jene Informationen über papierhistorische Ereignisse, neue Publikationen etc., welche nicht erst auf eine Publikation in der Frühlings- oder Herbst-Ausgabe unserer Periodika „IPH-Paper-History" warten können, an unseren webmaster emanuel.wenger@oeaw.ac.at.

In diesem Sommer wurde die Errichtung der ersten, dokumentierten Papiermühle nördlich der Alpen vor 625 Jahren auf vielfältige Weise gefeiert. Der deutsche Kaufmann Ulman Stromer begann vor den Toren Nürnbergs, assistiert von lombardischen Kunsthandwerkern aus Fabriano, mit der Produktion von Papier in der renovierten Walkmühle am 24. Juni 1390. Johannes Gutenbergs Erfindung im Jahr 1445, nur 55 Jahre später, mit beweglichen Buchstaben zu drucken, passte hervorragend zu dem neuen und viel preiswerteren Schreibmaterial; seine geniale Art des Druckens mündete in eine unerwartet riesige Verbreitung von Wissen und Information, in weiterhin steigende Nachfrage nach mehr Papier und daher auch für die technische Entwicklung und später die Suche nach neuen Fasern. Die Bedeutung der Erfindung Gutenbergs ist in Torbjörn Helles Beitrag „Paper and the history of printing" in dieser Ausgabe unserer Zeitschrift beschrieben und besprochen.

In Fabriano wird zur Zeit die Drucklegung der Manuskripte vom IPH-Kongress 2014 vorbereitet, aber leider sind eine Reihe von Texten nicht rechtzeitig vor dem Redaktionschluss am 31.12.2014 eingereicht worden und dies macht es den Kongress-Koordinatoren unnötig schwer und so wird sich die endgültige Publikation von Band 20 des Kongress-Bandes verzögern. Parallel zu dieser wichtigen Arbeit in Italien hat die Planung für den nächsten IPH-Kongress in Spanien 2016 bereits begonnen. Es ist das 3. Mal, dass nationale und internationale Papierhistoriker zu einem IPH-Kongress in Spanien zusammentreffen, und diesmal wird es hoffentlich wie geplant in Valencia sein, in der Nähe von Xàtiva, wo arabische Papiermacher vor 900 Jahren begannen, Papier in Europa herzustellen; die Gastgeber sind GENERALITAT VALENCIANA CULTUR ARTS IVCC+R. Bitte beachtet, dass der ‚Call for papers' für den IPH-Kongress 2016 sobald als möglich auf unserer website mit Informationen zu Thema, Programm, Datum und Redaktionsschluss Eurer Vorschläge zu Vorträgen veröffentlicht wird.

In der ersten Juni-Woche wurde das jährliche NPH-Treffen der nordischen Papierhistoriker in der schönen Stadt Bergen in Norwegen von Kari Greve organiziert. Leider konnte ich nicht persönlich daran teilnhemen, da ich zeitgleich in Paris bei einer Fortsetzung der Studien am data-base Projekt Khartasia teilnahm. Während zweier fazinierenden Wochen zusammen mit Claude Laroque, Agniszka Helman-Wazny und Mitgliedern des CRC (Centre de Recherches sur les Collections, Muséum National d'Histoire Naturelle <MNHN>) wurden Muster von Bastfasern aus einer Auswahl klassisch asiatischer Papierpflanzen vom Jardin des plantes sowie von künstlich gealterterten, handgeschöpften, neuen Papieren aus China angefertigt.

Mit diesem Material können die Maulbeerbaum-Fasern beobachtet und dokumentiert werden, bevor die papiertechnologische Vorbereitung und der Unterschied zwischen Maulbeer-Fasern von der Pflanze und vom Papier wahrgenommen werden.
Im CRC presentierte Nina Jethwa aus Indien einen interessanten Vortrag über Produktion von handgeschöpftem Papier aus reinen Baumwoll-Lumpen, das in Pondicherry in der Abteilung Handgeschöpftes Papier/Archiv des Sri Aurobindo Ashram hergestellt wird. Ich bin sicher, dass das indische Papier-Projekt und sein Nutzen, beschrieben in ihrem Artikel in dieser Ausgabe hier, für die Leser genau so interessant sein wird, wie es für die Zuhörer in Paris war.

Anna-Grethe Rischel

Chers membres de l'IPH,

Cela fait un an que se sont rencontrés en Italie, lors du mémorable congrès IPH à Fabriano, Camerino et Amalfi, celles et ceux qui s'intéressent au papier et à son histoire. Ce congrès était si parfaitement bien organisé, dans un environnement idéal, que le riche programme et les interventions présentées ont suscité des idées nouvelles, des discussions et critiques positives de la part d'un public prompt à participer. A la suite du congrès, il importe de garder contact avec de nouveaux ou anciens amis en utilisant la Liste des Membres, qui a été mise à jour. Merci de consulter notre site web et de faire parvenir à notre webmestre E. Wenger emanuel.wenger@oeaw.ac.at toute information concernant des manifestations ou publications récentes liées à l'histoire du papier qui ne pourraient attendre la date de parution dans notre périodique *Paper History*, qui sort au printemps et à l'automne.

L'établissement, voici 625 ans, du premier moulin à papier au nord des Alpes qui soit dûment documenté a été abondamment célébré cet été. Assisté d'artisans lombards venus de Fabriano, le négociant allemand Ulman Stromer commença à produire du papier le 24 juin 1390 dans un moulin rénové, précédemment voué au foulage, aux portes de Nuremberg. L'invention d'une nouvelle méthode d'impression à l'aide de caractères mobiles par Johannes Gutenberg en 1445, soit seulement 55 ans plus tard, s'avéra particulièrement adaptée à ce support nouveau et nettement plus économique. L'art ingénieux de l'imprimerie eut pour effet de répandre la connaissance et l'information selon des proportions complètement inattendues, suscitant une demande croissante de fourniture en papier et encourageant la croissance technologique qui amena par la suite à rechercher de nouvelles matières premières pour la fabrication du papier. Ce numéro de notre périodique présente une article de Torbjörn Helle intitulé "Paper and the history of printing", qui décrit et argumente l'importance de l'invention de Gutenberg.

Concernant la publication des actes du congrès IPH 2014, le travail éditorial de longue haleine qu'elle nécessite est en cours à Fabriano. Malheureusement, plusieurs textes attendus n'ont pas été reçus avant la date d'échéance du 31 décembre 2014, ce qui complique la tâche des coordinateurs du congrès chargés de la publication, et retarde la parution du Livre des Congrès, vol. 20. Tandis que la préparation des Actes est menée à bien en Italie, l'organisation du prochain congrès IPH 2016 a déjà commencé en Espagne. C'est la troisième fois que des congrès IPH nationaux et internationaux ont lieu en Espagne, et nous espérons qu'il pourra se dérouler comme prévu à Valencia, hébergé par la Generalitat Valenciana CulturArts IVCC+R près de la cité de Xàtiva, où les papetiers arabes initièrent l'art de la production papetière en Europe, il y a 900 ans. Veuillez noter que l'Appel à contributions pour le Congrès IPH 2016 paraîtra dès que possible sur notre site web: il contiendra des informations sur les thèmes, le programme, les dates de la manifestation ainsi que la date d'échéance pour la soumisson de vos interventions.

Début juin dernier a eu lieu la rencontre annuelle des Historiens du papier Scandinaves (NPH), organisée par Kari Greve en Norvège, dans la belle ville de Bergen. Je n'ai hélas pas été en mesure d'y participer, en raison de mon engagement envers le projet de la base de données Khartasia, qui poursuit ses avancées à Paris. J'y ai passé deux semaines fascinantes, en compagnie de Claude Laroque, Agnieszka Helman-Wazny et des membres du CRC, Centre de Recherches sur les Collections du Muséum National d'Histoire Naturelle (MNHN), à étudier des échantillons de fibres libériennes préparés à partir de plantes papetières asiatiques traditionnellement utilisées pour la fabrication du papier que nous avait procurés du Jardin des plantes de Paris et de papiers chinois récents, soumis à un vieillissement artificiel. Ces échantillons nous ont permis d'observer et de décrire les fibres de liber du mûrier avant la préparation technique de la pâte et de comparer les fibres du mûrier telles qu'elles se présentent dans la plante et dans le papier. Au CRC, Nina Jethwa (Inde) a donné une intéressante conférence sur la production manuelle de papier de chiffon pur coton au Département Archives/ Fabrication manuelle du papier de l'Ashram Sri Aurobindo à Pondichérry. Je suis convaincue que le projet indien, dont elle décrit les objectifs dans l'article que nous faisons paraître dans ce numéro de notre périodique, saura retenir l'attention des lecteurs autant qu'il a retenu celle du public parisien.

Anna-Grethe Rischel

Making the Invisible Visible

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"Making the Invisible Visible" is the working title of an ongoing process between the photographer Roberto Fortuna and the artist Anne Vilsboell. The following is a short insight in the very beginning of their collaboration.

Working and studying handmade paper for more than three decades, constantly trying to experiment getting to know even more of handmade paper's hidden treasures, naturally led to search for a way in which a field of possible variation in the same thing previously invisible to the senses could come forward and be experienced.

What we see and observe do not tell the whole story. When we see a handmade paper, we are eventually capable of discovering a watermark by holding the paper up against light; we might see a filigree or a shadow watermark, wire lines and chain lines, but what about all other physical features inside the ark? After the renaissance in the 1950's of handmade paper as an artistic means of expression in USA a multitude of handmade paper variations have developed, very different from the former traditional mill productions. The inner invisible life of a handmade paper has exploded in a multitude of invisible fibrous web formations.

A deep wish to see whether it is possible to illustrate all the other physical features, other than the traditional ones of a handmade paper, made me contact the Royal Danish Academy of Fine Arts/ School of Conservation already in 1987. I wanted to have microscopic photos taken of my handmade papers in order to observe the fiber formations inside a given paper space. At that time I was obsessed by creating large, transparent paper wall installations and felt a need to get even more into the substance than I could observe, when just having a handmade sheet in front of me, even if it was held against light. Sheets of paper got high-lighted in 1µ, which illustrated how fibers were twirling and spiralling inside the handmade paper space.

** Photos: Roberto Fortuna, Text: Anne Vilsboell*

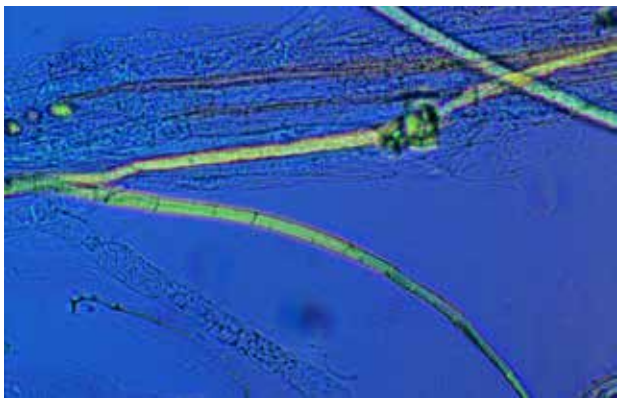

Fig.1 Handmade paper space enlarged 1µ

Always knowing that there was more inside there than just that, thousands of tests have been made with fluids that could pull forward the inner character of this fiber formation, treating paper with oils, wax and all kinds of binders, found on the market world-wide.

I wanted to get further - to seek the conjuncture of the visible and the invisible, - to obtain a level of illumination and to see further than one sees. I wanted to demonstrate that paper, both eternal and primitive, possesses a material imagination and its own inner hidden language. I wanted to try to show that there is a predicative logo that does not emerge into view before insight and abstraction. It does not emerge into view at all, but remains latent even in language and that just through its observed presence creates a poetic space. I wanted to show, how a sensible matter exists between the visible and the transparency of the essence.

In the nineties I worked with triptychs in order to illustrate a possible visible paper process through the actual artwork. The first part was a sprayed

Fig.2 Sitting in the Garden, 130 x 300cm, Collection Syddansk University

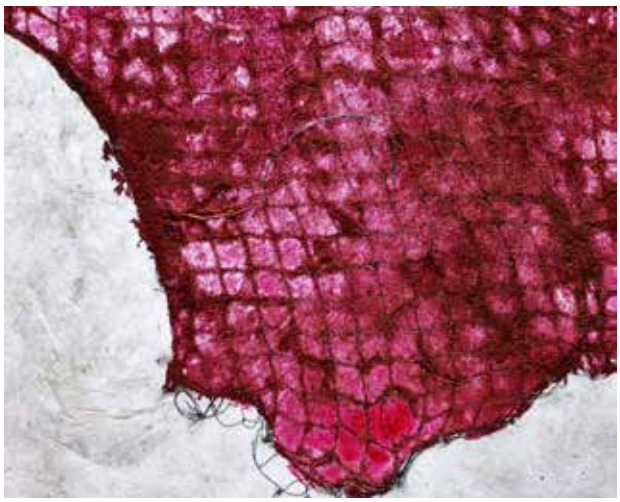

Fig.3a Illuminated handmade abaca paper with embossed nylon mesh

pulp space, the second part was a handmade paper with a line drawing in black pulp and a small space filled with pigments, and the third part was again handmade paper. This paper was built up by dyed handmade paper and layers of pigments, where the tactile quality of the surface was underlined with embossments. The different beating time of the fibers gives the surface of the painting a changing color scheme within the same color and vibrations, according to the way the paper absorbs the color. The triptych "Sitting in the Garden" was an attempt to show that paper has a language of its own, which can change indefinitely.
For a long time I have been thinking about building up walls with a variety of expressions of the invisible life of handmade paper.

In 2014 I contacted the paper conservator and president of IPH, Anna-Grethe Rischel that I have known since 1986. I asked if she could help with

Fig.3c Illuminated handmade abaca paper with painted area with pigments and binder

contacts to people that could take microscopic photos of the interaction between fibres and colored pigments in handmade paper. We met and had a wonderful enthusiastic conversation on paper, of course, and Anna- Grethe suggested that I contacted the professional photographer Roberto Fortuna, who works for and at the National Museum in Denmark. In August 2014 Roberto and I met at the National Museum in Brede.

Fig.3b Illuminated pulp drawing in handmade abaca paper

I brought several different test possibilities for Roberto, and after a long, interesting conversation he promised to give it a try with his magnificent photographic equipment to study the possibilities and examine, whether or not it was possible through his lenses to get closer to the matter. Roberto works with a Camera Hasselblad and digital Phase One back piece with 80 million pixel resolution, an extremely high resolution.

Roberto would start with the first tests, which partly included handmade paper that, among other things, had elements like mesh inside the paper and partly painted handmade paper.

We met again in October, where I brought more tests, and Roberto showed me the results of the first session. It was amazing to see, how the inner life of the paper was brought forward, but it also

Fig.4a Handmade daphne paper, colored daphne paper, wax

Fig.4b Daphne fiber, colored daphne daphne pulp, wax

Fig.5a Handmade linen paper with embossed linen threads

Fig.5b Illuminated handmade linen paper with linen threads

became evident that is was difficult to get through the painted areas in the paper. Roberto told me that he would like to keep on working with the project, and he showed me, how he works.
He illuminates the paper from behind, and/or from the sides, uses a faint visible surface light to get the texture of the paper into the photo as well as the invisible fibers inside the paper.

While I was present, Roberto began working on the second test group, and we discussed how we could develop the idea. We found that at first we had to concentrate on the unpainted handmade paper.
For our next meeting I brought many different handmade papers, made of grass, leaf and bast fibers, handmade papers, which was surface-treated with oil, wax , sized, surface glued and unglued, coloured and uncoloured and again one sample of a painting.
Roberto had now tests enough to work on for some months, and the last time that we met in August 2015, the whole natural inside world of handmade paper spaces had developed into illuminated dreamy forests, sea waves, caves and strange human like creatures – wonders.
Having Roberto's photos transferred to handmade paper will be the next step in order to see, whether or not the luminosity in the photographs will still stand out.

We aim at building up several walls with the actual handmade paper tests, the photo in itself and the transferred photo in unity. All three steps can take on a multitude of expression. It is a matter of choice. The more philosophically based theories behind this project will be developed further.
As my original intention is to capture pigments and fibers and their interaction, further steps will be to see, if we can succeed in highlighting the symbiosis of these two worlds: the world of fiber and the world of pigment. Until now we have been in the test phase for observing the possibilities. Now we know more, and we continue the process to build up an entire body of work, which eventually will be presented for interested observers… when we are ready.

Fig.6 Illuminated handmade, ironed daphne paper, wax, threads

Ole Bentsen and Norway's first paper mill

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Bentse Brug was the first paper mill in Norway, founded 1696 and located on the bank of the Aker River in the city then called Christiania, now Oslo. It was founded by Ole Bentsen – who gave the mill its name – and his business companion and investor Gerhard Treschow. The story of Bentse Brug is a story about big investments and much hard labor, about a pioneer founder with ideas and optimism and a frustrated investor – and unfortunately we cannot promise the reader a very happy ending.

Ole Bentsen

Ole Bentsen was born in 1653 and was son of a well-to-do saw mill owner. After the death of his father, he inherited in addition to vast woodlands also a saw mill and a flour mill by Øvre Vøyen waterfall in the Aker River in Christiania. Through the timber trade with Holland, he came in contact with Dutch paper makers, and started to nourish the idea of a Norwegian paper mill on his property by the Aker River. In 1684, Ole Bentsen undertook a 7 months journey to paper mills in Holland to befriend useful contacts and gather information and trade secrets – procured through solid bribes – from builders, merchants and paper makers. Upon his return to Norway, he immediately wrote an application to the Danish-Norwegian King Christian V for the royal privilege to found a Norwegian paper mill.

King Christian V's finances were exhausted after the 30 years' war, and he was eager to explore the economical possibilities offered by Norway's natural resources; in particular the power of its many waterfalls. In order to entice budding entrepreneurs, he promised 1683 in a decree that if a product could be manufactured domestically, the producer would be guaranteed monopoly by an embargo on any import of a similar product. Following this decree, Ole Bentsen would be guaranteed a monopoly on paper in Norway, if his paper mill turned out to be a success. After 1 ½ years, the king's reply finally arrived. Ole Bentsen was given the sole rights to found a paper mill, and he was also to be exempt from import toll on all products needed to build the mill. He was likewise exempt from all public taxes and tolls for the following 10 years. However, he did not receive a guarantee on a monopoly on paper in Norway – the king wanted to see the produced paper first and ascertain that it could match the quality of the paper produced in Denmark. The royal privileges he received on June 1st 1686 were valid for 15 years.

Ole Bentsen immediately started work on his paper mill. First, he had to dig out a canal from the river to the site of the future paper mill. Four men with spades were hired to do the job, and after 6 months of toiling, the canal was finished. The project was then delayed by a long-winded lawsuit with the neighbors concerning who had rights to the water. Another basic necessity, which further delayed the project and probably cost the entrepreneur many sleepless nights, was the construction of a road to the mill site, so that the building materials could be transported by horse carts. The road had to run through marsh land, and bridges also had to be constructed here and there along the way. A storage house for building materials and housing for the construction workers also had to be built next to the building site.
All this work cost a lot of money, and Bentsen's funds were running out. All the preparatory construction work had cost him 540 Riksdaler, which was a giant sum – and he also had other business branches that began to suffer from this drainage of finances. He had to put the building plans on ice for a while.
In 1693, with almost half the period for the royal privileges already gone – and still no paper mill in sight – Ole Bentsen realized that without a substantial amount of fresh capital he would never be able to finish the paper mill. He therefore accepted a previously declined offer from the wealthy investor Gerhard Treschow, and the two men became business partners.

Gerhard Treschow

Gerhard Treschow was born into a prosperous family of merchants from Stege on the Island of Moen in Denmark. He received a solid education and also studied abroad, at the University of Utrecht. In 1683 he was appointed customs officer in Christiania, and started investing in a wide range of upcoming businesses in Norway. He owned a brick manufacture business, several saw mills and he quickly also became one of the biggest ship owners in Christiania. Gerhard Treschow eventually was one of the wealthiest men in Christiania. The tax on wigs – a wig was a necessity for every man of a certain social standing - was a luxury

* *Published in Norwegian in Nordisk Pappershistorisk Tidskrift 1/ 2015, p. 3-5*

Fig. 1. Norway's first water mark, probably created by the first paper master at Bentse Brug; Pieter Gerritz Bleyleven, Bentse Brug 1695. The two partners' initials still decorate the water mark: Gerhard Treschow and Ole Bentsen. Illustration from Fiskaa 1973, p. 356

tax, and therefore gives an indication of the tax payer's wealth. Gerhard Treschow paid the highest wig tax of all the citizens of Christiania.

They made an odd couple; Ole Bentsen and Gerhard Treschow. One of them was a saw mill owner without any education to speak of, with many ideas and poor financial skills – the other was a highly educated and relatively sophisticated investor and civil servant. On the 7th of February 1694 the two of them signed a contract. Treschow was to pay for the remaining construction work on the paper mill with security in ownership of one half of the waterfall and one half of the property. Bentsen was to supervise the construction works and to engage the necessary experts to run the paper mill.

The most pressing was to get hold of an experienced paper master, who might teach the paper making skills to the Norwegian workers. Such a paper master must be procured from Holland, and Bentsen undertook a new journey to the paper makers in Zaandam in April 1694. He contracted the paper maker Peter Gerritz Bleyleven as the first paper master at Bentse Brug. However, the paper mill was not yet quite finished when Bleyleven arrived, and during the first weeks or even months in Christiania the paper maker found himself doing heavy construction work to get the mill ready. This might have put a damper on Bleyleven's work spirit, and in August 1695, Treschow sued him for "unwillingness, stubbornness and for even staying away from work". Bleyleven was relieved of his duties, and Bentsen yet again had to travel to Holland to find a replacement.

In the meantime, Treschow's dissatisfaction with the paper project grew and he became increasingly annoyed with both the project and his partner. So far, the mill had only brought him expenses, and the expenses had far exceeded his estimates. During his two years as partner, he had paid the exorbitant sum of 8.563 Riksdaler for the construction of the mill and the purchase of rags as raw material for the paper production. He now claimed more than half the ownership as compensation, and Bentsen was forced to part with a larger part of his property to satisfy Treschow. According to the new contract, signed by both parties in 1695, Treschow now owned 5/8 of the paper mill, half of Bentsen's flour mill and half the Vøyen waterfall. Treschow now emerged more and more as the dominating part in the partnership, whereas Bentsen seems to have become the junior partner.

On his third trip to Holland, Bentsen procured a new paper master: Claas Jantzen Lodewijk was contracted to start working in the paper mill on November 15th 1695 and work there for two years. The contract refers in several places to the Zaandam paper and its many excellent qualities, and Lodewijk was obliged to produce paper of the same high quality "as the one produced in Zaandam". Bentsen also contracted a Dutch paper coucher by the name of Cornelis Dircksz Hill.

Despite all the difficulties and obstacles they met with during the paper mill's first year, 300 reams of fine, white paper were exported to Denmark from Bentse Brug in 1695; mainly the result of Lodewijk and Hill's combined efforts towards the end of the year.

Fig. 2. Water mark from Bentse Brug 1698, probably by the paper master Claas Jansz Lodewijk. Gerhard Treschow's initials now stand alone. Illustration from Fiskaa 1973, p. 356

The end of the partnership

By 1696 the paper mill Bentse Brug was up and running, led by two competent Dutch paper makers, and the paper export was going increasingly well. The relationship between the two business partners Bentsen and Treschow, on the other hand, grew increasingly worse. Having procured the Dutch masters and secured the smooth running of the paper mill, Bentsen had made himself expendable. Treschow did not need him anymore.

Bentsen was now subjected to a series of harassment and humiliations initiated by Treschow. The two Dutchmen were instructed not to allow Bentsen access to the paper mill. Treschow also ordered the paper master to channel all water from the river to the paper mill, so that there would be too little water left to run Bentsen's flour mill next door. Without consulting Bentsen, Treschow hired six Norwegian workers to the mill. They were all trained by Hill and Lodewijk.
In 1697, poor Bentsen experienced the absolute humiliation, as Treschow reduced the former entrepreneur and founder to an inspector at the mill, paying him a monthly salary of 6 Riksdaler. As if that was not enough, he also demanded that there be held a foreclosure on Bentsen's flour mill and the waterfall, to make up for the money still owed him by Bentsen. Bentsen was now bankrupt and had lost everything. The paper mill, which had been his idea, and which he had constructed, equipped and procured the experts to run, was now a thriving business – but without him. Gerhard Treschow applied in 1696 for a royal privilege on paper production in Norway, which was granted him in 1698. He also received the privilege of a yearly toll free import of 30.000 pounds of rags, the rights to sell writing paper to the royal court (provided that the quality of paper could match the Danish produced paper), and 10 years of tax exemption.

The privileges given to Ole Bentsen in 1686 seem to have been forgotten or ignored. There is no mention of them. Treschow changed the name of the paper mill from "Bentse Brug" to "Upper Mill", to avoid any connotations to Ole Bentsen. This attempt at "damnatio memoriae" did however not succeed – the original name "Bentse Brug" stuck to the mill.

Rag troubles

Everybody running a paper mill in Norway until ca. 1860 encountered the same problems that Gerhard Treschow was now facing: The lack of raw material for the paper production. In 1700, Christiania was a city of about 5.000 inhabitants, the majority of which could not afford fine linen shirts or linen for their tables or their beds. Most Norwegians wore rough, homespun woolen clothing all year round, a material that was unfit for paper production. Copenhagen boasted 60.000 inhabitants, and the amount of linen among them was accordingly higher.
The solution to this problem was to import rags. We have already seen that the toll free import of rags was one of the privileges both Bentsen and Treschow obtained from Christian V. Even with this privilege it was no easy task to provide the amount of rags necessary for a constant run of the paper mill. This problem was not particular to Norway; all countries with paper manufacture experienced the lack of raw material as a big and increasingly crippling problem. The export of rags was accordingly taxed highly, and in some instances followed by punishment of the exporter. The rags imported by Gerhard Treschow, were gathered from other Norwegian cities as well as from abroad; especially from Hannover.

The production went well, and Bentse Brug exported paper to both England and Denmark (1.269 reams of paper to Denmark in 1697, and 123 reams of paper to Norwegian cities in the same year). Treschow asked the king to raise the import toll on paper, to force people to buy the paper from Bentse Brug and not any foreign produced paper. The import toll was henceforth doubled, and Treschow had to promise to keep a

consistently high quality and to use the Norwegian heraldic lion in his water marks.

Treschow before court

In 1713, Ole Bentsen sued his former business partner Treschow. He claimed compensation for his lost property, for the mill site and for all the hard work he had put into the construction of the paper mill. The case was brought to court two years later, and the verdict was in favor of Ole Bentsen on all points. Treschow was sentenced to pay Bentsen 2.500 Riksdaler. At this time, Norway was without a banking business, and the usual practice was to borrow from others. Everybody with business interests was indebted to other capitalists, and so the few wealthy families in Norway in the 17th and 18th century were all linked to each other by an intricate web of lending and borrowing. Treschow had his share of creditors, and seeing the results of the Bentsen court case, these creditors now all came forward with their claims. To meet his obligations, Treschow was forced to sell Bentse Brug to one of his creditors; the merchant Johan Jochum Lonicer. Lonicer paid out Treschow's debt to Ole Bentsen and the rest of the creditors and took over the paper mill.

Epilogue

The story of Ole Bentsen, Gerhard Treschow and the founding of the first Norwegian paper mill, ends here. But the story of Bentse Brug continues until 1898, when the paper factory was closed. Bentse Brug was for a long time a paragon in the paper industry, with owners that were constantly willing to modernize and develop the paper production. In 1838, the first paper machine in Norway – a Bryan Donkin-machine with a 7, 5 meter long running wire – was installed at Bentse Brug. Bentse Brug was also the first Norwegian paper producer to use wood pulp as raw material; thanks to the Danish engineer Waldemar Drewsen, who was hired to Bentse Brug in 1858. Drewsen built a small pulp mill – Christiania's first – next to the mill in 1863. This was discontinued after a few years, and the wood pulp was henceforth procured from Bjørsheim pulp mill. Drewsen bought three more paper machines for Bentse Brug. The paper factory (now called Drewsen & Son) produced paper for the newspaper industry, and was the largest and the most modern paper factory in Norway.

3. Bentse Brug ca. 1870. Unknown photographer

During the 1890's Bentse Brug was the first Norwegian paper factory to use sulfite cellulose. However, rags remained even through the later period the main constituent of all the paper ever produced at Bentse Brug.

Despite all modernizations, Bentse Brug was headed for closure. There were several reasons for this. The transport with horses and carts to and fro the factory, was undertaken on primitive and cumbersome roads along the Aker River, and there were as many as 30 horses trafficking this route every day. The factory's location on the river bank was restrictive to any improvements of the communication routes, and the water power from the increasingly polluted river did not meet the modern demands for increased power and efficiency. In 1898, Bentse Brug closed its doors after 203 years of paper production. Nothing remains of the old paper mill.

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Paper and the history of printing

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Gutenberg's printing method: The most important invention of the second millennium?

At the millennium shift some years ago, many comments and judgements of the finished millennium were made. One example: Which events and which persons had had the most profound historical effects during that millennium?
Among these assessments there was an evaluation of which *invention* in the millennium could be considered as having had the largest historical impact on the society. In the USA, several such evaluations concluded that the printing method, developed by Johann Gutenberg around 1450, was the most important invention. *Time Magazine, Life Magazine* and *Encyclopedia Britannica* made surveys with this conclusion.

Then, what was the essential content in Gutenberg's invention? When consulting encyclopedias, the main message one gets is that he developed a method for production of printing plates based on *the use of separate, cast metal types*.

If, however, one looks up on *"history of printing"* in Wikipedia, a main basis for information today, one will find well documented expert papers claiming that the main credit for the invention of printing should be given to the Chinese and the Koreans. That is the case both for the general concepts of printing, and for the use of separate, cast types (cf. [2], [3] and [4]). The Chinese produced printed documents 800 years before Gutenberg and applied separate types some 400 years before him. The Chinese contributions to the development of printing have been given increased attention during recent years, along with the generally raised interest and knowledge of the history of China.
So, could our celebration of Gutenberg's printing method just be based on misconceptions and a lack of historical knowledge, and thus being yet another example of the well-known European chauvinism?
All my life I have worked with paper; aspects like paper production and application technology; paper property requirements for various end uses etc. Although not being a professional historian, I have kept an interest in the fascinating history of paper, and been interested in the various end use areas of paper. I became interested in the development of the art of printing, which thus had a decisive historical effect of the millennium. In the following, I will present my comments and conclusions on the development of the art of printing.

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Methods and materials for writing and printing

A requirement for printing will be visible writing symbols. In the development of writing, the Mesopotamians were early pioneers with their cuneiform writing, wedge formed signs imprinted in moist clay, which were baked to bricks or tablets. Their symbols thus were topographical and without any interest as colored symbols. "Matrixes", however, made to produce series of cuneiform scriptures by being pressed onto samples of moist clay, has been found [5].

The Egyptians developed the hieroglyph symbols, which were carved or marked onto stone by colors. Papyrus was the basis for written documents in ancient Egypt. The surface of papyrus is hard and uneven, not suited for printing. I do not know of any attempts of printing in ancient Egypt.
The ancient, pre-colonial cultures in Central America had developed writing symbols that were painted onto various materials. These cultures collapsed before or during the European conquest. Although it is recorded that they made sort of "books" on a material resembling paper, there is, to my knowledge, no indication of printing in these cultures.
Then we have China, with an extremely long and continuous cultural history, less interrupted than in any other society. Their tradition of writing, being rich and varied, extends far back and will certainly be an essential element in any discussion of the history of printing.
Before a detailed analysis of printing, a clarification and limitation of the topic has to be made. Should any transfer of colored symbols by an inked tool, for instance a stamp, be considered as printing? Such activities are certainly related to printing; having a history extending very long back, and being known from a number of cultures. However, the amount of information contained in such stamped pattern

Fig. 1: Stamp from the Han-dynasty.

will typically be much less than commonly found in printed messages; often just a mark or signature. The transfer of colored patterns to textiles using carved matrixes is also related, but will normally not provide the kind of information typically given by printed texts.

By printing, I will in the following mean *the production of texts containing stories, statements or reasoning, using mechanical matrixes with topographic types in the surface.* (After about 1800, other printing methods have been developed. They have, however, no relevance in the present context). In China, "dragon bones" have been found, 5000 years' old pieces of horn or bone, having scratched or painted characters on the surface [6]. These ancient characters are often clearly related to the present ones; a fact that illustrates the continuous Chinese cultural tradition. Many Chinese characters actually got their final design 2000 years ago. They are, as is well known, not based on a phonetic modelling of the language. The characters were usually written applying water based inks, using soot as the black pigment, and a brush to draw the characters. The technique or rather, the art of drawing the characters, the *calligraphy*, early obtained a high, almost religious status in China, a situation that has remained ever since.

These strong formal conditions related to the writing methods, have acted as a conservative element for the ways of writing and for the design of the Chinese characters.

The substrate for writing in China changed over time. At an early phase, pieces of wood and later pieces of bamboo were used. Silk textiles were used as the substrate for high quality writing of prestigious texts. On silk, the ink penetrates into and through the material. One therefore did write only on one side of the material, a tradition that has been maintained up to this day.

The invention of paper – the ideal information material

It is commonly agreed that paper was invented in China during the Han dynasty which constituted the first great period of the country. It is now assumed that a sort of paper was made from hemp fibers from rags already around 100 B.C. However, the invention of paper is attributed to the person Ts'ai Lun, in the year A.D. 105. He developed a method of making paper from inner tree bark and hemp ends. These materials have long fibers, and the paper made from such raw materials will therefore be somewhat lumpy and uneven, however quite strong. Ts'ai Lun's paper was therefore rather thin, porous and soft, having a textile-like structure. Such paper resembles the more expensive silk, being suited for a continuation of the established writing technique for this material. (For a very comprehensive survey of the early production and use of paper, see [8]).

Paper quickly became the dominant writing substrate in China. During the Han dynasty, China had a strong development culturally and in the civil society, and established a considerable bureaucracy, using paper for the collection and distribution of information.
The documents were mainly kept as scrolls, as was the tradition even for papyrus in Egypt and later in Hellas and Rome during the classical period [9]. Books ("codex") represent a later development, mainly related to the format for the Bible in the early Christian period [10].

The development of printing plates in China and surrounding countries

In China the increasing use of paper-based documents in large numbers of copies created a demand for more effective production of the documents (during the Tang dynasty, about A.D. 600 - 900 the tax collecting authorities alone needed more than half a million sheets of paper annually [2]). The idea of producing the documents by some sort of printing, using carved matrixes (printing plates) and ink must

Fig. 2: Pagoda and printed magic text of Empress Shotoku, Japan, about AD 765

have been close at hand. As already mentioned, the Chinese had been using inked stamps for centuries, and therefore an expansion of the stamp into a sheet sized object must have seemed reasonable.

It is assumed that the Chinese around the year A.D. 500 started making prints based on carved wood matrixes. This is the so called block prints for effective printing of standardized texts or documents [3], [11]. The oldest printed texts that have been found are assumed to originate from about A.D. 750.

The art of paper making had spread to Japan in the 6th century, and about the year A.D. 765 the Empress Shotoku had "a million" Charms made with a magic text, intended to protect against a smallpox epidemic. The text copies were put into small pagodas, which were placed in temples around the entire country. Tradition claims that the empress herself developed the applied printing process, and a considerable number of the prints and pagodas are still existing (Fig.2).

Fig. 3: The oldest printed document with known printing date; Diamond Sutra, printed A.D. 868

The oldest document with known time of printing is an example of the Diamond Sutra, a classical Buddhist scripture. It was found 1908 at the Silk Road and is obviously made by a well-established technique according to its high quality. The print was made during the Tang dynasty in the period, when China reached its highest cultural level, compared to other nations. During the Tang dynasty, many printed products were made; cultural texts, bank notes, playing cards etc.

But all this printing was based on carved wood matrixes of whole pages, i.e. block prints. The large number of Chinese characters, each one having a rather complex design, made carving of the wood matrixes quite demanding and complex.

The invention of single printing types

In 1010 the Chinese Pi Sheng made single and separate topographical Chinese characters that could be used for producing a printed text, and later used anew to form another text, i.e. a technique similar to that later used by Johann Gutenberg [3], [11].

Pi Sheng formed his types from clay that subsequently was burned to ceramic. The printing was started by having an iron plate on which a layer of wax and resin was placed. The text was then constructed by the separate character types on the plate. By heating the plate, the wax/resin melted and the types were fixed at the subsequent cooling. The types were evened to a flat surface by putting a flat plate on top of the character types, thus suited to give a regular printing surface. After the printing has taken place, rewarming of the plate would loosen the types, making them ready for use in a new print [12].

The ceramic types were brittle and thus easily damaged. They were also poorly wetted by the water based inks. Therefore Pi Sheng's single character types did not receive any general acceptance. Instead carving of single characters in hardwood was started. Printing using separate character types, however, never became a dominant technique in China.

Separate types of characters made from metal were first developed in Korea [2]. Around 1200 the Goryeo- dynasty ruled in Korea (giving name to the country), and was characterized by a strong cultural activity. The dynasty established Buddhism as the state's religion, and was eager to protect and strengthen its position. However, under the reign of Djengis Khan the Mongols invaded China and threatened even Korea at this time. To protect and conserve the Buddhism an extensive work was

started to spread its classical scriptures [2]. In the year 1234 there are reports of printing with the use of single metal types. Models of the characters were carved in wood and used to form sand moulds, in which bronze types were cast. In the period 1236 – 1252 a complete set of the classical scriptures of Buddhism were printed, an immense job requiring 80.000 printing plates. These were, however, block prints carved in wood, and the whole collection is still stored in the Hain monastery in Korea.

It is important to be aware that there was never a general transfer in China to the use of separate types for printing. There are several reasons for this fact. The large number of very complex characters in itself will reduce the benefit of using single types. Another point is that the printers were very concerned about the correct reproduction of texts. This will be easier to secure by whole, carved pages than by pages made from single types with a larger risk for errors. Most printed Chinese texts were therefore made as block prints from whole, carved wooden plates, even after single type printing had been introduced. In this context, it is important to be aware that most printed texts in China were made for the authorities, unlike Europe where non – governmental instances often wanted to make prints.

Fig. 4: Printer tightening the press during printing according to the Gutenberg method

The procedure steps in the traditional Chinese/ Korean printing were mainly the following ones, starting from a printing plate that in most instances was a carved wooden block:

Firstly, the printing ink was added to the type surfaces of the printing plate. Immediately after that, the paper sheet was carefully laid onto the inked plate. To ensure effective contact and thus transfer the ink to paper [3], the top side of the sheet was then carefully rubbed by a soft brush. This completed the print. For such a method the paper has to be soft, flexible and absorbent, as the textile-like Chinese paper actually was for producing an effective ink transfer and thus a quality print. The ink penetrates into, and partly through the paper, limiting the possible print to one side.

The development and use of texts and books in early European history

Alexander the Great conquered Egypt in 332 B.C. and the city Alexandria became the center of Hellenistic culture. The basis for writing in the classical period in Greece and Rome was mainly papyrus. The writing was by hand, and there is no indication of any attempt of printing. Papyrus cannot be folded, and was therefore stored as scrolls, similar to the Chinese texts on paper [8], [9].

From ancient times, animal hides have been used as an alternative basis for drawing and writing. Around the year 175 B.C. an improved quality grade was developed in Pergamon, in present Turkey (today named Bergama). The material, termed *parchment*, became a serious competitor to papyrus. The quality of parchment was superior to the papyrus, the costs, however, were higher. Parchment is an opaque and relatively stiff material. Writing on it was done with a quill, and the opaque material allowed writing on both sides.

The Chinese always tried to keep their paper making skill as a secret to foreigners and were successful in doing this until they lost in a battle against an Arab army in 751 at Talas during the Muslim expansion. Here some Chinese papermakers were taken prisoners, and the Muslims started right away a paper production, based, however, on rag fibre materials only, and introduced several improvements to the production process [8]. I have not seen any reports indicating printing in the Muslim world. Following the Arab conquest of Egypt, paper production started there as well; the production of papyrus came to an

end and the technique was even totally forgotten. In the continuous fights during the following centuries between Christianity and Islam, there was a strong animosity in Europe against everything that could be associated with Islam, including paper. In Europe parchment therefore became the dominant applied substrate in the following centuries for written documents. More than 500 years therefore elapsed, before paper was accepted in Europe and came into common use there.

The binding of parchment, occasionally even of papyrus, into books (codex) instead of scrolls started during the period after the birth of Christ [10]. The Christians presented their holy scriptures as books from the first establishment of the Church. It was apparently a way to distance themselves from the Jews who always kept their Toras in the shape of scrolls. Text on both sides of the sheet feels natural in books. Books are, as we know them, a unique European invention, and indeed a more reader friendly design than scrolls, especially if one wants to shift between readings in different locations.

During the Middle Ages Europe expanded rapidly, economically as well as culturally [12]. The Church, however, was split and in a crisis. International commerce expanded, and especially in Italy and Germany mighty city states developed. The trade required correspondence and accounting, causing reading and writing skills to become more common. Paper started to be more accepted, especially in secular, commercial contexts from about 1200. Paper production had started in Spain by the Muslims and on Sicily. Paper was much cheaper than parchment. Paper therefore replaced the stiff, opaque and quite dense parchment in Europe. It is thus quite natural that the European paper had to be of a denser, thicker and stiffer quality than the traditional Chinese paper. To carry letters on both sides the ink could not be allowed to penetrate into the paper and through the paper. This was achieved by soaking the paper into a gelatin solution that resulted in a dense paper with a hard surface.

The production in Europe of books increased and was made by copying by hand. Such books became expensive, and errors and miscopying was common. From around 1300 one finds some use of block printed books in Europe, based on the use of carved wooden matrixes. The applied method appears to be very similar to the ancient Chinese, and although no such connection is known, it appears likely that the Chinese technique somehow has been transferred to Europe. The quality, however, of the European block books was low and poorer than the Chinese books, a fact that can be related to the difference in the paper material applied. The stiff European material did not get sufficient contact with the inked matrix during the printing process, causing the ink transfer to the paper to be insufficient.

Fig. 5: For building the words for printing by single types, Gutenberg had "set boxes" with small compartments for each letter. (Observe that all have equal lengths). He designed a spring loaded bevel to build lines of the letter types, all having equal lengths, ensuring that all types had surfaces in the same plane.

After the end of the 14th century, the demand for more efficient book production became more and more urgent. The Renaissance was underway and new ideas were launched [13]. The Church experienced strong internal tensions. Critics tried to argue and publish their views, while the leadership in the Church did their outmost to stop this by controlling the edition of books, confiscating those that they considered containing heretic messages. The main part of the book productions was still done by copying by hand. Production of books by printing was an idea close at hand and a well-considered technique. Inventors in several European countries did their outmost to develop an acceptable printing process. Thus the time was more than ready; but the results of the printing attempts were unsatisfactory.

Johann Gutenberg's process

Johann Gutenberg worked during his entire life with the printing process [14]. Very few details are, however, known about his work and hardly anything is documented. The main explanation for this is the secrecy that he for commercial reasons had to maintain. This is illustrated by his frequent involvements in legal disputes. But the important

point is that he worked out effective solutions for each of the various process steps that his printing process required. And the result was proven by the print quality of the Gutenberg Bible from 1455. Its print quality established a completely new standard for printing. To sum up, one may conclude that he delivered an almost perfect printing process that immediately was generally accepted, and that was maintained almost unaltered for 300 years.

To understand his work, it is therefore important to acknowledge that Gutenberg contributed to the printing process in several quite different and critical fields:

1. *He developed a printing process suited for the stiff and dense European paper*
2. *He used wine presses to establish the required print pressure to ensure that all letters were well copied on the stiff and hard European paper*
3. *He developed effective production methods for manufacturing of single letters types of even very small letters*
4. *He designed an optimal alloy of lead, tin and antimony for the casting of types*
5. *He made the individual types with a standardized length, ensuring that all letter surfaces lay in one plane*
6. *He changed the applied printing ink from being water based to oil based colors*
7. *He invented a speedy and simple method for building words and lines from loose types, filling in with small pieces between the words in order to produce lines of equal lengths*
8. *His printing method was suited for printing on both sides of the sheet*
9. *His printing method allowed a high speed and production efficiency*

We may look at each of these process elements developed by Gutenberg, while comparing them to the Chinese alternatives.

1. The adjustment of the printing method to the paper properties

China/Korea

The traditional Chinese paper was thin, porous and somewhat transparent, however soft, textile-like and quite strong, well suited as a writing base using a brush and water color ink. Writing/printing always on one side only, as the water based ink will penetrate such paper. In the printing process, the paper is laid onto an inked printing matrix, with a subsequent careful treatment with a soft brush on top, to ensure efficient contact of the paper to the matrix, and thus satisfactory ink transfer from all inked characters. Both the ink absorption into the paper and the brush treatment excluded printing on the other side of the paper.

Fig. 6: Gutenberg's printing: In front we see printers inking the plate, operating the press and piling up printed sheets. Behind, one sees setters who build print matrixes by single letter types from the set-boxes.

Gutenberg:

The European paper that Gutenberg had at hand was dense, stiff and opaque, suited as a writing base for quills (the tradition from parchment). The paper had usually been dipped into a gelatin solution during production in order to achieve a structure that prevented the ink from penetrating the paper. The stiffness of such paper reduced the contact efficiency with the printing plate, if laid loose onto it, in line with the Chinese tradition. A completely modified technique was required. Gutenberg achieved this by developing a very sturdy metal printing plate of extremely uniform heights of the types, and by pressing the printing plate against the paper with an extremely high load. The ink did not penetrate deep into the paper structure, and therefore allowed printing on both sides of the sheet.

2. The use of a press in printing

China/Korea:
Efficient ink transfer to the soft and absorbent Chinese paper was achieved just by laying the paper onto the printing plate, combined with a soft brushing on the top side, without the need for an extra press load.

Gutenberg:
Satisfactory ink transfer from the printing plate to the hard and stiff European paper required that every type had to be pressed somewhat into the paper surface. This required a load of several kg for each letter, and combined a load of several tons to print a page. Gutenberg achieved this by laying the inked printing plate and the paper into a press that was developed to extract the juice of wine grapes, and tighten it. Such presses for wine and olive oil pressing were not known in China. (The wooden matrixes used for block printing did not stand the required pressure load in such presses, and were crushed).
The importance of this point can be illustrated by the fact that the process itself was – and still is - termed "pressing" in Germany and Scandinavia, and not "printing". And even in English we talk about *"printing press"*.

3. The casting of single letter types:

China/Korea:
In the most common method, the character was carved in hardwood. The carved characters were then used for making moulds in casting sand, which was then used to cast a type in metal (bronze, lead, tin). The method was cumbersome and the accuracy in shape and thickness was hard to control in sufficient detail.

Gutenberg:
He first made rods of steel with a model of the letter sign in its end [14]. Here, Gutenberg had proper experience, as he early in his carrier had worked as medal engraver, and sold medallions. Using these steel rods he hammered the shape of the letter type into pieces of softer metal (cupper). These formed voids were then used as moulds to cast letter types by easily melting metal alloys. By such a steel rod a large number of cupper forms could be made, and one cupper form could be used to cast a large number of letter types (3.000 letter types per day could be made by a clever craftsman [14]. This letter type production method may have been the most important one among Gutenberg's contributions to printing.
The method gave single rods of fixed rectangular shape, standardized length, and the letter type at the end of each rod. In the casting, the width of the single rods could be varied, depending on the width of the letter – *m* and *w* could be made wider than *l* and *i*.

As the single letter rods were of standardized length, it was easy to form a printing plate with all types being in the same plane, an important point for obtaining that all letters should come in proper and even contact with the paper surface.

4.The metal in the letter types

China/Korea:
The most commonly used metals were lead, tin or bronze.

Gutenberg:
He used alloys of lead, bronze and antimony. Lead has a low melting point, known from ancient times. Tin also has a low melting point and gives the melted alloy lower viscosity and faster cooling and solidifying. Antimony increases the hardness and wear resistance.

5. The evening of the letter type surfaces on the printing plate

China/Korea:
The soft Chinese paper gave satisfying contact with the printing plate, even when the top surfaces of the loose letter types did not lie in one level.

Gutenberg:
As each letter type had to be pressed somewhat into the paper during printing for proper ink transfer, Gutenberg faced an extreme requirement for even position of the type surfaces. His method of casting the types on the ends of rods of standardized length, as well as his mounting method for assembling the letters, allowed a perfect positioning.

6.The printing ink

China/Korea:
The old and strict rules for the Chinese calligraphy even set the standard for printed texts: Water based ink, using soot as pigment, was used also for printing.

Gutenberg:
The metal types were not well wetted by water. Gutenberg therefore switched to oil based inks. Such inks were well known from artist painters.

7.The building of the printing plates (the matrixes)

China/Korea:
The metal letter types were arranged for the planned text, and put alongside each other on a metal plate, where a mixture of resin and wax was laid. Upon heating, the resin and wax will melt and during a subsequent cooling, the types will be fixed and ready for printing. After finished printing, the plate may be heated to loosen the types, which then are ready for another text.

Gutenberg:
Gutenberg designed a spring loaded, adjustable bevel for a speedy setting of the letter types. Here, the cast types, of standardized length and cross sectional form, were put alongside each other, to form a complete line of text. Full and uniform line lengths were achieved by putting small metal pieces in between the words. (In hand copying of books there is no similar possibility for achieving uniform line lengths and thus uniform column widths. The technique provides a very speedy and effective building of lines).

8. Printing on both sides of the paper sheet

China/Korea:
The Chinese paper was thin, porous and partly transparent, and the water based inks that were used in printing, penetrated into and throughout the paper. It therefore was impossible to print on both sides of the paper.

Gutenberg:
The European paper was stiffer, denser, opaque and less porous. The ink stayed on the surface without penetrating the paper, which therefore could be printed on both sides.

9. Efficiency of the printing process

China/Korea:
The Chinese printing method appears reasonably efficient, but is quite laborious, and the number of copies from a given set-up limited.

Fig. 7: Johann Gutenberg

Gutenberg:
The Gutenberg's printing method had several advantages that contributed to effective production of large number of copies. The letter types were small, allowing quite dense texts. They were wear resistant, allowing many re-uses. The number of copies printed per time unit, exceeded that of the Chinese paper

The result of Johann Gutenberg's development work

The intention of this paper has been to explain that the main contribution to the art of printing by Johann Gutenberg was not that he just developed a method to efficiently producing single letter types for printing, but rather that he developed a high quality and efficient printing *process*, consisting of several new process steps that easily could be learnt and exploited.

The printing of Gutenberg's famous Bible, in some 180 copies, was finished 1455. Its print quality was almost perfect. The deeply felt European problem of high quality and efficient printing was therefore solved. This fact is illustrated by the dramatic expansion of the Gutenberg's printing process that one witnessed in the following years, and that the method remained almost unchanged for the following 300 years.

Fig. 8: A page of the 1455 Gutenberg Bible. The print is almost perfect, with small although clear letters, well-shaped lines and columns. After printing, the page has been hand decorated with figures and colors.

In the 45 years up to 1500, more than 30.000 book titles were published in Europe, with a total of 12 – 20 million copies. It is claimed that the number of books in Europe increased by a factor of more than 100 within these less than 50 years.

And the book publishing expanded even more after 1500. People with new ideas could spread their views to the public across borders; the level of knowledge was raised. The so called Enlightening period started about 1600 and changed profoundly the views on history and society at large. This development could not have happened without the efficient spreading of information that the printing technology made possible. During the past 500 years the printing process has had a decisive importance for the world history. The conclusion that Gutenberg's printing method was the millennium's most important invention is thus very well motivated.

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Preservation in the Tropics: Preventive Conservation and the Search for Sustainable ISO Conservation Material

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This article touches upon the unfolding programme of preventive conservation in a small ashram situated on the coast of the Bay of Bengal, in the south of India. The story of archival conservation at Sri Aurobindo Ashram joins the multitude of worldwide efforts to preserve humanity's cultural heritage.

Fig.1 – Sri Aurobindo, circa 1912.

The life and works of Sri Aurobindo (1872-1950) and the Mother (1878-1973) span a tumultuous period in world history. Embodying an intense spiritual knowledge, their works formed a bedrock of hope for humanity in a century convulsed by war, nationalism and the struggle for de-colonisation.
No less relevant today is the voice of a spiritual certitude reaffirming our divine destiny.

The soul in man is greater than his fate.
Sri Aurobindo, *Savitri, p.691*

Over a period of sixty years, Sri Aurobindo produced tens of thousands of pages of yogic philosophy,

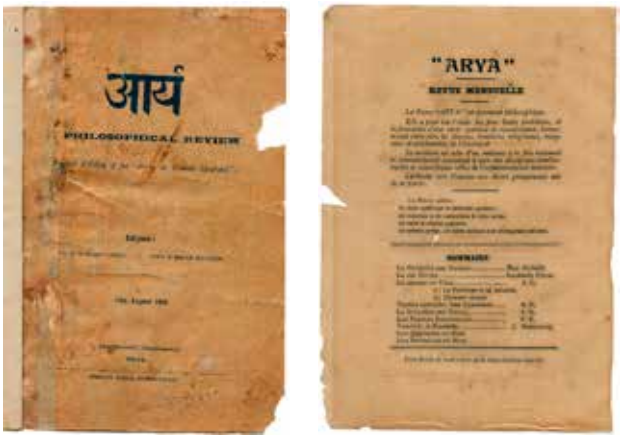


Fig. 2 Published in English and French, the first issue of Arya appeared on the 15th August 1914. It was a beacon of light during the outbreak of the first World War.

poetry, exegesis, essays, criticism, translations, letters and notes written in English, Bengali and other languages. Combined with the eloquent literary writings of the Mother, born Blanche Rachel Mirra Alfassa in Paris, and a historical library of documents and manuscripts relating to life in Sri Aurobindo Ashram, the total quantum of paper-based material in the Ashram's care exceeds 100,000 manuscript pages.
A major portion of the 75,000 manuscript pages from Sri Aurobindo's literary years are connected with his revision of works first published in the monthly philosophical review, *Arya*. The *Arya* was Sri Aurobindo's message to humanity and it comprised some of his most important works. It could be said that *The Life Divine*, *The Synthesis of Yoga*, *The Secret of the Veda*, *Essays on the Gita* and other works that appeared in the *Arya* are among the most original and profound philosophical writings of the 20th century.
With the majority of manuscripts written in iron gall ink and on machine-made paper of high lignin content, the manuscripts of the *Arya* revision exhibit many of the characteristics associated with iron gall

Fig.3 Exercise book from the local market used by Sri Aurobindo for work connected with the Arya.
16 cm x19.8 cm, ruled laid paper, watermark 'Deer Brand'.

**Article based on a talk at La Centre de Recherche sur La Conservation des Collections, Paris, in June 2015.*

Fig. 4 Manuscript dated 1914 illustrating iron gall ink degradation.

ink degradation such as transference, bleed-through, acid burn, sinking of ink and haloing. Foxing, fungus and brittleness are also inherent in the acidic, short-fibred sheets.

The manuscripts of the *Arya* along with much of the collection, present a considerable preservation challenge in Pondicherry's intense tropical climate where daytime temperatures exceed 30 degrees Celsius throughout the year and relative humidity fluctuates between 60% and 85% in the driest of seasons. The Coromandal coast lends itself perfectly to every conceivable mechanism of natural accelerated aging. With proximity to the ocean, intense sunlight, hot, sticky, salty air, high humidity and a plethora of fungi, microbes, insects

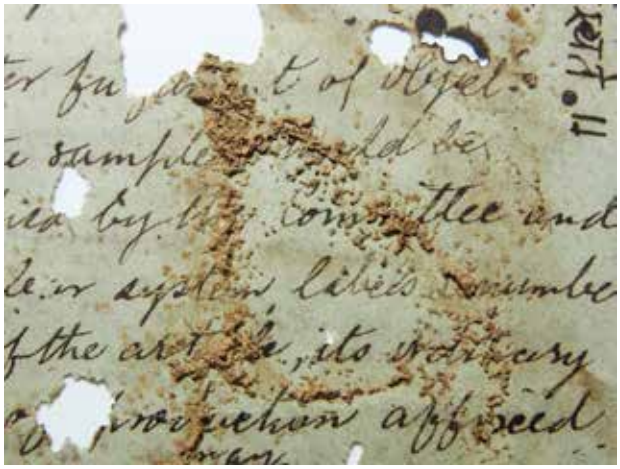


Fig.5 Illustration of a damaged manuscript partially destroyed by termites.

Fig.6 Dis-bound exercise book interleafed with buffered tissue and housed in protective cotton rag folders produced at Sri Aurobindo Handmade Paper mill.

and reptiles that would delight the Darwinian mind, Pondicherry could certainly be described as one of Nature's accelerated aging chambers. In a tropical region where buildings and materials are constantly exposed to the intensities of Nature, the conservation challenge can be trying.

Archival conservation in Sri Aurobindo Ashram has grown organically with the primary aim of preserving with utmost care and love the precious writings of Sri Aurobindo and the Mother.

As early as the 1950's, disciples tried to repair some of Sri Aurobindo's manuscripts using acidic backing paper and glue, sticky tape and protective plastic pouches. Though a commendable beginning, neither effort was quite successful and was discontinued. Perhaps in hindsight this may have been fortuitous as degraded acidic lining from old repairs and melted plastics are among today's more difficult conservation issues.

The appearance of early plastics in the local market provided convenient protection against dust and insects and a means to segregate and transport document bundles. The consequence of long-term storage within these enclosures, and the accelerated aging mechanisms of nitrocellulose plasticisers, could hardly be envisaged at the time. But today we

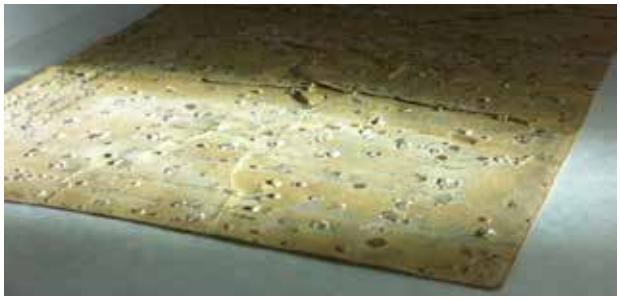
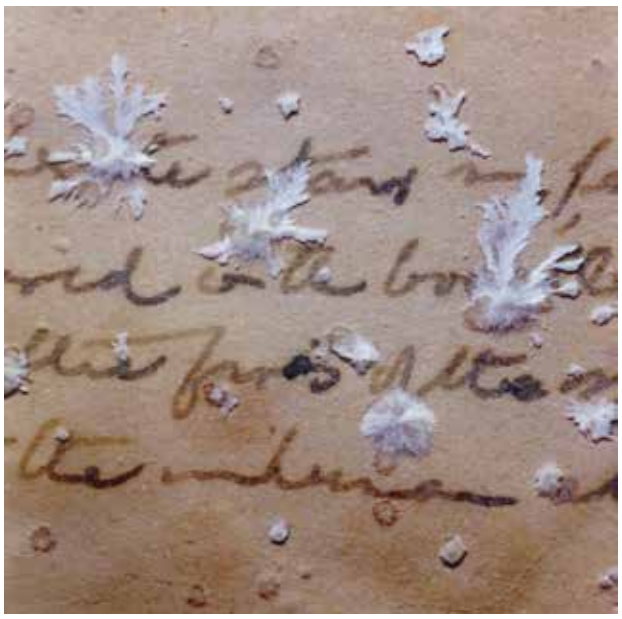


Fig.7 Manuscript, dated 1935. Damage caused by a degraded plastic enclosure.



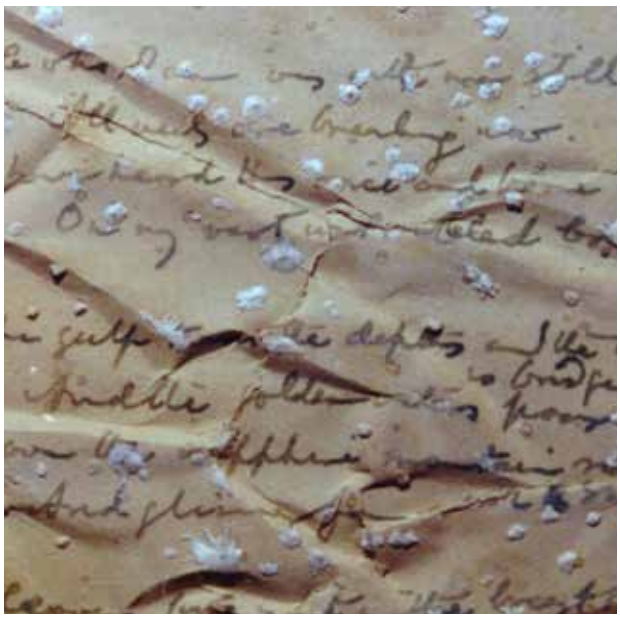


Fig. 8 and 9 Photographic images illustrating crystalline deposits of cellulose nitrate. Sublimation of camphor in nitrocellulose plasticisers is known to induce cellulose nitrate crystallisation causing plastics to become brittle and distorted. [1, 2]

find extraordinary cases of damage and distortion caused by the degradation of early plastics, catalysed by the high temperature and moisture levels of the tropics.

In the early 1970's concerted efforts were again taken up to consolidate, organise and preserve the collection. The condition of the manuscripts was seen to be fast deteriorating. In addition to prolonged exposure to the elements, extensive handling during the publication of Sri Aurobindo's Complete Works had also taken its toll on the fragile documents.

Following fumigation and careful cleaning, the first priority was reproduction, and work began to systematically microfilm every page. With financial assistance, a camera and microfilm reader were procured from abroad and the task of microfilming undertaken with care and dedication by members of the Ashram. Air-conditioning was a far-off dream, so a sterile environment out of the question. Instead, man and nature worked together. 100ft microfilm rolls were manually processed in a clean little dark room and then hung to dry from wall to wall across the serene but sultry colonial rooms of No 3 Rue Dupleix. Although the process could not be deemed archival, the results by grace were reasonably good.

With little access to current literature or learning aids, the art of paper conservation was still little understood. By the 1970's the conservation technique of cellulose acetate lamination had reached India and though drawbacks of the well intentioned treatment were not fully understood at the time, particularly for acidic, untreated manuscripts in a tropical climate, lamination set itself in full swing.

Eager to gain some practical training, two young members of the ashram archives attended a conservation workshop at the Nehru Memorial Museum and Library, New Delhi, where a brief exposure was given to conservation methods at the National Archives. Demonstrations were given on the stabilisation of paper manuscripts by aqueous deacidification followed by cellulose acetate lamination.

On return to Pondicherry the young members set about procuring the necessary material to laminate the manuscripts. However, after an encouraging start, the procedure was soon felt to be far too invasive. Following a very brief but immensely valuable exchange with the British Library, the preservation programme promptly turned away

Fig.10 Laminated manuscript showing signs of warping and discolouration.

Fig.11 20HP Hollander beater pulping virgin bleached white cotton hosiery waste trims procured from the South Indian textile industry.

from lamination to preventive care with a policy of minimal intervention.

Following the experienced advice to simply house and store the documents in a clean, controlled environment as best could be maintained, work of a new kind began. An old fruit store room was converted into a dedicated cool storage space where the manuscripts could be protected from the harsh climatic variations. An air conditioner and dehumidifier were installed at considerable cost and the manuscripts carefully cleaned and housed in folders and storage boxes, made from acid-free cotton rag paper produced at the ashram's handmade paper mill.

Today, the manuscripts of Sri Aurobindo and the Mother along with many other documents of historical importance are maintained in a custom-built cold storage vault, within a controlled environment regulated by an HVAC system designed in-house and built in the ashram's engineering workshop. The temperature of the chamber reads a steady 19-19.5 degrees Celsius with an average relative humidity 50%. The system has been designed to operate at lower temperatures for long-term storage of the manuscripts on completion of the re-housing programme.

The availability of archival quality conservation material in India remains limited. Where certified, imported archival storage materials are available, the cost far exceeds the budget of the country's myriad small archives, libraries and private collectors. Moreover, conservation material designed for document storage facilities in the northern hemisphere fail to withstand the rigors of the Indian climate.

A tradition of hand papermaking in India has bridged this gap admirably over the years, providing an indigenous and sustainable solution for the creation of protective microclimates for artefacts, though quality standards are still a fair distance from the ideal.

Permissible levels of any element deemed to be an impurity in conservation housing material must necessarily be strictly monitored where the safeguard of cultural heritage is concerned. Archival paper enclosures containing, for example, trace residual bleach, optical brighteners, transition metals, mould spores, bacteria and dust from a rural production process may very well trigger and accelerate degradation processes in the artefacts they were intended to protect.

The issue is challenging and cannot easily be resolved, but a growing awareness and knowledge of environmental mechanisms and inherent stresses affecting collections can help to formulate a way forward. The experience of the papermaker and the knowledge of the conservator and the conservation scientist culminate in a comprehensive understanding of the preservation issues at hand and the means by which they could be overcome. Archival conservation in Sri Aurobindo Ashram strives in this direction, committed to the preservation of cultural heritage.

Perfection is not a summit, it is not an extreme. There is no extreme: whatsoever you do, there is always the possibility of something better and exactly this possibility is the very meaning of progress

- The Mother

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Fig.12 A phase box cut from 200lbs cotton rag board alkaline sized and buffered with precipitated calcium carbonate.

Meetings, conferences, seminars, courses and events

June 2015
Peter Bower, United Kingdom, Paola Munafò, Italy and Anna-Grethe Rischel, Denmark, have been appointed Honorary Members of ISTOCARTA, the Fondazione Gianfranco Fedrigoni, Istituto Europeo di Storia della Carta e delle Scienze Cartarie (Gianfranco Fedrigoni Foundation: the European Institute of the History of Paper and Paper Science, Italy)

October 2. – 3. 2015
„Rencontres papetières en Vendômois“ (Vendôme area paperhistory meeting)
www.afhepp.org

October 2. – 4. 2015
26th Annual Conference 2015, Winchester Royal Hotel, Winchester www.baph.org.uk

October 12. – 16. 2015
XIII IADA Congress, Berlin 2015, Staatsbibliothek zu Berlin
www.iada-home.org

October 31. November 1. 2015
SPH Jahrestagung in Einsiedeln
www.papierhistoriker.ch

April 13. – 15, 2016
16th international seminar on the care and conservation of manuscripts in Copenhagen
http://nfi.ku.dk/cc

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