

Evangelos Livieratos *

Graticule versus point positioning in Ptolemy cartographies

Keywords: History of maps; Ptolemy maps; map comparison; cartometry; optimal fitting.

Summary

Cartographic representations in the various editions of Ptolemy's *Geographia* suffer significant differences between the pictorial positioning of geographical places given in the text and the associated longitude and latitude coordinates. While the point positioning of geographical places differs in most cases from map to map, the opposite holds for the graticule of meridians and parallels, which in most of the cases are almost coinciding. This antithesis is illustrated in this paper using two Ptolemaic representations of the island of Crete and digital optimal fitting techniques for the comparison process.

Introduction

The question of the correspondence between the longitude and latitude coordinates of geographic-place positions and their depiction on drawn maps, referenced to the graticule of meridians and parallels, is familiar in the study of maps based on Ptolemy's *Geographia* (Dilke 1987: 177). This brings in mind the still open old discussion, and its newer versions, on the affinity between the data in Ptolemy's texts and the various accompanying cartographic representations (see e.g. Bagrow 1945, 1947; Washburn 1985).

The point positions of place locations in *Geographia* are given in lists of longitude and latitude coordinates in degrees and minutes of arc rounded in steps of five minutes of arc. This rounding-off error corresponds to c. 10 kilometres on the surface of the earth and this is a nominal positional limit of Ptolemy cartography mainly concerning the latitudes. For longitudes the discussion is different, given the uncertainty in the relevant determination of time, which is reflected to the longitude uncertainty on the surface of the earth. These are the only positioning data given in Ptolemy's *Geographia* and evidently they are the only source of geometric information available for the map designers in order to report the given geographic positions on a map using, presumably, an auxiliary graticule of meridians and parallels. This graticule is, in general, not traced on map's surface from its one edge to the other in terms of meridians and parallels at least for the case of the regional maps as given in 'Tabulae'. Usually, the 'Tabula' latitude and longitude 'scaling' is given on the map-frame which bounds the geographic window of the cartographic representation. In this setting, the only way to test on the map the placement exactness of points given in the *Geographia* list of coordinates, with respect to the graticule, is to trace the relevant meridians and parallels on the 'Tabula' surface.

The advances of the new digital technologies allow now the study of this numerical cartographic problem on the digital copies of Ptolemaic 'Tabulae' on which the graticule of

* Professor of cartography, Aristotle University of Thessaloniki, Greece. [livier@auth.gr]

the meridians and parallels are easily traced. A first direct control gives easily the exactness or not of the point placement on the maps by comparing the spatial relation of the point longitude and latitude, given in the *Geographia* list, with its map placement with respect to the a posteriori traced graticule. In the paper we discuss the problem using two Ptolemaic representations from the late 15th and the late 17th century focused on Crete.

Comparison using georeference

In order to study the differences or the accordance of point positioning on a map using Ptolemy's text coordinates or using their reference to the relevant geographic graticule, we introduce the method of 'georeference' as applied in modern cartography. Due to this method, a map only available in its pictorial version, with no reference to some geographic parameterisation, is transformed in its 'geoparametric' form by calibrating, with their numerical values, points of known coordinates. The used points could be either punctual geographical places (i.e. towns, promontories, debouchments), or the intersections of the meridians and parallels as depicted on the map. For the illustration of the case we use a *Geographia*-based map referred to Europe's Tabula X, representing Greece (Fig. 1).



Figure 1. Europe's Tabula X, *Geographia*, Rome 1490. The graticule is traced on the digital version of the map.

The focus is on Crete¹ mainly for the sake of convenience in the digital processing. This test map is from *Geographia* Rome 1490-printed edition extracted from the Nordenskiöld (1978: 163-4) facsimile atlas. The map is printed in two parts on two separate pages, which after the proper scanning is digitally unified using an optimal similarity fitting which preserves the conformality of the figures. The following step is the tracing of the graticule of meridians and parallels by connecting the relevant scales of longitudes and latitudes. The concentration on Crete is now easy by cropping the area of interest where the corresponding part of the graticule is visible (Fig. 2).



Figure 2. Crete in Europe's Tabula X, *Geographia*, Rome 1490.
The graticule is traced on the digital version of the map, as in Fig. 1.

The point coordinates for Crete are taken from *Geographia* book three, chapter XV, as given in *Codex Ebnerianus* a manuscript prepared by Donnus Nicolaus Germanus in the mid-fifteenth century (Stevenson 1991: 92) which served as the basis for the later printed editions of Rome (1478, 1490², 1507, 1508), Ulm (1482, 1486) and Strasbourg (1513, 1520, 1522, 1525) according to Fischer (1991: 10). Comparing the traced graticule with the values of longitude and latitude given in the list of coordinates for Crete, we observe immediately a perfect fitness in the integer longitudes and latitudes, as it is shown in Fig. 2, e.g. the meridian of 53 degrees is actually passing from *Minoa* and *Poesilasium*, the meridian of 54 degrees from *Melus*, *Lappa* and *Psychium* and the meridian of 55 degrees from *Olus* (or *Olulis*) and *Inatus*. The same holds for the parallel of 35 degrees passing exactly from *Minoa* but close from *Elautherae*. The problem of comparing the point-wise with the graticule-wise positioning is usually confronted by calibrating the map-image with respect to geographical coordinates (the so called *georeference* of the map-image). This can be done by assigning known values of coordinates to selected points of the map-image. In our case we can calibrate the map-image in two ways:

- (a) Assigning coordinate values to the point-location of place names given in *Geographia* and

¹ Two recent publications on historical maps of Crete refreshed the interest for this island (Zacharakis 2004; Melas 2005: 7).

² The edition of *Geographia* used in this study.

- (b) Assigning coordinate values to the intersections of the graticule, namely the meridians and parallels.

In both cases we make the fully legitimate assumption that, in the calibration process, the assigned values of coordinates are unprojected geographic coordinates (longitude – latitude) referred to a sphere of unit radius. This assumption applied to both cases of map-image calibration, as described above, gives a common ground for comparison of the two calibrated map-images. In case (a), the calibration is done by assigning unprojected geographical coordinates to the map-image points as derived from the list of coordinates in *Geographia*. Here, the coordinates of ten towns on the coastline are used and the result is shown in Fig. 3. We can easily conclude that the resulting calibrated graticule (in red) does not coincide with the graticule originally drawn on the map. In case (b), the calibration is done by assigning unprojected geographical coordinates to fifteen graticule intersections and the result is shown in Fig. 4. Equally easy is the conclusion that the resulting calibrated graticule (in red) coincides pretty well with the one originally drawn on the map.



Figure 3. The calibrated map-image using geographical coordinates of ten towns on island's coastline.



Figure 4. The calibrated map-image using geographical coordinates of fifteen graticule intersections.

Comparing the two calibrated map-images, by a proper optimal fitting, we obtain the resulting field of displacements as shown in Fig. 5.

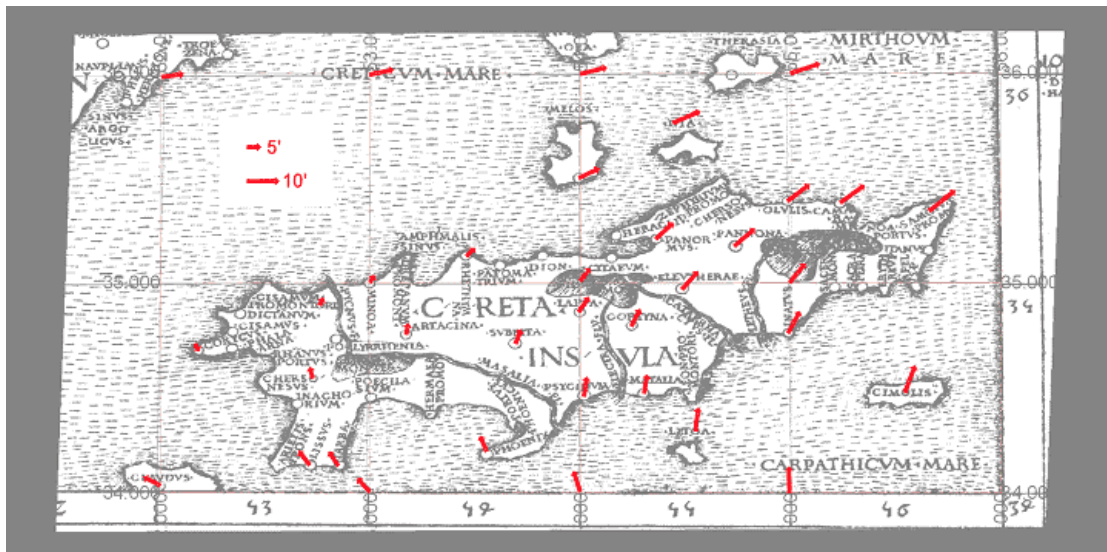


Figure 5. The metric field of displacements obtained from the comparison of the two map-images derived by point-wise and graticule-wise calibration.

The spatial field of displacements in Fig. 5 shows a clear coincidence at the NW part of Crete, which is not the case for the rest of the island's surface. Eastwards the 54 degrees meridian we notice a uniform NE trend of the displacements of the order of 10 minutes of arc almost twice the intrinsic resolution of Ptolemy's positioning. The results demonstrate a clear internal inconsistency between the point positioning according to the coordinates given in *Geographia* and the inherent graticule of the map, which should be taken into consideration in the cartometric analysis of Ptolemaic maps.

Direct comparison of maps

We compare now the accordance of the map-image of Crete we used above with a counterpart depicted in Tabula X of a much newer *Geographia*, namely the colour 1695 Utrecht edition³ (Samourka Map Collection⁴), which is used here in its inverse greyscale raster form (Fig. 6).

³ Published also in 1698 and in 1704, 1730 (Amsterdam).

⁴ The Samourka Map Collection, www.maplibrary.gr/Sylloges_SamourkaGR.htm

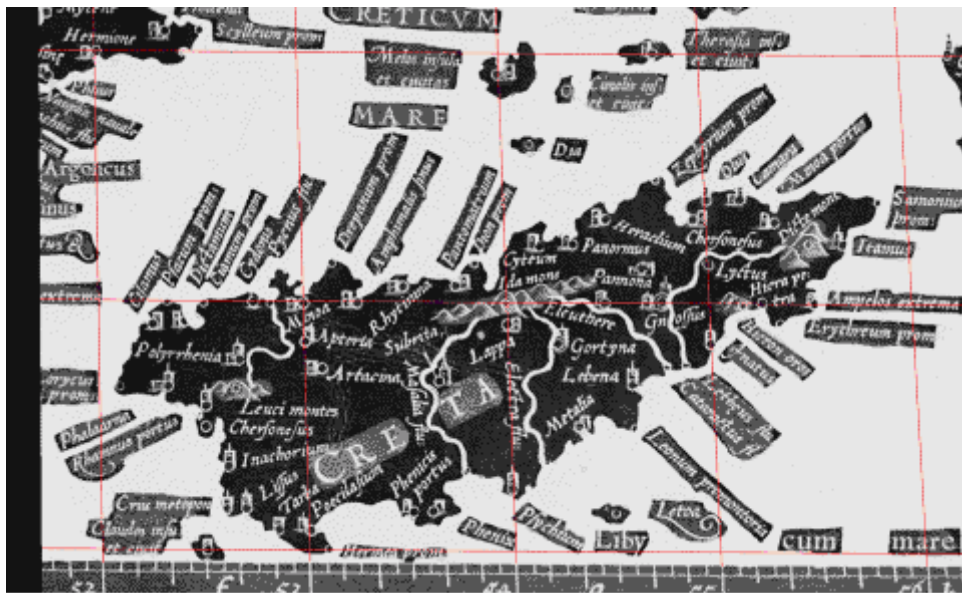


Figure 6. Crete in Europe's Tabula X, *Geographia*, Utrecht 1695.
The graticule (in red) is traced on the digital version of the map.

The map-image of Crete in this representation is spectacularly 'corrected' with respect to the previous two centuries older map. The cartometric comparisons of the two map-images set off the quantitative differences and measure the corrections applied to the newer map. In order to do so, both map-images are brought digitally in one-to-one correspondence using a conformal best fitting in order to eliminate the systematic rigid scale and orientation differences.

In Figs. 7 and 8, the field of displacements is shown, scaled in minutes of arc. Except for the south western part of the map, where the corrections reach almost half degree, and the correction of the position of *Melos insula* which is of the same order, the corrections over Crete's inland are of the order of the intrinsic accuracy of Ptolemy's positioning while the corrections along the island's coastline are almost double. Impressive is the coincidence of the point coordinates of *Hermione*, *Therasia insula*, *Minoa* and *Olus* (or *Olulis*). In Fig. 9 the outline of Crete's coastline drawn from Rome's map-image is overlapped to Utrecht's map-image in order to stress the evidence of the differences on a common metric background.

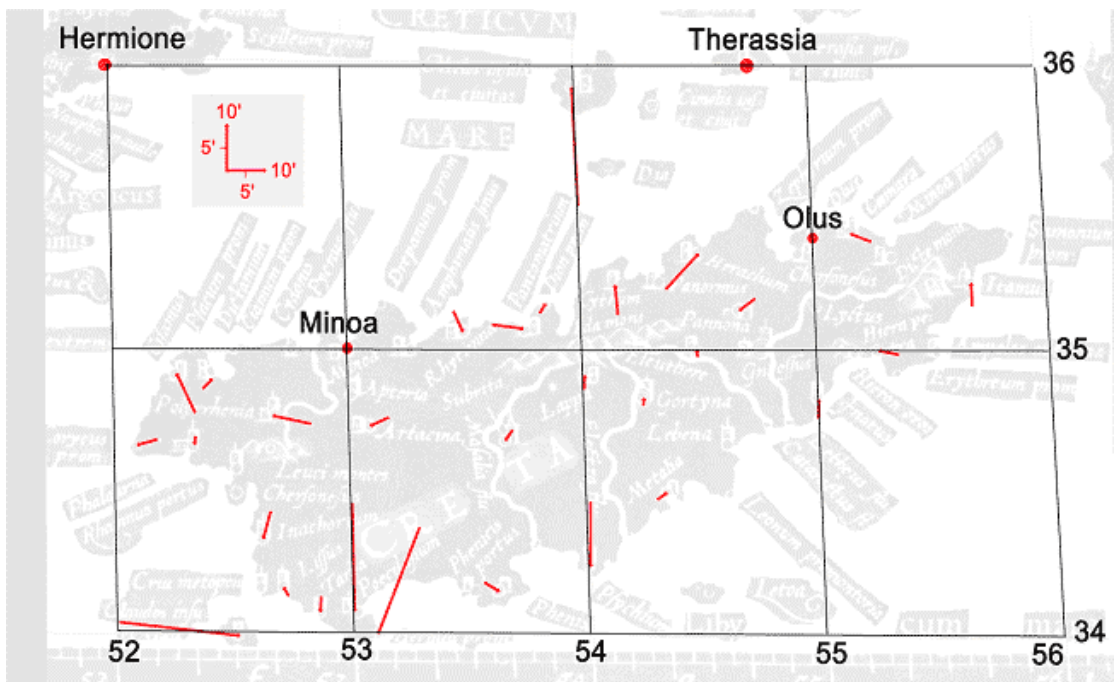


Figure 7. Utrecht's vs. Rome's Crete. The field of displacements.

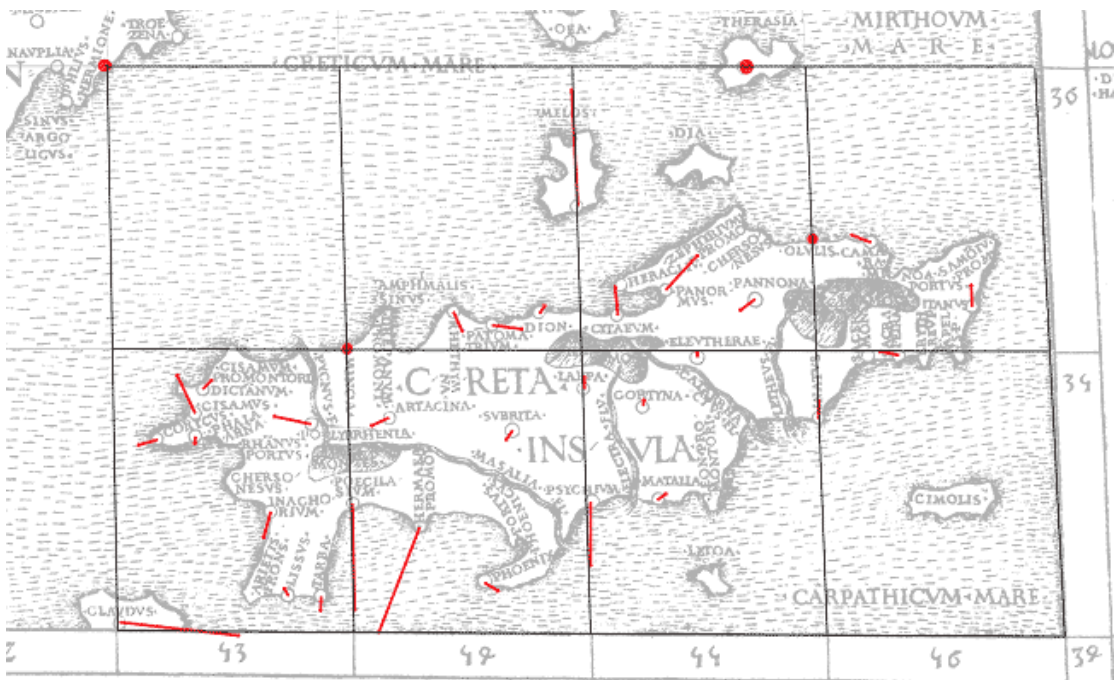


Figure 8. Rome's vs. Utrecht's Crete. The displacements are in the same scale as in Fig. 7.

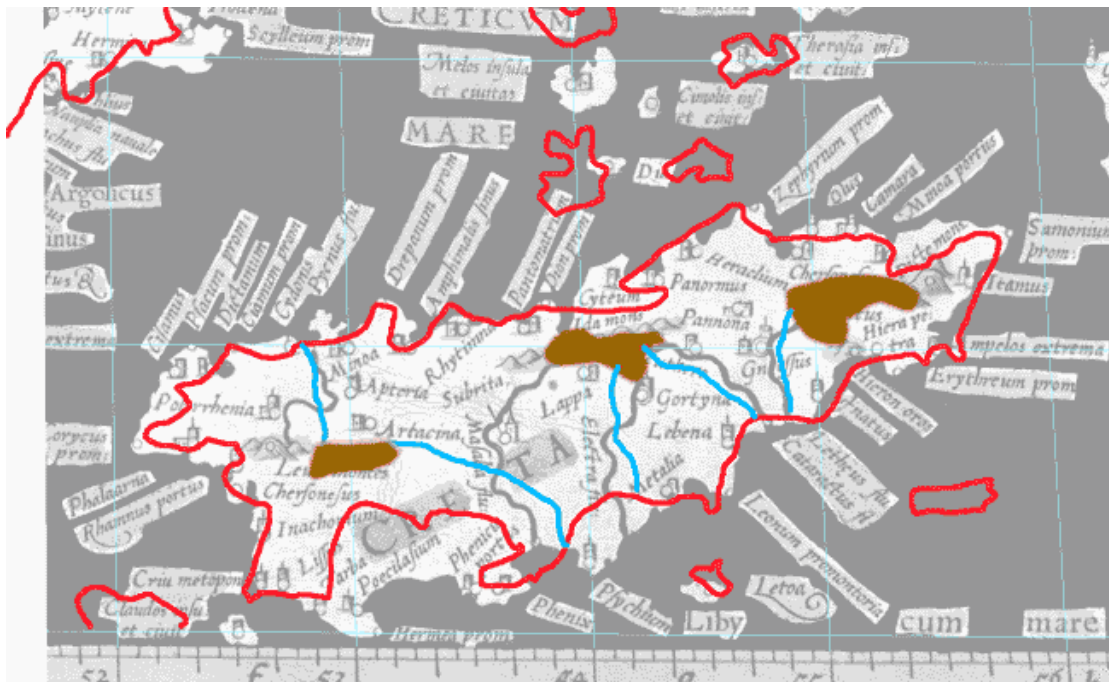


Figure 9. Rome's vs. Utrecht's Crete. Scale as in Figs. 7 and 8.

Concluding remarks

The relation between the geographical coordinates of longitude and latitude listed in various manuscripts and printed editions of Ptolemy's *Geographia* and the relevant regional cartographic representations drawn with the help of these coordinates, can be explored by using proper analytical transformations which, under certain acceptable geometric conditions, bring the coordinates and their pictorial representations in one-to-one correspondence allowing thus, useful tests of comparison and compliance. Applying this analysis to a certain Ptolemaic map-image coming from the very early copies of *Geographia* using associated geographic coordinates, which are compatible to the map-image, we found worth to study quantitative results concerning the discrepancies between the positioning of the coordinates on the map and their spatial relation to the graticule of meridians and parallels. This leads to the hypothesis that the map designer followed distinct procedures in plotting the map content, with the help of given coordinates in the *Geographia* text, and in the drawing of the geographic graticule. The test presented here is of local character, i.e. focused on the island of Crete just to demonstrate the method one can follow in order to study the issue. It can be easily extended to broader areas, e.g. to the entire surface of the Tabula, or to various Tabulae in order to construct a wider relevant model. New informatics and infographics technology offer the right tools and it is worth trying such analyses given the appropriate digital map-images.

Another project, which can be studied, following the same line of thought and methodology, is the comparison of two versions of the same map-image, belonging to different editions of Ptolemy's *Geographia*. Taking two map-images from two editions separated by almost two entire centuries one could drive through the obvious phenomenological conclusions on similarities and/or differences arriving to the formulation of rigorous quantitative upshots on the matter. The depiction of the results then, gives new and better views

and insights on the correspondences, differences, alterations, corrections and changes, which are documented in the diachronic *Geographia* map versions. In this way, theories, certainties or hypotheses expressed so far in terms of theoretical reasoning and conceptualism could be tested with rigour thanks to the digital advances in sciences and technologies.

Acknowledgement

Thanks are due to Mrs. Margarita Samourka for kindly given the permission of using the greyscale (inverted) high resolution digital map-image of Fig. 6, originally in coloured version. The 'Samourka Map Collection' in its digital form it is implemented by the National Centre for Maps and Cartographic Heritage of Greece.

References

- Bagrow, L. (1945). The origins of Ptolemy's *Geographia*. *Geografiska Annaler* 27 (3-4): 318-387.
- Bagrow, L. (1947). Supplementary notices to 'The origins of Ptolemy' *Geographia*'. *Imago Mundi* 4: 71-72.
- Dilke, O.A.W. (1987). The culmination of Greek cartography in Ptolemy. In Harley, J. B., D. Woodward (eds.) *History of cartography*, 1. Chicago: University Press, 177-200.
- Fischer, J. (1991). Introduction. In Stevenson, E. L. (ed.) *Claudius Ptolemy, The Geography*. New York: Dover, 3-15
- Melas, V. (2005). Preface. In Melas, V., V. Tsokopoulos, D. Kapsalis (eds.) *Candia, Crete, Kriti*. Athens: National Bank Cultural Foundation, 7-8. In Greek.
- Stevenson, E. L., ed. (1991). *Claudius Ptolemy, The Geography*. New York: Dover.
- Washburn, W. E. (1985). A proposed explanation of the closed Indian ocean on some Ptolemaic maps of the twelfth-fifteenth centuries. *Revista da Universidade de Coimbra* 33: 431-441.
- Zacharakis, C. G. (2004). *De situ insulae Cretae*. Heraklion: Mikros Nautilus.