

Unveiling the World's First Metal-Type-Printed Book: The Song of Enlightenment, 1239

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Abstract

Six very similar versions of *The Song of Enlightenment* (南明泉和尚頌證道歌), printed between the 13th and the 16th centuries, with a postscript by Choi Yi (崔怡, 1166 ~ 1249) dated September 1239, had been accepted by Korean historians and Korea Heritage Service as woodblock-printed documents with a theory that (i) four out of six versions were woodblock-printed from the 13th to the 15th century using identical woodblocks duplicated from a metal-type-printed version and (ii) the other two versions were also printed using woodblocks duplicated in the 16th century. This paper presents how photographic images of all six versions were compared and analyzed by using digital forensic investigation method to determine their printing techniques and printing sequence. We have determined that the one particular version, Gongin version: 空印本, is very likely the original metal-type-printed version printed in 1239 —138 years before Jikji (直指), printed in 1377 and 216 years before Johannes Gutenberg's 42-Line Bible printed in 1455, both registered in the UNESCO Memory of the World Programme in 2001. We present the Gongin version of *The Song of Enlightenment* as the world's oldest extant metal-type-printed book with additional evidence in need of immediate attention and that the history of early printing must be revised with the birth of the world's first metal-type-printed Buddhist text in 1239.

Keywords

The Song of Enlightenment, Buddhist Text, Metal Type Printing, Woodblock Printing, Image Analysis

1. Introduction

In 2001 the UNESCO Memory of the World Programme acknowledged and registered Jikji (직지, 直指) as the world's oldest metal-type printed book in Korea in 1377, printed 78 years before Johannes Gutenberg's 42-Line Bible printed in 1455. Most Westerners learned and still say the earliest metal-type printed book is the 42-line Gutenberg Bible. If you are from East Asia, though, you may think of Jikji. How and when did moveable type first come about? What is the whole story about metal type printing technology development and the first use for printing books? That is the question the authors will pursue.

Thomas Francis Carter, an American scholar on printing history, opened his book, *The Invention of Printing in China and Its Spread Westward* (1925), by noting that "Four great inventions, that spread through Europe at the beginning of the Renaissance, had a large share in creating the modern world. Paper and printing paved the way for the religious reformation and made possible popular education." According to Carter, the other two inventions were gun power, which caused the fall of the feudal system, and the compass which led to the discovery of America [1]. Earlier in 1876, Theodore Low De Vinne, an American commercial printer and a leading scholar on typography, had written that "Typography had to wait for the invention of paper, the only material that is mechanically adapted for printing," as well as the suitable ink, unlike the old "mixtures, which are more like liquid shoe blacking than writing fluid ... used by the scribes of the dark ages," which he considered "unsuitable ink" for printing [2]. Giving credits to Jules Klaproth (1834), Stanislas Julien (1847), Sir Ernest Satow (1882), and Hermann Hülle (1923) on their introductory citations of the works of Chinese and Koreans in the

early development of typography, Carter highlighted the critical role the Far East played in the development of early printing in the West [1].

Referring to further "evidence that... metal type was in use in Korea during the period 1232-1241," Carter speculated the beginning of "a new era in the history of printing" in the 1400s when "a very perfect phonetic alphabet" was devised in Korea under "the great literary" King Sejong who reigned in 1419-1450, facilitating the use of metal-type printing technology. He also wrote, "The first mention of a type foundry is in 1392, the very year the new dynasty, the Joseon (조선, 朝鮮) dynasty, was started" and the Department of Books was established, according to the Korean annals [1]. Historian Pow-Key Sohn noted that "Printing with movable type in Korea was developed at least two centuries earlier than in the West" in his paper, "Early Korean Printing," which he delivered at the Colloquium Orientologicum, Berkeley, CA, in 1956 [3]. With the invention of appropriate paper, ink, and movable metal type, the world history of movable type printing was enabled with Korea playing a pivotal role.

The above question, "What is the earliest book printed from cast-metal movable type?" is the catchphrase for a collaborative research project called "From Jikji to Gutenberg", involving over 30 scholars living in 13 different time zones, to investigate the technological evidence related to the invention of book printing and what appears to be independent developments that lead to thriving print cultures in Eastern Asia and Western Europe. The project will produce a catalog of scholarly essays to be published and an international exhibit to be held simultaneously in 44 research libraries around the world. This cooperative transnational exhibit will commemorate the 650th anniversary of the printing of Jikji in July 2027 [4].

The authors of this paper are reporting that the six versions of *Nammyeong Cheon Hwasangsong Jeungdoga* (南明泉和尚頌證道歌, "Hymn of Monk Cheon in Homage to the Buddha" or "The Song of Enlightenment"), all with a postscript dated 1239, were printed using different templates. One version, in particular, exhibits a very strong possibility of being the world's oldest metal-type-printed version, printed in 1239, 138 years before Jikji's printing date of 1377 [5-13]. In this paper, the birth of the world's first metal-type-printed Buddhist text in 1239 is traced and unveiled through image comparisons by digital forensic methods and image comparison/analysis of all six versions. The geopolitical aspect of the Goryeo (고려, 高麗, 918-1392) dynasty around the time of printing (1230s) is also reviewed.

2. Brief History of Metal Type Printing in Korea and Debates

In Korea, movable metal-type printing was developed at least two centuries earlier than in the West. However, typography in Korea neither played as great a role in general nor had a tremendous impact on ordinary citizen's life, as it did in Europe. In the West, movable metal-type printing was closely associated with the widespread penetration of knowledge to the public. In Korea, however, printing remained largely under the stringent control of the central government [14,15]. Also in Korea, metal-type printing was used to print urgent documents or booklets in small quantities, while woodblock printing was used for mass printing. It was customary for the central government to send books or documents printed with metal type to local governments, temples, and academies. In contrast woodblocks were used to print books for mass distribution. After printing, the woodblocks were stored for additional printing in the future, sometimes for decades to hundreds of years. Many woodblocks remain in Korea.

Jikji (直指) is the abbreviated title of a Korean Buddhist document whose title, *Baegunhwasangchorokbuljo jikji simcheyojeol* (白雲和尚抄錄佛祖直指心體要節), can be translated to "Anthology of Great Buddhist Priests' Zen Teachings" [16]. It was printed at Heungdeoksa (興德寺) Temple in the old Cheongju (淸州) city of Korea during the Goryeo Dynasty in July 1377 and has been recognized as the world's oldest extant book printed with movable metal type, 78 years before Johannes Gutenberg's "42-Line Bible" printed during the years 1452-1455. UNESCO confirmed Jikji as the world's oldest movable metal-type-printed book in September 2001 and included it in the Memory of the World Programme [16]. The first half of the two-volume work of the Jikji is lost, and only the second half (volume II) has survived. It is kept at the ManuscriptsOrientaux division of the National

Library of France (The Bibliothèque nationale de France, BnF). The BnF has hosted a digital copy of Jikji online [17].

Over the years, there have been many discussions in Korea on the possibility of finding metal-type-printed books before 1377, the printing date of Jikji. According to the writings of Yi Gyubo(李奎報, 1169-1241), twenty eight-copies of *Sangjeong Gogyeum Yemun* (詳定古今禮文) which can be translated as "The Prescribed Ritual Text of the Past and Present" or "Detailed and Authentic Code of Etiquette" were printed, using movable metal type, in 1234 on Ganghwa Island, where the Goryeo government took refuge to resist against the Mongol invasion [14,15,18].

For many years, historians in Korea have been searching for metal-type-printed books printed before 1377. One copy of a re-carved woodblock printed version of a book called *Nammyeong Cheon Hwasangsong Jeungdoga* (南明泉和尚頌證道歌, "The Song of Enlightenment" or "Hymn of Monk Cheon in Homage to the Buddha"), with a postscript dated 1239, has been reported as early as in 1959 [3]. The book was determined to be a woodblock printed version from the characteristics of printed characters [18]. Since that time, five more similar, or nearly identical, versions of the book have been found [19-29]. Since 1970s, one of the six versions received very strong attention as a possible metal-type-printed version printed in 1239 [28-30]. It has been the center of heated debates over the printing technique among historians. The heated debate continued intermittently for 50 years [5-13, 28-30].

In this study, detailed images from the six different versions of "The Song of Enlightenment" were compared and analyzed to derive an agreeable answer to this problem with convincing evidence. We have compared images of printed characters and measured inked area of individual characters in all six versions to gain insight into printing techniques and printing sequence of each version. In addition, we have carefully inspected any sign of metal casting defect and characteristics of woodblock printing to find clues for printing techniques used for each version.

3. Six Very Similar Versions of The Song of Enlightenment (南明泉和尚頌證道歌)

The Song of Enlightenment (證道歌) is a Chan (禪; 禪; Zen; 선; meaning mediation or mediative state) discourse, written sometime in the first half of the 8th century is usually attributed to the Zen Master Yongjia Xuanjue (永嘉禪師, 675–713) [6]. The teaching has been a Chan (or Zen) favorite since it first appeared more than thirteen hundred years ago. The name of the Buddhist monk, Yongjia Xuanjue (永嘉玄覺), has been attached to this song, *The Song of Enlightenment*. He was referred to by his place of birth, Yongjia (永嘉), in addition to his ordination name, Xuanjue (玄覺). His birth place Yongjia (永嘉) was the name of one of two counties in the city of Wenzhou (溫州) formed in 674. It is located on currently China's southeast coast.

A particular version of interest of *The Song of Enlightenment* called *Nammyeong Cheon Hwasangsong Jeungdoga* (南明泉和尚頌證道歌, *The Song of Enlightenment with Commentaries by Buddhist Monk Nammyeong Cheon*) has been introduced into the Goryeo (高麗) dynasty of Korea between 11th and 12th century. In this paper, *The Song of Enlightenment* refers this particular version for simplicity. This book has presumably been printed using movable metal types in 1239 and carved as woodblocks afterwards for wide distribution due to strong demands from Buddhist temples in the Goryeo (高麗) and Joseon (朝鮮) dynasties of Korea until 16th centuries. The book is still considered as very important. It is printed and electronically distributed worldwide. It is generally accepted as valuable texts of one of many Buddhist teachings Buddhist communities around the world.

Six very similar ancient books of *Nammyeong Cheon Hwasangsong Jeungdoga* (南明泉和尚頌證道歌; *The Song of Enlightenment*) were found in Korea over the 100 years from the 1920s. They are believed to be printed between the 13th and 16th centuries. Some versions were nearly identical, leading historians and experts in ancient books to believe they were printed using identical woodblocks. They are the A: Gongin version (空印本), B: Banyasa version (般若寺本), C: Daegu version (大邱本), D: Samseong version (三省本), E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本). The printing sequence of the six very similar versions of *The Song of Enlightenment* were determined in previous studies [5-13]. Characteristics and approximate date of

public appearance of all six versions in Korea are briefly summarized in Table 1 for reference. Factual printing dates for the C: Daegu version (大邱本) and E: Jongno Public Library version (鍾路圖書館本) are also noted for easy understanding of changes in printed characters over time in later sections. A detailed description can also be found in the previous report [5-13].

To date, it has been confirmed that more than 10 types of similar books of *The Song of Enlightenment* (南明泉和頌證道歌) remain in Korea. If this book is recognized as a metal-type printed book and Korean citizens' interest increases, there is a high probability that new ancient books that will prove the early history of the development of metal-type printing technology will be discovered in the future.

Table 1. Characteristics of six very similar versions of *The Song of Enlightenment* (南明泉和尚頌證道歌).

Symbol	Version Name	Public Appearance	Designation Status	Remarks
A	Gongin version (空印本)	1970s	Korean Treasure Designated on June 29, 2012	- Recognized as a duplicated woodblock printed version of the D: Samseong version (三省本) and printed much later in the Joseon dynasty (14th~15th century) using identical woodblocks. - There have been debates on the possibility of movable metal-type printing in 1239, during the Goryeo dynasty, since the 1970s.
B	Banyasa version (般若寺本)	2010s	Cultural heritage designation denied	- The first leaf (pages 1 and 2) is missing. - All pages are darkened by oxidation, water damage and aging of paper. - The contents are the same as other versions. - Shapes of printed characters are very similar to the A: Gongin version (空印本).
C	Daegu version (大邱本)	1990s	The application denied due to intentional removal of epilog pages.	During the application evaluation process, it was discovered that the prayer or epilog (跋文), written by Kim Su-on (金守溫) dated June 1472, was intentionally removed before application submission.
D	Samseong version (三省本)	1970s	Korean Treasure Designated on May 30, 1984	- Initially recognized as a woodblock printed book from the 13th–14th century during the Goryeo dynasty - Woodblock were duplicated from the metal-type printed book
E	Jongno Public Library version (鍾路圖書館本)	2021 (Library Collected in 1920s)	Cultural Heritage of Seoul City Designated on March 11, 2021	- Similar to the F: National Library of Korea version (國立中央圖書館本). - The woodblocks were re-carved at Simwonsa Temple (深源寺) in Mt. Jabi (慈悲山), Hwangju (黃州) in current North Korea. - The factual printing date of June 1526 was verified from the book's imprint on the backside.
F	National Library of Korea version (國立中央圖書館本)	1940s	None	- The first discussion on printing technique took place in the 1950s regarding this version. - Identified as a woodblock-printed version using re-carved woodblocks in the 16th century

Figure 1 shows images of page 31 (the front side of the 16th leaf) of the six very similar versions. Since the first leaf (page 1 and 2) of the B: Banyasa version (般若寺本) is missing, images of page 31 containing multiple metal casting defects in the A: Gongin version (空印本) was selected for image comparisons. Magnified partial images of this page is used for version-to-version comparison of printed characters and signs of metal casting defects as evidence of the printing techniques of each version and their printing sequence validation.

The Song of Enlightenment (南明泉和尚頌證道歌)
Page 31 (or Front Side of 16th Leaf)

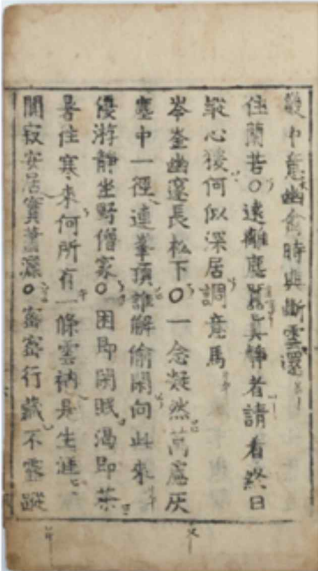
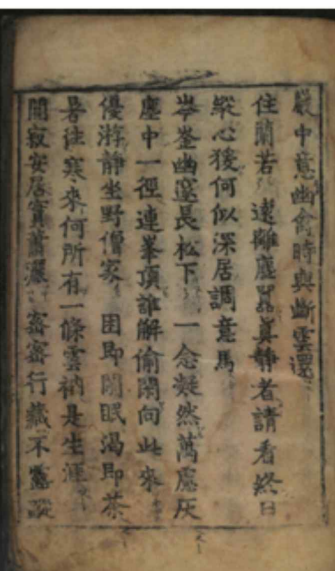
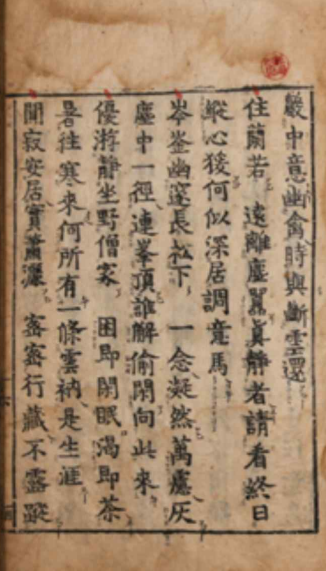
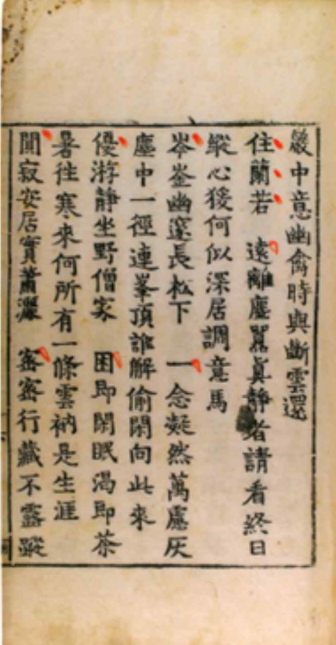
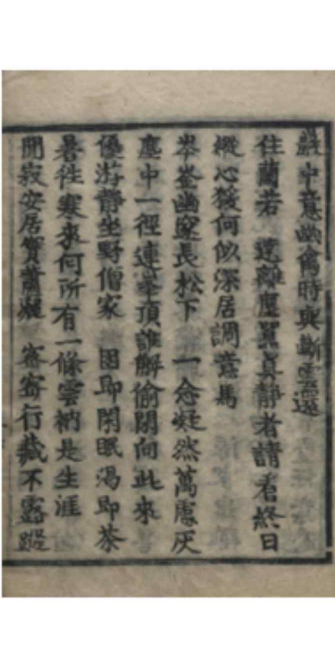
A: Gongin Version (空印本)	B: Banyasa Version (般若寺本)	C: Daegu Version (大邱本)
		
D: Samseong Version (三省本)	E: Jongno Library Version (鍾路圖書館本)	F: Central Library Version (中央圖書館本)
		

Figure 1. Six very similar printed versions of *The Song of Enlightenment* were printed from the 13th century to the 16th century using different printing techniques (metal-type printing and woodblock printing).

4. Choi Yi (崔怡, 1166 ~ 1249)'s Postscript dated September 1239

The Song of Enlightenment is a book consisting of 88 pages. It has 44 folded leaves with two prefaces, the main text, and two postscripts. All leaves of papers were printed on only one side, folded in half, and bound. The last page (page 88) was left blank. All six versions have very similar sizes and layouts of printed characters. Four versions (A: Gongin version (空印本), B: Banyasa version (般若寺本), C: Daegu version (大邱本), D: Samseong version (三省本)) are almost identical. The number of characters printed in this book amounts to 9,395. The main text is printed in large font with 9,322 characters, and the postscript is printed in small font with 73 characters. At first glance, it appears to be the same book printed using the same method. If we do not inspect every character, every line of characters, every page, and every printed borderline, it is easy to be fooled.

The E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本) are quite similar, but not identical. They are noticeably different in the shape of printed characters from the other four versions. Modified characters during a re-carving process can be found in the E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本). Intentionally deleted characters from the other four versions are also found in several places. At the bottom of the printed side in the center of the folded paper, all the names of presumably engravers or proofreaders printed in other books have been omitted in these two versions.

All six versions have a postscript written by Choi Yi (崔怡, 1166-1249) dated September 1239. Based on the factual printing dates of 1472 for the C: Daegu version (大邱本) and 1526 for the E: Jongno Public Library version (鍾路圖書館本) from their imprint, the date on the postscript cannot be used to determine the actual printing dates for the other four versions (A: Gongin version (空印本), B: Banyasa version (般若寺本), D: Samseong version (三省本) and F: National Library of Korea version (國立中央圖書館本). Therefore, we must seek other evidence to determine the printing dates and printing techniques. Since all six versions were printed from the 13th to 16th centuries, more than one version cannot be metal-type printed. Only the first version has the possibility of being a metal-type-printed version because identical typesetting over four centuries is not possible. The movable nature of the metal type makes it extremely difficult, even if the original metal type was available for four centuries. Thus, the complicated issues come down to three fundamental questions: (1) Which version was printed first, (2) what is the printing date of the first version, and (3) whether the first version is printed using metal type or woodblocks. We should look for clues and answers to these questions.

Jinyang-gong (晉陽公) Choi Yi (崔怡, 1166-1249)'s postscript was printed in 73 smaller Chinese characters on the last page (page 87) of the book describing the reasons for printing the book. It was dated at the beginning of September 1239. He was a powerful ruler of the Goryeo (高麗) dynasty (918–1392) of Korea. It was 162 years after the original publication date (1077) of *The Song of Enlightenment* (南明泉和尚頌證道歌) during the Song (宋) dynasty (960–1279) of China [5-13, 24,25].

Based on the author's understanding, his statement can be translated as follows:

The book had long been an essential textbook for Zen practice, but it was no longer available. Thus, he recruited workers to cast movable metal-type characters to print the book and made it available for a long time.

His five-line statement was vertically written from right to left in Chinese characters as shown below.

夫南明證道歌者實禪門之樞要也故後學

叅禪之流莫不由斯而入升堂奧矣然則
其可塞而不傳通乎於是募工重彫鑄
字本以壽其傳焉時己亥九月上旬中書令
晉陽公崔怡謹誌

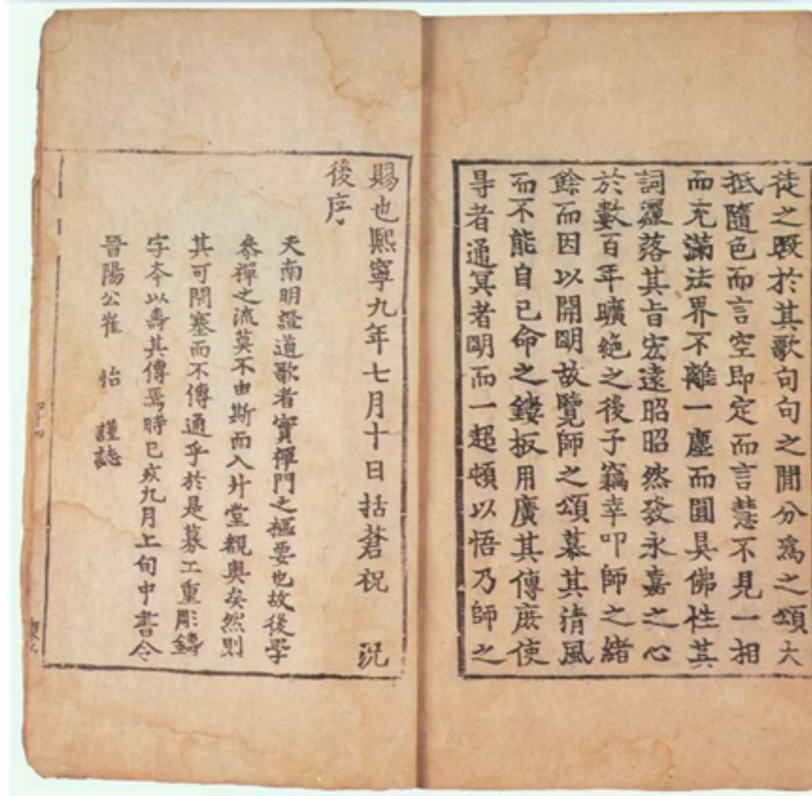
Figure 2 shows printed images of a Jinyang-gong (晉陽公) Choi Yi's postscript dated September 1239 in the A: Gongin version (空印本) and D: Samseong version (三省本) [24,25]. The vertically written, five-line statement, in small characters, can be seen from the pages. The two books were almost identical. The printed characters were much more clear and beautiful in the D: Samseong version (三省本) than in the A: Gongin version (空印本). This led Korean historians to believe that the A: Gongin version (空印本) was printed much later after woodblock wear and tear, using the identical woodblocks used for printing the D: Samseong version (三省本) in the 1970s and 1980s. They believe that the poor printing quality is due to the woodblock damage. However, we do not agree on their interpretation. The printed character in the A: Gongin version (空印本) is generally light in color and thinner in strokes compared to the printed characters in the D: Samseong version (三省本). If the woodblock is worn by heavy usage, the strokes of printed characters should be thicker, not thinner. By carefully inspecting the missing strokes in printed characters, the D: Samseong version (三省本) is the worst due to the woodblock wear and tear. Detailed information can be found in previous report [6-8,12,13].

Among many Korean historians, there are endless debates on how to interpret some portion of Chinese characters of 於是募工重彫鑄字本 for the last 50 years. When the collector, Late Professor Emeritus Kim Du Jong (金斗鐘, 1896-1988) of Seoul National University, School of Medicine, of the F: National Library of Korea version (國立中央圖書館本) first read the Chinese characters, in particular 鑄字 (casted character), he had an impression that his collection was metal type printed. However, he found that the version in his collection has so many characteristics of woodblock prints such as cracks in printed characters near the growth rings of the woodblock. Thus, he focused on two characters 重彫 (re-carve), and determined that his book was a woodblock printed version using re-carved woodblocks. He studied Chinese classics and literature in Korea and went to Japan for medical school in Kyoto during the Japanese colonial period. After graduation in 1923, he went to Fèngtiān (奉天), Manchuria (currently Chényáng (沈陽) in China) for graduate study in medicine and served as a medical doctor until the independence of Korea from Japan in 1945. He was multilingual and fluent in Korean, Japanese, Chinese, and English. The authors strongly believed that his first impression of the postscript was probably correct. Unfortunately, the version in his possession did not match with the postscript stating metal type printing. Thus, he had to look for a better match with his collection by looking for an alternative interpretation [19].

If the meaning of the Chinese characters of “於是募工重彫鑄字本” is that “he recruited workers for casting movable metal-type characters to print the book”, the first printed book can be the metal-type-printed book. If the meaning was that “he recruited workers to re-carve woodblocks from originally metal-type-printed book for printing,” it is a different story. The former interpretation leaves the possibility of a metal-type print in 1239. The latter interpretation implies that the first metal-type-printed book was published much earlier than 1239, but it was no longer available at the time the postscript was written in 1239. Judging from the fact that the first record of metal-type-print of the *Sangjeong Gogyeum Yemun* (詳定古今禮文) was in 1234, only 5 years before 1239, it is very probable that the true meaning of the postscript was about metal type casting for printing the original version of this book.



A: Gongin Version
(空印本)



D: Samseong
Version (三省本)

Figure 2. Jinyang-gong (晉陽公) Choi Yi (崔怡: 1166~1249)'s postscript (left side) dated September 1239 in the A: Gongin version (空印本) and D: Samseong version (三省本).

5. Image Comparisons and Analysis of Characters between Versions

Until Jikji (直指) was recognized as the world's oldest extant movable-metal-type printed book at the World Book Fair in 1972, Buddhist scholars, historians, and bibliographers in Korea were only

interested in the content of the book and not in the printing method. It was a well-known fact that in Korea, woodblock printing began in the 8th century and metal type printing began in the early 13th century. In addition to woodblock printing, traditional metal type printing continued in Korea until the early 20th century, so it was a very routine work for Koreans. This is why Koreans did not have much interest in the printing method itself.

In 1972, the Korean Society for the History of Science was founded and began discussing this issue, but the books known at the time were printed with re-carved woodblocks that were clearly understandable to anyone [19,21,26]. Since then, various versions of books have been discovered until the 2010s, but due to prejudice, it is still thought that all books are re-carved woodblock prints [14,15, 20-23]. The details of how a movable metal type print book have been misunderstood as woodblock printed books in Korea for 50 years have been discussed in detail elsewhere [6-8]. However, all the books discovered so far have an inscription indicating that they were printed with movable metal type in 1239. If one of them shows clear evidence for metal type printing, it can be recognized as the World's oldest extant metal-type printed book from 1239. By comparing and analyzing the printed character images of different versions, we would like to find the long-awaited answer for printing techniques used for each version.

Since Choi Yi's postscript dated September 1239 was printed in all six versions, printed between the 13th and 16th centuries, it cannot be considered trustworthy information for estimating the printing date of each version. However, the description of the background of book printing, in particular, understanding of the true intention of “於是募工重彫鑄字本” at the time of writing in September 1239, may be useful for determining whether at least the original version was metal-type-printed in September 1239 or all versions are printed using re-carved woodblocks from an already existing metal-type-printed version before September 1239 as many Korean scholars and historians have claimed for almost a half century. This is not an easy task, because Choi Yi was not a native Chinese speaker and the usage of characters may not be the same as our understanding of the current time. The authors have requested several Chinese and Korean scholars to interpret the possible meanings of the sentence without telling them the background. Their answers varied a lot and were as good as our own interpretation. One encouraging fact was that no one was against the existence of a metal-type-printed book from this sentence. True evidence should be found in the book itself through detective work, perhaps non-destructive and non-invasive forensic study.

Under conditions where all highly valuables books belong to private collectors and museums cannot be collected in one place for direct inspection and comparisons, image analysis is the most realistic method to find out the printing method in a non-contact and non-destructive way. If high-resolution images of each version are available, conclusions regarding printing methods can be obtained through image comparisons and analyses. Additionally, image comparison and analysis are possible anytime, anywhere without time and location constraints. As a digital forensic investigation method, image comparison and analysis of all six versions were chosen. The authors have used image analysis software (PicMan from WaferMasters, Inc., Dublin, CA, USA), originally developed for automatic and quantitative analysis of digital images in semiconductor, materials science, nanotechnology, and forest science. In recent years, the image analysis software and its applications has been widely adopted in the food industry, biology, medical research, and colorimetric applications in various fields. The key differentiation factor of PicMan from other commercial image manipulation or editing software is quantification and data export capability in spreadsheet format for additional statistical analysis as needed. Image modification, image highlighting, and arithmetic operation of images are also possible. The software program is small in size and written as an executable file, so installation is unnecessary and the operation is very fast. There are no special requirements for the PC specifications required to run the program, so it is possible to work with an ordinary personal laptop computer. Details of image analysis software and its applications can be found in previous reports [31-39].

Image comparison and analysis were completed page-by-page, line-by-line, and character-by-character in all printed pages, so as not to overlook even small differences which can be important clues for determining the printing technique used for all six versions. The exported numerical data after image comparison and analysis was used as valuable source data for additional numerical analyses toward statistical reasoning [5-13]. Quantified image data in various aspects and different formats can

significantly reduce subjectivity and human-originated deviations, errors, and mistakes. In addition, it has the advantage of being able to make objective judgments based on quantitative data rather than subjective judgments based on the observer's experience, and providing evidence for the judgment.

Figure 3 shows a screen-captured image of PicMan with a summary. Image comparison and inked area measurement results on two selected characters of 千 and 盛 from line 3 of page 37 in all six versions. The measured inked area was written below each character, in several pixels, for easy comparison. The inked area comparisons for the character 千 are straightforward. The inked area increases from 1,857 pixels for the A: Gongjin version (空印本) to 3,129 pixels for the D: Samseong version (三省本) monotonically. The inked area increase is 68.5% from the A: Gongjin version (空印本) to the D: Samseong version (三省本). Then, it dropped down to 2,594 pixels for the E: Jongno Public Library version (鍾路圖書館本) and increased to 2,707 pixels for the F: National Library of Korea version (國立中央圖書館本) printed using newly re-carved woodblocks in and after 16th century. The style of printed characters between the D: Samseong version (三省本) and the F: National Library of Korea version (國立中央圖書館本) is due to complete re-carving of a previous version in 1526. The authors suspect that all versions were printed using re-carved woodblocks based on previous versions [5-13]. When a woodblock is duplicated by re-carving after attaching horizontally flipped printed paper to a woodblock, the area of the printed character tends to increase as the engraver engraves the character outward so as not to cut inside the original printed character.

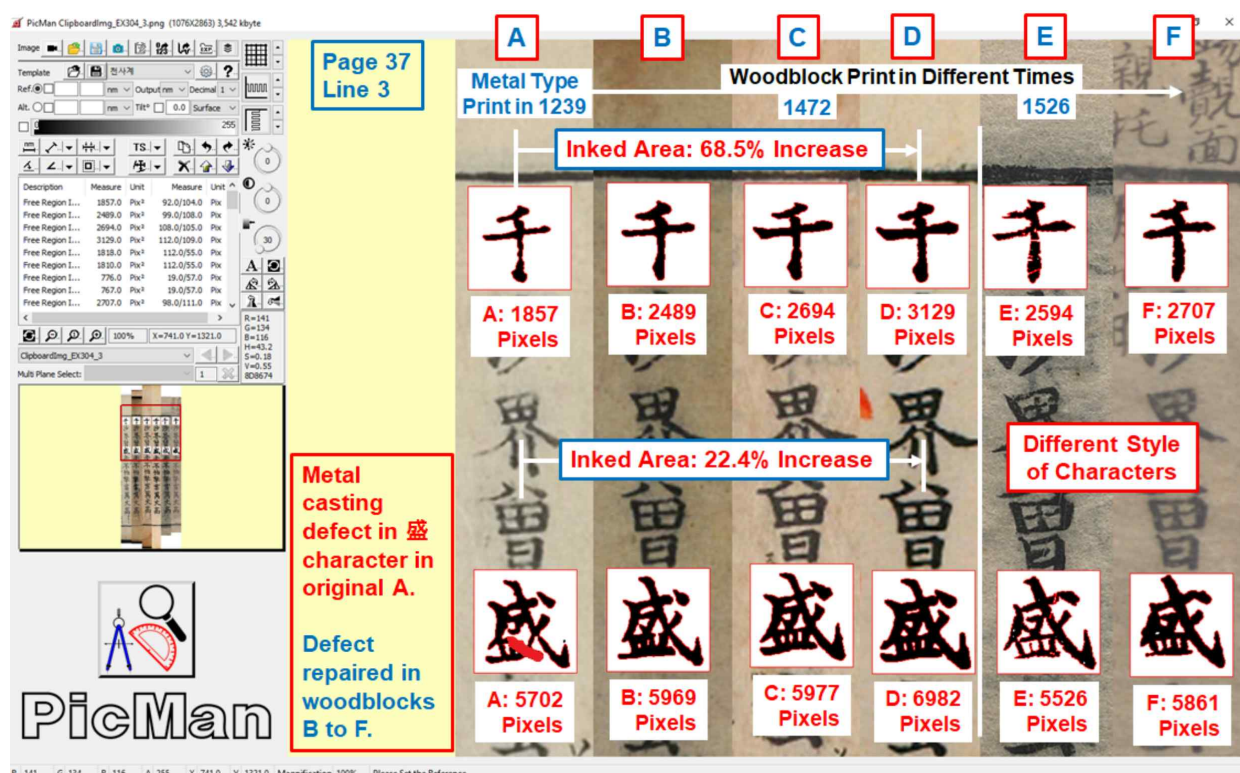


Figure 3. Image comparison and inked area measurement results on two selected characters of 千 and 盛 from line 3 of page 37 in all six versions. (A: Gongjin version (空印本), B: Banyasa version (般若寺本), C: Daegu version (大邱本), D: Samseong version (三省本), E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本))

Inked areas of the fifth character from the top, 盛 in all six versions were also measured. The character 盛 in the A: Gongjin version (空印本) showed a defect formed during metal casting of metal type as highlighted in red color. The metal casting defect in the second character 盛 in the A: Gongjin version (空印本) has been partially repaired during re-carving woodblocks in the B: Banyasa version (般若寺本) and repaired again for perfection in other following versions. The metal casting defect in the 盛 in the A: Gongjin version (空印本) is clear evidence for the A: Gongjin version (空印本) being a metal-

type-printed version. Even with the metal casting defect (a backslash-shaped defect highlighted by red color) in the character 盛 in the A: Gongjin version (空印本), the inked area increases from 5,702 pixels for the A: Gongjin version (空印本) to 6,982 pixels for the D: Samseong version (三省本) monotonically. The inked area increase is 22.4% from the A: Gongjin version (空印本) to the D: Samseong version (三省本). The increase of inked area seemed to be smaller than the first character of 千. This is due to the high coverage of ink in the unit area. The character 千 only has three strokes while the character 盛 has eleven strokes. The denominators for 千 and 盛 were 1,857 pixels and 5,702 pixels. The denominator for the character 盛 is 3.1 times bigger than that for the character 千. The same amount of inked area (numerator) increases only gives 1/3 of the area increase ratio for the character 盛. The inked area shrunk down to 5,526 pixels for the E: Jongno Public Library version (鍾路圖書館本) and increased to 5,861 pixels for the F: National Library of Korea version (國立中央圖書館本) printed using newly re-carved woodblocks in and after 16th century.

Figure 4 summarizes the inked area measurement results of the two characters of 千 and 盛 from line 3 of page 37 in all six versions as a graphical form. As suggested in the previous study, the monotonic increase of inked area increased by thickening strokes in re-carved woodblocks is related to the psychology of woodblock carvers. When woodblock engravers engrave characters on woodblocks based on the horizontally flipped copy of the print, they naturally hesitate not to engrave inside the printed characters [5-13]. It is the natural psychology of humans. Based on the increasing trends of inked area of two characters of 千 and 盛 in the four versions (A to D) and significant decrease of inked area in the version E and F, the printing sequence of all six versions can also be concluded as suggested. The sudden change of character shape between the version D and E is very strong evidence for totally new and different woodblocks from the previous three versions (B to D). Another evidence that clearly distinguishes the E: Jongno Public Library version (鍾路圖書館本) and the F: National Library of Korea version (國立中央圖書館本) from other three woodblock prints is that the names of the person considered to be the engraver or proofreader of the page is missing from the bottom of the folded portion of printed book.

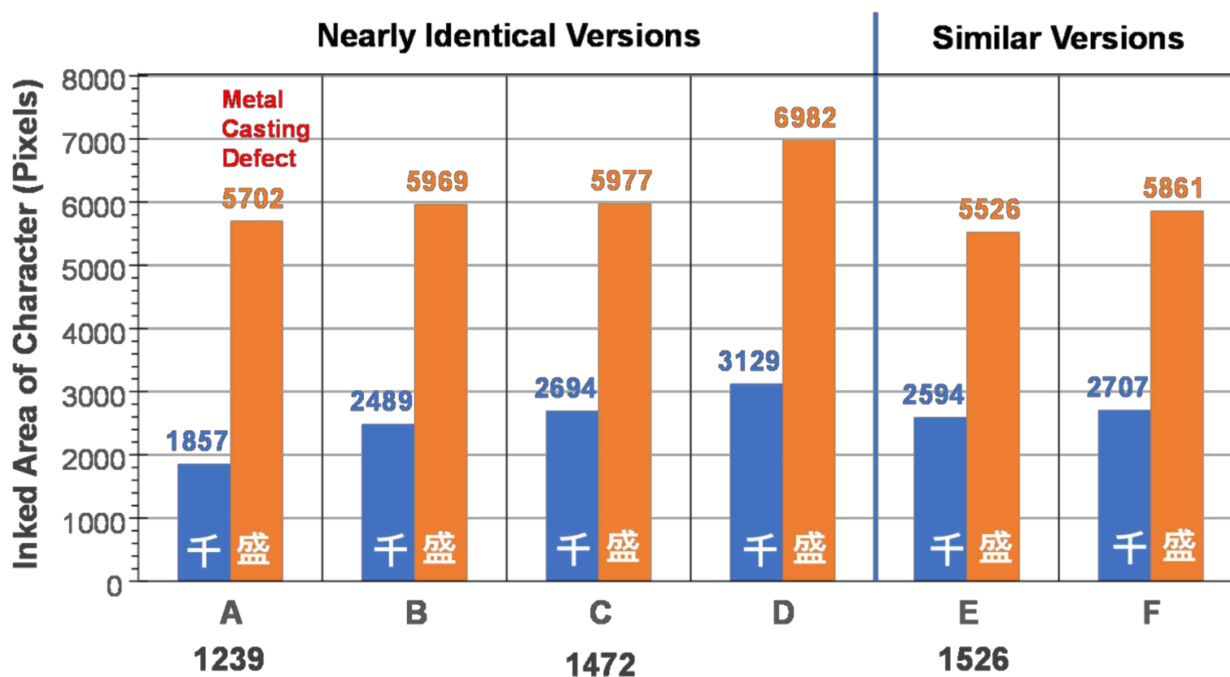


Figure 4. Inked area measurement results on two selected characters of 千 and 盛 from line 3 of page 37 in all six versions. (A: Gongjin version (空印本), B: Banyasa version (般若寺本) C: Daegu version (大邱本), D: Samseong version (三省本), E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本))

6. Metal Casting Defects

As seen from the character 盛 in the A: Gongjin version (空印本) in Figure 3, metal casting defects (a backslash-shaped defect highlighted by red color) can serve as direct evidence of a metal-type-printed book. The authors have carefully investigated all six versions and searched for possible metal casting-originated defects. The authors had multiple opportunities for direct inspection of the A: Gongjin version (空印本) in person. More than 50 metal casting-related defects have been found only from the A: Gongjin version (空印本). All other versions did not have metal casting originated defects. Figure 5 shows four examples of metal casting defects observed in page 31 of the A Gongjin version (空印本).

Template Type	Metal Type	Duplicated Woodblock					
Year of Print	1239		1472		1526		
Symbol	A	B	C	D	E	F	
Page 31 Line 2 1st Character	Metal Casting Defect						
Page 31 Line 4 14th Character	Metal Casting Defect						
Page 31 Line 6 15th Character	Metal Casting Defect						
Page 31 Line 7 6th Character	Metal Casting Defect						

Figure 5. Metal casting defects are found on page 31 of the A: Gongjin version (空印本) and corresponding characters in other versions (B: Banyasa version (般若寺本) C: Daegu version (大邱本),

D: Samseong version (三省本), E: Jongno Public Library version (鍾路圖書館本) and F: National Library of Korea version (國立中央圖書館本)). Metal casting defects were highlighted in red color.

Metal casting defects were highlighted with red colors. This particular page has more defects than other pages. Four metal casting defects were found on a single page. The metal casting-related defects have been observed and reported by other researchers since the 1980s [28-30], but ignored by the majority of historians with prejudice for almost 50 years [5-13]. Very interestingly, all four metal casting defects were corrected in the following versions (B - F) during making duplicated woodblocks for printing them. This is very clear evidence that the A: Gongjin version (空印本) is the original metal type printed book in 1239 as noted in the postscript. It is time to reevaluate this newly found evidence without prejudice for unveiling true history of metal type printing technology development in early 13th century in the Goryeo dynasty of Korea.

7. Recommendations

All evidence points out that the A: Gongjin version (空印本) of *The Song of Enlightenment* (南明泉和尚頌證道歌) is very likely to be the original metal-type-printed version from 1239 and is the world's oldest extant metal-type-printed book found to date. It predates Jikji by 138 years and predates the 42-line Gutenberg Bible by 216 years. One thing in common for these three books (*The Song of Enlightenment*, Jikji, and the 42-line Gutenberg Bible) is the fact that they are religious texts. Due to the spirituality of printed materials in religious aspects, these printed documents have survived.

The invention of printing technology is considered one of the top inventions in the history of mankind [4]. The invention of the printing press by Johannes Gutenberg in ~1455 was ranked as the top of "The Greatest Inventions in The Past 1000 Years" because it allowed literacy to greatly expand [40]. Without the invention of the metal type, the printing press would have no place. As the title of Carter's book published in 1925 "The Invention of printing in China and its spread westward" from Columbia University Press [1] implies, the invention of printing techniques in the East spread westward through the Silk Road. In one chapter, Carter introduced information about the first metal-type printing done in 1403 in the Choseon dynasty of Korea. In a column by Berthold Laufer of Field Museum, Chicago, on the reviews of books, Laufer suggested to Carter the fact that "a Chinese Book of Etiquette was printed with movable type by the Koreans in the Goryeo dynasty [41]. He further informed Carter that the old types in the possession of the former imperial household of Korea, numbering about 500,000 pieces, were transferred to the care of the Government-General of Choseon (Korea) according to the Annual Report on Reform and Progress in Choseon 1914-1915, while Korea was under Japanese control from 1910 to 1945. *Sangjeong Gogyeum Yemun* (詳定古今禮文) which can be translated as "The Prescribed Ritual Text of the Past and Present" or "Detailed and Authentic Code of Etiquette" is referred to as "a Chinese Book of Etiquette" by Berthold Laufer in his review of Carter's 1925 book.

In the history of the Goryeo dynasty of Korea, the 13th century was a chaotic period due to the Mongolian invasions (nine times for 28 years from 1231 to 1259). The Goryeo government printed books with movable metal type even during such difficult circumstances in a small island refuge (Ganghwa Island). Movable metal type printing was already a practical printing method in Goryeo. There may be more metal-type-printed books in Korea, older than Jikji, still to be discovered. We should not leave out any possibility because the Jikji has been recognized as the world's oldest extant metal-type-printed book and registered in the Memory of the World Programme of UNESCO. If we do not act now, the value of the precious cultural heritage can be underestimated and make it difficult to maintain their condition under less suitable storage conditions by a private citizen collector. It is our duty as descendants to recognize, conserve, and pass our precious cultural heritage down to the next generations. We would like to urge respected scholars around the world to closely look at the almost 800-year old, World's oldest metal-type-printed book with Buddhist text: The Gongjin version (空印本) of *The Song of Enlightenment* (南明泉和尚頌證道歌). As Choi Yi's postscript describes in five-line sentences below:

夫南明證道歌者實禪門之樞要也故後學
叅禪之流莫不由斯而入升堂奧矣然則

其可塞而不傳通乎於是募工重彫鑄
字本以壽其傳焉時己亥九月上旬中書令
晉陽公崔怡謹誌

"The book had long been an essential textbook for Zen practice, but it was no longer available. Thus, I recruited workers to cast movable metal-type characters to print the book and made it available for a long time.

*Jungseoryung (中書令) Jinyang-gong (晉陽公) Choi Yi(崔怡)
Early September 1239"*

It is our turn to pass on this precious cultural heritage saving history, one of the most innovative inventions of mankind, for the next generations.

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