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Analysis and evaluation of the XVIIIth century plan of Lublin as an example of a comprehensive approach in the research of early cartographic materials[1]

Summary:
The paper proposes the methodology for a comprehensive, interdisciplinary approach to analysing early plans which consists of technological (history of science), historical (document of the past) and cartometric (reliability of geometric properties) parts. The research combines archive queries and methods typical for historical research with modern digital methods, including the use of GIS. It is then tested on the oldest plan of Lublin, an interesting cartographic artefact and valuable historical document of more than just regional importance.

Introduction

The majority of research dealing with early maps made by cartographers focuses on cartometric analyses. Numerical methods have a long tradition in cartography and form a broad resource of scientific tools. Early cartographic materials are in the area of interest of many other groups of specialists exploring the past. Each of them concentrates on the aspect of an early map which is interesting for their particular research. Therefore, it happens that scientists, who use an early map as a historic source, omit its geometric properties, which may lead to wrong conclusions. On the other hand, cartographers concentrating on geometry do not explore the historical context of a map and its value as an artefact documenting the history of the science.

This paper suggests a comprehensive approach to evaluating and analysing early maps, based on a large-scale document –a plan of the Polish city of Lublin. The comprehensiveness is understood as the research process including three aspects of early plan reception: cartometry, historical source document and artefact showing the art of map-making. According to the above, the paper consists of three major parts. The first evaluates the plan as a part of cartographic heritage, the second analyses the plan's historical content and the third evaluates the geometrical accuracy of the plan.

The object of the research

The plan selected for the research is the "Plan de la ville et fauxbourgs de Lublin" (Fig. 1). Several factors, listed below, were taken into consideration when choosing it.

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Figure 1: *Plan de la ville et fauxbourgs de Lublin* (reduced).

1. The plan is the oldest one showing the whole city at the time. It was drawn in 1716 and the only older plan is that of 1649 by Karol Bekiewicz, which shows the vicinity of Lublin's Krakowska Gate.
2. The plan has been used as a historical source in numerous research works. It has, however, never been the subject of research itself. All negative opinions and low evaluations are based on very cursory analyses.
3. The plan is an important historical and cartographic document. The circumstances of its creation (described later) justify calling it a thematic plan of the city.

The plan is now held in the Special Collection section of Hieronim Łopaciński Voivod-ship Public Library in Lublin (sign. 1/VI). The handwritten, coloured plan has been glued to cardboard, which –unfortunately– makes inspection of presumptive watermarks virtually impossible. The size of the internal border is 780 by 560 millimetres.

The plan was drawn during negotiations of the Tarnogród Confederation held in Lublin. The confederation was formed in Tarnogród on 26th of November 1715 in order to dethrone and remove the Saxons from Poland. The Polish king, August II Wettin, planned to strengthen his position with the help of Saxon military forces, which lead to protests among both the nobility, loath to participate in the costs of army upkeep, and peasants, charged with contributions. The field marshal, Jakob von Flemming, was unable to scotch the protests and the confederates were unable to come to an agreement with the Saxons and asked Peter I, the Tsar of Russia, for mediation. Lublin was the first city to host negotiations, participated by Flemming and Bishop Konstanty Szaniawski (both on behalf of the king), Grigory Dolgorukov (Russian mediator) and confederates, including Potocki, Olszanowski, Szaniawski and Stecki (Raczyński 1841).

The plan was created exclusively for the negotiations' time and purposes. It cannot be referred to as a general purpose plan as its content is adapted to the participants' needs. It is clearly seen that the author has generalized some of the environment features. For example, parcels and building shapes were not in his scope of interest. He has concentrated on participants' accommodation and negotiation places, zones of control, field fortification etc. These are very important conclusions, which stress the fact that the plan is not a topographical image of Lublin and cannot be treated as a plan giving general information about the city. Knowing the author's goals, one can describe the plan as important cartographic material (the oldest plan of Lublin) of significant historical value (a source document of the history of the Tarnogród Confederation).

Little is known about the author. In most previous works his surname was spelt incorrectly, mainly "d'Orxer" (this form is also used in the Łopaciński library catalogue). Graphology analysis helped to define the correct form of the name which is "d'Örken" or "d'Öcken". Unfortunately, search queries in both Polish and foreign archives have not resulted in additional information. What can be assumed is that:

- he came to negotiations with the king's or mediator's men (he put Dolgorukov first in the legend of the plan and did not mention the confederate leaders),
- he was an army engineer paying a lot of attention to the city's fortification system, moreover, a cartographer and the domain of an engineer in the army of that time was the same (Olszewicz 1921),
- his nationality can be guessed by his surname – he could have been French as "d'" precedes his surname (however, French was an international language in the XVIII century), while "Ö" justifies the idea of associating him with Germanic language countries (the Great Northern War involved, among others, Saxon and Swedish forces).

The d'Örken plan as a cartographic artefact

A comprehensive approach to early cartography consists of both cartometric analysis and evaluation of the historical context. The first step should, however, be exploration and evaluation of the plan itself, the plan as a cartographic item.

The process of map evaluation is a long-known topic in cartography. Numerous criteria of evaluation have been described, as well as the requirements which a map should fulfil. They are diverse; however, there is a group of main, constant criteria such as accuracy, reliability and completeness of content, mathematical base, graphic form and readability (Kałamucki 1996).

Each evaluation should be made with a certain goal in mind. In the case of an early map the goal is to answer the question: how does the evaluated map compare with others of that time? Does it have innovative elements? Is it exceptional in terms of graphics? What is the quality of drawing, etc.? In the presented paper the following criteria were used: mathematical base, explanation (legend), content, graphics and colour, on-plan description, technical quality and general composition.
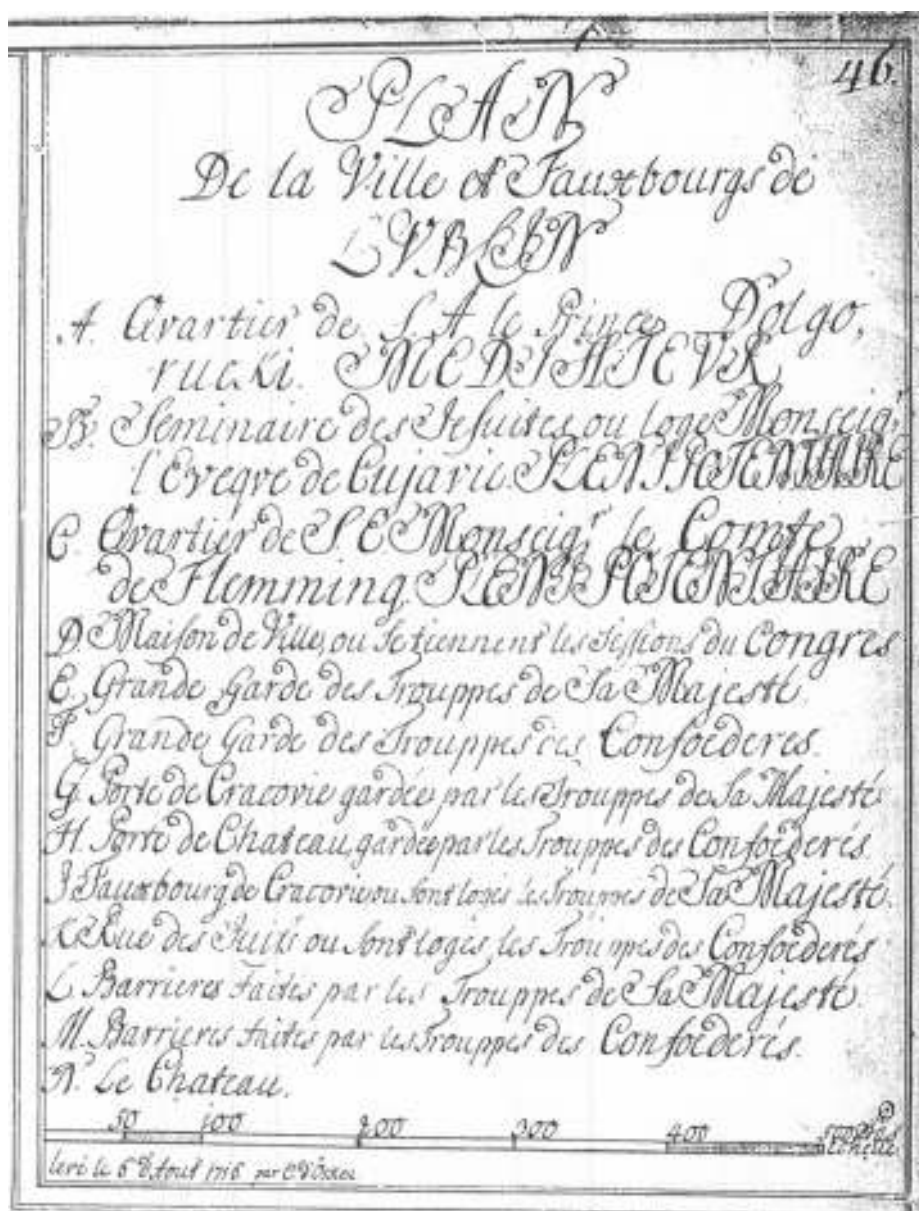
Figure 2: Legend of the plan of Lublin.

The plan has a linear scale with units described as "pas" (steps). The scale is quite large (approx. 1:3600), maybe even too large for a thematic plan which does not require much detailed information to be included.

The legend is typical for plans of that time (Fig. 2). It contains, besides the title and information about scale and the author, thirteen explanations of letters used on the plan.

Evaluating the content of the plan, one needs to keep in mind the aim of the author as well as the group of potential readers. It already has been mentioned that the plan can be described as thematic, made for participants of the negotiations to use. The thematic information given on the plan is almost complete, lacking only the confederates' quarters. It is completed by environment features (hydrography, relief), which are depicted quite well –the relief information is limited to steep slopes in river valleys, but it is really

detailed. The hydrography can also be described as detailed –it contains information about rivers, ponds, wetlands and canals.

The general content consists also of anthropogenic elements –buildings and the communication network. Roads are correct and detailed. Buildings in the Old Town are shown as a built-up area (squares), while the rest of the town has single buildings drawn on the plan. There are two distinguished types of building – churches and places related to the negotiations. The former are marked with a cross inside the building, the latter – with letters explained in the legend. It is worth mentioning that, on plans of the turn of the XVII and XVIII century, single, detailed buildings were rarely drawn, mainly on special-purpose plans (e.g. taxation plans). The general-purpose plans depicted built-up areas in the form of squares only.

The green and agricultural areas are shown in detail –there are several classes of them, including two types of wetlands, fields within and outside the suburbs and residential gardens. Such extensive information, especially the identification of gardens, is typical for more modern plans.

The last class of objects is fortification, depicted in a very detailed way. It is, however, nothing exceptional, as most of the plans of this time concentrate on military features. This resulted from the fact that plans were created by army engineers during a period of many conflicts in Europe.

A few interesting features are worth mentioning when evaluating the plan's graphics. As stated above, churches are distinguished in a special way. There is not one common sign, however –in some cases buildings are shown topographically, while some are depicted by a single rectangle, which represents a church or a church-monastery complex.

The other non-standardized sign is the linear signature of roads. Communication lines on XVIII century plans were created "incidentally" when delimiting built-up areas, as spaces between them. On the described plan this approach is true on the densely inhabited area of the Old Town. The rest of the plan, even the suburbs with buildings, has dashed lines marking streets and roads

The topography is shown in a way that makes the plan a very interesting object. Most of the plans of that time used a perspective view to show relief, sometimes adding hachures[2] (mainly outside inhabited areas). The hachure method was popularized in the second half of the XVIII century. On the d'Örken plan, drawn in 1716, all of the relief is depicted using hachure, with no perspective view (Fig. 3). These two features are characteristic, making the plan unique and worth preserving.

The composition of the plan is reasonable and economic –empty areas are minimized, the sheet is used in full. The plan is not very decorative (compared with others of the time), which results from its purpose and drawing technique.

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[2] Hachure as introduced in 1670 by Jean-Dominique Cassini, in the form of short lines perpendicular to a slope. It was a prototype of the "classic" hachure method described by Lehmann.

Figure 3: Methods of presentation of relief (from left: plan of Lublin (d'Örken 1716), plan of Nijmegen (Brakel 1719) and plan of Jerusalem (Lamy 1720)).

The plan lacks textual description, although the scale would allow placing, for example, street or churches names. The road directions are described in French and – being the only Polish name – the Bystrzyca River is named "Stara Rzeka" ("the Old River"). All texts are written in a tidy, non-decorative style. Probably one tool has been used to draw the whole plan – a quill. It is seemingly a simple tool, but one can draw lines of different thickness, from 0.1 to 0.7, using its oblique-cut end (Gilderdale 1999).

Analysis of the plan's contents

The most crucial point, influencing later stages of cartometric analysis, is a selection of stable points, used as the basis of such analysis. To do this properly, one needs to know the past environment of a town and how it influenced the current properties of urban space relations. Without this knowledge, gained with the use of geographical-historical methods,[3] cartometric analysis is not full and can even lead to incorrect results.

The following section shows in full the interdisciplinary character of research on the history of cartography – there are several types of sources used, including historical documents, archaeological excavation and the results of urbanists' work. It is also often inevitable (and highly recommended) to work with specialists in these subjects.

The analysed elements of the plan are as follow:

- layout, extent and legend,
- roads, streets and squares network,
- buildings,
- other urban areas and objects (fortifications, fields),
- land relief,
- hydrography,
- thematic content.

The above selection is obviously arbitrary and the listed features are plan-dependant. In the case of more modern plans an important factor would be cadastre information, while, for example, fortifications would be less useful.

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[3] Methods of analysis and evaluation of early maps were divided by A. Konias (1984) into geographical-historical and cartographical-mathematical. The first is based on a description and visual analysis of the presented space, the second on accuracy assessment.

Analysis of the communication network led to relating the depicted situation to modern town space. It is important, however, that only the Old Town has preserved streets in the same form as they are seen on the plan. On the former suburban areas only a few (mainly most vital and important) routes were virtually unchanged (streets: Krakowskie Przedmieście, Narutowicza, Lipowa and Kalinowszczyzna), while in most cases both the range and run of important routes (for example Mazovia route) have changed. Street analysis played a supplementary role in topology problems, such as the relation of the fortification to gullies in the north-west part of the plan or the relation of modern-day Litewski Square, the fortification and non-existing church of the Order of St. John of God.

Analysis of buildings gave similar results, helping to verify the accuracy of the depiction of some of them (mainly churches) in terms of placement, orientation and a relation of signature to a building's function (buildings marked with cross signature are –in most cases– churches, but some of them are a church-monastery complex). All this was crucial in the process of selecting base points for cartometric analysis. It also helped to verify the plan's value as a historical source. Some researchers rated it low, claiming the author has made mistakes (e.g. the topology of objects in Litewski Square, Jesuit College and Cathedral relations), which turned out to be not very true, as it was based on little knowledge of the plan itself.

Detailed analysis of fortification was conducted for two reasons. They were distinguished by the author himself, who made them one of the most important features of the plan. In addition, the level of their details allows using fortification as a great element helping in the identification of other, often less detailed, objects depicted on the plan.

The plan shows both the city walls and field fortifications, known as the 3rd and 4th line (Teodorowicz-Czerepińska et al. 1999). All of them were militarily defunct at the time of the plan's creation, which can be read on the plan itself (fortification is entitled "vieille Fortification"). The most recent line (built in 1670) forms a western boundary of the suburb and is still a visible feature in Lublin's environment (Fig. 4).

Figure 4: Detail from the city's fortification on the plan of Lublin from 1716 and the same area today. Red marks former a flèche, white marks the outline of post-war house which fits into a long abandoned 18th century scheme of land property.

Analysis of natural environment elements has shown they are depicted properly. The hydrography and situation in valleys of both Bystrzyca and Czechówka rivers, including remains of Wielki Staw Królewski (the Great King's Pond), is correct. The relief is very detailed and fits well with other features.

The last stage of the descriptive analysis dealt with thematic elements, related to the Tarnogród confederation. The most important and valuable result is information of spatial relations not available in other sources, such as participants' quarters and –probably even more important– forces zones of control. They are shown on the plan, with both sides' posts: the king's forces are in control of the eastern part of the Krakowskie suburb, while the confederates are encamped in the Jewish district. The Old Town has been guarded with barricades too, which formed –together with the city walls– a neutral zone with very limited access, which can be read in the confederates' edict of 13th June 1716. It declared that all people, regardless of gender, state, privileges or character, not taking part in the treaty and staying in Lublin (understood as the space surrounded by the city walls) would be caught and brought to confederation marshals (Raczyński 1841).

Cartometric analysis

Geometric correctness of the plan was evaluated on the basis of the following analyses: scale and its variation, distance, direction and area errors. All the above were based on measurements made on the original plan using 30 previously determined stable points.[4] Measurements of true values were made on the basis of a topographic map at 1:2000 scale (coordinate system: "Układ 1965").

A linear scale of the plan gives values in steps. The XVII- and XVIII-century units were of very high diversity (Grygorenko 1981) and "steps" in this case could be one of many variations of this unit (a "step" measured on the plan's linear scale using a calculated mean scale is equal to 96 cm).

In all of the analyses needing a scale value, a mean scale was used. It was calculated as an arithmetic mean of 435 local scales. The result was the scale of approximately 1:3586. However, the difference of extremes' values was very high –the denominator varied from 1881 to 6941.

Such a high diversity of local scales led to the idea of illustrating its spatial variation. The method proposed by E. Krzywicka-Blum (1994) was used. The first step was to create a triangular network over the original plan and calculate the arithmetic mean scale for 3 sides of each triangle. The resulting value was then assigned to a centre point of each triangle and these points were used for interpolation. The result is shown in Fig. 5.

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[4] As mentioned, stable points selection should be preceded with detailed analysis of a plan, which allows eliminating points that appear to be useful, but – after evaluation – do not guarantee correct results.

Figure 5: Isolines of scale variation of the plan and points used for interpolation (reduced).

Distance analysis consists of absolute and relative errors calculation. The absolute Gaussian mean error for all 435 values is almost 251,5 metres. The numbers are not very self-explanatory, that is why most of the coefficients used are illustrated by means of graphic methods. One way to visualize analysis results is the circle method (Fig. 6). Each of the stable points becomes a centre of a circle whose diameter is proportional to the sum of absolute distance errors from the given point to the rest. Fig. 6 corresponds with scale variation isolines (Fig. 5), allowing to distinguish several unique zones on the plan, which is confirmed by later analyses.
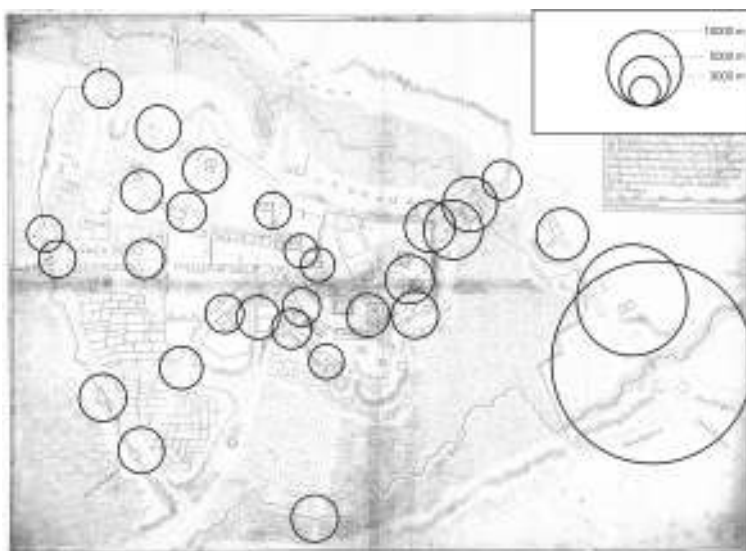

Figure 6: The sum of absolute distance errors for particular points (reduced).

The relative mean error of distance is 26.8% (Gaussian) and 21.8% (arithmetic). Direction (angles) analysis was reduced to the comparison of azimuths from each point to the rest on an early and modern plan. The Gaussian mean of absolute error is less then 16.5

degrees, while maximum individual error is 70 degrees. Relative errors are quite low too. Error distribution and means are shown in Fig. 7.
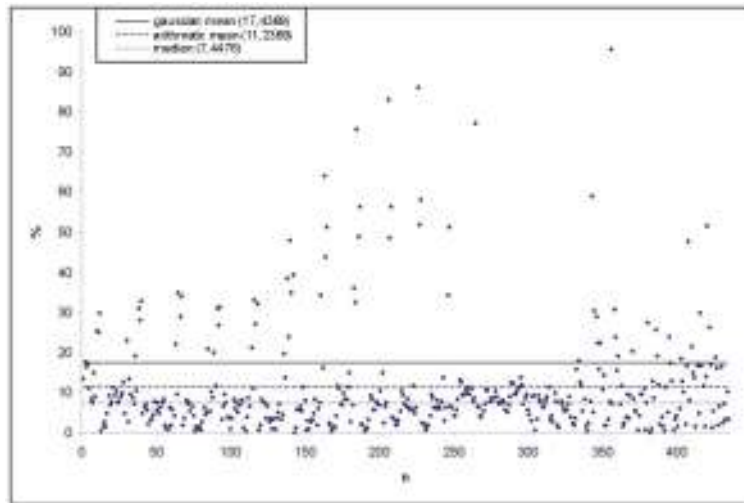

Figure 7: Diagram of distribution of azimuth relative errors.

The plan has no geographic coordinates, hence the location error was calculated with the use of azimuth (recomputed to metres) and distance errors. For each of the stable points the individual location error in relation to other points was calculated as well as the mean Gaussian error.

The location and azimuth errors can be shown graphically together by means of the polar coordinates method. Just like the circle method mentioned above, it is an effective but not popular way to describe an early map. Fig. 8 shows polar coordinates for one of the stable points (no. 21, in the axis of Krakowska Gate) of the analysed plan. The diagram is constructed by imposing the early and modern plan (in the same scale) in such a way that the location of a selected point agrees on both. Then, all of the remaining points on both plans are marked and joined with the selected one. The set (or even one) of diagrams presents a topology of the objects in a self-explanatory way.
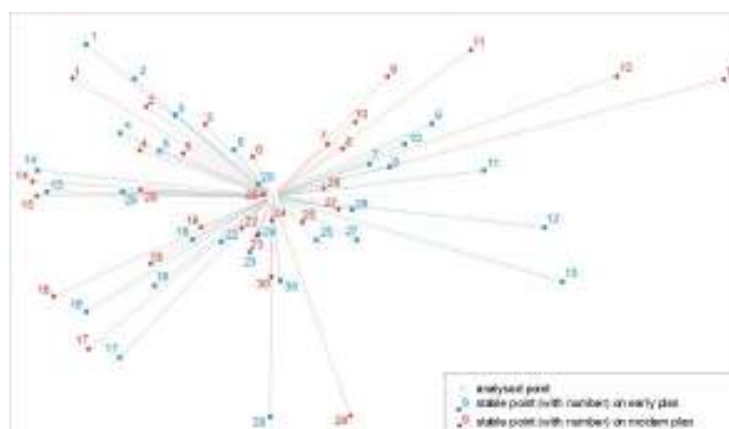

Figure 8: Polar coordinates method (reduced).

The last analysed features were areas and their errors. They were calculated using a triangle network with vertices in stable points. The triangles were not equal or similar in size,[5] that is why the weight coefficient was used. The coefficient of "1" was assigned to a theoretic triangle having an area equal to the arithmetic mean of all triangles' areas. The resulting error of each single triangle was then multiplied by its weight factor and grouped in classes as shown in Fig. 9.
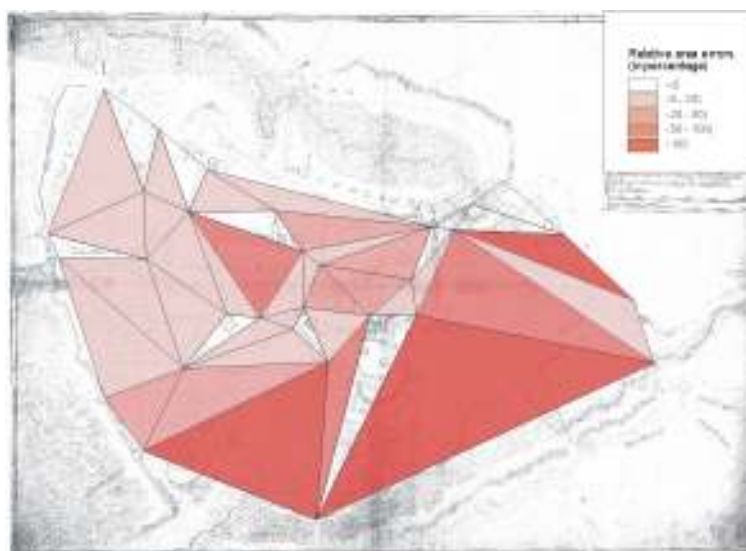

Figure 9: Relative area errors accounting for the weight of triangles (reduced).

The analysis process could not miss the most classic method – the distortion grid. The grid of parallel and perpendicular lines forming a hole of 200 metres by 200 metres was copied from the modern to the early plan. The result is shown in Fig. 10. The process was then reversed – the plan was transformed to fit the modern geodetic base. This was done using polynomial transformation with parameters based on the previously described stable points.

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[5] Inequality is the result of stable points' distribution. The ideal situation is a regular mesh of points, which is hard to obtain as points depend on verified (during descriptive analyses) features in a city environment. The final distribution of points is often a compromise between regularity and reliability.
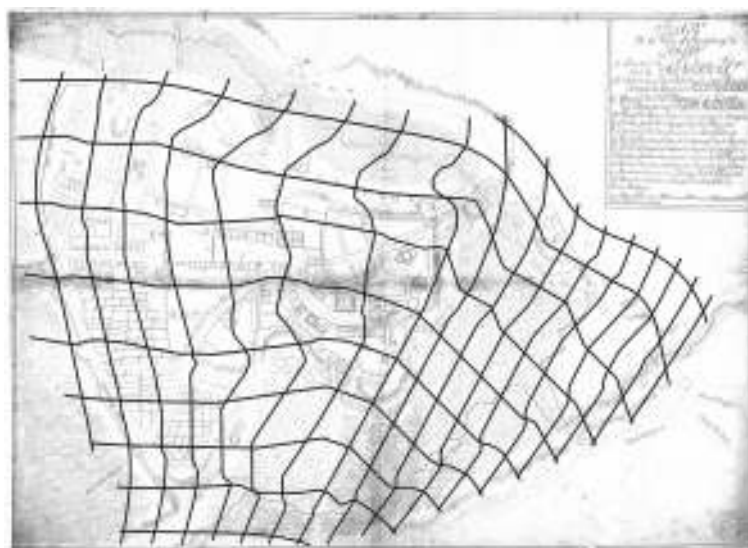
Figure 10: Distortion grid (reduced).

The cartometric analysis helped to discover several homogeneous zones on the plan. The centre (the Old Town and Krakowska Gate area) has a large scale and little distortion. The Krakowskie Przedmieście suburb area has bigger distortions and a scale around the mean. The east part of the plan, especially the Kalinowszczyzna suburb has the biggest errors.

Conclusions

The results of the analyses can be divided into two groups. The first consists of methodological conclusions.
1. The analysis and evaluation of an early map should consider the historical background and circumstances of a map's creation, the quality of the cartographer's work compared to others of that time, the correctness of map content and geometric quality of the map; it is the responsibility of the researcher and his/her goal to concentrate on one of the above, but none can be omitted.
2. Research in early cartography often requires cooperation with specialists on certain topics.
3. Cartometric analysis has a long tradition and there is no one specific set of methods to use; however, some are typical, including mean absolute and relative errors of distances, angles and areas as well as location errors
4. It is worth popularizing methods of visual presentation of errors, e.g. circle, polar coordinates and isolines of scale variation; the well-known distortion grid is a basic and almost obligatory method.

The second group of conclusions relates to the d'Örken's plan of Lublin. These are as follow.
1. The circumstances of the plan's creation were analysed and described (for the first time), which lead to calling the plan a "thematic" plan. This seriously changes requirements and expectations when dealing with this plan, and helps in obtaining proper results when using it as a historical source.

2. The surname of the author was verified; this makes further queries possible.
3. The plan is – in general – typical for the turn of XVII and XVIII century plans. The only distinguishing feature is the use of the quite modern method of relief presentation.
4. The analysis of the plan's contents helped identify objects and answer topological questions. The cityscape has been shown correctly, but not with the same level of detail all over the plan.
5. The detailed analysis of contents makes it a valuable source of information regarding the Tarnogród confederation.
6. The results of cartometric analysis justify dividing the plan into three parts of different geometric properties.
7. There is no information about measurements made by d'Örken. It can be assumed, however, that he made them, especially in the areas of important participants of the negotiations.

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