Dissertation submitted for the degree "Doctor of Engineering" at the School of Rural and Surveying Engineering, Facutly of Engineering, Aristotle University of Thessaloniki,[1] under the title:

Claudius Ptolemy *Γεωγραφική Ὑφήγησις*[2] *(Geographia)*: Digital analysis, evaluation, processing and mapping the coordinates of Greece, the Mediterranean and the Black Sea, based on 4 manuscripts and 15 printed editions, from Vaticanus Urbinas Gr. 82 (13th cent.) until today. The new Catalogue "GeoPtolemy- ϑ".

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Summary

In the 2nd century A.D., Claudius Ptolemy in his *Γεωγραφική Ὑφήγησις (Geographia)* collects critically all of the available geographic and cartographic knowledge of his times. In his important work he gives not only the verbal and numerical geographic description of the known world at the Roman times but also the instructions for the mapping of the spherical earth on a cartographic plane, a map, using the geographic coordinates of almost 6500 points on the terrestrial surface. His method, which is in fact the foundation of mathematical cartography, it is still valid and used for the representation of the globe on a map, analogue and/or digital.

His *Geographia* is a milestone in the development of cartography and the evolution of cartographic thinking influencing mapmaking as well, from the 13th c. onwards. A large number of scholars, scientists and engineers followed the Ptolemy's text, which soon becomes fundamental among the prepared European humanists, as soon as *Geographia* was transferred from Constantinople to Florence and translated into Latin in the early 15th c. The available literature on the impact of *Geographia* in the Renaissance world is large and rich, loaded continuously with new research.

Geographia's content consists, generally, of three thematic components:

i. The "theoretical", so to say, part in which the criticism on current geography is followed by Ptolemy's propositions, for a new view on the description of the known earth,

ii. The "numerical" part where the spherical earth is described with numbers, the coordinates of the known points, with their toponyms, on the terrestrial surface, and

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iii. The "technological" part, where the technical issues of mapmaking is exposed, combining the coordinates with the map projections and the map drafting and construction.

The up to now long research on the subject of Ptolemy's *Geographia* is mainly focused more on the first thematic component and less on the other two, excluding here the philological and/or sociological historic research about the work of Ptolemy and its influence on the European cultural and ideological environment of the Renaissance, which follows a different direction of concern.

With the development of mapmaking in the 15th c. onwards, according to *Geographia's* standards, the maps derived from Ptolemy's cartographic heritage created a distinct field of interest and research. On the other hand, the second thematic component, namely the treatment of Ptolemy's coordinates attracted the interest of scholarship but mainly on a qualitative basis rather than on the numerical approach.

Ptolemy's *Geographia,* after the culmination of its influence in Europe, almost for three consecutive centuries, declines from the 18th c. and after, due to the new scientific and technological advances in mapping sciences and mapmaking in general. Nevertheless, Ptolemy's methodological schemes and tools were never declined. On the contrary, with the radical development of digital technologies in cartography, in analytics and in graphics, embedding both in the same manifold, *Geographia* finds today new partners in research, on international level, mainly in the two thematic components (ii and iii) listed above.

The subject of the present dissertation is following the revival of the interest for Ptolemy's *Geographia,* concentrated basically on the second thematic field (ii) of *Geographia's* content. The spatial field of interest is the "central" geographic region of Ptolemy's work, namely Mediterranean and the Black Sea, with a special interest in the area of Greece. The idea is to create a new catalogue of coordinates for this region, based on a meticulous and systematic comparative analysis of 19 *Geographia* manuscripts and printed editions, from 13th c. up to our years (Tab. 1).

Treating 4 manuscripts and 15 printed editions, **a new Catalogue is derived, called "GeoPtolemy-ϑ",[4] concerning 3825 sites and the associated place names for the region of interest in this study. The complete new Catalogue is given in the 148 pages Appendix with the names and their description in English, Greek, Latin and Italian and the associated 7650 geographic coordinates**.

The new Catalogue is now mapped and compared in correspondence with modern maps representing almost 1800 points of Ptolemy-sites, identified on modern maps all over the geographic region under investigation here. Relevant cartographic analysis leads to the derivation of a new map model of the geospatial relation between the geometry of Ptolemy's *Geographia* representation and the modern counterpart associated to the spatial deformation patterns in the latitude and longitude distribution.

Experiments concerning the Tabula X of Europe maps, in some *Geographia* editions (e.g. Rome 1490, Ulm 1486, Strasbourg, 1525, Utrecht 1695), processed with the aid of the available

[4] ϑ, stands for Thessaloniki (in Greek: Θεσσαλονίκη).

coordinates, show the degree of consistency between the numerical part of *Geographia* and the maps created for insertion in certain *Geographia* editions, which are, in principle, supposed to be produced with respect to the corresponding coordinates. The results confirm the validity of the experiment, showing that the method, suggesting standardization in the process, allows a valuable investigation on the until now hidden relation between the coordinates and maps but also between maps and maps especially those belonging to the same family, as it is described in the relevant literature.

Manuscripts

13th c. -1472
1. Vatopedion codex Gr. 655, Mount Athos, 13th -14th c.
2. Vaticanus Urbinas Gr. 82, 13th c.
3. Codex Gr. 388, Marciana, Venice, 15th c.
4. Vaticanus Urbinas Lat. 277, 1472

Printed

15th c.
5. *Claudius Ptolemaeus Cosmographia*, Bologna, 1477
6. *Claudius Ptolemaeus Cosmographia*, Rome, 1478
7. *Claudius Ptolemaeus Cosmographia*, Ulm, 1482
16th c.
8. *Claudius Ptolemaeus Cosmographia*, Venice, 1511
9. *Claudius Ptolemaeus Cosmographia*, Strasbourg, 1513
10. *Claudius Ptolemaeus Cosmographia*, Strasbourg, 1520
11. *Claudius Ptolemaeus Cosmographia,* Lyon, 1535
12. *La Geografia di Claudio Tolomeo,* Venice, 1564
13. *La Geografia di Claudio Tolomeo,* Venice, 1574
14. *Geografia cioè discrittione Universale della terra,* Venice, 1598
17th c.
15. *Claudii Ptolemaei Alexandrini Geographiae,* Frankfurt, 1605
19th c.
16. *Claudii Ptolemaei Geographia*, Leipsic, 1843-45
17. *Klaudiou Ptolemaiou Geographike Hyphegesis,* Paris, 1883, 1901
20th c.
18. *Claudius Ptolemy The Geography,* New York, 1932
21st c.
19. *Ptolemaios, Handbuch der Geographie,* Bern-Basel, 2006

Tab. 1 The manuscripts and printed editions used in this dissertation.

In the **preface** of this dissertation, the motivation for the study and the objectives are set, introducing the methodology to be followed, the digital tools used and a comment on the writing style and the use of terminology, opting to address not only scientists and engineers but also the interested people from the humanities, especially in view of the fact that Ptolemy's *Geographia* is not so much treated in Greek literature, especially as far as its numerical component is concerned.

The **first chapter** reviews the ancient Greek cartography and their representatives and the impact given by Ptolemy and the *Geographia* itinerary from Byzantium to Florence and its dissemination in the Western World. The structure of *Geographia's* eight books is described in detail, accompanied with the "Tabulae" corresponding to the regions of the known world, as classified by Ptolemy. Emphasis is given on the catalogue of the Greek and Latin codices of Ptolemy's *Geographia*, dated from 13th to 16th c. and to the printed editions, published from 15th

c. until our days. An important part of this chapter is the extensive report to the relevant Greek and foreign literature concerning the components of the *Geographia* content.

The Ptolemaic system of meridians and parallels, the area of interest and the logic of Ptolemy's positioning scheme are exposed in the **second chapter**. The manuscripts and the printed editions used in this study are also listed here. In this chapter, the structure of the database, developed for the digital cataloguing and the management of the coordinates is described, explaining the process adopted for the comparative analysis and the evaluation of the coordinates.

In the **third chapter**, which is the core of the study, all the coordinates from each codex or printed edition are independently and cross checked, in order to detect discrepancies and deviations in the point placement and especially the gross errors, as well as the neglecting of toponyms or double writings and other various shortcomings in the place names and their coordinates. The analysis and the evaluation are visualized, in a systematic and standardized way, in relevant maps, where the coordinates are properly projected and checked.

The results of this comparative study between the coordinates of the toponyms in 4 codices and 15 printed editions, related to the region of interest, are presented in **chapter four**, together with the results coming out from the comparison and the evaluation carried out both numerically within the database and cartographically in projecting the data. The finally adopted **GeoPtolemy-ϑ** catalogue of toponyms and coordinates is then cross checked with all used versions of *Geographia* used here. Emphasis in this chapter is given to the visualization of the complicated and sometimes doubtful "genealogy" of the existing codices and the printed editions of *Geographia* and to the table which summarizes the characteristics of each codex and printed edition used in this work.

In the **fifth chapte**r, the Ptolemy's coordinates of the GeoPtolemy-ϑ Catalogue are mapped and properly compared one-to-one with modern map counterparts in order to model the spatial distribution of the systematic differences in longitude and latitude. The remaining part represents the spatial deformation of the Ptolemy map with respect to modern representations.

The last **sixth chapter** of this dissertation is focused on the study of the consistency of the new Catalogue coordinates with existing maps (e.g. the Tabulae X of Europe) belonging to specific mapmaking schools of *Geographia* production in a two centuries span, from the late 15th c. to the late 17th c. This standardizes a digital procedure for the comparison of *Geographia* derived maps, in order to support studies related to the technological part of mapmaking.

The text is documented with almost 680 footnotes, 123 original Tables and 374 Figures, including the original "genealogy tree" of Ptolemy's *Geographia* from the origins in 12th – 13th c. to 2006, the original standardized maps for the evaluation of the coordinates (ch. 3, ch. 4) and the 30 maps representing the results of cartographic analysis of the geometry of the Ptolemaic map, with respect to the actual map models, associated with the relevant deformation representations, in the terms of latitude and longitude (ch. 5, ch. 6). The cartographic documentation and the depiction of the results on maps are of basic concern in this study in the process of control, evaluation and visualization of the final results.

The importance of *Geographia* and the revival of the interest for this geographic masterpiece are approached today from a scientific and technological viewpoint which was not sufficiently treated until now. The real challenge today is the use of digital technologies allowing

processes which were unthinkable in the past. This is indeed valid especially for the numerical component of *Geographia,* but also for the maps of Ptolemaic origin produced from the 13th to 17th c. which are important objects of interest and study in the fields of history of cartography and maps and of cartographic heritage in the large.

Pages: 782 (incl. the Catalogue **GeoPtolemy-ϑ**, pages 148)
Images: 373
Tables: 123
Footnotes: 689

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