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Lines, Damned Lines and Statistics: Unearthing Structure in Ptolemy's *Geographia*

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Summary

Ever since the rediscovery of Ptolemy's *Geographia* in 1295, scholars have noted that it is troublingly inconsistent both internally and with the environment in which it was supposedly compiled. The problem for analysts to overcome is that the catalogue has been corrupted, amended and embellished throughout its history. It is therefore imperative to find more robust means to look for structural trends. Recent publications of the theoretical chapters and a digital catalogue of coordinates provide a variety of new possibilities. We are not alone in advocating computational procedures but will discuss two techniques that do not appear to have been considered in the literature so far and the conclusions they appear to give rise to.

First, statistical analysis of the coordinates assigned to localities demonstrates clearly that ostensible precision (whether to the nearest $1/12$, $1/6$, $1/4$, $1/3$ or $1/2$ degree) varies considerably by region and feature type and is locally heterogeneous. In other words, the composite nature of the data cannot only be confirmed, but we can build a clearer picture of how the sources varied by area. Secondly, while many studies have addressed either the point data or the finished maps, simple linear interpolation between coordinates following the catalogue provides a unique insight into the 'invisible hand' of the author(s). The unmistakable stylistic families that emerge, and the occasionally arbitrary limits imposed on them, provide further important evidence about the catalogue's internal structure.

Introduction



Figure 1: World Map from the Harley Manuscript, British Library (Image source: Wikipedia)

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Claudius Ptolemy's *Geographike hyphegesis*¹, is unquestionably one of the most important texts in the history of geography. Written in Alexandria in the mid-second century, its rediscovery in Constantinople and arrival in the West in 1397 had a major impact on the Age of Discovery. Columbus' plans for a westward route to India were based on Ptolemy's calculations, and Martin Waldseemüller's famous 1507 map depicting the new continent of 'America' maintains a Ptolemaic core with contemporary place names (Figure 2).

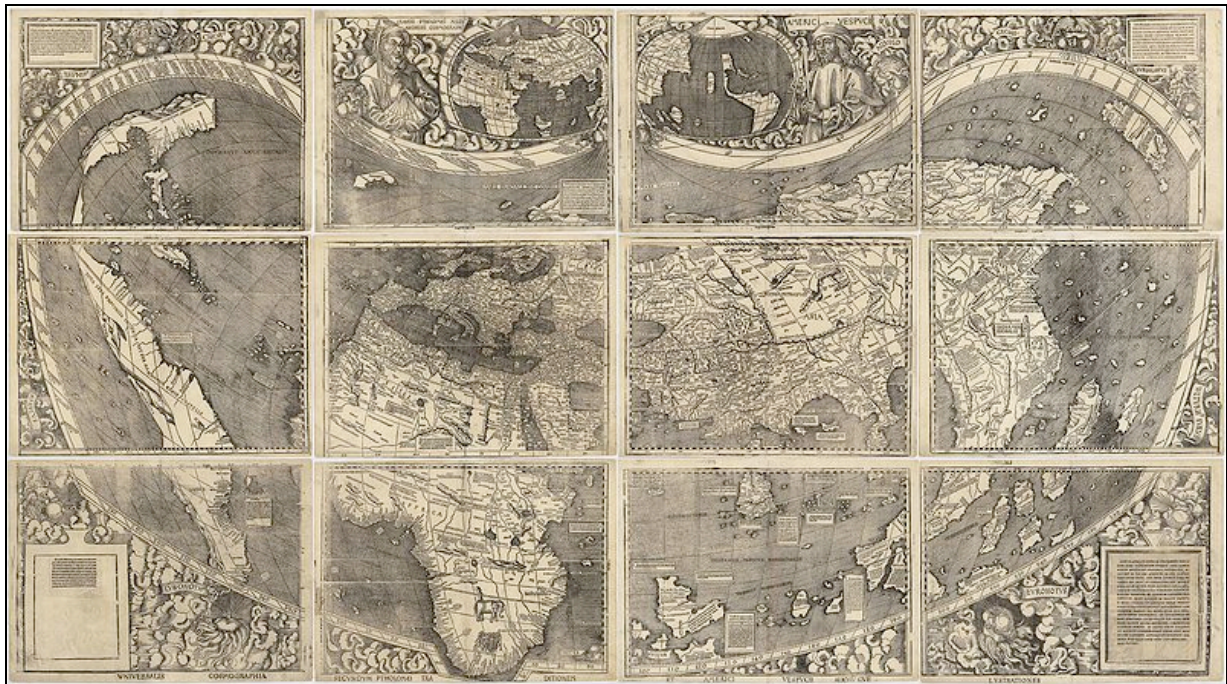


Figure 2: The Waldseemüller World Map's central panels are directly derived from Ptolemy's coordinates.
 (Image source: Wikipedia)

Yet despite its historical significance, and the considerable attention it received by Renaissance geographers and their successors, it remains a deeply problematic text. It is composed of both theoretical chapters and a catalogue of locations with coordinates. Extant manuscripts of medieval date also include maps that deviate in some respects from the texts². The most challenging issue is the sheer scale of the catalogue, comprising some 8,000 or so locations that stretch from the Atlantic Ocean to China and from the Baltic Sea to Tanzania. Not only are we left bewildered as to how Ptolemy managed to amass such an enormous quantity of (remarkably accurate) data when no other similar document has survived, but such a huge volume of information also renders it

¹ 'Guide to drawing a World Map' but more commonly referred to as the '*Geographia*' or 'Geography'.

² The size and style of these maps makes it unlikely that they are derived directly from antique precursors and they will not be considered further in this paper.

virtually intractable for analysis. Leo Bagrow argued that it was inauthentic on the basis that some place names demonstrably post-dated Ptolemy's lifetime (Bagrow 1945), but how representative are those he identified? The catalogue's innovative format of coordinate tables – explicitly intended to encourage insertion and correction – hides the stylistic hints we might turn to in more traditional material.

This has not stopped researchers from trying to find internal clues to the text's origins and recent work has finally permitted the kind of computational analysis that would seem to be the only way of getting to grips with such a voluminous and complex treatise. The most important developments have been a new English translation and commentary on the theoretical chapters (Berggren & Jones 2000) and a new German translation of the complete text with a database of coordinates by the University of Bern (Stückelberger & Graßhof 2006). This was followed by an additional volume of detailed analysis, although largely based on a traditional close-reading approach (Stückelberger & Mittenhuber 2009). Meanwhile the University of Thessaloniki has already begun to apply geostatistical methods to the catalogue (Livieratos et al. 2008).

This paper argues that such developments open the doors to a step-change in understanding this historic work. Based on a close reading of the theoretical chapters and a spatial and statistical analysis of the catalogue coordinates, it makes three arguments:

- 1) That despite the apparent implication of the title, the *Geographike hyphegesis* is both a guide to World Cartography (*geographia*) and Regional Cartography (*chorographia*)³. Furthermore, its sources were largely chorographic.
- 2) Coordinates at the ostensible precision of 1/12 of a degree of arc are almost exclusively found in an approximately 1:5 oblong region centred on the Mediterranean with Rome at its centre. This and other structural evidence suggest that multiple constituent sources can be distinguished.
- 3) That the central source(s), centred on the Mediterranean, may have come from a portico map. It is almost certainly not, however, the famous 'Map of Agrippa' in the Portico Vipsania in Rome and more likely to be Antonine in date.

The *Geographike hyphegesis* as a guide to *geographia* and *chorographia*

Somewhat counter-intuitively, the *Geographike hyphegesis* is in fact designed to permit both geographic and chorographic representation and has both geographic and chorographic sources. This view is based on five sub-arguments:

³ I will henceforth use the greek terms as the anglicized 'geography' is too easily confused with modern notions of mapping which combine both *geographia* and *chorographia*.

1. That Ptolemy explicitly differentiates between the practices of *geographia* and *chorographia*.
2. That the theoretical chapters deal with both *geographia* and *chorographia*; The catalogue (Books 2-7) is intentionally designed to facilitate both.
3. That Marinus of Tyre is an exclusively geographic (and not chorographic) source.
4. That Ptolemy uses Marinus' publications as a framework but corrects and supplements him heavily using chorographic sources, specifically maps (*pinaxi*).
5. That Ptolemy makes no claims for the precision of his coordinates beyond those required for *geographia*.

With regard to the first argument it seems indisputable that, to Ptolemy's mind at least, a meaningful distinction existed between two cartographic traditions: *geographia* ('world cartography') and *chorographia* ('regional cartography'). The very first chapter of the first book is dedicated to distinguishing between them and the skills they require:⁴

"The essence of world cartography (*geographia*) is to show the known world as a single and continuous entity, its nature, and how it is situated, taking account only of the things that are associated with it in its broader, general outlines (such as gulfs, great cities (*poleion megalon*), the more notable people and rivers and the more noteworthy things of each kind)." (Ptolemy. *Geog.* 1.1)⁵

"...regional cartography (*chorographia*), as an independent discipline, sets out the individual localities, each one independently and by itself, registering practically everything down to the least thing therein (for example, harbors, towns, districts, branches of principal rivers, and so on)..." (1.1)

Geographia is not concerned with mapping all the things in the world but rather with the cartographic issues associated with representing it as a whole. In particular these include issues of scale (1.22), density (1.1; 8.1), relevance (1.1; 1.19; 2.1) and spherical geometry (1.1). The epistemological differences between chorographic and geographic source material are mentioned (1.4; 1.19; 2.1) but there is an implication that, if anything, *chorographia* is considerably less precise (1.1; 1.11; 1.18; 1.21).

⁴ All Ptolemy translations are taken from Berggren & Jones 2000. Italicized Greek terms in parentheses are drawn from Müller 1883. Insertions in square brackets are authors own.

⁵ All further unqualified numeric references are to the *Geographike hyphegesis*.

Despite Ptolemy's apparent emphasis on *geographia* in the first book, the text as a whole is clearly intended to permit its reader to draw both geographic and chorographic maps. In particular, the theoretical discussion in Books 1 and 7 seems to focus on *geographia*⁶, while Book 8 discusses chorographic principles⁷ even to the extent of employing the same analogy with anatomical drawing used in the very first chapter (1.1; 8.1). This leaves us with an interesting question. If the theoretical chapters appear to treat of both geographic and chorographic ideas, to which (if either) is the catalogue itself more suited? Ptolemy himself makes clear that it is both:

“We have chosen an order of presentation with forethought to convenience in the drawing of the [world] map in every respect...

Moreover, this method of exposition will also make it possible, for anyone who wishes, to draw the parts of the of the *oikoumene* on planar surfaces, individually or in groups of provinces or satrapies, in whatever way they might fit the proportions of the maps. The localities contained by each chart will then be inscribed at the appropriate scale and relative placement.” (2.1)

Could this just be fortuitous coincidence for Ptolemy – the happy result that data required for a world map is therefore suitable for maps of its composite parts? It seems unlikely for two reasons. The first is that amongst its contents the catalogue contains the very “harbours, towns, districts and branches of principle rivers” (1.1) which Ptolemy cites as being precisely that material suited to chorographic, and not geographic, cartography.

The second reason follows from Ptolemy's assertion that map features should be drawn at such scale and density as to be easily discerned by the viewer (1.1). This is a point he returns to:

“The size of the globe should be determined by the number of things that the map-maker intends to inscribe on it and this depends on his competence and ambition, since the larger the globe is, the more detailed and at the same time the more reliable the map will prove to be”. (1.22)

We are fortunate to possess a passage in Strabo's *Geographia* that specifies just how large such world maps were expected to be:

6 “Our present object is to map our *oikoumene* as far as possible in proportionality with the real *oikoumene*” (1.2)

7 “The next thing is to set out what the concise summaries will be if we divide it into many maps, so that all the catalogued localities can be inscribed while still being at an appropriate scale for clarity”(8.1)

“But a world map requires a large globe, so that the aforementioned section of it containing the *oikoumene*, being such a small fraction of it, will be sufficient to hold the suitable parts of the *oikoumene* with clarity and give an appropriate display to the spectators. Now if one can fashion a globe this large it is better to do it in this way, and let it not have a diameter less than 10 feet. But if one cannot make a globe of this size or not much smaller one ought to draw the map on a planar surface of at least 7 feet⁸”. (Strabo *Geog.* 2.5.10)

Some quick statistics should be enough to convince us that this contradicts the idea that regional maps are merely a by-product of the catalogue. Taking the optimistic assumption that Strabo is referring to *height* of 7 feet, and the ‘long’ Doric foot of about 32.6 cm, the height of such a map would be approximately 2.3 metres high and – based on Ptolemy’s dimensions for his first projection (1.24) – twice the width, i.e. 4.6 metres. Ignoring the projection details for the time being, there are almost exactly 180 longitudinal degrees in Ptolemy’s *oikoumene* and thus a nominal maximum width per degree of just 2.5cm per degree. Dividing by 12 (the smallest gradation in Ptolemy’s catalogue), leaves just 2mm for each increment of 5 minutes. It is not this which is the problem so much as the fact, as Ptolemy acknowledges (8.1), that some regions have many more locations than others. Hispania, which is approximately 10 x 10 degrees, would thus (even using Strabo’s equirectangular cylindrical projection) have an area of about 525cm² (25cm x 25 cm), and yet it has 570 separate locations. Ptolemy’s own projections would only serve to compress the longitudinal distance and thus compound the problem. In short, we must accept that either Ptolemy does not follow his own advice, that he expects his readers to build globes considerably larger than 10 feet in diameter (which seem improbable), or that many of the locations listed in the catalogue are *only* intended for the chorographic maps described in 8.1.

The source of Ptolemy’s data

Having established the likelihood that Ptolemy’s work is intended to support both *geographia* and *chorographia*, and that a significant proportion of the catalogue is intended to be used by chorographers, we now inquire as to the likely source of his data. Ptolemy himself seems to suggest that his principal source is Marinus of Tyre of whom we know little other than what Ptolemy tells us. He tells us directly that Marinus’s work will form the basis of his own except in cases of inaccuracy or omission:

⁸ Translation: Berggren & Jones 2006.

“We have thus taken on a twofold task: first to preserve Marinós’ opinions as expressed throughout the whole of his compilation, except for those things that need some correction; second to see to it that the things he did not make clear will be inscribed as they should be, so far as is possible, using the researches of those who have visited the places, or their positions as recorded in the more accurate maps (*pinaxi*).” (1.19)

We are thus left to ask what it was that Marinós made, and did not make, clear. Looking at references to Marinós’ compilations *in toto*, two things stand out. The first is that Marinós’ own investigations seem largely concerned with *geographia*, not *chorographia*.

“Marinós of Tyre seems to be the latest author in our time to have undertaken this subject [*geographia*], and he has done it with absolute diligence.” (1.6)

“...his publications of the revision of the geographical map (*geographikon pinaxos*), which are numerous” (1.6)

“now if we saw no defect in his final compilation, we would content ourselves with making the map of the *oikoumene* on the basis of these writings alone. (1.6)

Secondly, he does not appear to have been a reliable source of coordinates beyond coastlines. This is partly reflected in the specific cases Ptolemy takes issue with which are largely (although not exclusively) coastal in nature (1.7-20) but also explicitly stated to be absent from Marinós’ work:

“Again, when one is putting the cities in their positions, one might have an easier time labeling those that are on the coast, since in general some indication of position is noted for them, but this is not so for the inland ones, since their relative positions with respect to each other or with respect to the cities on the coast are not indicated, with few exceptions - and in these instances sometimes only the longitude is defined, sometimes only the latitude”. (1.18)

If, then, “he did not have time in his final publication, as he himself says, to draw a map (*pinaxa*)” (1.17) how was Ptolemy able to derive the coordinates missing from Marinós’ text?

The most trustworthy source appears to have been measurements along the parallel of Rhodes to which Ptolemy refers twice (1.11; 1.21) and which he uses as the partial basis for his calculations of the length of the *oikoumene*. We also know that some of his latitudes come from Hipparchus, but more importantly that he has no other source of accurate latitudinal information and that the situation for longitude is even worse:

“Hipparchus alone has transmitted to us observed elevations of the celestial North pole for a few cities., i.e. few when compared to the multitude of cities to be recorded in the world cartography, and lists of the localities that are situated on the same parallels. And a few of those who came after him have transmitted some of the localities that are “oppositely situated”...Most intervals, however, and especially those to the east or west, have been reported in a cruder manner...” (1.4)

Even adding to these the data from solar eclipses, expeditions and travellers reports (1.4; 1.8-17) one thing becomes very clear: Ptolemy seems to be very short of data indeed, and thus while the compilation of a catalogue suitable for a World Map may be remarkable, the inclusion of detailed chorographic information as well seems downright miraculous. Can we offer an explanation? Let us begin by taking Ptolemy at his word: that he will supplement Marinus’ data “using the researches of those who have visited the places, or their positions as recorded in the more accurate maps (*pinaxi*)” (1.19). It seems clear that the linear nature of travelogues can have made them of limited use in determining coordinates across a region, so what are the maps (*pinaxi*) to which he refers? Could it be that he is making use of publicly available chorographic maps? Surely its inaccurate nature (1.1) is in conflict with the ostensibly mathematically determined nature of *geographia*? Not according to Ptolemy:

“It would therefore be reasonable for one who intended to practice world cartography (*geographia*) following these principles to give priority in his map to the features that have been obtained through the more accurate observations, as foundations, so to speak, but to fit the features that come from the other kinds of data to these, until their positions with respect to each other and to the first features stand as much as possible in agreement with those reports that are less subject to error” (1.4)

In other words, Ptolemy has no qualms about using low-grade data so long as it is connected up to a more accurate framework of coordinates provided by *geographia*. Furthermore, he makes no claims at all about the reliability of individual coordinates. We end this section then with the

following, albeit theoretical, conclusions: i) That Ptolemy's work is intended for both geographers and chorographers, ii) that its sources are not only geographic but also may well make use of chorographic maps (*pinaxi*). If this is in fact the case, are there any clues within the catalogue itself that could tell us more about the nature of these sources?

Internal structure within the catalogue of locations

The catalogue of locations has been the subject of debate for a long time. Occasional references to it continue from antiquity through to its rediscovery at the end of the thirteenth century (Berggren & Jones 2000:50-51) but the inclusion of places that post-date Ptolemy, not to mention the numerous discrepancies between manuscript traditions, have cast suspicion on its reliability, and even authenticity (Bagrow 1945). We are right to tread with care but outright rejection seems unwarranted. After all, the catalogue is specifically designed to encourage additions and correction:

“We have therefore put the degrees corresponding to each place at the outer edge of the columns in the manner of a table, setting the degrees of longitude before those of latitude, so that if anyone should come across corrections from fuller research, it will be possible to put them alongside in the remaining spaces of the columns.” (2.1)

In effect, Ptolemy developed the first Geographical Information System. Much more significantly, it makes GIS a natural technology for investigating the catalogue. In this endeavour we are hugely indebted to the work of the University of Bern who published the entire catalogue of locations from both the Ω and Ξ recensions as a database (Stückelberger & Graßhof 2006). That database provides the primary source for the following investigation. In particular we use the coordinates provided by the incomplete, but less corrupt, Ξ recension where possible, supplementing it with coordinates from Ω for the areas of Asia that are missing (Figure 3).

We attempt to demonstrate by means of maps and statistics that: i) the catalogue is structured to facilitate use by geographers and chorographers, ii) that a core central source can be distinguished from peripheral regions both statistically and stylistically iii) That relative precision of latitude and longitude are independent of one another, possibly reflecting the manner in which the source material was transmitted.

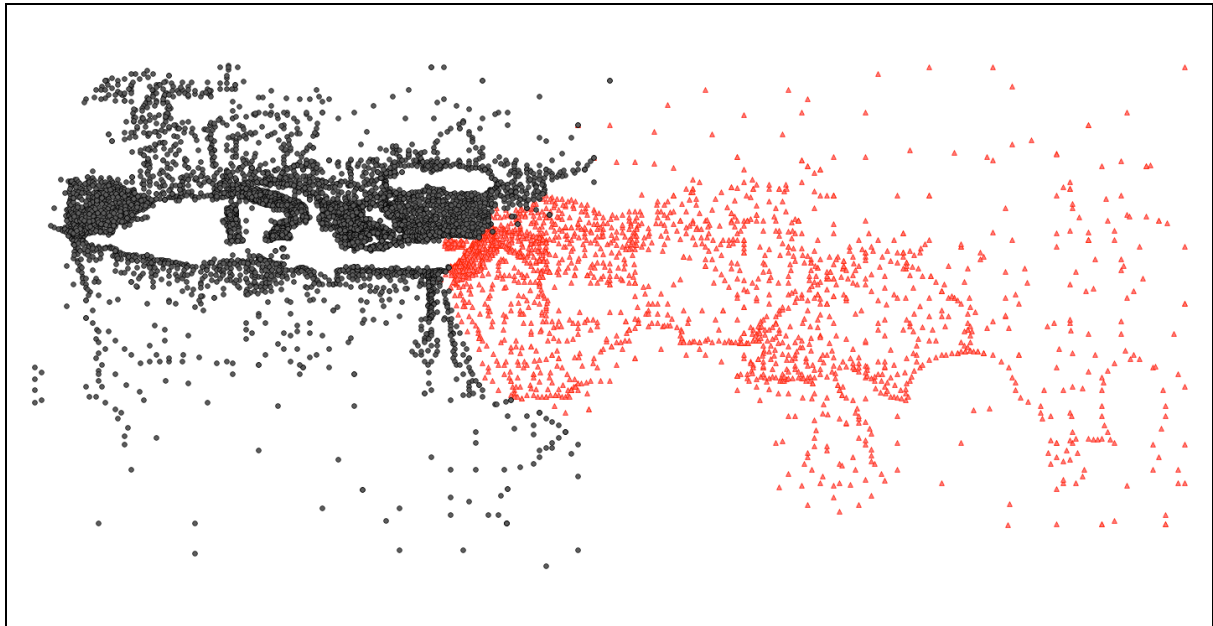


Figure 3: Ptolemy's coordinates plotted in a GIS. Grey circles are from the incomplete Ξ -recension. Pink triangles represent the remaining coordinates derived from the Ω -recension

Ptolemy makes very clear that the order of the coordinates in the catalogue is non-random. Not only is it divided by region but both regions and internal coordinates trend generally from N-W to S-E. This is explicitly intended to help the cartographer in his task (2.1). It also has the unfortunate side-effect of removing much contextual information as to whether natural groupings existed in Ptolemy's source data. Another pattern is also clearly observable: the order in which coordinates are listed within each region follow a strict pattern:

1. Definition of coasts/boundaries (inc. large islands), major rivers sources and occasional river bends
2. Inland physical features (esp. mountains and mountain ranges)
3. Inland cities
4. Offshore, point-based locations (occasionally defining the boundary of a larger island, e.g. Thule)

This pattern remains constant, almost without exception⁹, throughout the entire catalogue. Despite their apparent importance, the so-called 'noteworthy cities' (*poleis episemoi*) do not have a separate category and appear according to their natural ordering above.

This structure seems to be specifically designed to facilitate the dual purpose of the catalogue. The first two categories essentially form the linear features required for geographic cartography. Although specific places *can* be labelled, more fundamentally they serve to delineate the natural boundaries of each region even when unlabelled. In contrast, the latter two sections are

⁹ The Aegean archipelagos and Upper Nile do not comfortably conform.

predominantly point data which would be rendered meaningless without labels. We might surmise therefore that it is precisely these sections ('noteworthy cities' notwithstanding) that are used in chorographic maps and may be ignored in geographic ones (as demonstrated by the Ptolemaic world maps we possess). That the 'noteworthy islands and peninsulas' referred to in the 'Summary caption of the map of the *oikoumene*'¹⁰ (7.5) are all big enough to warrant inclusion in the first, and not the fourth, category seems to support this notion. The noteworthy cities themselves could be easily identified when constructing World Maps as they seem to have been specially marked out in the text (Berggren & Jones 2000:19)

The ordering mentioned above would be of only limited significance were it not for a further striking statistical correlation: that the ostensible 'precision' of Ptolemy's coordinates varies both spatially and categorically throughout the catalogue. Precision in this case is the apparent level of granularity at which Ptolemy assigns latitude and longitude.¹¹ As real world locations have arbitrary coordinate values with respect to a datum it is not possible to measure precision directly but the possibility of rapidly visualizing the complete dataset afforded by GIS makes the process of summarizing much simpler.

Superficial examination of the coordinates makes clear that the smallest latitudinal and longitudinal increment is 1/12 of a degree (or 5 minutes) of arc, both latitudinally and longitudinally. As the locations themselves are arbitrary, were all 8,000 or so of Ptolemy's coordinates assigned at this level of precision we would expect a random distribution in which about 8% of them fell exactly on the degree, about 8% fell on the degree + 5 minutes, and so on. When we plot the actual distribution however, the picture is entirely different (Figure 4).

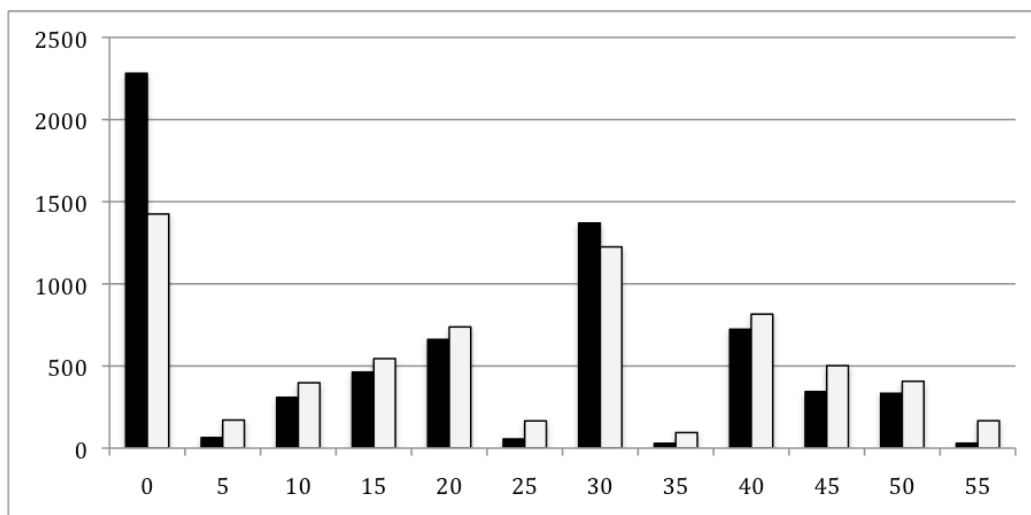


Figure 4: Quantity of coordinates falling on latitudinal (white) and longitudinal (black) degree divisions

¹⁰ Taprobane, Albion, The golden peninsula, Hibernia, Peloponnese, Sicily, Sardo, Corsica, Crete and Cyprus

¹¹ This should be distinguished from accuracy which is the degree to which they correspond to reality.

A comparatively small proportion of locations are assigned to values (which we will call ‘high precision’ coordinates) that can only have been assigned to the nearest twelfth of a degree, being indivisible by lower denominators¹². In fact, the chart appears to indicate that the coordinates are being assigned at variable levels of precision: sometimes to one twelfth, sometimes to one sixth, sometimes to one quarter and so on. Of course some of the locations assigned to coordinates with a higher denominator (such as a ½ degree) will also have been assigned at this higher level of precision - we have merely established that they cannot all be. The problem is therefore to work out which coordinates are assigned at which levels of precision. It transpires that this has both a spatial and categorical dimension.

Spatially we can start by plotting all those locations which are definitely assigned to the nearest twelfth of a degree in a GIS (Figure 5)¹³. This demonstrates beyond all doubt that there is a core body of data - comprising Hispania, Italia and its major island neighbours, Greece, Asia Minor, the Levant and Egypt - which contains a substantial number of coordinates assigned to this high level of precision. Indeed we are put strongly in mind of the Ptolemaic centre of the Waldseemüller map. The phenomenon appears in both manuscript traditions. In contrast, the peripheral regions, which include such well-established roman regions as Gaul and Africa Proconsularis are almost entirely devoid of ‘high precision’ coordinates.

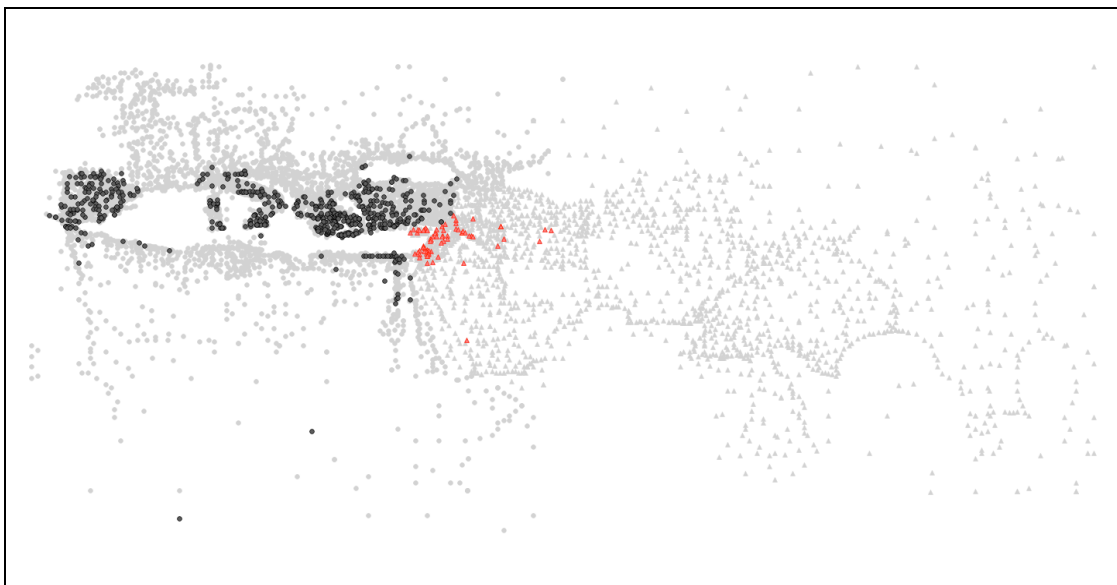


Figure 5: Coordinates definitely assigned at a precision of 1/12 of a degree of latitude or longitude. The effect is observed in both Ξ and Ω recensions

¹² At 5 minutes (1/12), 25 minutes (5/12), 35 minutes (7/12) and 55 minutes (11/12)

¹³ We remove a small number that fall on the traditional 2nd, 4th, 11th, 12th, 13th, anti-2nd and anti-4th Greek parallels. These are calculated by length of longest day and thus occasionally fall on a ‘high precision’ latitude, but many locations associated with them are only done so nominally (e.g. Cape Rhapton in Tanzania).

The situation is shown to be more complex however when we repeat the experiment with data from this core region. Once again it is clear that a sizeable proportion of the data has not been assigned to the nearest twelfth (Figure 6).

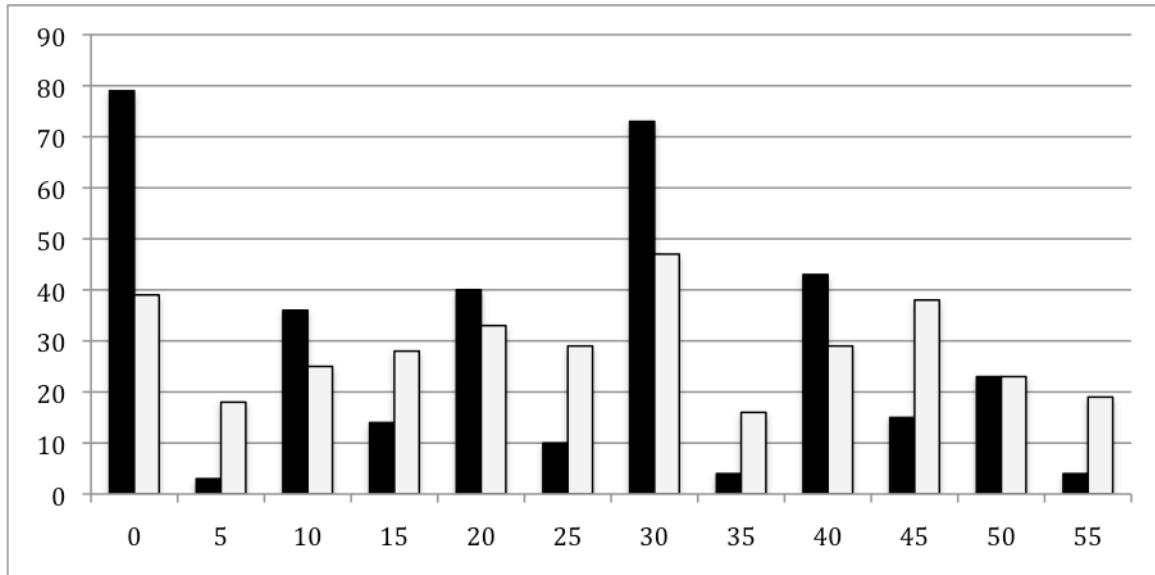


Figure 6: Coordinate distribution for Hispania Tarraconensis, a 'core' region (latitude = white, longitude = black)

Categorizing the data by Ptolemy's divisions is much more successful. Selecting just boundaries and inland cities displays a much more random looking distribution for latitude (Figure 7).

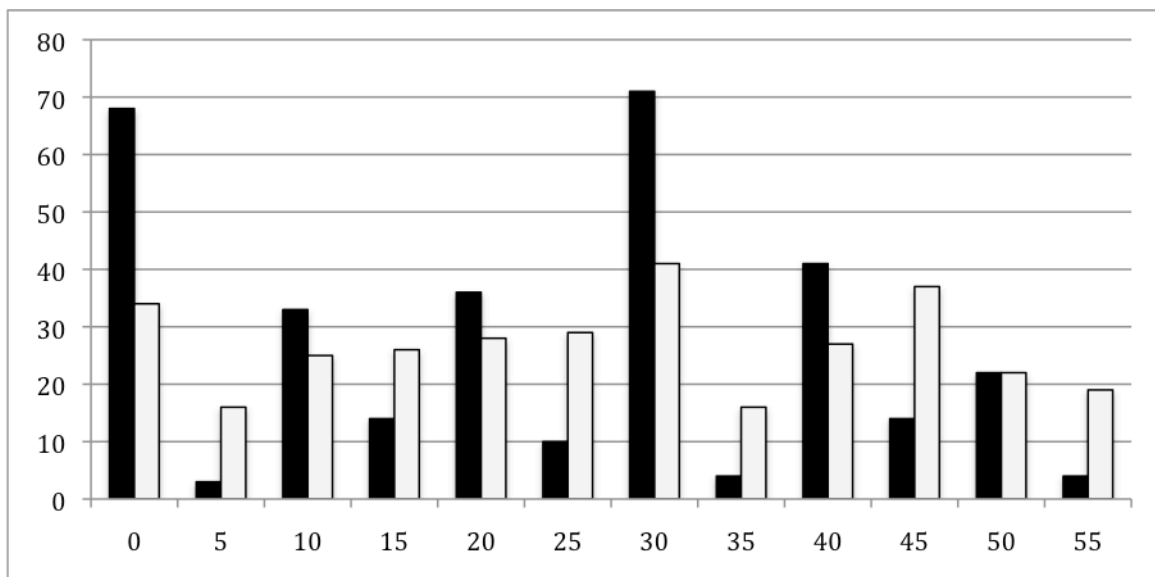


Figure 7: Distribution of boundary and settlement locations in Hispania Tarraconensis (latitude = white, longitude = black)

How random is it? A Chi-square test applied to the latitudinal coordinates of Hispania Tarraconensis, as well as many other core regions, gives a probability of non-random distribution at <0.05 . Not all of the core regions perform as well, especially those on the fringes such as Mauretania Tingitana and Thrace, but it is clear that we are close to defining sets of coordinates – based on Ptolemy’s own spatial and typological categorisation – which are statistically distinguishable from one another. This has enormous ramifications for the study of the text as it suggests that we may be able to see beyond the surface and identify the nature of its constituent sources. Longitude remains problematic however – there are enough high precision data points to be sure that such ostensible precision is being used but they are greatly outnumbered by those points at a lower level of precision. This is a topic to which we shall return.

Before turning to speculation about the nature of these sources, there are other methods we can use to explore variation within the data. The first is visualization of spatial ordering. As we know, the first two of Ptolemy’s divisions (boundaries, physical features) are essentially linear and require that he order the data so that adjacent locations are listed consecutively. The fourth division (offshore locations) also follows the coastline in order where possible. What of the inland settlements? We can test this very easily by simply ‘joining the dots’ in the order they are listed and the results once again display a striking disparity between the core regions and the periphery (Figure 8).

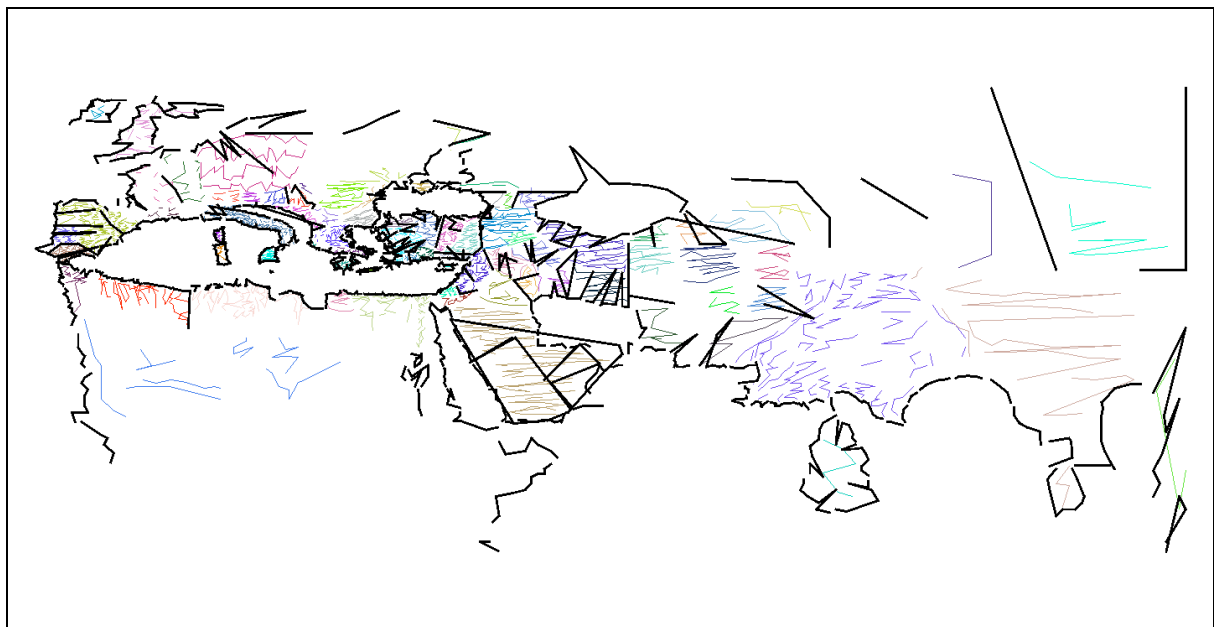


Figure 8: lines interpolated between settlements colour coded by region

In the core data, coordinates appear to group together in tightly bunched clusters. At the periphery they are generally ‘sketched out’ in linear rows, usually horizontally (Europe, much of Asia) or

vertically (northern Libye), but occasionally in a SW-NE sweep (India). Overlaying our 'high precision' coordinates over these features shows clearly the correlation between this stylistic variation and the 'core' data we identified in the previous section (Figure 9).

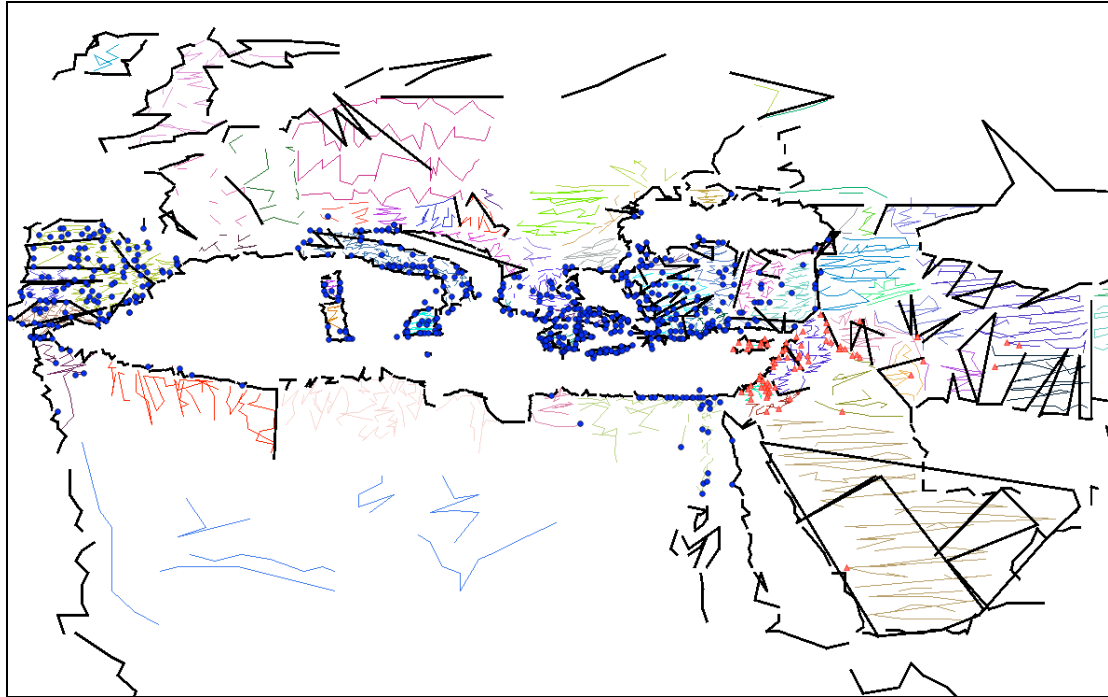


Figure 9: Lines interpolated between settlements overlaid with 'high precision' coordinates.

The second approach is to look for differences in the ways place names are recorded. One example of this is the inclusion of a town's civic status in its name. We know a good deal about the political rights individual cities enjoyed in the roman world and Ptolemy refers to some of his towns with the suffix '*colonia*'. However, when we map those towns we can see that he is by no means consistent in doing so (Figure 10). In fact, there are only four regions in which Roman colonies appear to be frequently named as such: Italia, Gallia Narbonensis, Mauretania Caesariensis and Africa Proconsularis. Even more interesting are the outliers. Hispania has only one case, '*Clunia colonia*' which is one of Ptolemy's 'noteworthy cities'. Could it be that these noteworthy cities have been inserted, or at least renamed, by Ptolemy?

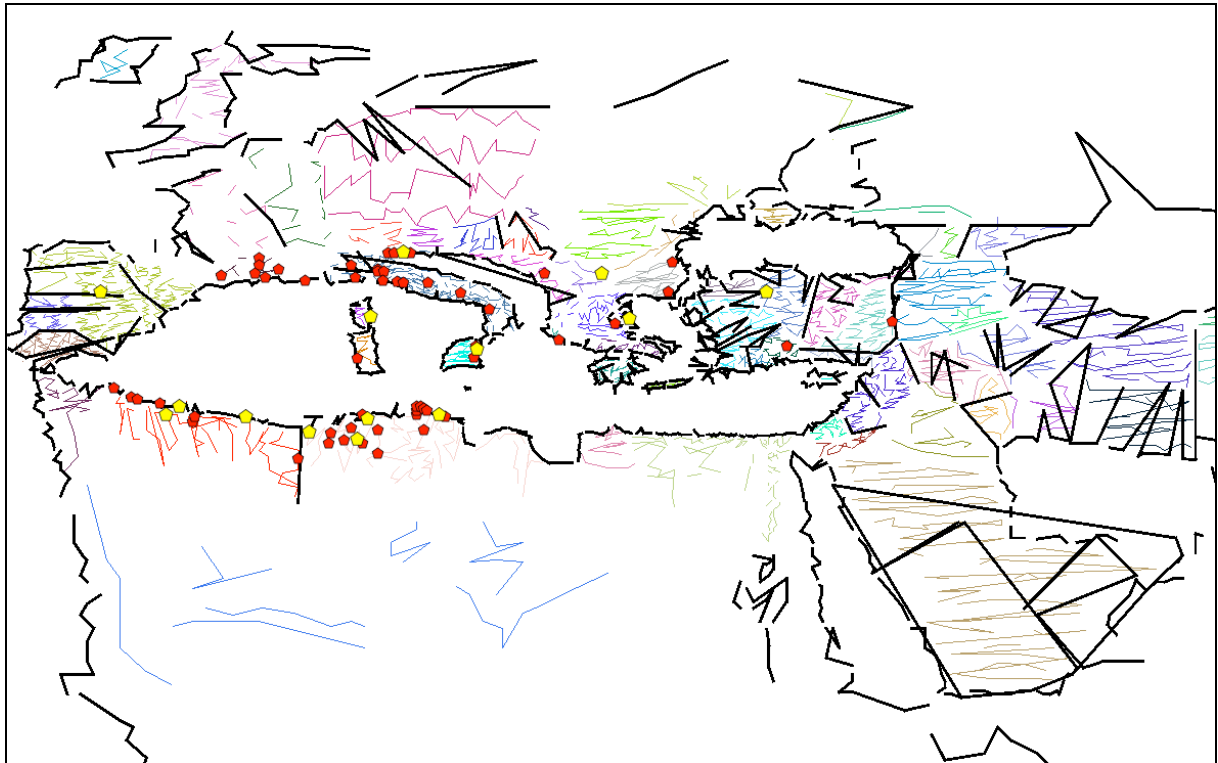


Figure 10: Locations explicitly designated 'colonia' by Ptolemy (yellow sites are also 'noteworthy cities')

The nature of Ptolemy's sources

We now finally turn to some limited speculation about the nature of Ptolemy's source data. It seems clear that in addition to those discussed by Ptolemy himself, (at least) two new sources can be identified:

- 1) A core body of settlement and boundary information surrounding the Mediterranean.
- 2) One or more adjacent peripheral datasets forming the northern, southern and eastern extremes of the map.

The central core data is of particular interest. It seems to perfectly address the key problem Ptolemy raises about working with the information Marinus provides:

“If this [i.e. Ptolemy's] method based on a text did not suffice to show how to set the map out, then it would be impossible for people without access to the picture to accomplish their object properly. And in fact this is what happens to most people who try to draw a map (*pinaxos*) based on Marinus, since they do not possess a model based on his final compilation” (1.18)

We know that Ptolemy isn't using a map from Marinus (1.17). So what is he using? The extended E-W orientation is certainly suggestive of a portico wall rather than a circular T-O map or globe.

Could it have been the ‘Map of Agrippa’ completed by Augustus in the Portico Vipsania? (Pliny *Nat. Hist.* 3.2.17). The absence of Gaul and the fact that Rome is almost exactly central to this set of points is certainly intriguing. Unfortunately harder evidence seems to contradict such a theory – in particular the presence of settlements of definite high precision throughout the data which clearly postdate the early Principate: *Flavionavia* and *Iria Flavia* in Hispania, *Domitiopolis* in Cilicia, *Aelia Capitolia* (Jerusalem) in Palestine, *Antinopolis* in Egypt, amongst others. Just as there are problematic inclusions there are also notable absences. We know that Charax (at the mouth of the Tigris) was featured on Agrippa’s portico (Pliny *Nat. Hist.* 6.139) but it lies well beyond the core region. Nevertheless, the case for a portico or mosaic remains a possibility and two final observations may provide additional evidence.

We have seen that latitude can be resolved to a random distribution in core regions and categories. In contrast however, longitude does not seem to fit the pattern so well. There are also noticeably fewer longitudinal coordinates with ‘high precision’ values. The reason for this, and for the high precision of the core dataset, might seem obvious to a geographer: precision tends to mirror accuracy and longitude is notoriously difficult to calculate, even with regard to a fixed meridian. Thus ‘high precision’ coordinates might be an indication of more certain data. Yet on closer inspection, the information we have does not support such a view. As an example, we may take Cape Cunicharium, a ‘high precision’ location on the south coast of Sardinia which according to Ptolemy sits virtually on the parallel of Rhodes, his principal geographic reference point (1.11; 1.21). In fact it sits three whole degrees further north (Figure 11). It would have been a simple matter for someone to test the latitude of such locations with a gnomon and yet it is apparent that this was never done - the data here is no more accurate than in many places in the peripheral regions. So if precision is not affected by accuracy and latitudinal and longitudinal are determined independently, what could be the causing the variation?

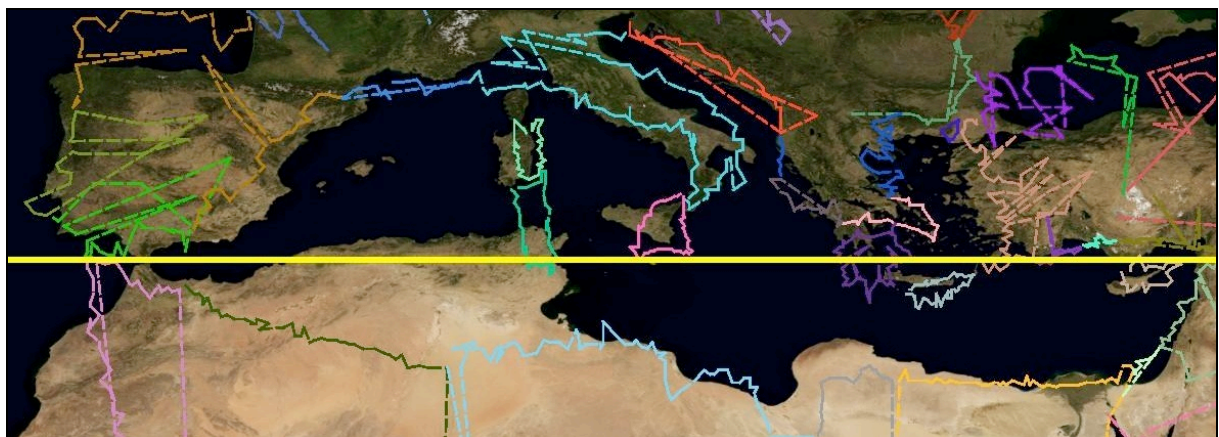


Figure 11: Modern satellite map overlaid with Ptolemy's coastline. (Image source: NASA)

We finish with a thought experiment. Imagine that we, too, have to tie Marinus' notes into a wider framework which we do not possess. We are aware of a large map of the Mediterranean in a public space. It is chorographic and contains no coordinates, but represents a coastal outline and many inland settlements, perhaps something similar to the Madaba Map, a sixth century mosaic depicting the Holy Land. How might we derive the information for our own use? The simplest way is presumably to lay a grid of degrees over it and then note down the intersection closest to each feature. Once we start to use fractions of degrees however, a curious phenomenon emerges: combining $1/2$ s, and $1/4$ s with $1/3$ s and $1/6$ ths does not give us even coverage (Figure 12). As a result, we are more likely to cluster locations together in the areas with greater coverage. This turns out to be precisely the phenomenon we observe (Figure 13). There is a further consideration: there exists a fundamental difference between the vertical and horizontal orientation caused not by the nature of latitude and longitude but by the left-right bias of writing and iconography. As the horizontal direction of a label often crosses several longitudinal lines it is natural to assign it to the longitude with the lowest common denominator. In contrast, text rarely crosses latitudinal lines, and it is therefore frequently necessary to assign it to a division with a higher denominator. As the scale of a map increases, the relative size of the text decreases in proportion to the features portrayed. It will therefore cross yet more of the divisions within the degree square tending to even lower denominators. It remains speculation but it may be precisely such changes in scale in Ptolemy's sources which lead to the absence of 'high precision' coordinates in peripheral regions. The *Geographike hyphegesis* remains a formidable work to analyse but we hope that in this short paper we have demonstrated that with a combination of close textual reading and geospatial analysis its construction and sources need not remain *terra incognita*.

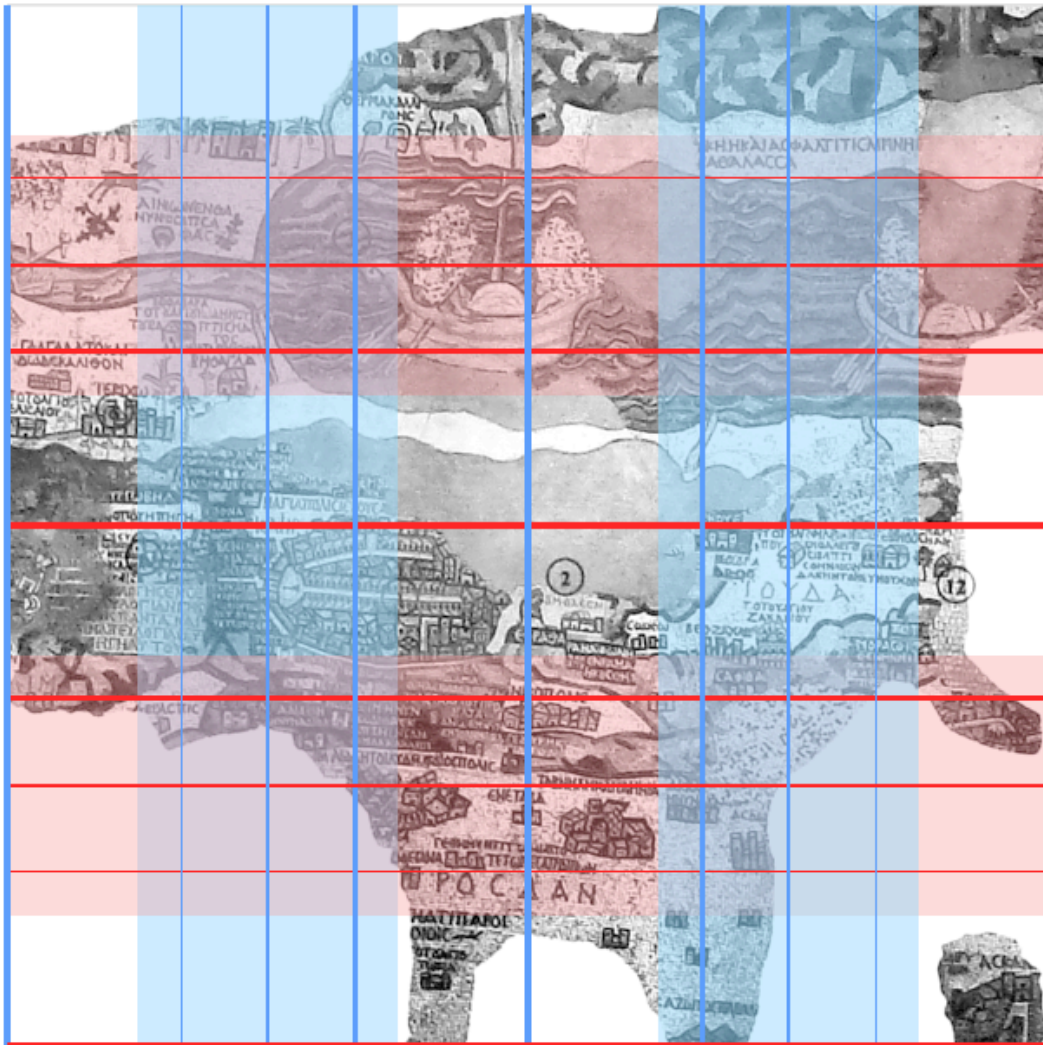


Figure 12: Madaba map overlaid with hypothetical grid divisions (1/2, 1/3, 1/4, 1/6). Blue and pink areas highlight nominal areas of coverage. (Image Source: Wikipedia)

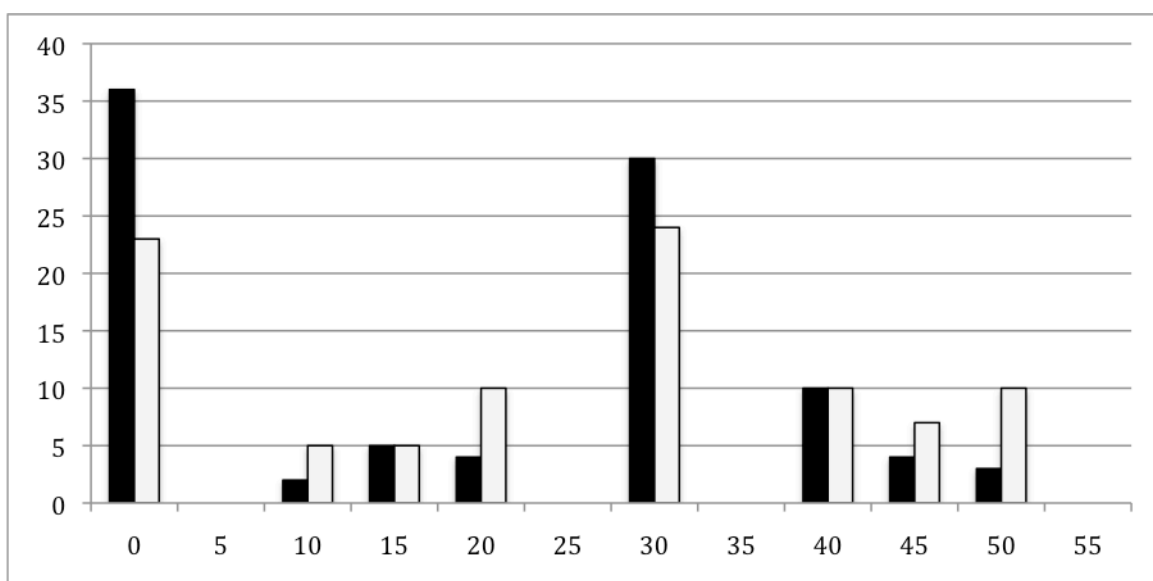


Figure 13: Distribution of coordinates of settlement locations in Germania (latitude = white, longitude = black)

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