

Cartographic analysis of two centuries of map printing using copperplates – examples from the Czech Republic and Malta collections

Abstract

This paper provides a comprehensive description of preserved copper plates used for map printing in order to enrich the existing knowledge and, at the same time, contribute with new knowledge on the topic of the engraving of old maps. The dimensions, thickness, and weight of individual printing plates were measured. Qualitative indicators of the material were also examined. Printing plates originating from countries north of the Alps (former Czech lands) and from Mediterranean regions (Malta and Italy) are represented. For the purpose of the study, the term printing plate refers to a copperplate on which the engraving was made using the burin or line etching technique. These are some of the oldest reproduction techniques used for printing old maps. The period studied covers the 18th century, approximately. Studies dealing with a large set of printing plates and their classification are rather an exception (Hameleers 1989). The issue of the qualitative properties of printing plates has not yet been comprehensively addressed in the literature focusing on the history of cartography.

Keywords

Copperplates • map printing • engraving • Czech Republic • Malta • Johann Christoph Müller

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Introduction

Research into old maps often focuses on manuscript or printed maps or atlases, which are the most frequently preserved cartographic products. From a process point of view, maps represent the final product following a series of connected activities and procedures. The initial phase covers data acquisition, processing, evaluation, and cartographic interpretation. The result is a manuscript map, or a model for print reproduction, which is usually considered an original work by the author. In the next phase, an engraver becomes involved, reproducing an original draft and influencing the original work with their style. The significance of these interventions is complicated to capture or quantify. Engravers were not just technicians; they were often skilled artists. Their role involved interpreting and translating the cartographer's or mapmaker's drawings and designs onto printing plates, typically made of copper. This process required a high degree of artistic skill and precision to accurately reflect the geographical information and artistic elements of the map (Woodward 1996).

A small number of these original drawings have survived (Čada & Vichrová 2009). Original printing plates, although still quite rare, can be traced more often. There are several options for examining this specific cartographic product, from the primary bibliography to the measurement of quantitative parameters to the examination of differences in the printed product. The presented study aims to provide a comprehensive inventory of preserved printing plates that the authors discovered in collections in the Czech Republic and Malta. Basic physical parameters were measured, the purpose of which was to compare their properties in relation to their different time and geographical origins. This

study has the potential for further research into the technology used or the quality of the input material.

The analysis of copperplates used in historical map-making holds significant relevance for both geography and the history of science. Copperplates were extensively used for printing maps before the advent of modern printing techniques. By studying these plates, geographers can trace the evolution of map-making techniques. Analysis of old copperplate maps can reveal the accuracy of geographical understanding in different historical periods. The content and style of maps etched on copperplates can shed light on the cultural and political contexts. This includes understanding the interests and biases of mapmakers. Studying copperplates can also provide insights into the technological advances in geographical exploration and cartography. Copperplate illustrations often depict an intersection of geography, biology, astronomy, and other sciences. This can provide a holistic view of how different scientific disciplines influenced each other and evolved together. The artistic aspects of copperplate engravings, especially in scientific illustrations, demonstrate the historical interplay between art and science.

There is only a limited number of preserved map printing copperplates (see further in this paper) held in several archives and museums. As it is only possible to work with the original printing plates in a limited manner, many studies, therefore, focus on them indirectly. Based on the analysis of the prints, conclusions are drawn about the number of printing plates used for individual maps and the time interval of their use, as in the case of the Nuremberg cartographer Johann Baptist Homann (1664–1724) (Heinz 1993). The classification of engraving changes, the identification of

printing plates, and the designation of the number of plates used and the condition they were found in is crucial for a correct cartobibliographic description (Verner 1965, Campbell 1989, Baynton-Williams 2007). The procedures proposed in this paper were refined on the basis of the study of other maps, such as those produced by the Dutch publishing house Covens & Mortier (Egmond 2002). Also, the extent of plate scratches can be used to identify the different map states (Woodward 1994). Other contributions pay attention to the issue of the complexity of the engraving preparation of the printing plate in terms of finances and time (Dörflinger 1983). Therefore, the present article builds on previous efforts to achieve a uniform description and to provide a better understanding of their history, techniques of origin, engraving, and publishing practice (Inventory of surviving copper plates 1994).

Methodology

The methodology was based on detailed measurements (in situ) of the dimensions of the plates as well as the inner and outer parts of the map frame (vertical vs. horizontal dimension in the middle of the plate edge, in millimetres). These data can be used to study the quantitative properties of the printing paper – such as changes in its size due to precipitation or poor drying after printing. These are the basic calibration values for cartometric analyses, which, in most cases, are performed on printed maps for objective reasons. The distance from the edges to the outer frame indicates the efficiency of the use of the input blank plate in relation to the future map format.

Another investigated quantity is the thickness of the plates. This was measured at the individual corners using a calliper micrometer at a distance of about 2 cm from the corner of the plate and then averaged (to the nearest tenth of a millimetre). Likewise, the average thickness was calculated for each set of plates, including indexes. Individual plates were weighed to the nearest gram. Each set as a whole, then, represents the average weight of 1 cm² of the plate expressed in grams and its standard deviation.

In order to obtain comparable data, the measured values were further standardised in the form of the surface area per weight (cm²/g or cm²/kg) or the bulk density of copper in grams per cm³. The obtained data allow for a comparison of the quality of copper used for the production of plates, from different time periods and places of origin, with regard to technological sophistication. The measurements are given in appendices 2 and 3.

For individual copperplate identification, a unique system was created. The unique abbreviations consist of two, three or four digits:

1. First letter from author's surname (e.g. M = Müller, P = Petroschi)
2. Second letter in order to distinguish authors (e.g. Pa = Pace)
3. First letter of covered area (e.g. B = Bohemia, M = Moravia, Ma = Malta, V = Valletta)
4. Clarifying note if necessary (e.g. r = register, s = small, d = diocese, t = trial)

The classification system and secondary use system is based on the work of Marc Hameleers (Hameleers 1989). We distinguish between maps for commercial purposes and maps intended for the needs of institutional cartography.

Commercial production emphasised financial profitability and marketability. In this case, the engravings were used to the very end of their life. In the case of irreversibly damaged content, the input raw material was usually melted down and reused. However, in order to maintain the availability of the product on the market, some publishers had one or more plates of the same map engraved, which were then used in parallel (Heinz 1993).

In the category of non-commercial producers of maps, we mainly include institutions connected with the ruling power or city authorities.

Based on the research, we identified interventions on the reverse side of the plates. Besides the cartographic materials, portraits can also be identified. A completely unique group is represented by oil painting on copper, for which old plates with a cartographic theme were demonstrably used as well.¹

Basic research on the available map printing copperplates that have been preserved

Several dozen surviving printing plates were identified, including a fragment of three etched copperplates of the original fifteen-leaf plan of London, dating from about 1553–1559.² From the legacy of the famous cartographer and publisher Abraham Ortelius, a plate of a map of Asia is known (1567).³ The copperplate of the eastern part of the double-sheet map of South America (1674) has been preserved from the golden age of French cartography. The map was intended for the *Atlas Nouveau* – a joint project of Guillaume Sanson and Alexis-Hubert Jaillot.⁴ An interesting feature of all of the above copies is the oil paintings found on their reverse. A copperplate of Ortelius's map of America in an oval projection (1587) was sold at auction in Arader Galleries on 28 July 2018.⁵ From the area of the northern Netherlands, printing plates of city plans can be documented – of Medemblik (1599), Delft (1675–1678), Utrecht (1598), Alkmaar (1597), Culemborg (1603), and also 22 copperplates of the water management map of the Rijnland region (1600). On the reverse of the plate of the Gluda area, there is an engraved image of the Battle of Nieuwpoort from 1600. From the 17th century, there is a fragment of a printing plate of a map of Africa (southeast coast) by the Amsterdam publisher Johann Jansson (c.1631) with an engraving of a polder map on its reverse.⁶ During the cataloguing and digitisation of the collections of the National Museum in Poznań in 2019, a fragment of a printing plate with a hitherto unknown engraving of the Comenius Map of Moravia from approximately 1734–1745 was discovered.⁷ A portrait of the Saxon Elector Frederick Christian is engraved on the reverse.

Other printing plates are owned by the Plantin-Moretus Museum in Antwerp.⁸ As part of the museum's permanent exhibition, printing plates of the plan of Cambrai, France (1581) and Utrecht, the Netherlands (1581) are on display. An etching of the plan of the town of Kingston upon Hull (c.1642), which is owned by the British Library, comes from the hands of the prominent Czech Baroque artist Václav Hollar.⁹ This is probably

¹Technology originating in Italy spread throughout Europe during the 16th century, thanks to the greater availability of metals. Oil paintings are also documented on copperplates with an engraving of portrait graphics (Schirò 2014).

²Two of them are owned by the Museum of London (Moorfields, Eastern City) and one by the Anhalt Art Gallery in the German town of Dessau (Western City).

³The right bottom sheet of the eight-leaf map (Heinz & Reiter 1998).

⁴This printing plate, which has been owned by the University of Texas at Arlington since 1986, was probably never used for printing and has therefore been preserved in very good condition (Davis-Allen & Reinhartz 1990).

⁵Probably one of the two plates of the map of America made by A. Ortelius, which was never used for printing (Broecke 2005).

⁶This plate is stored in the Westfries Museum, Hoorn (inv. Nr. D.116a). Additional printing plates for water management maps have been preserved in the archives of water authorities (waterschap) (Koeman & Egmond 1975).

⁷It was associate professor Milan Václav Drápela (Department of Geography, Masaryk University in Brno) who identified, in total, 13 unique copperplates of the Comenius map of Moravia (Drápela 1984). The Poznań fragment is a derivative of one of the two printing plates (KMM P, KMM A) by the Amsterdam publisher Claesz Janszoon Vischer from the engraver Abraham Goos (Stachoň & Chrást 2021).

⁸According to the museum's printed guide, its collections contain around 3,000 copper engravings (etchings), mostly book illustrations.

⁹British Library in London (Cartographic Items Maps 177.L.2).

his only surviving plate with a cartographic theme. The library's collections include, for example, a copperplate of the right of the plan of the Dutch coast, engraved by Antonio Francesco Lucini in Florence around 1640. An unsigned and undated copperplate (c.1580) copying part of the wall map of England and Wales by Christopher Saxton can be found in the library catalogue.¹⁰ In 2016, the library acquired a set of nine copperplates of maps of India, and triangulation diagrams for the needs of the East India Company from the turn of the 18th and 19th centuries.¹¹ Another existing plate is of the province of San Diego, created by the engraver Antonio Ysarti in Mexico City, probably in 1682.¹² According to a model from Joan Blaeu's atlas, a copper engraving of the city of Bruges by engraver Reinier Blockhuys was created in the 1830s. Complete sets of copperplates have been documented for maps of, for example, water systems, polders, military maps, especially in the Netherlands. Numerous sets of 18-20th century hydrographic charts for military naval purposes can be found in public collections.¹³ For completeness of the search, several other studies dealing with preserved printing plates can be quoted (Grove & Wallis 1991, David 2008a, Batten 2010, McKee 2010, Reinhartz 2018). A detailed analysis of a complete set of plates of this type has not yet been carried out.

Available comparative material

In total 64 available copper printing plates from the collection in the Czech Republic and seven from the collections in Malta were analysed (for a detailed description, see appendices 2 and 4). The analysed material is divided into two sets according to place of origin (see Fig. 1).

1. The estate of the Austrian engineer Johann Christoph Müller

The 18th century map printing copperplates from the estate of the Austrian engineer Johann Christoph Müller (1673–1721) can be divided into two subsets. The bigger subset (57 copperplates in total) contains maps that were created on behalf of the Austrian emperor. Their preparation was entrusted to the hands of freelance engravers. Chronologically, these are four plates of the map of Moravia from 1716 (see Fig. 2), including two plates with a topographical register (Moravian Land Archives in Brno), and 25 plates of a large map of Bohemia from 1720, including one plate for an overview map – the so-called *compendia* (National Technical Museum in Prague). A reduced version of the map was created six years later, again using 25 smaller copperplates. The second subset (seven copperplates in total) includes printing plates of maps derived from Müller's original work. These are four printing plates of the map of the Olomouc diocese and one plate for an overview map (Kroměříž Archdiocesan Museum). The engravings were created in the Nuremberg publishing house of Johann Baptista Homann's heirs in 1762. Forming part of this collection is what is most likely a trial print plate of the map of Moravia. The last copperplate from the second subset represents an engraving of a map of Cheb county from 1719 (State District Archive Cheb). A basic overview is given in the summary table (see Table 1).

¹⁰British Library in London (Cartographic Items Maps 177.j.2.).

¹¹British Library in London (Cartographic Items Maps 183.a.3.(1–9)).

¹²This printing plate is deposited in the Geography and Map Division Library of Congress.

¹³There are 64 (out of a total of 247) printing plates from the *Atlantic Neptune* atlas (1777) by J. F. W. des Barres, which previously belonged to the British Admiralty. Twenty-nine of them are now owned by the Library and Archives Canada, and others are owned by several US institutions (Terrell 1995). Dating from the end of the 18th century, a set of 270 printing plates of the maps of the East India Company hydrographer Alexander Dalrymple has been preserved, and these are stored mainly in the Admiralty Library (Portsmouth), the British Library, and several other institutions (David 2008b). The National Maritime Museum in Amsterdam also owns an extensive collection of 19th and 20th century hydrographic map printing plates (Guleij 2016).

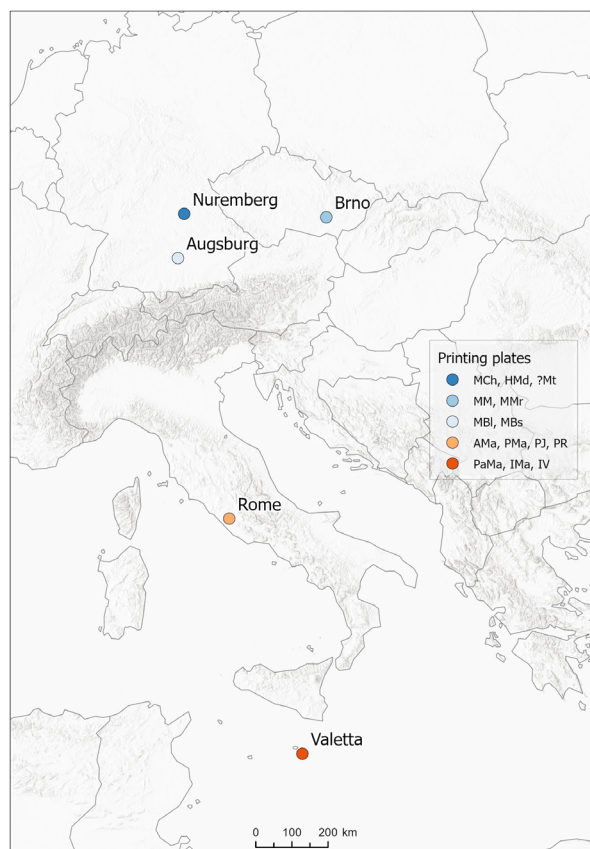


Figure 1. Overview map of the origin of printing plates
Source: own study (Esri. 'Terrain' [basemap]. Scale not given. 'Terrain: Multi-Directional Hillshade'. 25 June 2014. <https://www.arcgis.com/home/item.html?id=3cedfc19d7b941d89ee15b0e2f454070>. (29 January 2022); © EuroGeographics for the administrative boundaries.)

2. The Mediterranean map printing copperplates

The second set consists mainly of preserved printing plates of Malta's maps and other Mediterranean regions (seven copperplates in total). These are usually single sheet maps in the form of a book illustration from different authors and publishers. The copperplate of the Siege of Malta of 1565 is in the private collection of Joseph Schirò in Malta. Other copperplates come from MUŻA – Heritage Malta. A basic overview of the comparative material is given in the summary table (see Table 2).

A list of map titles (both sets) is given in Appendix 1.

Classification and categorisation of preserved plates of sets 1 and 2

In set 1, we find products of commercial and non-commercial map production. MM, MBI, MBs and MCh are topographic maps designed primarily for the economic and administrative needs of the nobility, the monarch or the city council, who also covered the costs of their acquisition. We can therefore consider them as publishers. The military purpose of the maps was triggered by a future sequence of events (The War of the Austrian Succession (1740–1748), The Seven Years War (1756–1763)).¹⁴ For these reasons, they can be included in a new category of administrative

¹⁴Several copies of the map with handwritten notes and an outline of the deployment of military regiments in Moravia, which are probably related to the War of the Austrian Succession, have been preserved at the Österreichische Nationalbibliothek in Vienna.

Table 1. Preserved copper printing plates for Johann Christoph Müller's maps and their derivatives

Area covered	Place of Creation	Date of Creation	Engraver (Publisher)	Abbreviation
Moravia	Brno	1714–1716	Johann Christoph Leidig	MM
Moravia registers	Brno	c.1790	Unknown	MMr
Cheb region	Nuremberg	c.1719	(Christoph Weigel elder)	MCh
Bohemia (large)	Augsburg	1720–1722	Michael Kauffer	MBI
Bohemia (small)	Augsburg	1726	Michael Kauffer	MBs
Olomouc diocese	Nuremberg	1762	(Homann heirs)	HMd
Moravia ('trial')	Nuremberg (?)	1762 (?)	(Homann heirs?)	?Mt

Source: own study

Table 2. Preserved copper printing plates from the Joseph Schirò Collection and MUŽA – Heritage Malta

Area covered	Place of Creation	Date of Creation	Engraver (Publisher)	Abbreviation
Three Cities of Malta	Rome	1582	Natale Bonifacio (Matteo Perez d'Aleccio)	AMa
Malta	Valletta	1771	Filippo Vincenzo Pace	PaMa
Malta	Valletta	1791	Sebastiano Ittar	IMa
Valletta	Valletta	1791	Sebastiano Ittar	IV
Malta	Rome	1733	Giovanni Petroschi (Salvatore and Giandomenico Marescandoli)	PMa
Kingdom of Jerusalem	Rome	1733	Giovanni Petroschi (Salvatore and Giandomenico Marescandoli)	PJ
Rhodes	Rome	1733	Giovanni Petroschi (Salvatore and Giandomenico Marescandoli)	PR

Source: own study



Figure 2. Detail from the map printing plate MM
Source: Moravian Land Archives in Brno, collection D 22 Šbirka
map a plánů (unprocessed amendments)

and economic maps of non-commercial cartographic production. Due to the non-existence of a state topographic service, although they originated from the hands of commercial engravers, they did not serve primarily the purpose of profit from their sale.

In the case of HMd, the production of the map was also commissioned from a supplier from the commercial sphere; however, only the engraving work and possible printing was commissioned. The map had already been sold by the client himself to potential customers from church circles. A completely unique finding is probably the trial ?Mt, which is registered in one collection together with HMd.

The printing plates from set 2 can be classified as commercial production. Most of them were engraved for the purpose of book illustration.

Results

The dimensions of the individual printing plates plotted on the scatter plot (see Fig. 3) show the expected variability in width and height. Logically, the format of the printing plate depends on the size of the displayed area and the selected scale. The investigated set includes small-format maps for book illustrations (IV, IMa) as well as separate large-format maps (PaMa, MM,

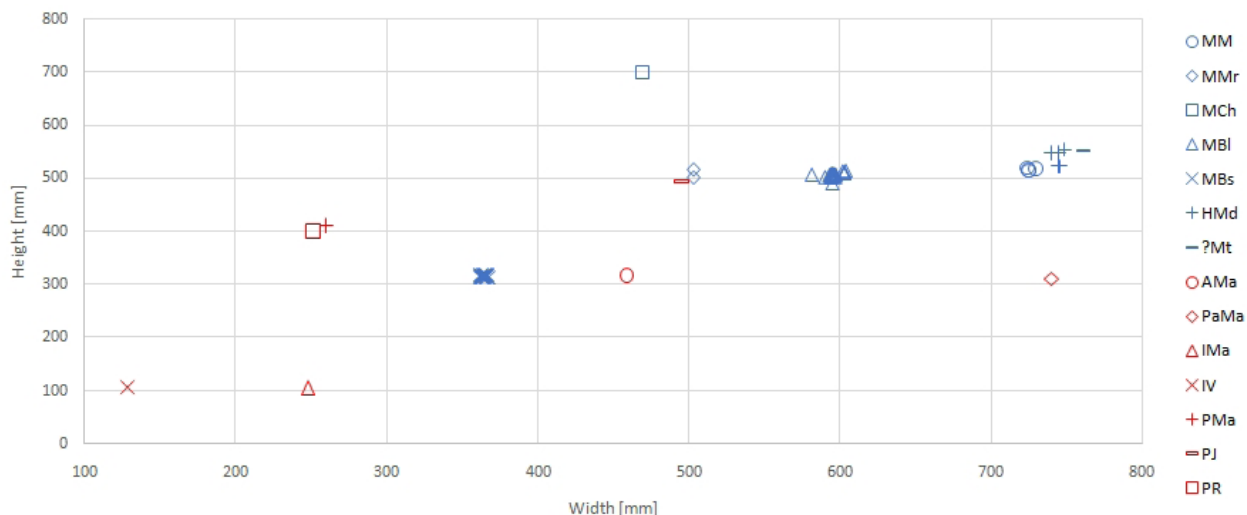


Figure 3. Dimensions of printing plates

Source: own study

HMD, ?Mt, MCh or MBI). In particular, MBs and MM printing plates form a compact size file without significant deviations. MBI and HMD show higher variability. The position of the values plotted in the graph shows the deviation between the registers and the map part of MM. The discrepancy in both sets is also confirmed by other measured quantities (see figures 4 and 5). The obtained values indicate different times of origin and quality of production technology.

A linear relationship between the weight and the area of the printing plates is observable across the examined set (see Fig. 4). It is worth noting the distribution of MBs values, which form a relatively compact set in terms of the surface area of the individual printing plates. Unlike the graph in figure 3, they are not clustered around the centroid but stretched horizontally. The reason is the different weights of the individual printing plates. A similar phenomenon can be observed in MBI and, to a lesser extent, in MM and HMD. Here, however, greater variability is evident in the direction of the y-axis – namely, in the values of the area of the printing plates. The position of AMa and MMr indicates a slight deviation from the imaginary correlation line, which is caused by their lower mass in relation to the area similar to HMD and ?Mt.

Printing plates originating north of the Alps show less diversity in thickness than Mediterranean specimens (see Fig. 5). The measured values range from approximately 1.5 to 2.5 mm. In contrast, the thickness of some Mediterranean printing plates varies from 1 to 3.1 mm.

The scatter plot (see Fig. 5) shows further significant variability in MBs. Both quantities have a rather linear dependence. In contrast to the dimensions, there are significant differences in both the weight (approx. 3/4 kg) and the thickness of the plates (approx. 0.6 mm). The variability may indicate, above all, the primitiveness of the production technology, producing qualitatively different outputs, or differences in the original input products, using semi-finished plates. Sections I and VI, which have been completely overwritten over time, do not show measurable deviations from the rest of the set. A similar trend is noticeable for HMD between a four-leaf and a single-leaf overview map. Despite the minimal size difference, the overview map plate is noticeably heavier and thicker than the rest of the file. On the contrary, ?Mt is close in size, weight and thickness to a set of detailed HMD plates. Leaving aside the overall dimensions,

MCh is very close to MBI in quality. The set of MBI printing plates shows a considerable variance of values in their thickness. The difference between the thinnest and thickest plate is similar to the 0.6 mm as seen in the case of MBs. However, the dependence on weight is not as clear-cut as with MBs, as even heavier plates have a low thickness. This relationship can be explained by the variation in the size of the individual plates (see Fig. 3). Graphs 3, 4, and 5 show the difference in the indicators between a set of printing plates from the Mediterranean and the northern areas, whether it is the overall size, thickness or weight. The only exception is PMA and PR (Rome), which is qualitatively similar to MBs (Augsburg). From this, it can be deduced that the input material is the same for two geographically different localities, which could be commercially interconnected.

The distance from the edge of the printing plate to the outer frame of the map drawing is very similar in height and width for both MBI and MBs files (see Table 3). The difference can only be seen in the distribution of deviations, which are more consistent with MBs. The overall composition of the map consists of five horizontal and five vertical map sheets. Their format is worth attention. For MBI, the height of the map field is always about 1.5–2 cm greater for plates from the first and last (fifth) row. The map field for the plates from the second, third and fourth rows is practically the same height. However, within each row, the map field is always about 1.5 cm wider at the first and last plate. At MBs, we observe the same trend, with the difference being of about 1 cm both in the height of the map field of the first and last row and in the width of the first and last plate in each row. For both the MBI and MBs with the largest number of files, there is an apparent shift in the engraver's practical experience in planning the format of the map field with respect to the size of the printing plate. The total material losses in the form of an unused edge are practically the same. However, they differ significantly from piece to piece in MBI, while the individual MBs plates have a consistent ratio of edge distance from the outer frame (see Table 3).

The box plot diagram shows the values of the ratio of the area of the printing plates in cm²/kg (see Fig. 6). The values of monolithic maps are also displayed for comparison across the entire file over time. In the case of multiple sets of printing plates, the variability within the MBs is evident, which corresponds to previous findings. The asymmetrical form of the graph indicates the possibility of using more input materials of different quality

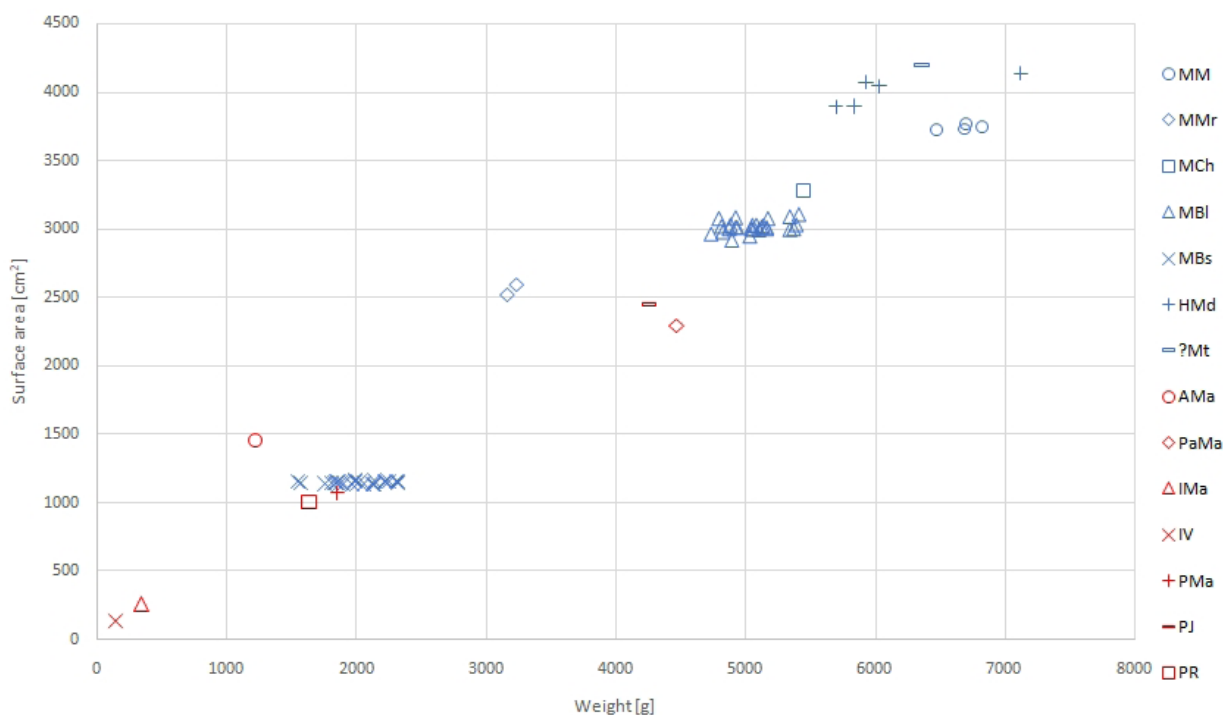


Figure 4. Dependence of weight on the surface area of printing plates

Source: own study

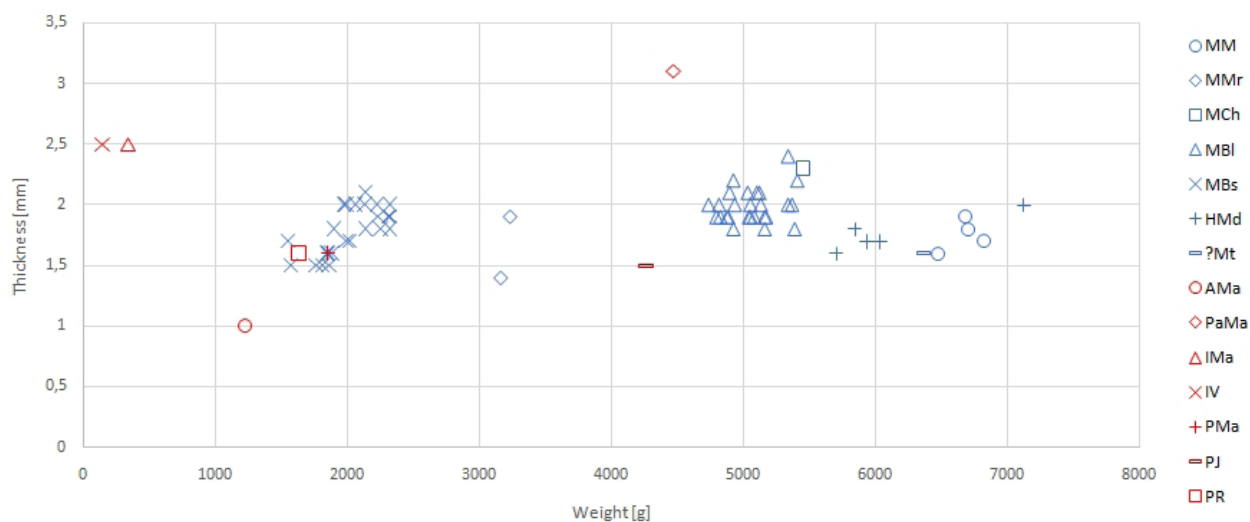


Figure 5. Dependence of weight on the thickness of printing plates

Source: own study

and origin. To a lesser extent, this is also the case for HMd and MBI. The mean HMd and ?Mt are almost identical. It can be rightly assumed that even the test engraving, without any further identification, comes from Homann's publishing house in addition to HMd. The position of the MM and MMr graphs is completely different. The measured values correspond to the archival records of the different acquisition times of the map printing plate and the topographical register. AMa is completely out of the range of the rest of the set. From its position, it is clear that it is a very thin

printing plate, which is confirmed by the thickness measurement itself (c.1 mm). Leaving aside the position of the MMr in the set of printing plates from the area north of the Alps, the position of the mean values is again less variable than in the case of the Mediterranean specimens. The only difference is the PMa and PJ values, which are practically identical to MBs or MM. In the case of these specimens of different geographical origin, it is possible to look for a common source of input material. MCh and MBI have similar values. The variability within a set of Mediterranean

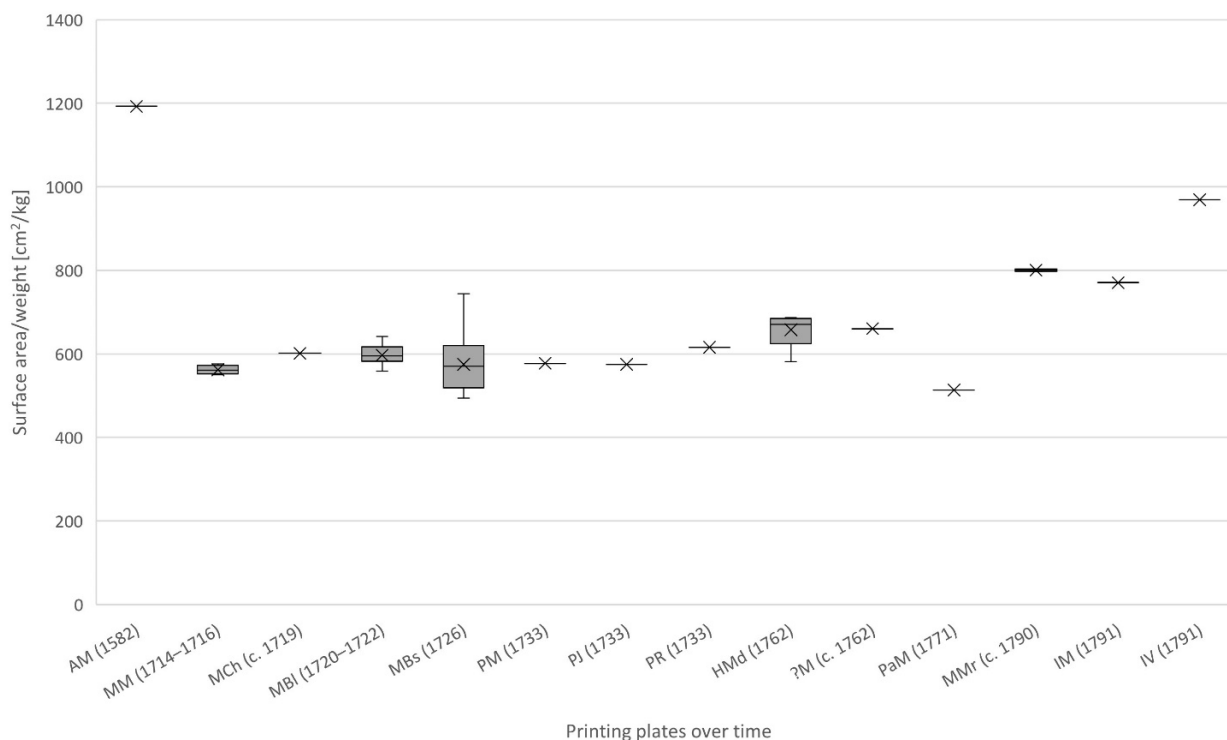


Figure 6. Development of the ratio of surface area and weight of printing plates over time
Source: own study

Table 3. The average size of the edges of the printing plates
MBI and MBs

Map		Edge – height [mm]	Edge – width [mm]
MBI	Average	26	30
	Standard deviation	10	10
MBs	Average	28	25
	Standard deviation	5	6

Source: own study

printing plates cannot be reliably explained; perhaps it is due to varying sources of input raw material or the inconsistent quality of copperplate production technology.

The distribution of the frequency of plate area values per kilogram is shown in Figure 7. The distribution is not completely symmetrical. It stretches in the direction of the maximum values. Values in the range of 551–600 cm²/kg are most often represented. The graph shows the highest concentration of values around the average, with measurements occurring even above 700 cm²/kg. The area-to-weight ratio of AM (c.1,200 cm²/kg) can be considered as a complete outlier.

Discussion

The achieved results were primarily conducted using information from the *Maps as Prints...* publication (Woodward 1996). The search conducted by the authors did not reveal other sources that would at least partially work with the physical parameters of the preserved printing plates to this extent.

Qualitative differences in the examined set of printing plates are not the result of rapid technological progress. The change in the technology of copperplate production has been recorded since the middle of the 16th century when rolling copperplates replaced hand-beaten ones (Woodward 1996). The reason for the differences can be found more in the local aspects of the quality of the production process and in the source raw material, including its availability.

From the point of view of the dimensions of the printing plates, it is obvious that the produced formats of copperplates should be compared. In many cases, the engraver used the area of a standard copperplate practically to its full extent. If we consider the maximum 70 x 50 cm format (imperial size), MM, MCh, HMD and ?Mt used this format. MBI printing plates are also of similar dimensions (Woodward 1996). Here, even at the cost of more waste, the engraver reduced one side by about 10 cm. The smaller available format of copperplates c.29.5 x 43.4 cm was used by the engravers MBs, PMa, and PR (Woodward 1996). Some of the examined plates have atypical dimensions, especially those adapted for book illustrations—AMa, PJ, IMa, IV or PaMa. In these cases, the input copperplate was cut to the required dimensions. For multi-leaf maps MBI and MBs, even due to differences in the size of the engraving and the printing plate, it is possible to observe the natural development of the engraver's skills and experience, which he underwent within six years of their creation.

The issue of accurate plate thickness measurement is debatable from several angles. The selected method finds limits in the device used. In order to be able to consider the measured thickness values as representative, it is appropriate to convert them to another indicator –for example, bulk density. Unlike the density of the metal, this assumes a certain degree of material inconsistency in the form of pores, cavities, and so on. However, this indicator is sufficient for a basic comparison. The density of copper corresponds to $c.8.96 \text{ g/cm}^3$. The average value of the measured set is $c.9 \text{ g/cm}^3$. This value can also be validated thanks to the preserved printing plate of a map of a part of South America by G. Sanson and A. H. Jaillot from 1674 (Davis-Allen & Reinhartz 1990). Its bulk density is $c.8.5 \text{ g/cm}^3$. Therefore, with the exception of a few outliers, the measured thickness values can be considered relevant (see appendices 2 and 3). With regard to geographical aspects, this printing plate appears to have a more compact set of plates from the area north of the Alps. The standard deviation corresponds to approximately 1 g/m^3 compared to $c.2.7 \text{ g/m}^3$ in the Mediterranean area. The smallest values of bulk density were achieved for printing plates that were engraved in Valletta (PaMa, IMA, IV), geographically furthest from the source of the raw material. The mines in Hungary (today's Slovakia) produced some of the main copper ore deposits, but the Italians also used other sources, such as from the Tyrol area (Woodward 1996). This finding offers space for additional research into the geographical correlation between the quality of the copperplates used and the place of extraction of the input raw material. It is necessary to take into account the fact that the cited data work within the time period of the 16th and 17th centuries. The comparison of the two largest sets of printing plates, MBI and MBs, which were prepared by the Augsburg engraver Michael Kauffer over a period of six years, brings interesting results. MBI reaches an average bulk density of 8.5 g/cm^3 , MBs 9.8 g/cm^3 . The size of the standard deviation does not exceed 1 g/cm^3 for both equally large groups. It is worth noting the noticeable change in the quality of the material in the form of copper purity in the very short term. As early as the 16th century, most of the copper trade was controlled by the Bavarian cities of Nuremberg and Augsburg (Woodward 1996). It is a matter of discussion whether the cause can be found in a qualitatively different source of copper ore or in the shortcomings of the metallurgical process of its extraction. However, from the achieved results, it is not possible to deduce the differences between the two cities, Nuremberg and Augsburg, in terms of preference for the materials used and their resources. The occurrence is rather accidental, as the same engraver (Michael Kauffer) worked in the case of MBI and MBs with qualitatively different materials in a relatively short period of time (1720–1726).

In addition, in the case of MBs, the measured parameters (thickness, surface area/weight) indicate the variable quality of the copperplates within the set. It is less likely that the engraver himself would prepare a plate for engraving from copper ingots. This activity fell under the responsibility of a specialised metalworker (Woodward 1996). It is also possible to produce an alloy of copper and other metals. Such a connection can be found more for printing plates PaMa, IMA, IV or lower MMr, whose bulk density reaches values between 4.1 and 6.5 g/cm^3 . However, in this case, the influence of the quality of their thickness measurement is representative of the values obtained. MM (10.2 g/cm^3) also achieves similar values as MBs, of which it is known only that the engraving was prepared by the Brno engraver Johann Leidig, originally from Swabia (the capital of which is Augsburg). The HMd file from Homann's Nuremberg publishing house has an average value of 8.7 g/cm^3 . This is a very similar value to Augsburg's MBI production, only with a time span of less than 40 years.

Determining the problematic thickness can be replaced by measuring more reliable indicators, namely the dimensions and weight of printing plates. When converting the surface area of the printing plate to one kilogram, $c.86\%$ of all values lie in the range of $501\text{--}700 \text{ cm}^2/\text{kg}$ (see Fig. 7). When values of less than $500 \text{ cm}^2/\text{kg}$ are taken into account, it is already about 90% . The maximum values are interesting, most of which are in the range of approximately $700\text{--}800 \text{ cm}^2/\text{kg}$, and one complete outlier value of $1,200 \text{ cm}^2/\text{kg}$ for AMa. A large deviation of MBs confirms the inconsistency of the file. In the case of HMd, the higher deviation is caused by a different value for the four-leaf and overview map of the diocese. A slight difference is also evident in other indicators (see figures 4 and 5). The MCh value is different compared with other plates (HMd, ?Mt) originating from Nuremberg. It is closer to the Augsburg MBI and MBs, which date from about the same time period. The discussed source reports the measurement of the same quantity in seven plates from the Atlantic Neptune atlas (Woodward 1996). The values range from 589 to $773 \text{ cm}^2/\text{kg}$. In the case of our group, the average value of $613 \text{ cm}^2/\text{kg}$ is closer to the lower limit of this interval. Values above $700 \text{ cm}^2/\text{kg}$ tend to have the character of remote measurements. Qualitative differences are evident from this basic comparison. As with the work of J. Ch. Müller, 64 printing plates have been preserved from the Atlantic Neptune atlas. Both works roughly cover the same time period. There is potential for comparing two comprehensive sets of different geographical origins.

The performed research confirms earlier conclusions about the different period of origin of MM and MMr. Assertions based on archival materials can be supported by the results of the exact measurements of the physical properties of both files. However, the position of MMr on the individual graphs is so different from other printing plates that it is not possible to perform even indirect time identification.

The chosen methodology for measuring the thickness of printing plates can be considered satisfactory, and the obtained values are representative. While maintaining the quality of measurement accuracy, it is not absolutely necessary to approach more sophisticated technologies (e.g. 3D scan), which are not always easily accessible in connection with the storage of archival material.

Conclusions

The conclusion of this research into copperplates encompasses a range of important insights into the cartographic practices over two centuries, particularly focusing on collections from the Czech Republic and Malta. The study involved a comprehensive analysis of 63 copper printing plates from the Czech Republic and seven from Malta, including measurements of their dimensions, thickness, and weight. This provided valuable data for understanding the variations in printing paper and the overall efficiency of the map printing process.

A key finding of the study is the notable variability in the dimensions and quality of copperplates used in historical map-making. This variability was influenced not only by technological advancements but also by local production quality and the availability and quality of raw materials. The research highlighted significant geographical differences in the characteristics of the plates, with those from north of the Alps showing less thickness diversity compared with their Mediterranean counterparts, indicating regional variations in copperplate production processes and raw materials.

The study also distinguished between commercially produced maps, which emphasised profitability and marketability, and non-commercial maps produced by institutions connected with ruling powers or city authorities. This distinction is crucial for understanding the historical context and purpose behind the

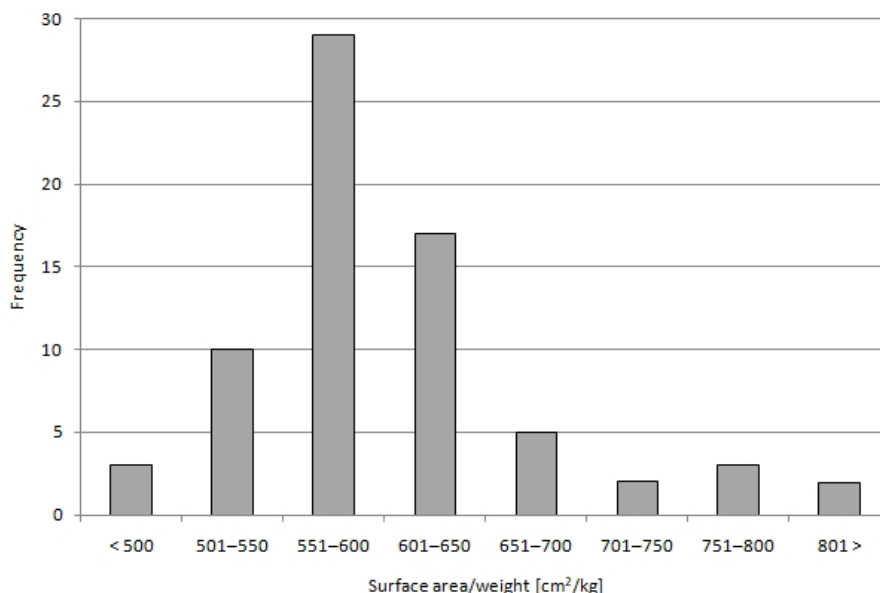


Figure 7. Distribution of the surface area values per kilogram in the whole set

Source: own study

maps. Additionally, the research uncovered how copperplates were used and reused, including the melting down of damaged plates and the use of the reverse side for other illustrations, such as portraits or oil paintings.

A unique system was developed for identifying individual copperplates, taking into account factors such as the author's surname, the area covered, and specific notes. This system aids in the classification and categorisation of the plates, which is essential for correct carto-bibliographic description. The detailed measurement of physical properties such as plate thickness, weight, and surface area allowed for comparisons across different time periods and origins, shedding light on the technological sophistication used in map printing.

The findings of this research open avenues for further exploration into the technology of map printing, the quality of input materials, and the influence of geographical factors on the production of copperplates. They also exemplify the use of detailed physical measurements as a methodological approach in cartographic history research, providing an example for future studies in this field.

Overall, this research significantly contributes to the understanding of historical map printing techniques, particularly the use of copperplates, and provides a foundation for further exploration in the field of cartographic history.

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Appendices

Appendix 1 *List of Map Titles*

MM:

TABULA GENERALIS | MARCHIONATŪS MORAVIAE | IN SEX CIRCULOS DIVISAE

MMr:

Register | Aber die große Mährische Landt: Karten alle darinnen befündliche Örthernach | nachdem A.B.C. geschwindzufünden. | ...

MCh:

MAPPA CHOROGRAPHICA DISTRICTVS EGRANI

MBI:

MAPPA | GEOGRAPHICA | REGNI | BOHEMIAE | IN DUODECIM CIRCULOS DIVISAE | CUM COMMITAT U GLACENSI | ET DISTRICTU EGERANO | ADIUNCTIS CIRCUMIACENTIIUM REGIONUM PARTIBUS CONTERMINIS | ex accuratatotius Regni perlustratione | et geometricadimensione | OMNIBUS, UT PAR EST, NUMERIS ABSOLUTA | et | ad usumcommodumnec | non omnia et singuladistinctiuscognoscenda | XXV. SECTIONIBUS

MBs:

MAPPA | CHOROGRAPHICA novissima et completissima | TOTIUS | REGNI | BOHEMIAE | IN DUODECIM CIRCULOS DIVISAE | CUM COMITATU GLACENSI ET DISTRICTU EGRANO | ADIUNCTIS CIRCUMIACENTIIUM REGIONUM PARTIBUS CONTERMINIS | ex accuratatotius Regni perlustratione | et geometricadimensione | MANDATO CÆSAREO | instituta | in hancformamredacta | et | ad usumcommodum | nec non omnia et singuladistinctiuscognoscenda | XXV SECTIONIBUS

HMd:

Detailed map:

TABULA ALMÆ | DIOECESIS AMPLISSIMI EPISCOPATVS | OLOMUCENSIS | In LXII. Decanatusdivisæ, ...

Overview map:

TABULA | GENERALIS DIOECESIS OLOMUCENSIS | In LXII Decanatusdivisæ, ...

?Mt:

TABULA GENERALIS | MARCHIONATUS | MORAVIA | IN SEX CIRCULOS DIVISÆ

AMa:

DIMOSTRATIONE DI TVTTA LA GVERRA

PaMa:

Malta colle sue Citta, Fortificazioni, Terre, Villaggi, Valloni, e Luoghi Alpestri, con le sue Isole adjacenti

IMa:

Isle de Malte

IV:

Cite Valette

PMa:

Isole di Malta e Gozzo di Sebastiano Pauli

PJ:

Regno di Gerusalemme in tempo delle Guerre Sagre: delineato, e descritto da Sebastiano Paoli per ineligenza della Istoria di Malta a Sua Altezza Eminentissima F.D. Antonio Manoel G.M.

PR:

Isola di Rodi di Sebastiano Pauli

Appendix 2 *Measurements of printing plates of Johann Christoph Müller maps and their derivatives deposited in the Czech Republic*

Printing plate	Section	Size [mm]	Weight [g]	Surface area/weight [cm ² /kg]	Thickness [mm]	Bulk density [g/cm ³]
MM	I	518 x 724	6820	550	1.7	10.7
	II	517 x 730	6700	563	1.8	9.9
	III	514 x 725	6470	576	1.6	10.9
	IV	515 x 725	6680	559	1.9	9.4
	Average			562	1.8	10.2
	Standard deviation			9	0.1	0.6
MMr	Register 1	501 x 503	3160	797	1.4	9.0
	Register 2	516 x 503	3230	804	1.9	6.5
	Average			801	1.7	7.8
	Standard deviation			3	0.3	1.2
MCh		699 x 469	5450	602	2.3	7.2
MBI	Sectio I	507 x 597	5050	599	1.9	8.8
	Sectio II	507 x 597	5080	596	1.9	8.8
	Sectio III	510 x 603	5170	595	1.9	8.8
	Sectio IV	507 x 581	5030	586	2.1	8.1
	Sectio V	513 x 602	5340	578	2.4	7.2
	Sectio VI	509 x 595	5390	562	1.8	9.9
	Sectio VII	507 x 596	5130	589	2.0	8.5
	Sectio VIII	511 x 603	4920	626	1.8	8.9
	Sectio IX	504 x 594	5340	561	2.0	8.9
	Sectio X	505 x 596	5160	583	1.9	9.0
	Sectio XI	505 x 596	5120	588	2.1	8.1
	Sectio XII	504 x 595	5370	558	2.0	9.0
	Sectio XIII	510 x 603	4790	642	1.9	8.2
	Sectio XIV	505 x 596	4930	611	2.0	8.2
	Sectio XV	490 x 595	4890	596	2.1	8.0
	Sectio XVI	505 x 594	5160	581	1.8	9.6
	Sectio XVII	503 x 595	5100	587	2.1	8.1
	Sectio XVIII	514 x 604	5410	574	2.2	7.9
	Sectio XIX	508 x 596	4880	620	1.9	8.5
	Sectio XX	508 x 594	4810	627	2.0	8.0
	Sectio XXI	502 x 590	4730	626	2.0	8.0
	Sectio XXII	505 x 594	5040	595	1.9	8.8
	Sectio XXIII	506 x 593	4870	616	1.9	8.5
	Sectio XXIV	506 x 595	4920	612	2.2	7.4
	Sectio XXV	501 x 594	4820	617	1.9	8.5

Printing plate	Section	Size [mm]	Weight [g]	Surface area/weight [cm ² /kg]	Thickness [mm]	Bulk density [g/cm ³]
	Overview	502 x 597	5050	593	2.0	8.4
	Average			597	2.0	8.5
	Standard deviation			22	0.1	0.6
MBs	Sectio I	317 x 364	2220	520	2.0	9.6
	Sectio II	317 x 365	2320	499	2.0	10.0
	Sectio III	317 x 366	2140	542	1.8	10.2
	Sectio IV	317 x 365	2220	521	2.0	9.6
	Sectio V	317 x 364	2320	497	1.8	11.2
	Sectio VI	318 x 366	1990	585	1.7	10.1
	Sectio VII	315 x 366	1860	620	1.5	10.8
	Sectio VIII	314 x 367	2020	570	1.7	10.3
	Sectio IX	316 x 366	1990	581	2.0	8.6
	Sectio X	315 x 364	2320	494	1.9	10.6
	Sectio XI	315 x 364	1880	610	1.6	10.2
	Sectio XII	315 x 364	1570	730	1.5	9.1
	Sectio XIII	317 x 364	1550	744	1.7	7.9
	Sectio XIV	314 x 363	1900	600	1.8	9.3
	Sectio XV	314 x 362	1970	577	2.0	8.7
	Sectio XVI	317 x 365	2250	514	1.8	10.8
	Sectio XVII	315 x 362	2060	554	2.0	9.0
	Sectio XVIII	314 x 362	2130	534	2.0	9.4
	Sectio XIX	316 x 362	1810	632	1.5	10.5
	Sectio XX	315 x 363	1840	621	1.6	10.1
	Sectio XXI	317 x 365	2310	501	1.9	10.5
	Sectio XXII	317 x 365	2230	519	1.9	10.1
	Sectio XXIII	314 x 362	2140	531	2.1	9.0
	Sectio XXIV	315 x 362	1760	648	1.5	10.3
	Sectio XXV	318 x 362	1850	622	1.6	10.0
	Average			575	1.8	9.8
	Standard deviation			66	0.2	0.8
HMd	I	547 x 740	6030	671	1.7	8.8
	II	547 x 745	5930	687	1.7	8.6
	III	522 x 746	5840	667	1.8	8.3
	IV	522 x 745	5700	682	1.6	9.2
	Overview	553 x 749	7120	582	2.0	8.6
	Average			658	1.8	8.7
	Standard deviation			39	0.1	0.3
?Mt		552 x 761	6360	660	1.6	9.5

Source: own study

Appendix 3 Measurements of printing plates of maps from Malta collections

Printing plate	Size [mm]	Weight [g]	Surface area/weight [cm ² /kg]	Thickness [mm]	Bulk density [g/cm ³]
AMa	459 x 317	1220	1193	1.0	8.4
PaMa	740 x 310	4465	514	3.1	6.3
IMa	248 x 105	338	770	2.5	5.2
IV	128 x 106	140	969	2.5	4.1
PMa	260 x 411	1850	578	1.6	10.8
PJ	495 x 495	4260	575	1.5	11.6
PR	251 x 400	1630	616	1.6	10.1

Source: own study

Appendix 4 List of used collections

Owner	Copperplate	City	Country
Moravian Land Archives	MM, MMr	Brno	CZ
State District Archive Cheb	MCh	Cheb	CZ
National Technical Museum	MBI, MBs	Prague	CZ
Archdiocesan Museum	HMd, ?Mt	Kroměříž	CZ
Joseph Schirò	Ama	Valletta	MT
MUŽA – Heritage Malta	PaMa, IMa, IV, PMa, PJ, PR	Valletta	MT

Source: own study

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