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Front cover photography: The image shows part of the cartouche of the map *Ducatus Carnioliae tabula chorographica* by Janez Dizma Florjančič from 1744. The personified Carniola is surrounded by the coats of arms of noble families and a mountainous landscape showing the entrance to a mine, a waterfall, a river gorge, and people on stilts (Geographical Museum GIAM ZRC SAZU).
Fotografija na naslovnici: Na sliki je predstavljen del kartuše zemljevida *Ducatus Carnioliae tabula chorographica* Janeza Dizme Florjančiča iz leta 1744. Personificirano Kranjsko obdajajo grbi plemiških rodbin in gorska pokrajina, kjer so upodobljeni vhod v rudnik, slap, rečna soteska in osebi na hoduljah (Zemljepisni muzej GIAM ZRC SAZU).

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A NEW STANDARDIZED METHODOLOGY FOR ANALYZING CARTOGRAPHIC INFORMATION ON OLD MAPS

Primož Gašperič

MARKO ZAPLATIL

The cartographic material at the Geographical Museum was of great importance for understanding old maps better.

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Primož Gašperič[1]

A new standardized methodology for analyzing cartographic information on old maps

ABSTRACT: This article presents a new methodology for analyzing old maps that was used to identify and interpret cartographic symbols on selected maps. It analyzes fifty-eight maps, originating from the sixteenth to nineteenth centuries and showing the territory of Slovenia. The basic criteria for selecting the maps were authorship, scale, and the territory depicted. The study included maps at a medium scale of 1:200,000 to 1:900,000. Approximately eighty entries were made for each map, and several thousand pieces of data were obtained, which then required a uniform and systematic examination of all cartographic symbols on the maps selected. Before the nineteenth century, changes in symbols for vegetation, relief, transport networks, and explanatory elements were the most evident. The article concludes by highlighting the reliability of cartographic content as a source for research. The new method for examining maps makes it easier to determine the cause-and-effect relationship of cartographic elements to map content.

KEY WORDS: cartographic methodology, old map, cartographic element, cartographic symbol

Nova standardizirana metoda za analizo kartografskih podatkov na starih zemljevidih

POVZETEK: Članek predstavlja novo metodologijo za analiziranje starih zemljevidov, ki je bila uporabljena za identifikacijo in interpretacijo kartografskih znakov na izbranih zemljevidih. Analizirali smo 58 zemljevidov, ki so nastali v obdobju od 16. do 19. stoletja in prikazujejo ozemlje Slovenije. Osnovni pogoji za izbor zemljevidov so bili avtorstvo, merilo in prikazano ozemlje. Študija je vključevala zemljevide srednjega merila od 1 : 200.000 do 1 : 900.000. Za vsak zemljevid smo naredili približno osemdeset vnosov in tako pridobili več tisoč podatkov, ki so zahtevali enoten in sistematičen pregled vseh kartografskih znakov na izbranih zemljevidih. Pred 19. stoletjem so bile najbolj očitne spremembe simbolov za rastlinstvo, relief, prometno omrežje in pojasnjevalne elemente. V zaključku je izpostavljena verodostojnost kartografske vsebine kot vira raziskav. Nova metoda za preučevanje zemljevidov olajša ugotavljanje vzročno-posledičnega vpliva kartografskih elementov na vsebino zemljevida.

KLJUČNE BESEDE: kartografska metodologija, star zemljevid, kartografski element, kartografski znak

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1 Introduction

Maps can have great communicative value (Fridl and Urbanc 2006) and are an important tool for understanding the current and past landscape. It is important to know a landscape's past because the present landscape largely reflects past developments (Komac 2009). Maps are a vital source of information (Urbanc et al. 2006). However, in the past, they were often neglected as a historical source of information, or their content and communicative value were underutilized (Harley and Woodward 1987). This has changed over the past decades (Chiang et al. 2020). Maps have become a valuable source for understanding spatial changes to landscapes, offering insight into the social, political, and natural situation of the time of their creation (Zorn, Breg Valjavec, and Ciglič 2018).

Maps can be studied in various ways: in terms of their time of origin (Höck and Leitner 1984; Marković 1993), the accuracy of the territory presented (Timár et al. 2006; Frajer and Geletič 2011), their authorship (Rojc 1990; Pedley 1992), the cartographic network and projections (Bönisch 1967; Molnár, Podobnikar, and Timár 2009), and so on. One way to standardize research is to analyze cartographic elements, which are the foundation of every map. As such, they are inextricably related to the development of cartography. They include natural and built elements, toponyms, and mathematical and explanatory elements.

In the past, the use and form of cartographic elements on maps were never formalized. Therefore, authors randomly selected the content of maps and the manner of representing the cartographic elements. The content of maps was in the domain of the client commissioning the map and the cartographer. On old maps, cartographic representation commonly deviated from geographic reality, which was often unknown. Due to unstandardized representation and production of maps, their analysis, comparison, and content-related evaluation have so far been very demanding and lacking methodological structure. For example,

Figure 1: Ioanes Sambucus's 1572 map of Illyria.

there have been substantial differences in representing settlements (point versus area symbols) and relief (side view: molehills, plan view: hachures and contour lines). Moreover, the density of information presented on maps has varied significantly, as well as the locations of this information (e.g., the type and location of the content in relation to the map frame). In the technical and cartographic sense, sixteenth-, seventeenth-, and eighteenth-century maps differ greatly from maps created in the nineteenth century or later. Therefore, a cursory or casual comparison may be inaccurate or misleading.

Slovenian and international literature predominantly uses chronological and descriptive approaches to examine maps in a specific period (e.g., Gašperič 2007). The most relevant and extensive contributions in analyzing cartographic elements are the volumes from the series The History of Cartography Project (2022). Interesting insights into the topic are also offered by a book that analyzes the cartographic elements of fantasy maps (Ekman 2013), and fictional maps (Gašperič and Komac 2019). However, a description of a specific map or a small group of maps from the same period can only satisfy readers looking for information on a specific cartographic representation or maps from a specific period. It does not reveal what these maps mean in cartographic terms, such as in relation to older or younger maps or in terms of the development of cartography.

To date, cartographic elements have been divided in various ways, such as from the historical, cartographic, geodesic, or art-research perspectives. Some authors have divided elements on large-scale topographic maps into two main groups: 1) geographical and 2) mathematical elements (Peterca et al. 1974) or 1) natural and 2) built elements (Lovrić 1988). Others have identified three groups: 1) natural elements, 2) anthropogenic (built) elements, and 3) toponyms (Petrovič 2010); or four groups: 1) mathematical, 2) natural-geographical, 3) socio-geographical, and 4) other elements (Vrišer 1998), or 1) mathematical basis, 2) geographical elements, 3) editorial information, and 4) additional elements (Peterca et al. 1974), or 1) mathematical basis, 2) cartographic image, 3) supporting elements, and 4) additional information (Markoski 2018). Some authors have interpreted the division of cartographic elements very randomly; for

BORUT ŽUNIČ

Figure 2: Henricus Hondius's 1636 map of Carniola.

example, in terms of their relevance on the map at the content level, or the desire to highlight a certain feature (Robinson et al. 1995; Monmonier 1996; Maps and Cartography … 2015).

Unlike the studies mentioned above, which mainly contain descriptive comparisons of individual maps or partial analyses of specific cartographic elements, the method presented in this article allows more comprehensive analysis of maps. It offers a framework for the analysis of selected characteristics of maps, such as scale, location, and content. Moreover, it proposes a more comprehensive division of cartographic elements, which allows for a uniform analysis and comparison of different types of maps from different periods. Each cartographic element (natural and built elements, toponyms, and mathematical and explanatory elements) is divided into three hierarchical levels down to cartographic symbols (Table 1).

This article proposes and utilizes a comprehensive method for examining cartographic elements on the selected set of maps, and it thus fills the research gap described above. The main contribution of this methodological approach is that it provides a uniform framework for comparing cartographic elements on maps designed in different time periods and differing in visual appearance, structure, and design. It formulates the process of studying cartographic elements by identifying, sorting, comparing, evaluating, and interpreting cartographic symbols on old maps. This covers the entire process chain of studying cartographic elements.

A data form was compiled based on a division of cartographic elements into the following five groups: natural elements, built elements, toponyms, mathematical elements, and explanatory elements. These make up the highest hierarchical level and are further divided into subgroups at a lower hierarchical level (Table 1). The data form built this way allows the uniform use of cartographic elements on all general geographical maps from the period observed.

In this article, general geographical maps created in the past (e.g., during the period examined: between the sixteenth and nineteenth centuries, figures 1–5) are referred to as »old maps.« The term *old maps* is conceptually distinguished from the term *historical maps*, which some authors (e.g., Chiang et al. 2020)

Figure 3: Alexis-Hubert Jaillot's 1709 map of Carniola.

use interchangeably. According to cartographic literature (e.g., Wallis and Robinson 1987), the term *historical map* denotes a cartographic representation of the situation in the area depicted and its development based on the interpretation of source material. The purpose of such representation is to chronologically present a selected topic, which is why this can often be referred to as a thematic map with historical content. It is suggested that a distinction be made between these two technical terms, and they are used in this sense in this article.

This article fills a gap in understanding the past, considering that old maps have been recognized as a primary source of information on a specific area and period. The proposed methodology is applicable in analyzing, comparing, and understanding relations and differences between territories and their cartographic representations on the one hand and the historical influences on cartographic representations on the other. The analysis was conducted at the temporal and spatial levels, using medium-scale maps.

The aim of the article is to present a new method for studying old medium-scale maps, which can be used to obtain information contained on maps with similar characteristics in terms of scale, location, and content, and to compare them on an equal basis.

2 Methods

2.1 Cartographic elements and their divisions

This article is about cartographic elements as fundamental components of cartographic content on maps. However, perceptions of what is fundamental vary. For cartographers, a cartographic element may be a line, dot, or molehill, for artists it can be a color or line, for landscape architects a specific structure or type of vegetation, for geographers a specific landform or type of road, and so on. This is why the term *cartographic element* is very broad and has several meanings. The Slovenian *Geografski terminološki slovar* (Kladnik, Lovrenčak, and Orožen Adamič 2005, 167) describes it as »an element on a map that represents a specific

Figure 4: Franz Xaver Baraga's untitled 1778 map, labeled *Krainska deschela* (Carniola).

structure, feature, or process more clearly or in greater detail, such as relief, a river system, a transportation network, or a settlement.« The term *element* in this perspective is understood in a broad sense as »a necessary or typical« (Oxford … 2022) and an »essential,« »relatively independent« (Slovar … 2014, 331) part of a whole, which, in the case at hand, is an old map. In reference to maps or in cartography in general, the term *cartographic element* is used.

Figure 5: Johann Walch's 1819 map of Styria, Carinthia, Carniola, and the County of Gorizia.

To examine the maps on an equal basis, a special digital data form (Figure 1) was created in Microsoft Access to analyze cartographic elements over the entire period studied. In terms of technical characteristics and design, maps differ considerably from the sixteenth to nineteenth centuries, which is why the depiction of individual cartographic elements differs significantly. Because the composition of maps was hence inconsistent, the aforementioned data form was used, which makes it possible to compare diverse maps. Microsoft Access made it possible to design the entry fields arbitrarily and link the data to pictorial material. Most importantly, the program collects and sorts all the data entered into the database so that they can be statistically processed and presented in the form of tables and graphs.

As shown in Table 1, the data form was built based on a breakdown of cartographic elements into the following five groups: 1) natural elements, 2) built elements, 3) toponyms, 4) mathematical elements, and 5) explanatory elements. These represent the highest hierarchical level and were further divided into subgroups at lower hierarchical levels (Table 1). Natural elements were divided into three subgroups (relief, vegetation, and water), built elements into four subgroups (settlements, built structures, roads, and borders), toponyms into five subgroups (choronyms, oronyms, hydronyms, settlement names, and names of built structures), mathematical elements into two subgroups (scale and graticule), and explanatory elements into five subgroups (title, colophon, explanatory text, decorative elements, and additional insets). Each of the subgroups was further divided into several subcategories, as presented in Table 1. The lowest (fourth) level represents the methods used to depict individual cartographic element on the map (e.g., forest depicted with a stylized tree symbol). The attempt to divide cartographic elements into groups is not new. However, a novel concept made it possible to standardize coverage of all elements on old maps.

2.2 The selection of old maps

The study included fifty-eight maps produced from the mid-sixteenth century to the end of the nineteenth century (Table 2). The main source of the maps was the map collection held by the Geographical Museum at the Anton Melik Geographical Institute of the Research Centre of the Slovenian Academy of Science and Arts, which holds several thousand maps, primarily of central Europe (Zorn and Gašperič 2016). In addition, collections from other museums and libraries, as well as private collections, were employed.

The basic criteria for the selection of maps were territorial (Slovenia), authorship, and scale. The maps analyzed represent the territory that today constitutes Slovenia or at least its majority (e.g., individual historical crownlands). The study did not take into account individual versions of maps. The term *version* refers to a map produced by the same author, at the same scale and showing the same area, but printed later. If a map was reprinted several times and the prints only differed in color or additions that did not affect the area mapped (e.g., an illustration or a cartouche), only one version was examined. This decision was made to eliminate numerous reprints that were very common for maps of Slovenian territory produced by Mercator, Homann, Mannert, and Kindermann.

Some maps were reprinted over an extended period of time, in various forms and with minor changes, but produced by different authors. The study included similar versions of maps produced by different authors. Regarding the scale, topographic maps at a medium scale (Vrišer 1998) or medium-large scale (Petrovič 2010) were analyzed, which means scales between 1 : 200,000 and 1:900,000. Medium-scale maps were selected because searching for and studying content on small-scale maps would have been too demanding (i.e., cartographic elements and symbols). On the other hand, the main challenge with large-scale maps would be their insufficient representation and uneven distribution over the period examined. Such maps were rare, especially in the sixteenth and seventeenth centuries.

2.3 Identifying information on old maps

The purpose of the digital data form was to establish a uniform database for the maps examined, which further allowed statistical comparison of cartographic elements. During the identification of basic information on the maps, several difficulties were encountered. Many maps did not contain any information about the year of publication, scale, authorship, and so on. In the case of missing date, information was sought in the literature and maps from equivalent editions. If it was impossible to determine the year, the following rules were applied:

- If it was possible to determine approximately, but not precisely, when a specific map was published, the oldest known year of publication was entered in the data form.
- If possible dates of the creation of the map spanned several decades or part of a century, the midpoint of this period was taken as the year of publication.
- If it was known from the sources when the maps started to be published, but it remained unknown until when they were published, the first year of publication was entered in the data form.

Because the majority of maps from the period studied lacked scale, this was calculated based on three to five selected distances on each map. The aim was to determine the distance between the same places. Distances between the following towns were selected as a starting point:

- Kranj (*Crainburg*)–Brežice (*Rann*);
- Trieste (Italy)–Ljubljana (*Laibach*);
- Piran (*Pirano*)–Novo Mesto (*Rudolfswert*);
- Udine (Italy)–Brežice (*Rann*);
- Dravograd (*Drauburg*)–Pula (*Polo*, Croatia).

On many maps, it was impossible to measure these distances accurately (or at all). The possible reasons for this are the following:

- The map was printed across two pages in a book or atlas, and the binding made it difficult to measure;
- Because of a distorted, inaccurate, and insufficiently detailed area mapped, not all the selected towns are displayed on the map; or
- The map does not depict the areas where these towns are located.

In the last case, distances were measured between towns close to those selected or other towns were selected for measuring the distances in various directions.

The entire area depicted within the map's inner frame was studied, even if it extended beyond the borders of today's Slovenia. The occurrence of individual cartographic elements is also affected by the map's form.

2.4 Data form structure

The digital data form created for the purpose of the study is divided into four data fields (Figure 1):

- Data field 1 (marked *1* in Figure 1) contains boxes for entering map data and selecting the basic commands (e.g., Save, Next, Back, Close, etc.);
- Data field 2 (marked *2*) contains buttons for selecting level-one and level-two cartographic elements, where it can be defined whether an individual group of elements is found on the map (options: Yes, No, Rarely); because of limited space, level-one buttons were placed under level-two buttons;
- Data field 3 (marked *3*) contains boxes for selecting and defining level-three cartographic elements and the methods of their representation; a specific box defines the presence of a cartographic element (e.g., built structures) or, more specifically, the user must select (e.g., a stylized symbol representing a built structure) and enter (e.g., which built structure is depicted: a castle, windmill, bridge, etc.) the characteristics of the elements examined, the methods of their representation, and the graphic variables used;
- Data field 4 (marked *4*) displays the map examined.

2.5 Map analysis

In the data form, maps were analyzed using the following protocol:

- Skimming the map to get a first impression of the cartographic representation and explanatory elements;
- Entering the basic information on the map in data field 1: year, title, author, and the ID number of the map image (Figure 2);
- Entering further data based on studying individual cartographic elements at all levels of the map selected (the »vertical« entry mode);

Table 1: A breakdown of cartographic elements, with methods of their representation. ► p. 32–33
Table 2: Basic information on the maps studied. ► p. 34–35

First level of cartographic elements	Second level of cartographic elements	Third level of cartographic elements	Depiction, method of representation
1 NATURAL ELEMENTS	1.1 Relief		Molehills (also set of molehills)
			Semicircles (also set of semicircles, caterpillars, plaited braids, fish scales, roof tiles, waves, pleated curtains)
			Triangles (also set of triangles, saw teeth, zigzag lines)
			Elevation contour (isohypse)
			Spot elevations
			Elevation layers (use of colors)
			Shading
			Hachures
			Dots
	1.2 Vegetation	1.2.1 Grassland	Grassland display (stylized image of grassland: surface with vertical lines, tufts of grass)
		1.2.2 Forest	Forest display (stylized image of trees: various density of the same or different trees)
		1.2.3 Other (e.g., vineyard, flood vegetation, olive grove)	Display of other vegetation (stylized image of vineyard, flood vegetation, olive grove)
	1.3 Water	1.3.1 River	Point symbols (geometric, pictorial, or alphanumeric)
			Line symbols (single line)
			Line symbols (two lines, often parallel)
			Area symbols (colored polygon)
			Other symbols for flowing water
		1.3.2 Body of water	Point symbols (geometric)
			Area symbols (colored shape)
			Other displays for bodies of water
		1.3.3 Point	Point symbols (e.g., waterfall)
2 BUILT ELEMENTS	2.1 Settlements		Point symbols (geometric symbols: square, circle, triangle, and others)
			Point symbols (stylized images of buildings)
			Area symbols (ground plan of a settlement/walls)
			Other symbols for settlements
	2.2 Built structures		Point symbols (geometric symbols: square, circle, triangle, and others)
			Point symbols (stylized images of buildings)
			Area symbols (ground plan of a settlement/walls)
			Other symbols for settlements

	2.3 Roads		Point symbols (geometric)
			Point symbols (stylized)
			Line symbols (single line, line of equal symbols)
			Line symbols (parallel lines)
			Other symbols for roads
	2.4 Borders		Line symbols (single line, line of equal symbols)
			Area symbols (colored area)
			Other symbols for borders
3 TOPONYMS	3.1 Choronyms		Letters of the name
	3.2 Oronyms		Letters of the name
	3.3 Hydronyms		Letters of the name
	3.4 Settlement names		Letters of the name
	3.5 Names of built structures		Letters of the name
4 MATHEMATICAL ELEMENTS	4.1 Scale		Numerical scale displays
			Graphic scale displays
			Verbal scale displays
	4.2 Graticule		Graticule displays
5 EXPLANATORY ELEMENTS	5.1 Title		Text
	5.2 Legend		Legend displays
	5.3 Colophon		Colophon displays
	5.4 Explanatory text		Text
	5.5 Decorative elements	5.5.1 Wind/compass rose	Wind/compass rose displays
		5.5.2 Cartouche	Cartouche displays
		5.5.3 Pictorial images (e.g., coats of arm, mythological symbol, ship, animal, human)	Displays of pictorial images
		5.5.4 Other (e.g., vignette)	Other image displays
	5.6 Additional inset	5.6.1 Panoramic image of landscape and city	Displays of panoramic images of landscapes and cities in an additional frame
		5.6.2 Other pictures	Displays of other pictures in an additional frame
		5.6.3 City plan	Displays of other city plans in an additional frame
		5.6.4 Map	Displays of maps in an additional frame
		5.6.5 Other (framed windows with various content)	Displays of other images in an additional frame

YEAR OF ISSUE	TITLE (original)	AUTHOR/PRODUCER	SCALE (measured distances)	PLACE OF ISSUE
1545–1552	*Descriptio Totius Illyridis XVI NO TAB*	Sebastian Münster (1488–1552)	1:702,878	/
1561	*Ducatus Carniolae et Histriae una cum Marcha Windorum*	Wolfgang Lazius (1514–1565)	1:513,979	Vienna
1569	*Ducatus Carniolae una cum Marcha Windorum*	Bolognino Zaltieri (Bolognius Zalterius)	1:486,766	Venice
1570	*Schlavoniae, Croatiae, Carniae, Istriae, Bosniae, finitimarumque regionum nova descriptio*	Abraham Ortelius (1527–1598), based on Augustin Hirschvogel	1:868,911	/
1572	*Illyricum*	Ioanes Sambucus (János Zsámboki) (1531–1584)	1:816,219	/
1573	*Goritiae, Karstii, Chaczeolae, Carniolae, Histriae, et Windorum marchae descrip[tio]*	Wolfgang Lazius (1514–1565)	1:692,240	Gorizia
1589	*Forum Iulium, Karstia, Carniola, Histria et Windorum Marchia*	Gerardus Mercator (1512–1594)	1:642,771	/
1593	*Carniolae Chaziolaeque Ducatus nec non et Goritiae Comitatus prouintiarum Norici ac Illirici uera propriaque delineatio*	Gerard (1509–1591) and Cornelis de Jode (1568–1600)	1:613,342	Antwerp
second half of the 16th century	*Sclauonia oder Windisch Marck, Bossen, Crabaten*	Sebastian Münster (1488–1552)	1:881,567	/
1635	*Karstia, Carniola, Histria et Windorum Marchia*	Willem Janszoon (1571–1638), Johan (1599–1673) and Cornelis (1610–1644) Blaeu	1:615,000*	/
1636	*Karstia, Carniola et Windorum Marchia*	Henricus Hondius (1597–1651), based on Gerardus Mercator	1:647,801	/
1649	*Karstia, Carniola, Histria et Windorum Marchia*	Matthäus Merian (1593–1650), based on Gerardus Mercator	1:747,443	/
1657	*Hertzogthüber Steyer, Karnten, Krain, & c./Duchés de Stirie, Carinthie, Carniole . . .*	Nicolas Sanson (1600–1667)	1:777,868	Paris
c. 1660	*Circuli Austriaci in quo Sunt Archiducatus Austriae Ducatus Stiriae Carintiae Carniolae Comitatus Tirolis et Episcopatus Tridentini*	Justus Danckerts (1635–1701)	1:750,583	Amsterdam
c. 1680	*Ducatus Carintiae et Carniolae Cilleiaeque Comitatus*	Frederick de Wit (1629/1630–1706)	1:515,632	Amsterdam
1681	*Partie du Cercle d'Austriche, ou sont Les Duches de Stirie, de Carinthie, de Carniole et autres Estats Hereditaries a la Maison d'Austriche*	Alexis–Hubert Jaillot (1632–1712), based on Nicolas Sanson	1:558,980	Paris
1681	*Carniolia, Karstia, Histria et Windorum Marchia*	Janez Vajkard Valvasor (1641–1693)	1:606,212	/
1689	*Carniolia Karstia Histria et Windorum Marchia*	Janez Vajkard Valvasor (1641–1693)	1:629,266	/
c. 1690	*Circuli Austriaci Orientalior Pars in qua Austria Propria et abea Dependentes, tum Ducatus, Stiriae, Carintiae, Carniola tum Comitatus, hisce inclusi, Cillensis et Goritiae, singuli subdivisi*	Gerard Valck (1652–1726)	1:747,765	Amsterdam
c. 1700	*Karstia, Carniola, Histria et Windorum Marchia*	Gerard Valck (1652–1726) and Petrus Schenk (1660–1718)	1:534,810	Amsterdam
1709	*Partie du Cercle d'Austriche, ou sont Les Duches de Stirie, de Carinthie, de Carniole et autres Estats Hereditaries a la Maison d'Austriche*	Alexis-Hubert Jaillot (1632–1712), based on Nicolas Sanson	1:681,511	Paris
1719	*Ducatus Carnioliae accuratissima delineatio*	Christoph Weigel the Elder (1654–1725), based on Janez Vajkard Valvasor	1:683,889	Nuremberg
after 1718	*Tabula Ducatus Carnioliae, Vindorum Marchiae et Histriae*	Johann Baptist Homann (1664–1724)	1:509,060	Nuremberg
1726–1750	*Ducatus Stiriae et Carintiae Carniolae Cilleiaeque Comitatus Nova Tabula*	Reinier (1698–1750) and Josua (1704–1765) Ottens	1:523,276	Amsterdam
first half of the 18th century	*Exactissima Ducatus Carniolae Vinidorum Marchiä et Histriae delineatio*	Matthäus Seutter (1678 – c. 1757)	1:522,218	Augsburg
1740	*Ducatus Carnioliae Tabula*	Johann van der Bruggen (1695–1740)	1:760,127	Vienna
1742	*Le Duche de Carniole*	Georges-Louis Le Rouge (c. 1712 – c. 1790)	1:640,885	Paris
1742	*Le Duché de Stirie*	Georges-Louis Le Rouge (c. 1712 – c. 1790)	1:447,356	Paris

1752	*Partie Méridionale du Cercle d'Autriche, qui comprend la Basse Partie du Duché de Stirie, le Duché de Carinthie, divisé en haute et basse, le Duché de Carniole, divisé en haute, basse, moyenne et interieure Carniole, et l'Istrie Impériale*	Didier Robert de Vaugondy (c. 1723 – 1786)	1:578,461	Paris
c. 1760	*Exactissima Ducatus Carnioliae, Vindorum Marchiae et Histriae delineatio*	Tobias Conrad Lotter (1717–1777)	1:526,909	/
1778	No title *(Krainska deschela)*	Franz Xaver Baraga	1:335,202	Ljubljana
1782	*Mappa Litho-Hydrographica Nationis Slavicae*	Baltazar Hacquet (1739/40–1815)	1:390,339	Ljubljana
1789–1806	*Inner Krain mit der windischen Mark und dem Triester Gebiethe. Nro.143.*	Franz Johann Joseph von Reilly (1766–1820)	1:499,328	Vienna
1791	*Kaartje van t Hertogdom Crain*	Guillaume Delisle (1675–1726)	1:319,998	Amsterdam
1796	*Unterkrain oder der Neustaedtler Kreis*	Joseph Karl Kindermann (1744–1801)	1:260,661	Graz
1798–1802	*Carte générale du Théâtre de la Guerre en Italie et dans les Alpes*	Bacler d'Albe (1761–1824)	1:257,509	/
1800	No title *(Herzogthum Krain)*	Franz Anton Schrämbl (1751–1803)	1:517,546	Vienna
1800	*Der Oesterreichische Kreis*	Conrad Mannert (1756–1834)	1:897,246	Nuremberg
1803	*Charte von Kaernthen und Krain, nebst den Grafschaften Görz und Gradiska und dem Gebiethe von Triest/Carte de la Carinthie et de la Carniole, avec les Comtés de Gorice et de Gradisca et le Gouvernement de Trieste*	Joseph Karl Kindermann (1744–1801)	1:498,119	Vienna
1807	*Charte vom Erzherzogthum Oesterreich, den Herzogthümern Steyermark, Salzburg, Kärnthen und Krain*	Conrad Mannert (1756–1834)	1:788,854	Nuremberg
1810	*Inner Oesterreich oder Die Herzogthümer Steyermark Kärnten und Krain. Die Grafschaften Goerz und Monfalcone. Die Bezirke Triest und Istrien. Nebst den angränzenden Theilenvon Italien Tyrol Salzburg Nieder Oesterreich Kroatien und Hungarn*	Zürner, probably Georg Adam (1756–1809)	1:336,735	Vienna
1812	*Carte des Provinces Illyriennes comprenant la Bosnie, l'Herzégovine, le Monténéro et quelques pays adjacens*	Gaetano Palma	1:650,000*	Trieste
1818	*Charte von dem Koenigreiche Illyrien*	Joseph Karl Kindermann (1744–1801)	1:533,835	Vienna
1818	*Charte von dem Königreiche Illyrien und dem Herzogthume Steyermark*	Carl Ferdinand Weiland (1782–1847)	1:608,669	Weimar
1819	*Königreich Illyrien und Herzogthum Steyermark in seine Kreise eingetheilt nebst den angrenzenden Theilen von Italien, Tyrol, Salzburg, Nieder–Oesterreich, Kroatien und Hungarn*	Zürner, probably Georg Adam (1756–1809)	1:336,787	Vienna
1819	*Charte von Steyermark Kaernthen und Krain, nebst der Grafschaft Görz*	Johann Walch (1757–1824)	1:498,558	Augsburg
1831	*Neueste Specialkarte von Krain nach der dermaligen Eintheilung in Bezirke*	Georg Ludwig von Ritter	1:277,842	Ljubljana
1832	*Karte vom Herzogthume Krain*	Gottfried Loschan (1796–1857)	1:295,094	Vienna
1836	*Königreich Illyrien, Gouvernement Laibach. Charte der Kreise: Laibach, Neustädtl, Adelsberg*	Renner (cartographer), O. C. Apelt (lithographer)	1:524,560	Leipzig
1841	*General-Post-&Strassenkarte des Königreichs Illyrien nebst dem k[öniglich] ungarischen Littorale*	R. A. Schulz	1:521,244	Vienna
1842	*General Post und Strassen Karte des Herzogthums Steyermark*	R. A. Schulz	1:401,368	Vienna
c. 1850	*Karte des Kronlandes Steiermark*	Josef Franz Kaiser (1786–1859)	1:382,487	Graz
1853	*Zemljovid Slovenske dežele in pokrajin*	Peter Kozler (1824–1879)	1:576,000*	Vienna
1853	*Königreich Illyrien*	Carl Christian Franz Radefeld (1788–1874)	1:880,000*	/
1859–1871	*Die Herzogthümer Steiermark, Kärnten, Krain, die gefürstete Grafschaft Görz und Gradiska, die Markcrafschaft Istrien, die Stadt Triest mit Gebiet und das ungarische Littorale*	Carl Gräf (1822 – c. 1897)	1:600,000*	Weimar
1863	*Die Herzogthümer Kärnthen und Krain, die Grafschaft Görz & Gradisca, die Markgrafschaft Istrien und die reichsunmittelbare Stadt Triest*	Hermann Berghaus (1828–1890)	1:770,985	Gotha
1878	*Die Kronländer Kärnthen, Krain, Görz - Gradisca - Istrien und Triest*	Friedrich H. Handtke (1815–1879)	1:872,626	Głogów
1885–1892	*Krain - Istrien*	Bibliographisches Institut	1:835,591	Leipzig

LEGEND: * Scale taken from literature or map

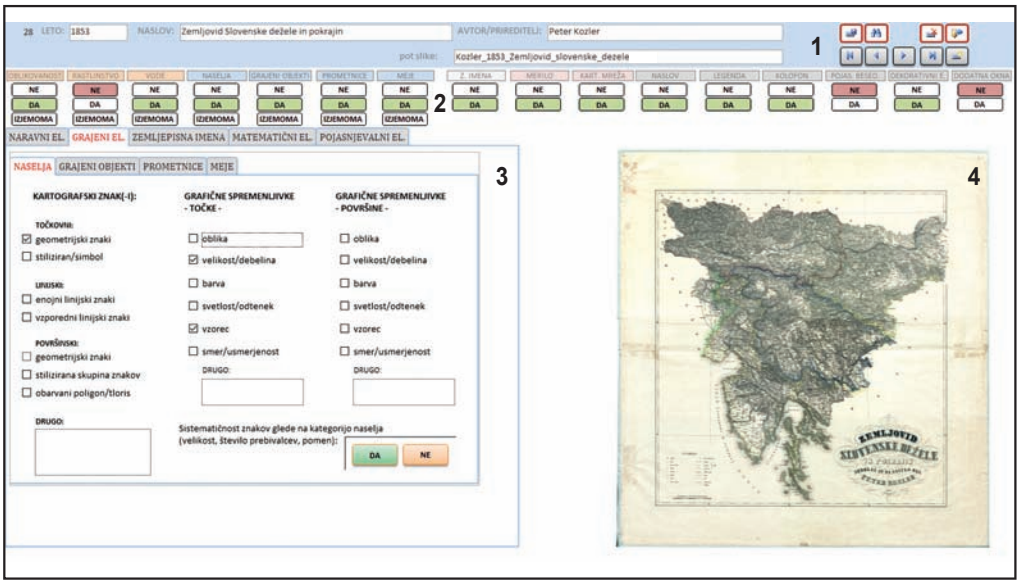


Figure 6: The data form was made in Slovene in digital format with the four basic data fields, explained in English in section 2.5.

- To get a clearer picture and avoid potential errors, data were not entered by level for all the maps simultaneously (the »horizontal« entry mode);
- Two pieces of data were provided in data field 2: the type of level-one cartographic element was selected, and for this element the presence of a level-two cartographic element was indicated by selecting »Yes« (evenly present across the map), »No« (absent), or »Rarely« (present only in some sections of the map; Figure 3);
- Data on the method used to represent the cartographic element at hand and its graphic variables (shape, size, color, brightness, pattern, and direction) were provided in data field 3, along with data on any special features (the »Other« box) if relevant and answers to questions related to a specific cartographic element (Figure 4);
- A low-resolution image of the map was entered in data field 4, which aided data entry and made it easier to move between the data form pages (right side of the data form; Figure 1);
- After entering all the data, they were double checked for accuracy and saved.

Each map was evaluated separately. First, an individual group of cartographic elements was selected in the data form, a group of representation methods was ascribed to it, and the types of representation included in the map were defined. For example, for natural elements, the method of representing relief with molehills was identified. This was followed by an assessment of the representation method using graphic

Figure 7: Data field 1.

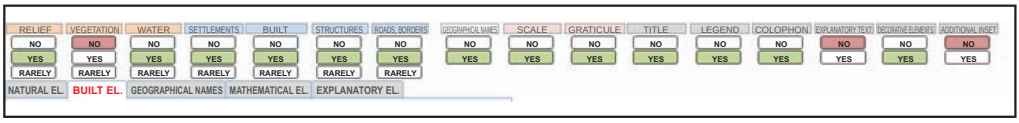


Figure 8: Data field 2.

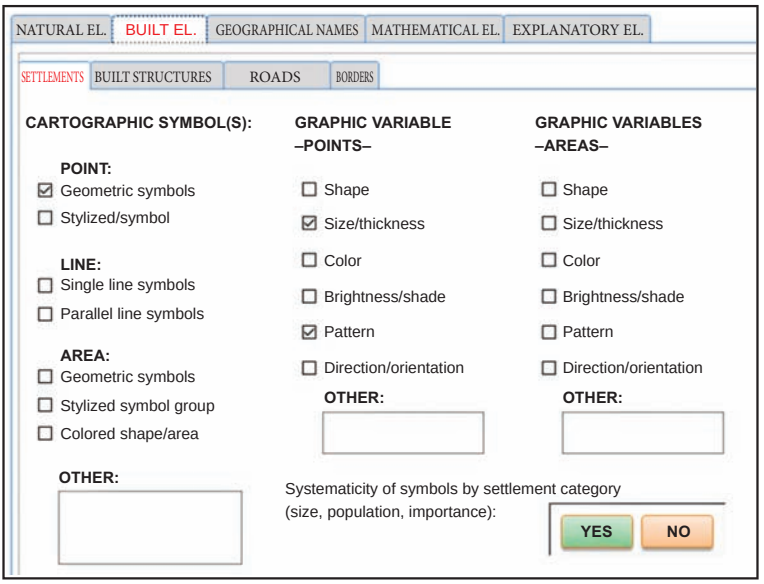


Figure 9: Data field 3.

variables. Their division and interpretation were adopted from Fridl (1999), who based her study on the systematic processing of cartographic means of expression (Bertin 1981). Graphic variables were assessed for the methods of representation of natural and built elements, and for geographical names. For mathematical and explanatory elements, assessing graphic variables does not make sense, and so their data characteristics were defined instead (e.g., location on the map, shape, type, and composition).

In terms of the dimension or type of the feature depicted (Fridl 1999), cartographic symbols can be divided into point, line, and area or surface symbols (i.e., shapes). The terms »point symbol,« »line symbol,« and »area symbol« are used below.

3 Results

For natural (cartographic) elements, the representation of relief was studied (Figure 5). The greatest change can be observed around 1800, when molehills and shading were replaced by hachures (Gašperič 2010). Of all the cartographic elements examined, relief had the largest number of representation methods. Chronologically, these methods are divided into the period from the sixteenth to the eighteenth centuries (molehills and shading), and the nineteenth century, when hachures, contour lines, and dots were used (Figure 6).

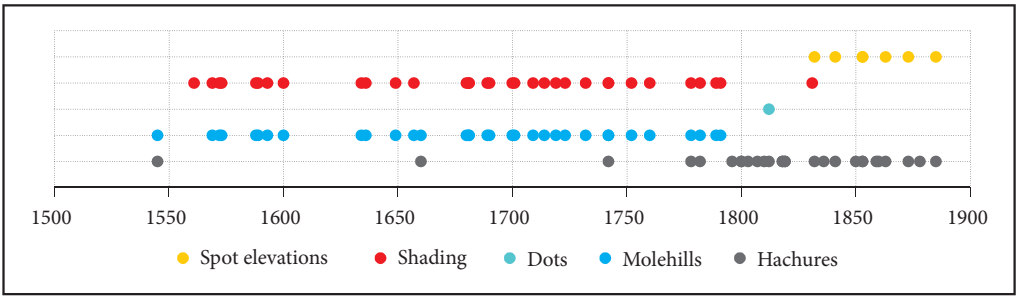


Figure 10: Occurrence of relief representations on maps from the mid-sixteenth century to the end of the nineteenth century.

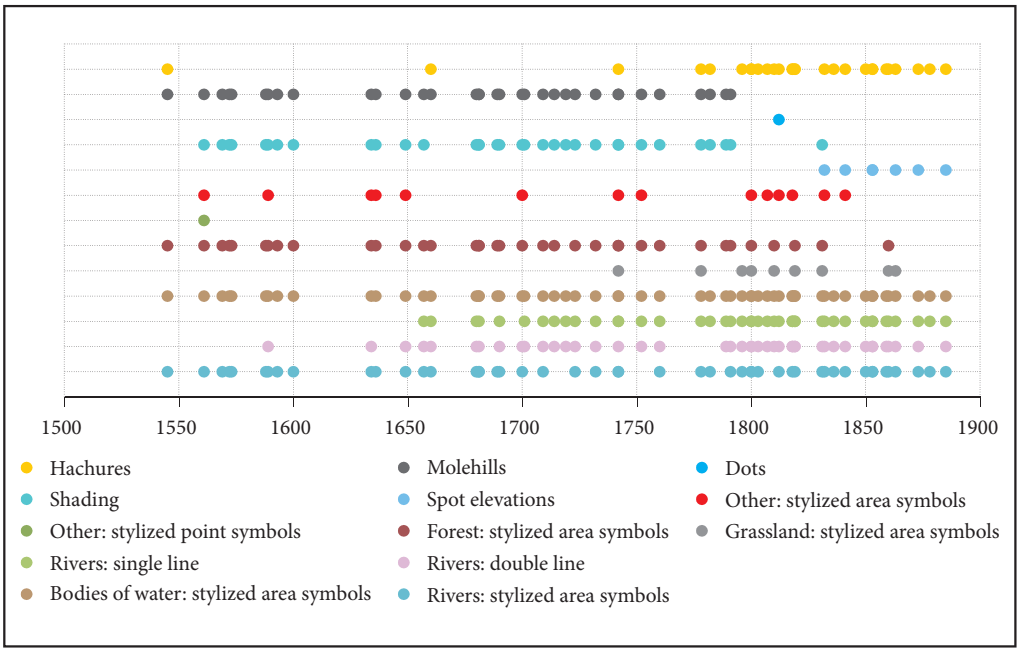


Figure 11: Occurrence of natural elements' representations in the period studied.

In terms of vegetation, forest representations predominate over those of grassland and other vegetation types. From the sixteenth to nineteenth centuries, the number of maps depicting vegetation declines, and vegetation is gone completely by the second half of the nineteenth century. Except for a 1561 map, vegetation is typically depicted with a stylized area symbol (Figure 7). Cartographers gradually realized that depicting vegetation on medium-scale maps was inappropriate because accurate representation demanded additional fieldwork and limited map clarity and usefulness.

Waters are represented on all maps, but until the mid-seventeenth century even rivers are depicted with area symbols (Figure 8); later, a more accurate line representation begins to be used. The share of names of rivers gradually declines. In the sixteenth century, the shares vary and can even be 100%, from the early seventeenth century onward up to 50% of waters are named, and after 1800 only up to 25% (Figure 9). The reason for this may be the production of increasingly detailed maps showing a denser river system. Naming all watercourses would definitely affect a map's clarity.

Figure 12: Occurrence of level-two and level-three natural elements in the period studied. ►

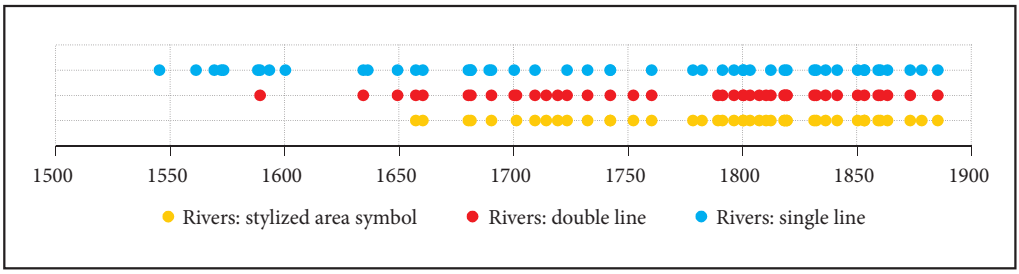
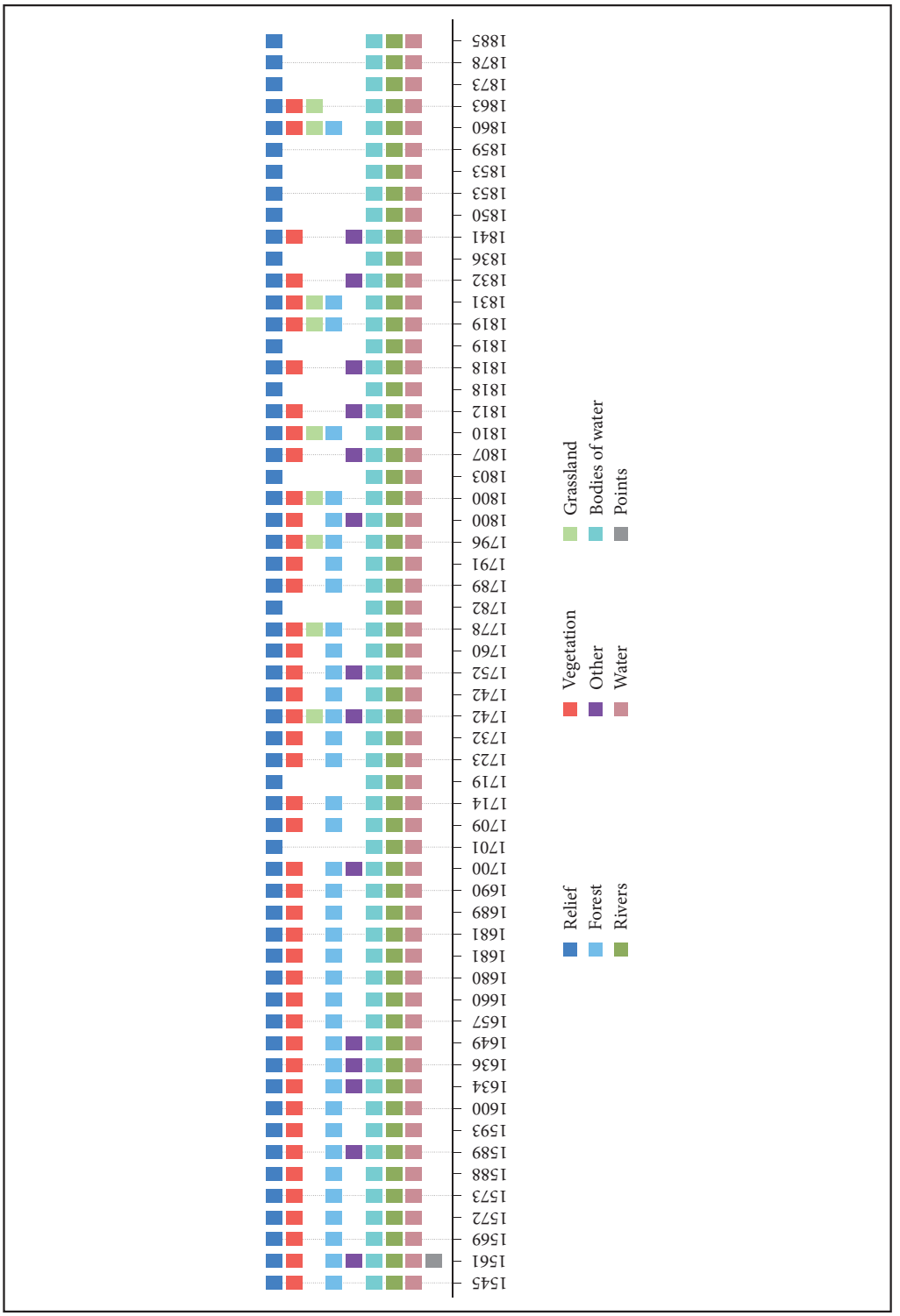


Figure 13: Occurrence of river representations on maps from the mid-sixteenth century to the end of the nineteenth century.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Relief
Forest
Rivers
Vegetation
Other
Water
Grassland
Bodies of water
Points

With built elements, the single- or double-line representations of roads stand out. None can be found in the sixteenth and seventeenth centuries, in the eighteenth century they begin to appear only exceptionally, and in the nineteenth century they are used on every map (Figure 10). There may be several reasons for this, but a change can be observed in the perception of the importance of roads and hence their representation on maps.

Settlement representations on maps are often not distinguished from those of built structures. Both are usually depicted with stylized point symbols. With regard to cartographic symbols and the names of selected castles – for example, Kamen (*Stein*), Bogenšperk (*Wagensberg*), Strmol (*Stermal*), and Borl (*Ankenstein*), it can be established that the authors were not familiar with all the settlements and castles or did not distinguish between them, and hence they also marked them accordingly. In the specific examples listed, they marked a named castle as a settlement.

Borders are marked on most maps. Single lines predominate over colored areas. The latter are common on eighteenth-century maps, whereas lines are used throughout the period studied (Figure 11).

Graticules and scales were examined among mathematical elements. They appear on most maps. The scale is most often provided in a verbal form; a graphic form is also very common, whereas a numerical scale is used only exceptionally (Figure 12).

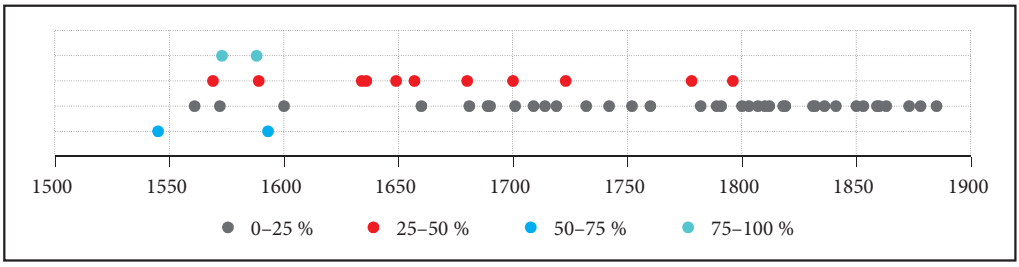


Figure 14: Occurrence of maps from the mid-sixteenth century to the end of the nineteenth century by share of hydronyms used on them.

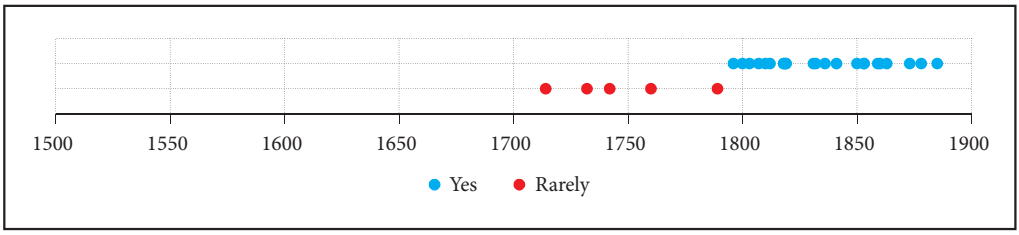


Figure 15: Occurrence of roads on maps from the mid-sixteenth century to the end of the nineteenth century.

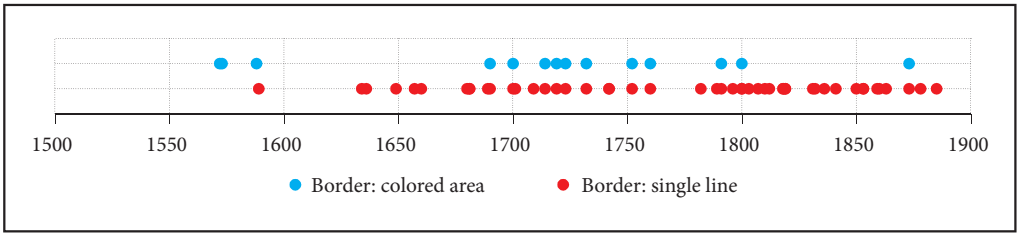


Figure 16: Occurrence of borders represented with line or area symbols on maps from the mid-sixteenth century to the end of the nineteenth century.

The graticule is not labeled on any map. Until the nineteenth century, only printing degrees between the two map frames was common; later a longitude and latitude grid was also drawn on most maps (Figure 13). Conic and pseudoconic projections predominate; from the mid-seventeenth century onward, cylindrical projection also appears in places (Figure 14).

Toponyms appear on all maps. Choronyms are largely written in all capital letters and other toponyms in small caps. On nearly all maps, the names of rivers are provided both in the direction of their flow and in its opposite direction. In evaluating the graphic variables, the most frequent changes with all toponyms occur in size, and changes in shape are also common (Figure 15).

The group of explanatory elements was newly designed for the purposes of this study. On most maps, the title is provided inside the inner map frame. Decorative elements are also common, especially a cartouche, which can be found on most maps between the sixteenth and eighteenth centuries, after which it gradually disappears. In turn, vignettes and oval frames are more common in the nineteenth century. Legends

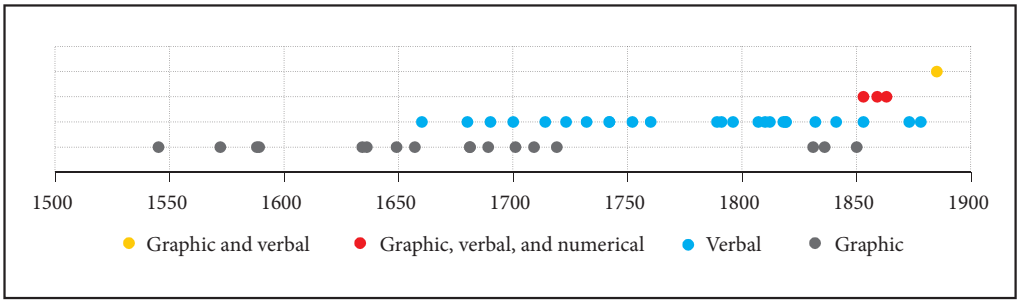


Figure 17: Occurrence of scale representations as provided on individual maps from the mid-sixteenth century to the end of the nineteenth century.

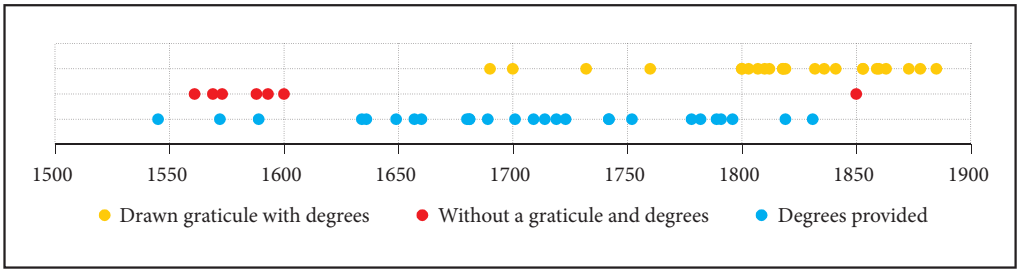


Figure 18: Occurrence of various types of graticules on maps from the mid-sixteenth century to the end of the nineteenth century.

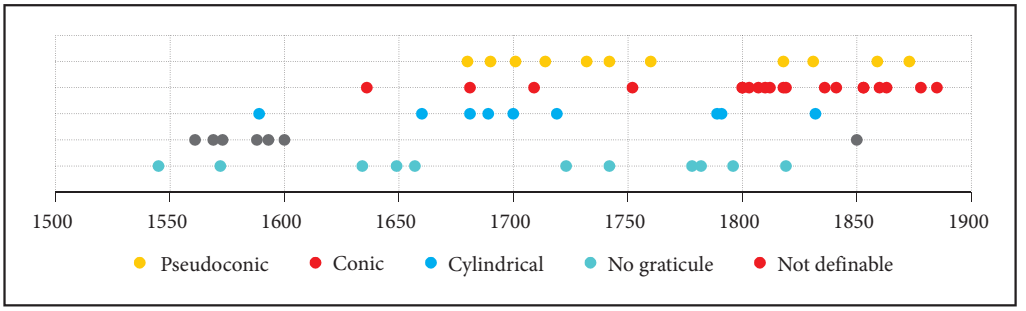


Figure 19: Occurrence of map projections between the mid-sixteenth century and the end of the nineteenth century.

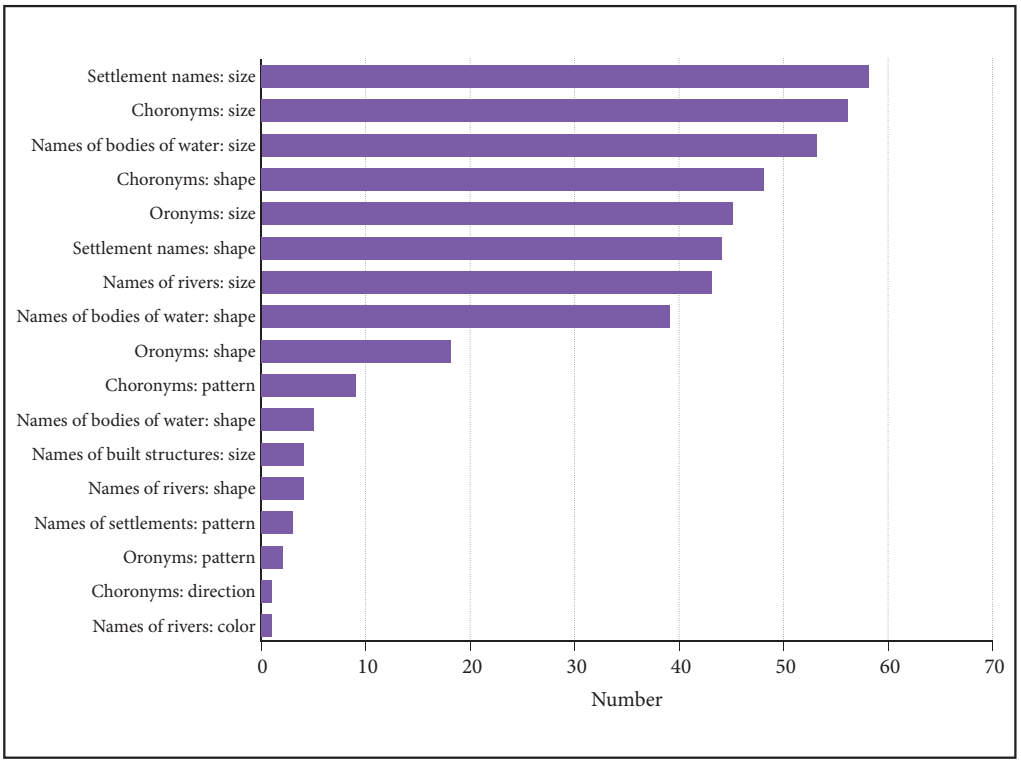


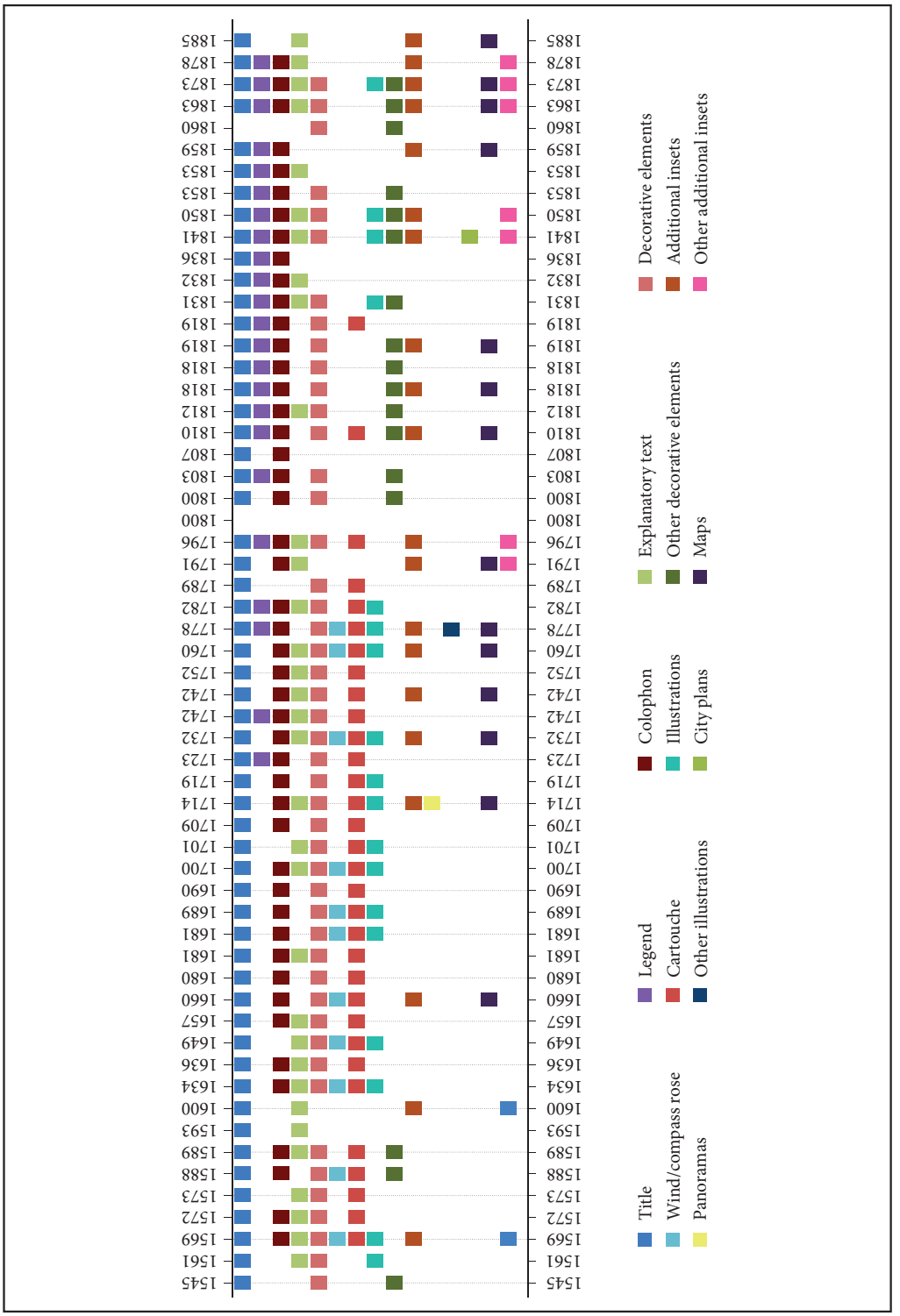
Figure 20: Applying graphic variables to all toponyms.

are more common on more recent maps; none can be found on maps before the early eighteenth century. Colophons appear throughout the period studied, as do explanatory texts and additional insets, albeit not as frequently (Figure 16).

European cartography had various centers during the period studied. Thus, the maps of Slovenian territory reflected Dutch, Belgian, French, Italian, and, first and foremost, German and Austrian cartography. This can already be seen from the names of their authors. Only three authors of the maps examined can be treated as »Slovenian.« These were authors that lived in what is now Slovenia (Johann Weikhard (Janez Vajkard) Valvasor and Peter Kozler) or worked there for an extended period of time (Balthasar Hacquet; Figure 17).

Different types of cartographic elements developed at different paces (Figure 18). In some places, a chain reaction occurred, whereby a change in the representation or frequency of one type of cartographic element affected another type. Hence, for instance, the shift from a stylized representation of relief (molehills) to a plastic representation (hachures) and the subsequent »freeing up« of space on the map led to the more frequent use of other elements (e.g., roads, rivers, and geographical names). The representations of vegetation (forest) were replaced by other cartographic elements (e.g., river systems, relief, roads, and geographical names). An increase in the number of representations of rivers led to a smaller number or share of hydronyms. The density of road symbols increased from the end of the eighteenth century onward, which facilitated better orientation, but also led to poorer map readability. In addition, roads were often depicted very similarly to rivers.

Figure 21: Occurrence of level-two and level-three explanatory elements in the period studied. ►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Decorative elements
Additional insets
Other additional insets
Explanatory text
Other decorative elements
Maps
Colophon
Illustrations
City plans
Legend
Cartouche
Other illustrations
Title
Wind/compass rose
Panoramas

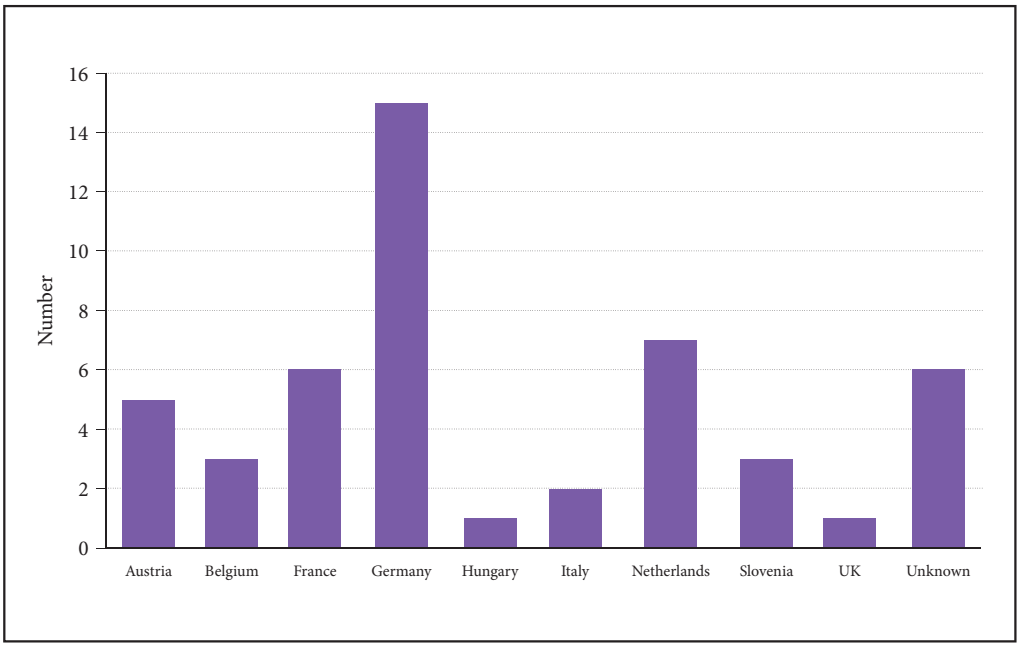


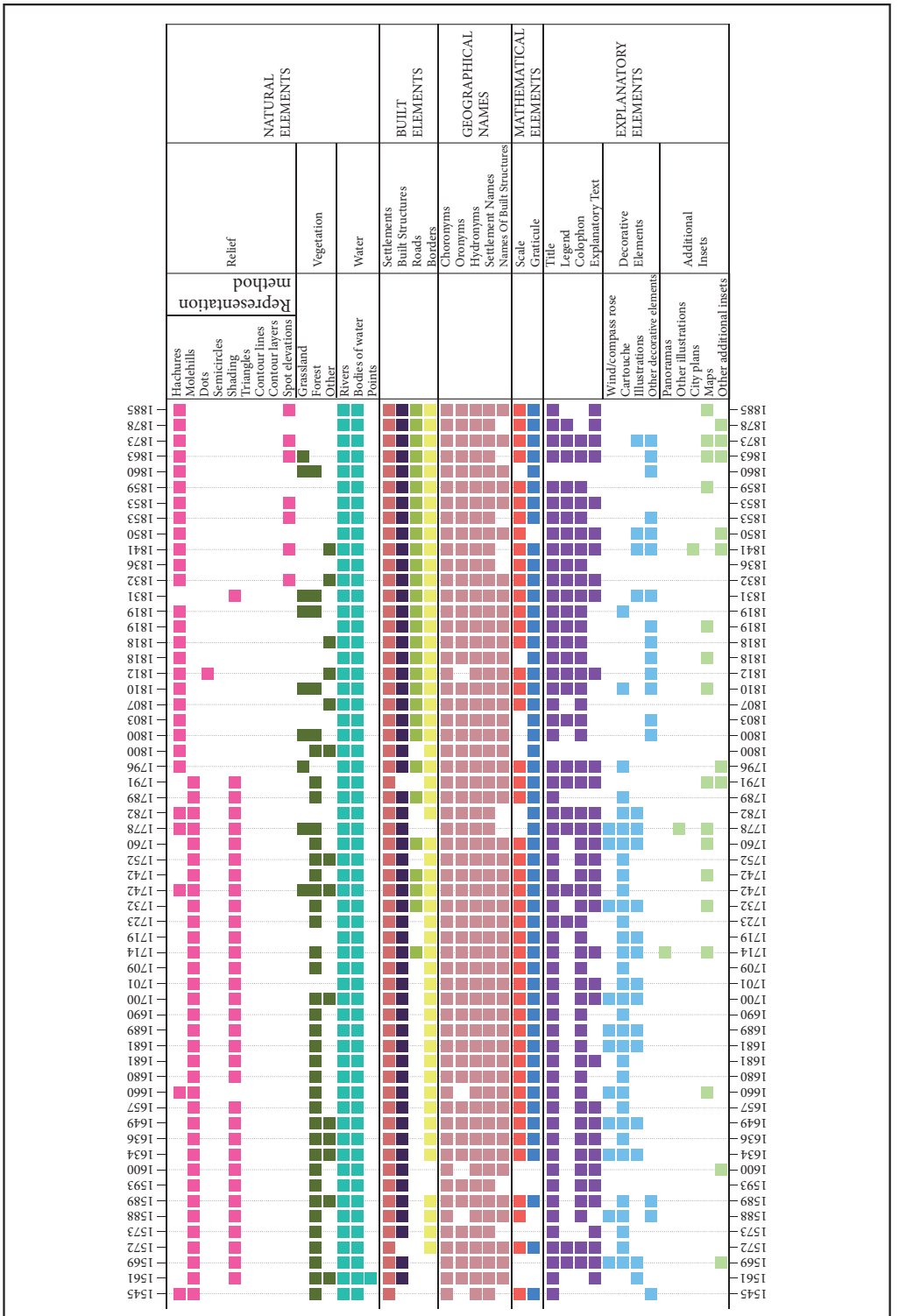
Figure 22: Map authors by origin (modern country).

4 Discussion

The new method of studying cartographic elements was used to compare cartographic elements across different periods and to identify, evaluate, and interpret cartographic content on an equal footing. The advantage of this standardized method is that, by using it, established or generalized interpretations can be confirmed or rejected because the findings are based on data analysis and not on the opinion of the map researcher or reader.

The unexpected result in this study is related to built elements, for which the (lack of) presence of roads represented with single or double lines stands out. There are none in the sixteenth and seventeenth centuries, they appear only exceptionally in the eighteenth century, and they are used on all maps in the nineteenth century (Figure 10). This reflects a change in the perception of the importance of roads and hence the representation of roads on maps. The question is why roads began to be depicted on the maps relatively late, despite an extensive road network and substantial quantities of goods passing through Slovenian territory. Based on information gathered from the literature and cartographic material, the answer is multifaceted. Poor road conditions began to improve through gradual renovation in the nineteenth century, when numerous measurements were made and precise drawings and maps were produced. The perception of the maps' communicative value also changed, which was demonstrated in the case of the road network. Medium- and small-scale maps were not used for wayfinding, but to spread knowledge and obtain a better understanding of a region (Delano-Smith 2007). Until the early modern period, people traveled on foot or by horse. The use of horse-drawn wagons began to increase in the sixteenth century, and by the eighteenth century higher-quality roads facilitated the use of wagons in most goods transport (Zwitter 2014). It was not only the quality of roads, but also the type and quantity of cargo that influenced their importance. Information shows that large quantities of diverse goods were transported on Slovenian roads. A cart load

Figure 23: Cartographic elements of all levels depicted on maps from the mid-sixteenth century to the end of the nineteenth century. ►


NATURAL ELEMENTS
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Molehills
Dots
Semicircles
Shading
Triangles
Contour lines
Contour layers
Spot elevations
Vegetation
Grassland
Forest
Other
Water
Rivers
Bodies of water
Points
Representation method
BUILT ELEMENTS
Settlements
Built Structures
Roads
Borders
GEOGRAPHICAL NAMES
Choronyms
Oronyms
Hydronyms
Settlement Names
Names Of Built Structures
MATHEMATICAL ELEMENTS
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Graticule
EXPLANATORY ELEMENTS
Title
Legend
Colophon
Explanatory Text
Decorative Elements
Wind/compass rose
Cartouche
Illustrations
Other decorative elements
Additional Insets
Panoramas
Other illustrations
City plans
Maps
Other additional insets
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1878
1885

was measured in a unit known as a *tovor* 'seam', usually corresponding to approximately 150 kg (Kosi 1998). In the sixteenth century, the transport of goods between the Mediterranean region and the surrounding countryside (in both directions) could even amount to 200,000 seams during the peak season (Gestrin 1991). It can be concluded that it exceeded 30,000 tons per year. At the end of the sixteenth century, an average of around 20,000 oxen per year were driven through Slovenian territory to the Republic of Venice (Zwitter 2014). The 1787 data show that approximately 15,500 wagons of various sizes passed through the Vrhnika toll station in both directions (Šorn 1979). In 1806 and 1807, the transit transport between Ljubljana and Trieste alone included 80,000 wagons (Holz 1994).

Gradually the belief developed that even features that may have previously been taken for granted (e.g., roads for going from one place to another) must be depicted on maps. The main reason for this, though, may be cartographic development itself or the change in the representation of relief. As already mentioned (Figure 5), around 1800 a change occurred in the representation of the Earth's surface, when a stylized representation using molehills (a profile perspective) was replaced by hachuring (a plan perspective). In this way, technical limitations hindering a detailed representation of roads were eliminated.

The method presented is designed to examine all maps in the period studied. However, a limitation of the study is related to the problems in searching for cartographic material or with its public accessibility, and to identifying and interpreting specific cartographic symbols. In principle, more maps means better results but, when looking for cartographic material, one may not be aware of all the material available in archives, libraries, private collections, and online. In addition, identifying cartographic symbols may be subjective, not only in terms of the researcher or map reader, but also the cartographer, who is either familiar or unfamiliar with the territory mapped, or is overly casual in its representation. A good example is the representation of an olive grove on a 1561 map by Wolfgang Lazius, who also used the same or a similar symbol for areas more suitable for viticulture (Figure 19). Hence it follows that the new method presented in this article is primarily intended for studying old maps from the fifteenth to nineteenth centuries. Old maps are usually very simplified, whereas modern maps (especially from the end of the nineteenth century onward) are already made following a uniform standard and based on expert data. Due to differences in the cartographic content, an examination of even older maps (from before the fifteenth century) or more recent maps (from the twentieth century) would require changes in methodology.

This study has certain limitations. On the oldest maps in particular, certain representation methods are unclear or inconsistent (e.g., molehills, trees, and so on), which made it more difficult to identify individual characteristics (e.g., those of graphic variables). Because of poorer technical possibilities and knowledge, as well as non-standardized symbols and map structure, on old maps individual symbols are drawn without any special principles. This resulted in idiosyncratic depictions, which are often difficult to classify under a specific evaluation category. To avoid this, uniform rules for evaluating all maps equally were defined in the data form.

Figure 24: A similar green cartographic symbol was used to represent an olive grove near Koper and Trieste (left), and a vineyard in the Bizeljsko region (right) on a 1561 map by Wolfgang Lazius.

In addition, a review of the geographical, cartographic, and historical literature did not identify any study comparably analyzing cartographic elements on old maps. Unfortunately, it was therefore impossible to make a comparison with other studies.

5 Conclusion

This article presents a new method for simultaneously examining a random number of cartographic elements and symbols on maps with similar characteristics in terms of scale, location, and content. This study proved that old maps are an important primary source of information that cannot be found in written or pictorial archival material (Zorn 2007). They provide an important complement to historical written sources, but the depictions on them may be the result of the author's or producer's preferences or (incorrect) perceptions (Štular 2010). In 1733, the Anglo-Irish satirist Jonathan Swift nicely verbalized the problem of the cartographer's ignorance in his poem On Poetry: A Rhapsody:

»So geographers, in Afric maps,
»With savage pictures fill their gaps,
»And o'er unhabitable downs
»Place elephants for want of towns.«

Therefore, old maps require a critical and standardized research approach, like the one presented in this article. A special digital data form was created to examine the maps and analyze cartographic elements over the entire period studied in a uniform way. The data form was built based on a division of cartographic elements into the five main groups, which were further divided into four subgroups at lower hierarchical levels. The study included fifty-eight medium-scale topographic maps produced from the mid-sixteenth century to the end of the nineteenth century.

The results show that different types of cartographic elements developed at different paces at different times (Figure 18). The main findings regarding the cartographic elements on old maps are provided here.

In terms of vegetation, stylized representations of forest predominate. However, in the second half of the nineteenth century there is no longer any vegetation depicted on maps because cartographers realized the inappropriateness of such practice, which required additional fieldwork and limited the map's clarity and usefulness. Roads were only rarely depicted before the eighteenth century, whereas they appear on all maps since the nineteenth century. This had to do with a shift in the perception of the importance of roads for economic importance and their cartographic representation. Settlements are often depicted interchangeably with built structures (e.g., castles), which shows that the authors were unfamiliar with the area displayed. Borders are marked on most maps, most often as colored areas and single lines with various patterns.

The scale is usually provided in verbal and graphic form (the numeric form was rare), but the graticule is not labelled on any map.

The group of explanatory elements was newly designed for the purposes of this study. It was established that the title is provided on most maps, usually inside the inner map frame. Cartouches stand out among the decorative elements, especially between the sixteenth and eighteenth centuries, and later other decorative elements (e.g., vignettes) are common. Legends only begin to be used in the early eighteenth century.

In some places, a chain reaction occurred, where a change in the representation or frequency of one type of cartographic element affected another type. Hence, for instance, the shift from a stylized representation of relief (molehills) to a plastic representation (hachures) and the subsequent »freeing up« of space on the map led to more frequent use of other elements (e.g., roads, rivers, and geographical names). It is similar with representations of vegetation (forest was replaced by river systems, relief, roads, and geographical names) and rivers (this led to a smaller number of hydronyms). The density of road symbols increased from the end of the eighteenth century onward, which facilitated better orientation, but also led to poorer map readability because roads were often depicted very similarly to rivers.

This methodology can be further improved by changing the selection of data studied. If more modern maps were selected, this would primarily require an expansion of the representation methods selected.

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