CO-480

CARTOMETRIC ANALYSIS OF JAUME OLIVES' PORTOLAN ATLAS OF 1563

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INTRODUCTION

The first mention of portolan charts dates from 1269, when such charts were used for a voyage from Saint Louis in the south of France to Tunis (Irás, 2006). The oldest surviving portolan chart is the so called Carta Pisana from around 1300 (probably 1290). The oldest dated portolan chart was created in 1311 by Pietro Vesconte, the author of the first nautical atlas of 1318 (Kupcik 2008). The most important portolan works include the Catalan world chart from around 1375 (Kupcik, 2008). It was created in Majorca and depicts the entire medieval world.

The designation ‘portolan’ chart comes from the Latin term portulano, or possibly from the Italian term portolano, meaning manuscripts with nautical instructions. The terms ‘portolan chart’ and ‘portolan’ were officially recognized by the Academy of Paris in 1762 (Kupcik, in press). Portolan charts used to be drawn on parchment or leather, even though paper was sometimes used. With only a few exceptions, all were made in the workshops of Italian and Catalan cartographers and this situation lasted until the finding of water routes to India and discovering America.

AIM

The issue of visualisation of inaccurate early maps has become a frequent topic. Works by the students L. Vejrova (2008) and L. Srajerova (Veverka, Srajerova, 2009) dealt with the visualisation of cartometric features of early maps of Czech lands with the use of distortion grid, displacement vector and scale isolines. Several research studies have been published recently (Goczyla, Waloszek, 2008; Lloyd, Lilley, 2009; Cechurova, Veverka, 2009; Bayer, Potuckova, Cabelka, 2009; Leyk, Boesch, 2010).

This paper aims to provide cartometric assessment of Jaume Olives’ portolan atlas of 1563 and visualisation of its planimetric inaccuracies. The results are represented in the form of distortion grid, displacement vectors, and isolines of local rotation and local scale that demonstrate map inaccuracies in a clear and precise way. These are accompanied by the calculations basic cartometric characteristics and mean scales of the atlas sheets.

JAUME OLIVES’ PORTOLAN ATLAS FROM OLOMOUC

In 2006, when the Olomouc Research Library moved into a new building, a portolan atlas of mid-16th century was discovered. The existence of this unique atlas had been known already at the beginning of the 1930s but was forgotten throughout the Second World War, and since then, no-one knew where the atlas was located or, indeed, whether it existed at all. The portolan atlas comes from 1563 and the data on the compass rose sheet indicate that Jaume Olives (from the Oliva family) is the author. Jaume Olives comes from a Catalan chart-maker family, whose members were active mainly in the 16th and 17th centuries in Majorca, Venice, Livorno, Messina, Naples, Barcelona, and Marseille. To this day, only six nautical atlases by this author have survived, including the Olomouc specimen. Apart from the one kept in the Olomouc Research Library, the other precious specimens are kept in the Bibliotheque Municipale in Valenciennes, France, the Museo Marítim in Barcelona, Spain, the Hispanic Society of America in New York, USA, the Biblioteca Ambrosiana in Milan, Italy, and the Biblioteca Nazionale in Florence, Italy (Kupčík in press).

The Olomouc portolan atlas was created using a very demanding and costly technique of hand painting on parchment. The atlas is richly coloured; apart from a wide range of colours that are still fresh, silver-plating and gilding has been used for decoration.

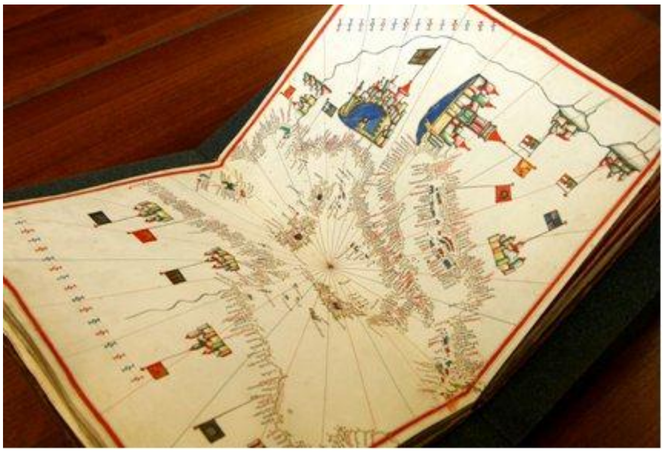

Fig. 1 Jaume Olives' portolan atlas.

The atlas consists of seven 295×455mm parchment sheets. Geographically it covers the Mediterranean and the Black Sea and the northern part of the Atlantic Ocean. All the sheets are bent in the back and stuck to paper. The front end paper consists of 6 loose paper sheets, the back of 7 sheets. The atlas is bound in brown leather and decorated with pressed blind-blocking. The volume is in a very good condition, only the last sheet has been damaged by moisture. Digital copies can be viewed at http://mapy.vkol.cz/.

The first sheet contains a compass rose. Above the rose there is the author's autograph and the place and year of the creation of the atlas. The rose and the map sheets are oriented to the south (Kupcik, in press).

The second sheet is the first map chart, representing the eastern Mediterranean and the Black Sea. It shows that the maps were not created with focus on temporal correctness and updates. For example, the island of Rhodos is represented with a white cross in a red field belonging to the order of St. John, whose members settled on the island after 1309 but in 1522 (i.e. 41 years before the publication of the atlas) fled to Malta after their capitulation to the Turks (Kupcik, in press).

The third sheet represents the central Mediterranean, from the Ionian Sea to the Balearic Islands and the Catalan coast. The map is one of the most complex representations of the Adriatic Sea from the mid-16th century. Architectural symbols make it easy to identify important seaports. The cities of Venice, Genoa, Bratislava, Budapest and others are dominant in the map.

The representation in the fourth sheet makes it very interesting among the works of this period. The map represents the western Mediterranean and Atlantic, from the Skagerrak Strait to today's coast of Morocco, including the British Isles. Major cities (e.g. Paris, Barcelona, Valencia, Granada or Lisbon) are represented by pictorial silhouettes. The map clearly depicts inland rivers, e.g. the Thames, Rhine and Maas, but the plotting of the foreland of Scandinavia, Iceland and Greenland is inaccurate. This map is a clear evidence of poor exchange of information between the north and the south of Europe. The inaccuracies considerably increase towards the north (Kupcik, in press).

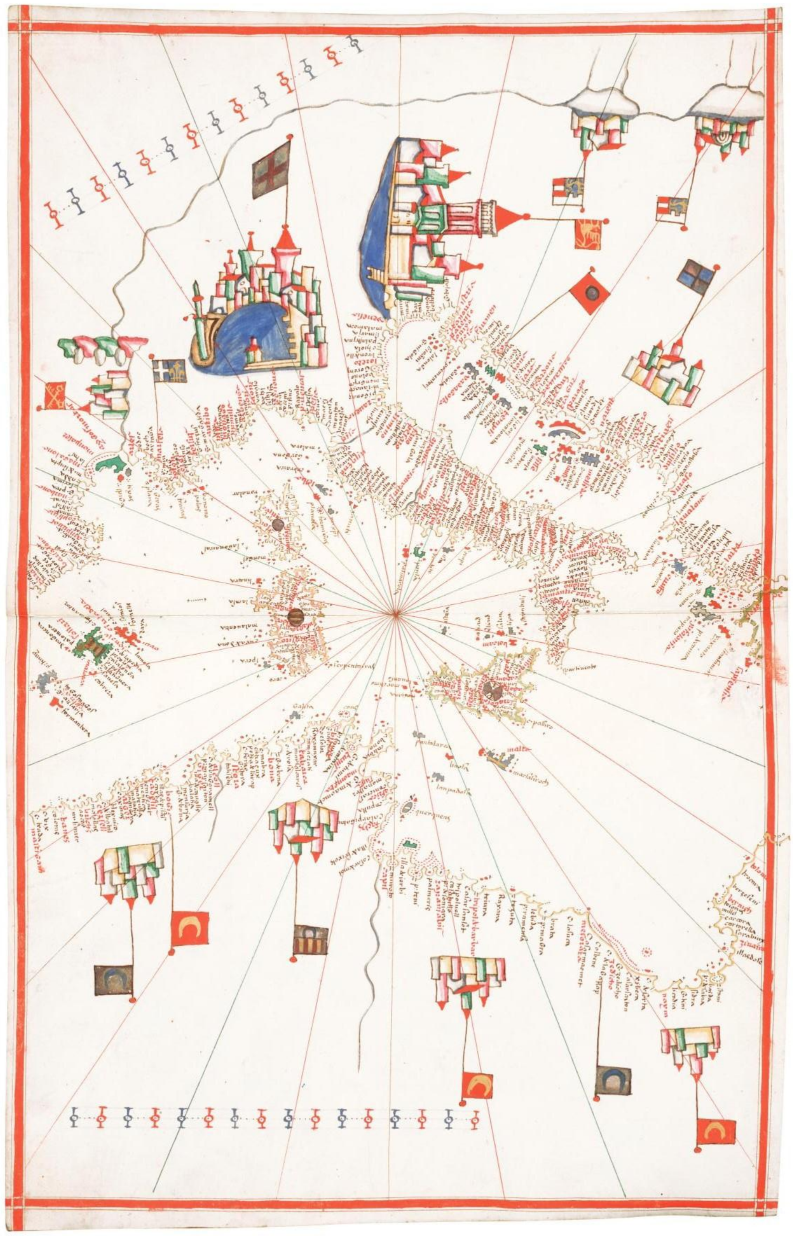

Fig. 2 Italy at the third sheet of Jaume Olives' portolan atlas.

The fifth sheet represents the western and south-western coast of Portugal and Spain, the western coast of Africa, the eastern part of the Atlantic, with Madeira, the Canary and the Cape Verde islands. The map clearly shows inland waters (e.g. the Senegal river). The major cities of Lisbon, St. Louis and El Aaiún are represented by pictorial point signs composed of two parts – the image of the settlement itself and the flag of the authority dominating the city.

The sixth sheet covers the northern Atlantic. It contains a series of imaginary islands. One of the phenomena of historic geography is the Illa de brasil that used to be depicted from 1325 on maps to the west of Ireland. In the western Atlantic the biggest depicted mythical islands are the legendary Antilia and the Island of Seven Cities (http://mapy.vkol.cz/dig/mii33/popis.htm). After test analyses, this sheet was excluded from cartometric analyses due to an insufficient number of comparative points.

The seventh sheet represents the eastern part of the Mediterranean, without the Black and the Sea of Azov. Compared to the previous maps, this map is drawn on rough parchment with less pronounced colours. The map image contains corrections that are a poor attempt to cover the original errors.

PROCESSING METHOD

Cartometric analyses were completed in the MapAnalyst (version 1.3.13) environment. First, suitable reference data had to be selected. Alternative outputs from databases were tested. After thoroughly examining the possibilities to use of the Macon database and data provided by the ESRI company, we decided that the most suitable solution is the already implemented OpenStreetMap application. It is true that data are not generated in an entirely accurate manner but taking into account the estimated scales of the atlas sheets and the territorial extent covered by the atlas we found them satisfactory. In the MapAnalyst environment we created sets of pairs of comparative points (a pair of a comparative point in the old map and its image in the reference map). Then we used them to select transformation, suitable parameters, to calculate basic statistics and to perform visualisation of cartometric features. We chose parameters that made it possible to easily compare individual sheets. Analysis results were exported into the SVG format and subsequently processed in the Inkscape program.

The MapAnalyst program was created to perform cartometric analyses of early maps. Its main purpose is to create distortion grids, displacement vectors, to calculate local scale and rotation, and to subsequently perform visualisation that would represent the geometrical accuracy of the maps. MapAnalyst makes use of methods and algorithms developed by Dieter Beineke (Bundeswehr University of Munich). The program is freely downloadable (http://mapanalyst.cartography.ch) and can be freely modified in Java thanks to open source code.

OpenStreetMap is an open source project (http://www.openstreetmap.org/) designed for the generation of freely accessible geographical data and their subsequent visualisation in topographical maps. Data are supplied under the Creative Commons Attribution-ShareAlike 2.0 licence. OpenStreeMap is directly implemented in the basic setting of MapAnalyst (from version 1.3, 2009). The disadvantages of the Mercator representation (high surface distortion) are automatically modified by the program.

CARTOMETRIC ASSESSMENT OF THE ATLAS

Cartometric analyses focus on the assessment of planimetric inaccuracies, especially positional inaccuracies, the layout of distances and directions between identical objects in the old and the reference map. All the map sheets (excluding the sixth sheet) were assessed using the methods of distortion grid, displacement vector, rotation and scale isolines. Analyses were performed with the use of the method of distortion grid, displacement vector, rotation and scale isolines. Emphasis was put on the distinction of errors and inaccuracies in the maps. Errors were made by the author when creating the map while inaccuracies are the result of paper being an unstable material that is subject to changes in the environment. As a result, the parchment shrinks and the geometry of the map is distorted.

Transformation

The scanned originals of the atlas sheets were imported into MapAnalyst as an 'old map' and the implemented OpenStreetMap was used as a 'reference map'. Thus, we created a set of comparative points that were used as a basis for the analysis calculations.

The comparative points were placed so that there was no danger of a significant change in the position since the time of the creation of the atlas, i.e. in the coastline (capes), important geographical points and river mouths. Points were always placed using the same scale, with maximum approximation of the old and reference map, so that positioning errors were minimised. When placing the points in a river mouth, we first connected the river banks by a guiding line and then placed the comparative points in the middle of the line. The number of comparative points changed in each project (dealing with each atlas sheet) depending on the size of the depicted territory, its topography and the accuracy of the coastline in the map. We aimed at placing the points evenly over the whole represented territory.

After sets of comparative points in the old and reference maps were created, we performed the transformation of both sets of the coordinate systems. In all cases, we used the four-parameter Helmert transformation.

Tab. 1 Cartometric assessment of portolan charts by Jaume Olives.

	2nd atlas sheet	3rd atlas sheet	4th atlas sheet	5th atlas sheet	7th atlas sheet
Average rotation	172°	172°	174°	179°	170°
Standard deviation [m]	33,105	38,388	65,384	48,532	26,126
Mean positional error [m]	46,817	54,289	92,467	68,635	36,948
No. of comparative points	164	137	167	78	138

Average calculated scale	1 : 6 088 700	1 : 6 650 900	1 : 7 313 600	1 : 8 332 800	1 : 4 757 700
Scale cited in literature	1 : 6 000 000	1 : 6 500 000	1 : 6 700 000	1 : 8 600 000	1 : 4 380 000

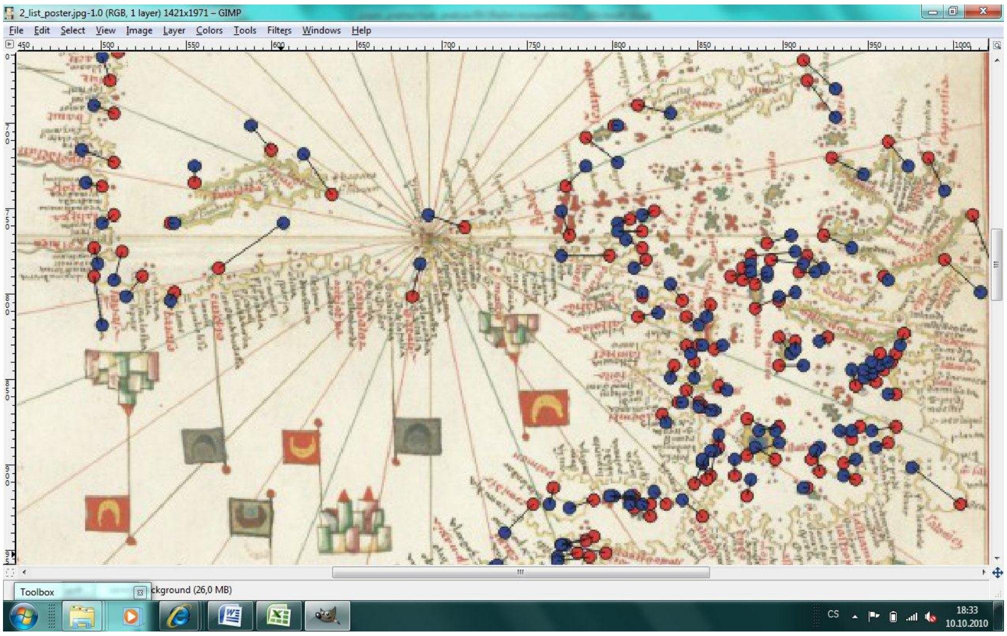

Fig. 3 Point for cartometric analysis at the 5th atlas sheet.

Distortion grid is one of the methods used to express planimetric inaccuracies. The rotated, compressed or enlarged part of distortion grid illustrates local deformation and rotation of the old map. Before the analysis calculation, input parameters were set to identical values, namely Mesh Size: 100,000 m, Extension: Around Points / Rectangular, Smoothness: max. Distortion grids of all atlas sheets were portrayed in the form of vectors with the Scale Factor 1.0 (vector lengths were not re-multiplied).

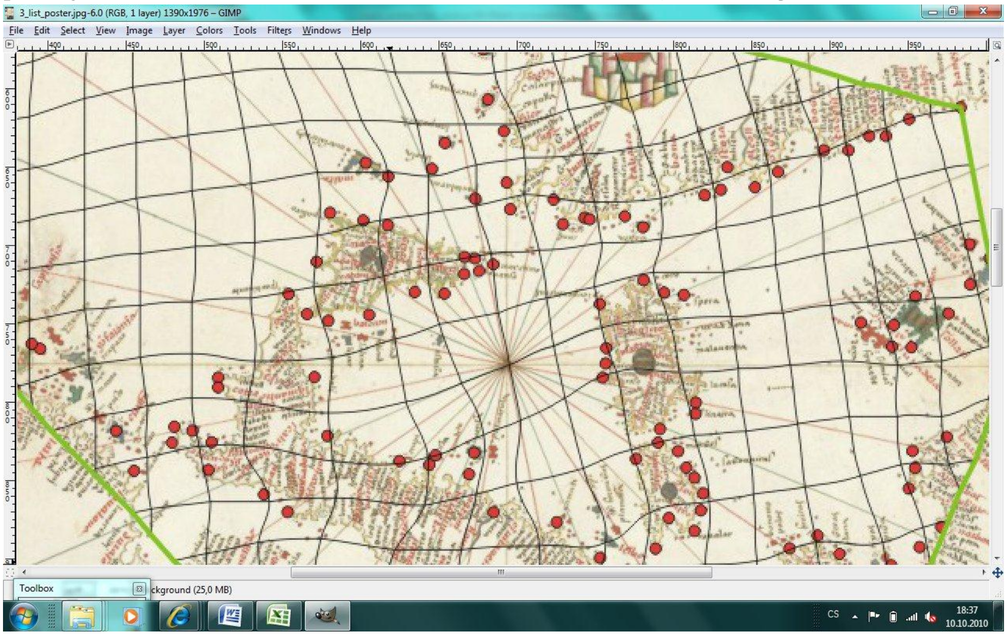

Fig. 4 Distortion grid at the 3rd atlas sheet to express its planimetric inaccuracies.

All the displacement vectors start at points identified in the old map and end at the point to which the point would move if the old map was identified with the reference map. The end point is calculated with the use of transformation between the sets of comparative points in the old and the reference map. Vectors of significant length point at serious errors.

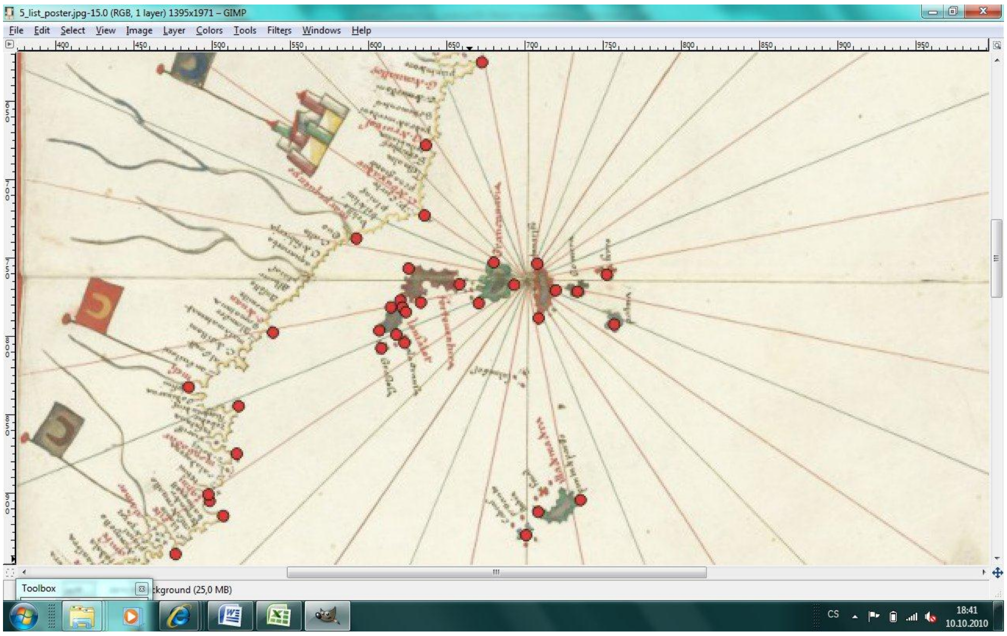

Fig. 5 Displacement vectors at the 2nd atlas sheet express length and direction of distortion.

Scale and rotation isolines are lines that connect places with the same scale or rotation values. The underlying algorithm uses two invisible raster grids that maintain evenly distributed scale and rotation values. The resulting values can be reached in three steps: First, two raster grids are created, with the values of average scale and average rotation. Then, scale and rotation values are calculated for each cell and, finally, the resulting isolines of the raster grid are obtained by using the algorithm that produces a contour line. The calculations are made on the basis of the selected transformation and the method of least squares. Isoline shapes depend on the determination of the radius of the circle of influence at each point, which defines the maximum distance between the points that influence the resulting value at the point. The resulting lines are plotted in the area between points, where the calculation itself takes place. Optional parameters were set to the same values, so that individual outputs can be visually compared, namely Scale Interval: 1 : 100 000, Rotation Interval: 1°.

Fig. 6 Scale isolines at the 4th atlas sheet.

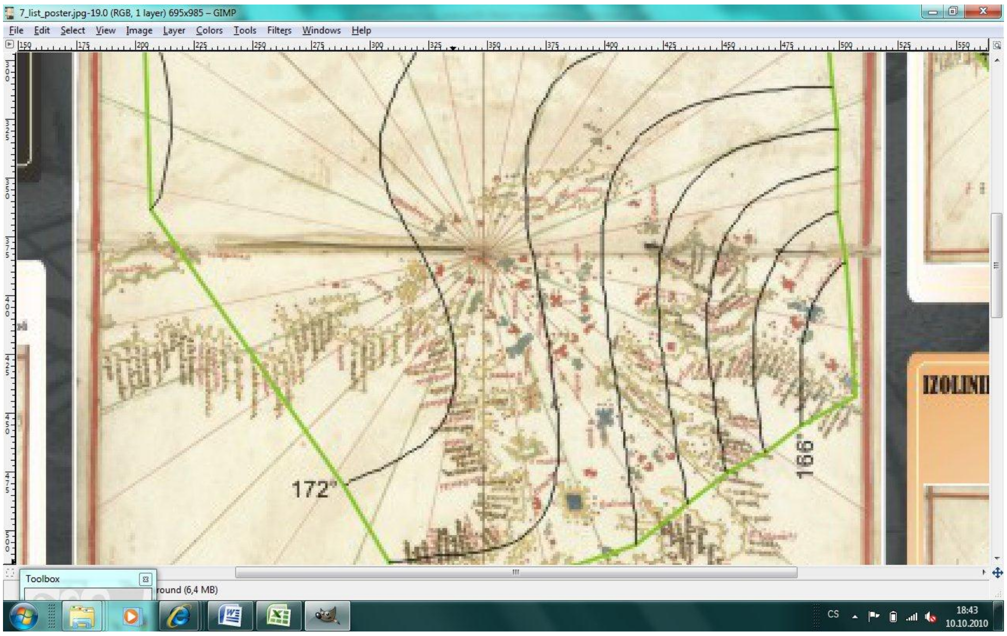

Fig. 7 Rotation isolines at the 7th atlas sheet.

RESULTS

The average scale of the map on the second sheet of 1 : 6 088 700 corresponds almost entirely to the value cited in literature (Brandt, 1931) (1 : 6 000 000). The distortion grid illustrates that the island of Cyprus shows the biggest distortion; in the map it is plotted too much to the north, as can be well seen from the displacement vector. The second significant distortion can be found in the case of Black Sea (plotted in the west and extended in the direction of parallels).

In the case of the third atlas sheet, the average map scale was set to 1 : 6 650 900, which corresponds roughly to the value cited in Brandt (1931) (1 : 6 500 000). The increase of local map scales in the southern direction points out the shortening of the distance 'southern Europe – northern Africa’. The map displacement vector clearly shows the plotting of the Dalmatian coast in the east; the western coast of Corsica is situated comparatively far too much in the west.

In terms of distortion grid, the fourth sheet appears to be the most interesting one. Erroneous plotting of the Orkney Islands below the southernmost projection of the Scandinavian peninsula causes the grid’s rotation at this place. This sheet illustrates the difference in the knowledge the cartographers of the Jaume Olives' times had of southern and northern Europe. Errors in plotting and inaccuracies increase towards the north and are clearly visible not only in the distortion grid and the displacement vector but also in the local isolines. These outputs again clearly demonstrate the transition between the south and the north; towards the north both the map's rotation and its scale get bigger. The average map scale was calculated at 1 : 7 313 600, which is different from the scale cited in past (Brandt, 1931) (1 : 6 700 000).

The fifth sheet contains a grave error in the plotting of the Cape Verde islands in the east. This causes a substantial error in the distortion grid, as well as an increase of the values of the local scale. The average map scale of 1 : 8 332 800 is relatively different from the scale cited in literature (Brandt, 1931) (1 : 8 600 000) .

The average map scale of the seventh atlas sheet is 1 : 4 757 700, which is different from the scale cited in literature (Brandt, 1931) (1 : 4 380 000). Most islands in the Aegean Sea on this sheet are plotted in higher latitudes.

These cartometric analysis results are very similar to the values cited by Brandt (Brandt, 1931) calculated manually almost 80 years ago (Brandt, 1931). Table 1 shows the comparison of the scale values of each atlas sheet calculated by our researchers and by Brandt (1931).

Map sheets are rotated clockwise from 170°to 179°. These values correspond to the map’s orientation to the south. The standard deviation values range from 26,126 to 65,384m and the values of the mean positional error range from 36,948 to 92,467m. Using this criterion, the seventh atlas sheet can be considered the most accurate. On the other hand, the fourth atlas sheet can be considered the least accurate.

Five sets of visualisation maps corresponding to each of the five atlas sheets were created as part of the study. Each set contains a distortion grid visualisation for the area of the whole sheet, a distortion grid of the studied area, a displacement vector, scale isolines and rotation isolines. The ratio of the complete set of these 25 maps was left at 1 : 1, respecting the originals in the Olomouc portolan atlas (the maps are drawn on sheets of A2 format).

DISCUSSION

Critical assessment of the results of cartometric analyses of atlas sheets shows some problematic points. The selection of reference data is one of them. The OpenStreetMap application is the only one that enables problem-free analyses of all the atlas sheets towards one cartographic product. It is a pity that there are no more such tools.

Another critical point is represented by the placement of comparative points in the coastline, which does not ensure an even placement of such points. Nevertheless, this cannot be remedied because it is the nature of portolan charts to depict the coastline and the structures nearby (Lafreniere, Rivet, 2010). Despite the fact, comparative points were placed as evenly as possible, including the maps' edge points.

The limiting factor of MapAnalyst is the fact that the vector is not understood as an oriented line segment and cannot be modified as such. Therefore, for the purpose of this study, the displacement vector was understood merely as a connecting line between the comparative point in the old map and the comparative point in the reference map. Displacement vector always starts at the comparative point in the old map and leads to the comparative point in the reference map, respecting the condition of map identification.

Finally, it should be noted that the resulting isolines were not significantly modified compared to the exported outputs, so that they would not lose their informative value. It is true that the lines are not perfectly smooth and curved but they accurately capture the essence of the represented phenomenon.

CONCLUSIONS

The unique specimen of Jaume Olives' portolan atlas of 1563 that was discovered in the Olomouc Research Library in 2006 was assessed with the use of cartometric methods, using the MapAnalyst environment, with a special emphasis on the maps' accuracy. The results compare the findings of Brandt (Brandt, 1931), who made manual calculations in 1931. This is proven by analyses of distortion grid, displacement vector and map rotation and scale isolines. The analyses resulted in the total of 25 outputs, with the ratio of 1 : 1 compared to the original maps (drawn on sheets of A2 format) that visualise planimetric inaccuracies of the atlas. The outputs can be used, among others, for similar comparative studies or as illustrations during historic cartography lessons (Morelissen, Bijlsma, Tapley, 2010).

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