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Identifying Editions of the Ptolemy of Rome Maps (1478/90–1507/08) by Copper Plates Changes

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Abstract: Traditionally, it has been considered that the Ptolemaic or classical maps from the four editions of Ptolemy's *Geography* published in Rome (1478, 1490, 1507, and 1508) are apparently indistinguishable at first glance because they have been printed from the same plates. This poses a problem for antiquarians, collectors, and curators who wish to accurately date their copies. Recently, two very comprehensive articles have been published on the different paper watermarks associated with each edition, which would allow for the correct identification of each one. However, there are occasions when the maps do not display watermarks. This article aims to provide some keys to distinguish between the incunabula editions (1478, 1490) and those of 1507–1508 in cases of the absence of watermarks. In this process of detecting differences, we have used digitized images of the maps. The results show small modifications in the copper plates made between the editions of 1490 and 1507/08. Our findings reveal that seven previously unknown reworked maps have been identified.

Keywords: Ptolemy; geography; watermarks; historical cartography; incunabula; cooper plates

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1. Introduction

The introduction of the printing press in Europe ca. 1455 decisively contributed to the dissemination of knowledge. Before the publication of the first printed book in history, the Gutenberg's Bible, documents were manuscripts and could only be reproduced manually, which was slow and costly. Although we often think of the incunabula period (ca. 1455–1500) as related to books and texts, printing techniques for illustrations and maps were also developed, such as engraving on copper plates (chalcography) or carving on woodblocks (xylography) [1].

The printing of maps spread throughout Europe and became a prosperous industry from the 16th century onwards [2]. Due to the high cost of producing plates, it was very common for them to be reused in subsequent reprints or editions. Therefore, we expect to find maps printed from the same plates but in different years, decades, or even centuries.

For historians of cartography, curators, antiquarians, and collectors, the precise dating of printed maps and atlases is crucial, allowing the tracing of their lineage through successive copies and editions. Assigning one date or another to a printed map can help understand its genealogy, determine its historical importance and rarity, and decisively influence its market value. Hence, the interest in finding distinctions between editions printed in different years from the same plates arises.

The object of study of this article is the maps printed in the four editions (1478, 1490, 1507, and 1508) of Claudius Ptolemy's *Geography*, published in Rome. It is considered that the first printed map in history is a simple world map inserted in the 1472 edition of the *Etymologies* of Saint Isidore by Gunther Zainer [3] (No. 77 in Campbell's catalog [4]). In reality, this world map is a small schematic tripartite diagram of the T-O type according to

Woodward's classification (1987) [5], and, to the eyes of a person unfamiliar with medieval cartography, it would hardly be recognizable as a map. In fact, the first maps in the modern sense to be printed are, chronologically, those of the first two incunabula editions of the *Geography*: Bologna (1477) [6] and Rome (1478) [7]. The public's interest in *Geography* led to its maps being published in six incunabula editions and in another 26 editions during the 16th century, according to Fatichenti's list [8]. Sanz compiled a list with the main characteristics of all editions published until 1715 [9].

The *Geography* was written by the Greco-Egyptian astronomer and geographer Claudius Ptolemy around the year 150 AD and is considered the most important and influential work in the history of cartography. In that work, the foundations of scientific cartography are established for the first time, and they have not changed fundamentally since then [10]. They are the following:

1. The use of map projections to represent a spherical world on a plane.
2. The location of points to be represented on the map using a coordinate system (longitude and latitude).
3. The use of a grid of meridians and parallels.
4. The establishment of a prime meridian for longitudes (the Fortunate Isles, i.e., the present-day Canary Islands) and a prime parallel (the equator).
5. The orientation of maps to the north.

In Book 8, Chapter II of his *Geography,* Ptolemy gave instructions to divide the known world into 26 partial or regional maps, the so-called Ptolemaic canon, as follows (translation from Stevenson [11]: "*We Will make ten maps for Europe; we Will make four maps for Africa; for Asia we will make twelve maps to include the whole, and we will state to which continent each map belongs, and how many and how great are the regions or provinces in each, and we will further explain (. . .)*". These 26 partial maps plus the one of the *oikoumene*, or known world, were included in the printed editions of the *Geography* and, specifically, in the four Roman editions that are the subject of this study.

The *editio princeps* of Ptolemy's *Geography* was published in Vicenza, Italy in 1475, but without maps. The first edition with maps was released in 1477, in Bologna, Italy. However, its engraving quality was poor, and it did not have a significant subsequent influence. Hence, the edition from Rome in 1478 became the most important among the incunabula editions of the *Geography*. This is not only because its maps were reprinted in 1490 and subsequently in 1507 and 1508 (including six new modern maps), but also because of the high quality of the engraving and the use of the innovative technique of metal punches to engrave the letters on the plate [4]. It should be highlighted that the maps of the Rome editions were engraved on two plates.

The current consensus is that 25 out of the 27 Ptolemaic maps (26 partial + 1 world map) from the Roman editions of 1478, 1490, and 1507/1508 are a priori indistinguishable because they come from the same unmodified plates. Nordenskiöld comments in his Facsimile Atlas that, after comparing copies of the four editions, "the maps in the edition 1490 consist of new, perfectly unaltered impressions from the plates, employed for the edition 1478, and that the same plates have been used for the original maps in the editions 1507 and 1508. But before the plates were employed for the last two editions a few slight corrections or repairs of damaged parts had been made" [12]. Shirley, besides affirming that "many consider the Rome plates to be the finest Ptolemaic plates produced until Gerard Mercator engraved his classical world atlas of 1578", refers to the editions of 1490 and 1507 as coming from "unchanged plates" [13].

Despite the claims above, Campbell [14] and Peerlings et al. [15,16] did find differences between successive editions in some of the maps. Furthermore, the latter provide a useful guide to unequivocally identify each edition by its own specific watermark.

The cause that motivated this investigation was the necessity to identify two unwatermarked specimens of the *Secunda Europe Tabula* (Hispania) acquired by the Spanish National Geographic Institute (*Instituto Geográfico Nacional*, IGN). The aim of our research is to give some guidelines to distinguish the maps from these four editions (1478, 1490, 1507,

and 1508) which were printed with the same copper plates, by detecting modifications in them. Thus, 26 maps were analyzed and we found differences in 9 (including those discovered by previous authors).

We have used digitized images of the maps since these changes are practically imperceptible to the naked eye. The study highlights the importance of digitized images, and the advances in digitization technologies promise future discoveries useful for dating ancient cartography. In this way, it has been possible to determine that some maps have been re-engraved, which makes it possible to establish the lineage and circumstances of the documents, as in previous works [17–19].

2. Materials and Methods

The starting point is the presumed impossibility of distinguishing the printed Ptolemaic maps from the four editions of Rome, with the exceptions that we will see below. This is based on the fact that the plates used in the four editions are the same. However, there are two objections to this starting assertion: there are maps in which changes are noted that appear in the editions of 1507/08; moreover, it is also possible to discern the editions by the watermarks on the paper.

Firstly, the methods used by other authors for this analysis, as well as the results obtained through these approaches, are examined. Building upon the above-mentioned knowledge and making use of existing digitized images of the maps, efforts are made towards identifying differences between editions by comparing these images in great detail. Within this analysis, considerations will be given to differences in image sharpness and identifying edition-specific details.

2.1. Methods for Identifying the Edition of Ptolemaic Maps from the Rome Editions

The process can be tackled in three different ways: through direct observation, by analyzing the paper watermarks, and by comparing digital images of the maps for distinguishing different states of the plates. These methods are described below.

2.1.1. Differences Visible at the Naked Eye

First, the differences detectable at first glance in the editions from Rome have been commented on, at least, by the following authors:

- Nordenskiöld [12] (p. 14) states that "before the plates were employed for the last two editions (1507, 1508) a few slight corrections or repair of damaged parts had been made. In *Table VI Europe* various emendations had thus been conducted to represent the tributaries of the Po, and in *Table IX Europe* the name "Bosphorus Thracius" has been incorporated."
- Sanz [9] (p. 75) practically repeats the same information as Nordenskiöld, from whom he takes it.
- Campbell [14] (p. 132) also mentions that the maps *Sexta Europe Tabula* and *Nona Europe Tabula* have undergone changes between editions and provide more details about the differences found. Additionally, he also points out two particular cases where second states of plates have been found in one edition of 1478 and another of 1490, although he attributes it to the practice of some booksellers to complete imperfect copies by adding loose maps from other editions.
- Peerlings et al. [16] (pp. 143; 151–153; 157–158), apparently unaware of Campbell's (1987) writing, announce the "discovery" of two "new" states of plates in the *Sexta Europe Tabula* and *Nona Europe Tabula*. They also find a second state of a plate in the *Tabula Nova Italie*, which shows there were corrections between the editions of 1507 and 1508. As expected, they reveal the appearance of the maps *Sexta Europe* (Italy) and *Nona Europe* (the Balkans) in their first state of the plate, mostly in the editions of 1478/1490, and a second state of the plate in those of 1507/1508. They also mention exceptions, with examples of the second state within an edition of 1478 and the first state in three copies from 1508. These exceptions, which are challenging to explain,

may be due to the widespread practice among booksellers of "completing" imperfect editions with maps obtained from other editions [16].

2.1.2. Paper Watermarks

Next, another way to distinguish between editions is by the watermark patterns on the paper, thanks to the discoveries by Peerlings et al. [15,16]. In 2018, they even recognized three printing phases in the editions of 1507/08: Phase 1 (1507), Phase 2 (1507/08), and Phase 3 (1508) [16]. From this, it is deduced that some maps do not always correspond to the nominal edition in which they are inserted but may be included within either of the two (meaning that there are maps printed in 1507 that were included in the 1508 edition and vice versa).

2.1.3. Analysis of Digitized Images of Maps for Detecting Different States of the Plates

Nevertheless, what can we do when the maps do not have watermarks on the paper? According to Peerlings et al. [16] (pp. 324–325), blank paper sheets were cut in half to print the two copper plates used for each map. This would explain the presence of none, one, or two watermarks in the analyzed maps. Besides, they affirm that "none, one or two watermarks appearing in a division of respectively 25, 50 and 25% in the maps is the mathematically expected distribution of watermarks when a sheet of paper containing one watermark is cut in two, to print two separate halves of a map, which are united again after printing to form one map". Therefore, there is a priori probability of 25% of maps without watermarks; consequently, it is impossible to date using this method. The absence of watermarks on a map is not that rare, and the two specimens of the map *Secunda Europe Tabula* (Spain and Portugal) held by the IGN do not have watermarks. The attempt to date these two specimens is what motivated this study. Both are available at http://www.ign.es/web/biblioteca_cartoteca/abnetcl.cgi?TITN=39953 (accessed on 30 May 2024); http://www.ign.es/web/biblioteca_cartoteca/abnetcl.cgi?TITN=63672 (accessed on 30 May 2024).

Because plates sometimes undergo modifications between consecutive editions, which are not always intentional, we initially tried to find differences in the *Secunda Europe Tabula*, which is the motivation of our research. It should be noted that the differences between the editions mentioned by Campbell [14] and Peerlings et al. [16] are visible to the naked eye. That is, they are corrections in geographical content. After "discovering" a "new" (already found by Campbell) plate state in the *Sexta Europe Tabula*, Peerlings et al. [16] (p. 151) analyzed the 27 Ptolemaic maps, aiming to reveal other differences. However, they only found the ones already mentioned in the *Nona Europe Tabula* and the modern map *Tabula Nova Italie*.

A first inconclusive indication that allows for a higher probability of belonging either to the incunabula editions or to those of 1507/08 is the sharpness of the image. As is known, the subjection of copper plates to strong pressure during printing causes wear on a relatively soft material like copper [1]. Woodward [1] refers to Zonca [20], who believed up to 1000 copies could be printed from an untouched plate and up to 2000 prints with reworking. Skelton estimates a print run of about 500 copies for the 1478 edition [7]. This same figure is documented in a contract for the printing of the 1477 Bologna edition, from which it can be deduced that it was a reasonable print run for those years. However, Azzini suggests that the print run of the 1478 edition should not have been much different from 275 copies, which was the number printed in previous works by the printer responsible for the 1478 Roman edition, Konrad Sweynheym, although he died in 1477 before seeing the work published [21].

Let us turn to the Incunabula Short Title Catalogue (ISTC. https://data.cerl.org/istc/_search; accessed on 30 May 2024) and search for surviving recorded editions from 1478 (ISTC No. ip01083000) and 1490 (ISTC No. ip01086000). Thus, we find 40 institutions holding copies of 1478 (complete or incomplete) and 137 institutions (more than triple) with copies of 1490. Although some institutions preserve more than one copy, and some

copies are fragmentary or imperfect, these figures can provide an approximate idea of the number of copies printed for each of the two editions.

Obviously, the 1478 edition should have a slightly lower survival rate than that of 1490 due to its older age, so the ratio between print runs would probably not reach triple. We can assume that in 1490, between double and triple the number of copies was printed compared to 1478. According to Skelton's estimates of 500 copies for 1478 [7] and assuming double the number of copies for 1490, we would get about 1000 copies printed in 1490. With Azzini's more modest estimates of about 275 copies for 1478, multiplying by two would result in about 550 copies in 1490 [21]. Adding both editions, approximately 1500 copies would have been printed with Skelton's initial data and 875 with Azzini's, although these figures are approximate and only indicative. It should be highlighted that Zonca considered that after 1000 prints, it was necessary to rework the plates [20]. Given that this number was likely reached between the two editions, it would have been necessary to rework the plates in 1507 due to problems with the sharpness of the engraving.

Our study has used this technique to determine different states of the plates and provides novel data through the analysis and comparison of digitized images of the maps.

2.2. Maps Analyzed

This study focuses only on the 26 Ptolemaic regional maps, disregarding the 7 new "modern" maps added in 1507: a world map, northern Europe, Spain, France, Central Europe, Italy, and the Holy Land [8] (p. 91). Modern maps (*tabulae modernae*) began to be added to *Geography* manuscripts in the second half of the 15th century, with the aim of updating the classic Ptolemaic maps using more modern sources such as nautical charts (on the first modern maps added, see [22] (pp. 320–324)). The first printed editions that included modern maps were those of Florence [23] and Ulm [24], both in 1482. The earliest two editions from Rome, from 1478 and 1490, do not contain modern maps.

The maps used in this study are those unequivocally identified as belonging to a specific edition, either by being found within a complete codex with a date or by watermark analysis. Next, we present the maps and editions employed in our analysis (Table 1). Although a resolution of 300 dpi is sufficient to produce a map printout, the resolution of each image depends on the criteria followed by the institutions for digitizing, storing, and publishing on the web.

Table 1. Maps analyzed in this research.

Edition	Institution (Call Number)	Available at (accessed on 30 May 2024)
1478	*Real Academia de la Historia* (Inc. San Román 2)	https://bibliotecadigital.rah.es/es/consulta/registro.do?id=44475
	Biblioteca Universitaria di Napoli (Inc. 270)	https://www.loc.gov/item/2021668470/
	Library of Congress (LoC) (Incun. 1478.P855)	https://www.loc.gov/item/65058844/
1490	*Real Academia de la Historia* (Inc. 16)	https://bibliotecadigital.rah.es/es/consulta/resultados_busqueda.do?autor_numcontrol&materia_numcontrol&id=15030&forma=ficha&posicion=7
	Biblioteca Nazionale Centrale di Firenze (not known)	https://bibdig.museogalileo.it/Teca/Viewer?an=1056116
	Biblioteca Nacional de España (BNE) (INC/756)	https://bdh-rd.bne.es/viewer.vm?id=0000137330&page=1
	Biblioteca Nacional de España (INC/1105)	https://bdh-rd.bne.es/viewer.vm?id=0000137330&page=1
	Library of Congress (Incun. 1490.P8)	https://www.loc.gov/item/48042565/

Table 1. *Cont.*

Edition	Institution (Call Number)	Available at (accessed on 30 May 2024)
1507	*Biblioteca Nacional de España* (GMG/780)	http://bdh-rd.bne.es/viewer.vm?id=0000010733&page=1
	Biblioteca Nacional de España (R/20753)	http://bdh-rd.bne.es/viewer.vm?id=0000010733&page=1
	Österreichechische Nationalbibliothek (47.C.20 ALT PRUNK)	https://digital.onb.ac.at/OnbViewer/viewer.faces?doc=ABO_+Z182430007
	Institut Cartogràfic y Geològic de Catalunya (ICGC) (only *Secunda Europe Tabula*) (RM.3221)	https://cartotecadigital.icgc.cat/digital/collection/espanya/id/817/rec/5
	Barry Lawrence Ruderman Antique Maps Inc. (only *Secunda Europe Tabula*)	https://www.raremaps.com/gallery/detail/66987/spain-portugal-secunda-europe-tabula-ptolemy
1508	*Bibliothèque Nationale de France* (BnF) (GE DD-1007) (RES)	https://gallica.bnf.fr/ark:/12148/btv1b55006577p.r=marcobeneventano?rk=21459;2

3. Results

From the comparison of digitized images of the maps, the following differences were detected.

3.1. Sharpness Differences in the Printed Image

Figure 1 illustrates this loss of sharpness in the 1507 edition (BNE. GMG/780) compared to the 1478 edition (LoC. Incun. 1478.P855). Due to deterioration, the rectangles highlighting MENLARIA and SETABICULA are hardly noticeable in the 1507 specimen (right). The dashed line corresponding to an administrative division running above SETABIS (left) has also nearly disappeared in the 1507 specimen (right). The letters are also blurred, for example, the "A" in TESTANI; in general, all the "A"s have their inner triangle in black in the image on the right. Upon close observation, it can be seen that the shading of the sea and mountains is reworked in the 1507 specimen.

Figure 1. Detail of the *Secunda Europe Tabula*. (**Left**): LoC. Incun. 1478.P855 (1478). (**Right**): BNE. GMG/780 (1507).

These observations regarding sharpness are not conclusive about which specific edition it is and only lead us to assume that a copy belongs to the editions of 1507/08 if its wear is evident.

3.2. Identifying Details of Editions "Secunda Europe Tabula"

In all the consulted copies, differences were detected between the incunabular editions (1478/90) and non-incunabular editions (1507/08) of the *Secunda Europe Tabula* (Hispania, Spain), as shown in Figure 2. In the 1507 copies, the engraver touched up the coastline's

shading and invaded with a stroke from the right the circle of the population center MANOBA. This also occurs in the circle of the population SEX. Additionally, the circle of the population VESCIS has been re-engraved with a punch, so remnants of the previous circle are visible.

Figure 2. Details of the *Secunda Europe Tabula*. (**Left**): BNE. INC/756 (1490). (**Right**): BNE. GMG/780. (1507).

Another distinctive detail that occurs systematically is the duplicated stroke under the straight line (administrative division) below the population ARCILACIS (Figure 3). In the copy dated 1507 from the ICGC, significant wear of the plate can also be observed, especially in the texts.

Figure 3. Details of the *Secunda Europe Tabula*. (**Left**): BNE. INC/756 (1490). (**Right**): ICGC. RM.3221. (1507).

Generalized differences have also been found in the shading of the mountains, clearly reworked in the editions of 1507/1508. The re-engraved lines are thicker after the reworking, and some strokes even change in the angle of their direction (Figure 4).

3.3. Identifying Details of Editions "Tertia Europe Tabula"

Although the research initially aimed to identify the specific edition of a copy of the *Secunda Tabula Europe*, it was decided to expand the study to find differences in other maps. The following map in the Ptolemaic order is the *Tertia Europe Tabula* (France). In addition to the widespread wear of the plate affecting all copies from 1507/08, retouches are easily identified in almost all the shading of the mountains on the Ptolemaic map of France, sometimes with changes in the angle of the strokes. In Figure 5, the differences in

sharpness in the text ADVLAS MONS between the 1478 copy (left) and the 1508 copy (right) are noticeable. The shading of the mountains has also been re-engraved, even featuring changes in the angle of the lines imitating the relief effect.

Figure 4. Details of the *Secunda Europe Tabula*. (**Left**): LoC. Incun. 1478.P855 (1478). (**Right**): LoC. G113.P7 1508 (1508).

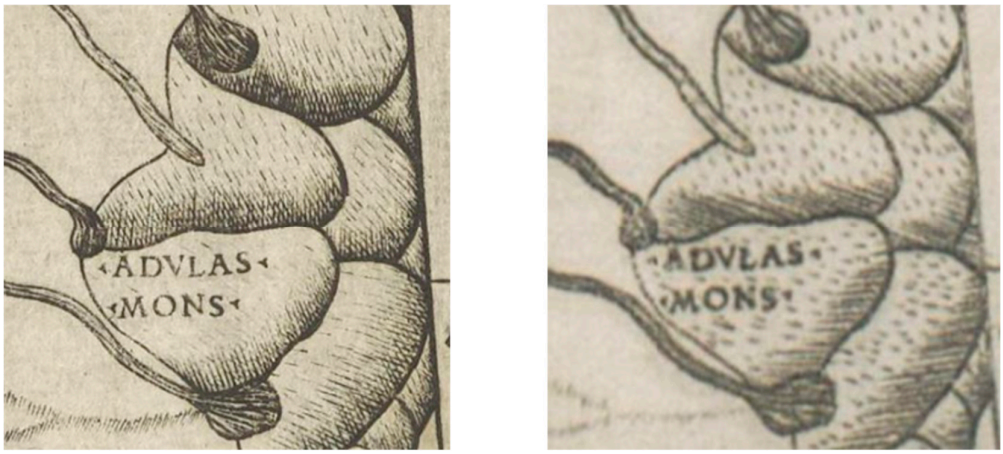

Figure 5. Details of the *Tertia Europe Tabula.* (**Left**): LoC. Incun. 1478.P855 (1478). (**Right**): BnF. GE DD-1007 (RES) (1508).

3.4. Identifying Details of Editions "Quarta Europe Tabula"

In the *Quarta Europe Tabula*, the shading of some mountains has been re-engraved. Additionally, a couple of additional strokes have been discovered in the 1507/08 editions that do not exist in the incunabular editions. In the 1507 copy (Figure 6), observe the two diagonal lines on the mountain to the left of SARMA (although it is not visible in the figure, the full label in the map is "SARMATICI MONTES"), as well as the evident reworking on the mountain northeast of AVI (full label in the map: "ARES FLAVIAE").

3.5. Identifying Details of Editions "Quinta Europe Tabula"

In the *Quinta Europe Tabula*, a re-engraving with a change in the inclination of the shading of the mountains can be observed in the editions of 1507/08, specifically a stroke crossing the letters OSC of the text MOSCHIVS FLV (men) (Figure 7). Due to its unusual location, this stroke could be the result of an accidental scratch.

Figure 6. Details of the *Quarta Europe Tabula*. (**Left**): LoC. Incun. 1478.P855 (1478). (**Right**): BNE. GMG/780 (1507).

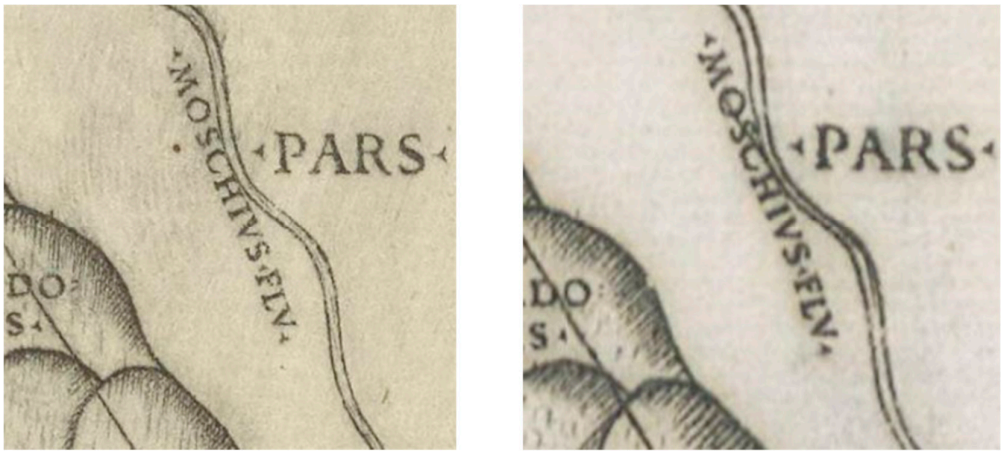

Figure 7. Details of the *Quinta Europe Tabula*. (**Left**): LoC. Incun. 1490.P8 (1478). (**Right**): BnF. GE DD-1007 (RES) (1508).

3.6. Identifying Details of Editions "Octava Europe Tabula"

In the *Octava Europe Tabula*, there is also a general retouching of the shading of the mountains in the editions of 1507/08. Figure 8 illustrates that the part to the left of the river was re-engraved in 1507 after losing its sharpness.

3.7. Identifying Details of Editions "Decima Europe Tabula"

In the *Decima Europe Tabula*, among other amendments, it is evident that the coastline shading has been re-engraved and is notably wider in the editions of 1507/08 (Figure 9).

3.8. Identifying Details of Editions "Prima Africae Tabula"

The first map of Africa, *Prima Africae Tabula*, according to Ptolemaic nomenclature, is the only non-European map where we have detected changes in the plate. In Figure 10, it can be observed that in the 1507 edition, the mountain shading labeled CENABA MONS has practically vanished due to wear, as well as the letter A of CENABA. Also, the shading on the mountains to its right and above has been re-engraved. Furthermore, the line separating the two mountains labeled CENABA and MONS has crossed the horizontal line, delimiting the base of both, invading the blank space of the image due to an oversight by the engraver.

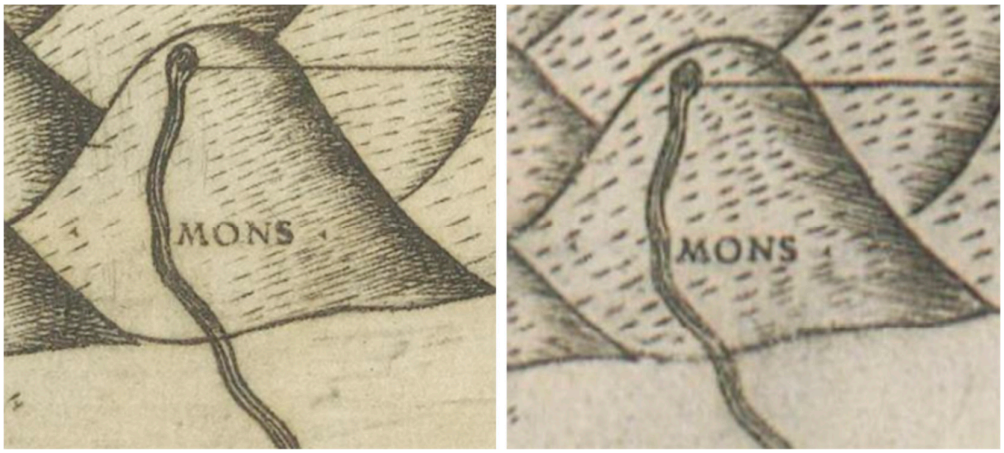

Figure 8. Details of the *Octava Europe Tabula*. (**Left**): LoC. Incun. 1478.P855 (1478). (**Right**): BnF. GE DD-1007 (RES) (1508).

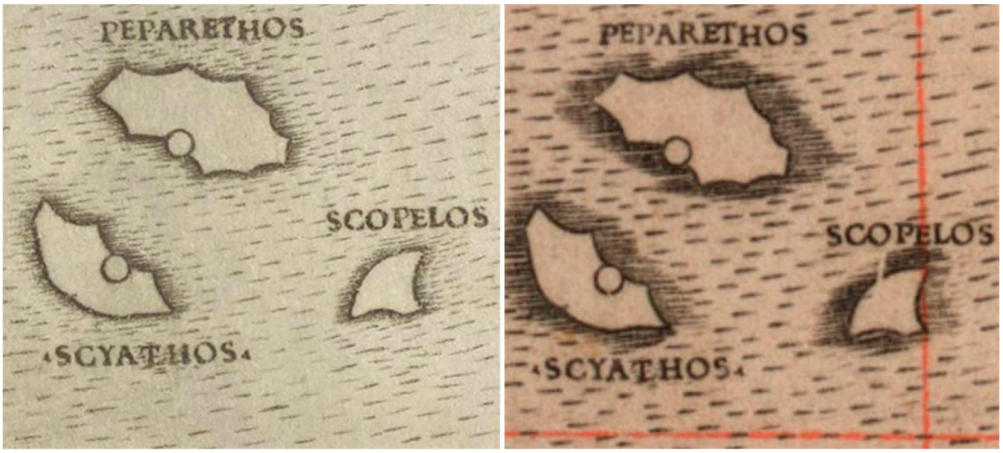

Figure 9. Details of the *Decima Europe Tabula*. (**Left**): Incun. 1490.P8 (1490). (**Right**): BNE. GMG/780. (1507).

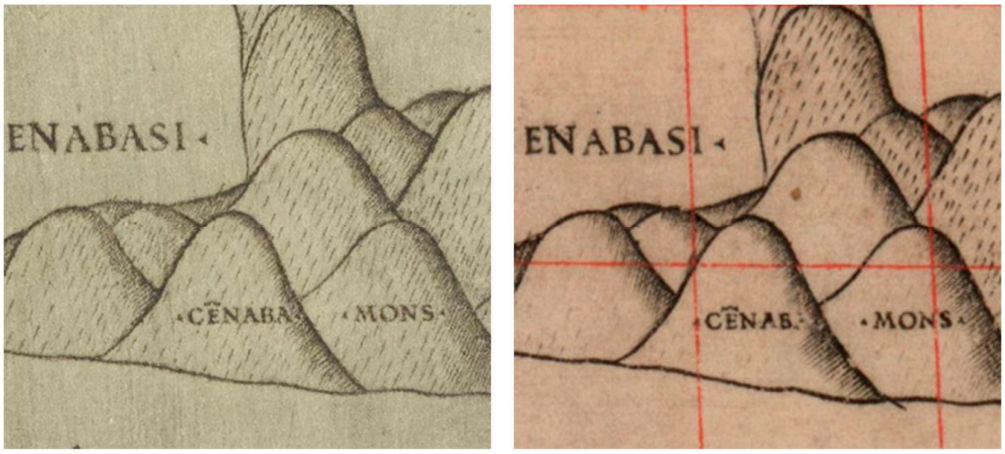

Figure 10. Details of the *Prima Africae Tabula*. (**Left**): Incun. 1490.P8 (1490). (**Right**): BNE. GMG/780. (1507).

3.9. The Rest of the Ptolemaic Maps

When analyzing the rest of the Ptolemaic maps, excepted for *Sexta* and *Nona Europe*, (already studied by Campbell [14] and Peerlings et al. [16]), no modifications were found.

Hence, two maps of Europe (*Prima* and *Septima Europe Tabula*), three maps of Africa (*Secunda*, *Tertia*, and *Quarta*), and the 12 of Asia do not appear to have been reworked. This circumstance does not exclude the possibility that a more detailed examination of these maps in the future could uncover some differences between the editions of 1478/90 and 1507/08.

4. Discussion

Some scattered references in previous literature have generally considered that the 27 classic or Ptolemaic maps from the four editions of Ptolemy's work in Rome originate from the same unchanged copper plates. This viewpoint is supported by Nordenskiöld [12], Sanz [9], and Shirley [13]. However, Campbell [14] and Peerlings et al. [16] detected modifications in the plates of the *Sexta Europe* and *Nona Europe* maps. Peerlings et al. [16] also identified different plate states in the *Tabula Nova Italie*, which were added in the 1507/08 editions and in Johann Ruysch's world map included from 1508 but featured in some copies from 1507. These last two maps are not the subject of this article since they are modern maps added to the Ptolemaic canon.

From the above statements, it can be deduced that, in principle, for most Ptolemaic maps, it is impossible to identify at first glance which of the four editions they belong to.

The simplest way to unequivocally identify each edition is through the paper's watermark [15,16]. Nevertheless, the maps were printed from two copper plates on two separate sheets from a single sheet cut in half, so the statistical probability of a map not having a watermark is 25%. In such cases, other methods would have to be used to distinguish the editions.

In previous sections, it was shown that one indication of the greater or lesser antiquity of an edition is the wear of the plate. Due to successive printings, the engraving gradually loses sharpness, especially after 1000 copies. However, the lack of sharpness alone does not allow the exact date of the edition to be established, unless the pattern of wear is known to be fully contained within a single edition.

The reason for this investigation was to identify two unwatermarked copies of the *Secunda Europe Tabula* (Hispania) acquired by the IGN. In the study of this map, and despite the fact that the image resolution is not homogeneous for every publishing institution, we have been able to observe differences in the plates by comparing scanned maps. These modifications appear from 1507 onwards. When the study was extended to the rest of the Ptolemaic maps, a second plate state was found in six out of the ten European maps (in addition to those known in the *Sexta* and *Nona Europe* maps), and in the *Prima Africae Tabula*. No changes were observed in the plates of the remaining Ptolemaic maps, at least according to our observations.

Based on these results, two questions arise:

First, why were the plates altered? In the case of the Ptolemaic maps, it is clear that the wear of some plates led the new publishers to attempt to correct this situation.

Second, why were those plates chosen and not all maps modified? In Section 3.9, it was seen that, of the 26 regional Ptolemaic maps, changes were only detected in nine maps (eight from Europe and one from Africa). Suppose we observe a map with the points collected by Ptolemy in his *Geography* (the black and red colors, insignificant for our case, correspond to the two types of manuscripts from which those coordinates have been obtained). Thus, we see a high density of points in Europe and near the Mediterranean coasts in general, as well as in the Middle East.

One possible explanation for reworking the plates of almost all European maps is that the editors considered these to contain the most relevant geographical information for a predominantly European audience. For the same reason, four of the six modern maps added in the 1507/08 editions are from Europe. In Figure 11, it can be observed that, as we move south of Africa and east of Asia, the density of information decreases dramatically.

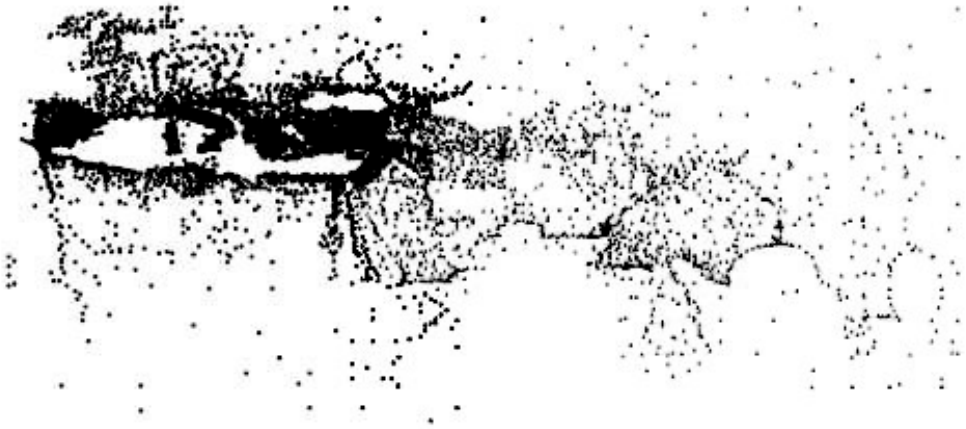

Figure 11. Ptolemy's coordinates plotted in a GIS. Taken from Isaksen [25].

Additionally, another important aspect is the strategic value of the maps: Portuguese discoveries after 1488, when Bartolomeu Dias rounded the Cape of Good Hope, and 1498, when Vasco da Gama reached India, rendered most of the Ptolemaic geographic information about Africa and Asia obsolete. In other words, the publishers may not have wanted to invest effort in reworking more than some plates of Europe. Furthermore, due to their strategic, historical, and symbolic nature, the first one of Africa, which covered the Strait of Gibraltar and the route to the Atlantic, was also altered. The rest would be considered completely obsolete by 1507 and would cover areas of lesser interest to a European audience as well.

5. Conclusions

Authors such as Nordenskiöld [12], Sanz [9], or Shirley [13] considered the maps from the four editions of Ptolemy's work in Rome to be essentially indistinguishable because they were printed from the same plates. Nevertheless, other researchers such as Campbell [14] and Peerlings et al. [16] detected second plate states in two of Ptolemy's partial maps (*Sexta* and *Nona Europe*) and in the modern map added in 1507, *Tabula Nova Italie*.

Furthermore, Peerlings et al. [15,16] identified the different watermarks corresponding to each edition, which enables the discernment of editions as long as these watermarks are present. The map's printing process, using two copper plates each and on separate sheets of paper from a sheet cut in half, makes the probability of a map not containing a watermark in either of its halves 25%.

The initial objective of this study arose from the need to identify the editions of two unwatermarked copies of the *Secunda Europe Tabula* (*Hispania*) acquired by the *Instituto Geográfico Nacional*. According to the state of the art, identification is not possible if there are no watermarks in the document. To this end, these maps were compared with those from other editions using digitized images of maps, and it was found that the plates had been reworked in the 1507/08 editions. Extending this analysis to other Ptolemaic maps, a total of nine modified maps were documented, including the *Sexta* and *Nona Europe* maps already identified by Campbell [13] and Peerlings et al. [16].

Although the methodology employed, image comparison by naked eyes, is not novel, the results are highly relevant: nine of the plates (eight from Europe and one from Africa) from the Roman editions were altered before the publication of the 1507 edition. Our major finding has been identifying seven previously unknown reworked maps. Thus, the incunabular editions of 1478/1490 can be differentiated from those of 1507/1508 without the need to rely on watermarks.

This article provides some specific details that allow the distinction of these two groups. Due to space constraints, images of other areas of these plates that have also undergone modifications have not been shown. We strongly believe this research will be

useful for historians of cartography, curators, antiquarians, and collectors when dating maps from these editions that do not contain watermarks.

As future lines of research, the exploration of automatic or semi-automatic methods and image-change-detection algorithms would be interesting.

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