Ptolemy’s *Geography* and the Tabulae modernae – A Comparison of Maps Using the Example of the Arabian Peninsula

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The geographical understanding of the world plays a crucial role in shaping the reality and the imagination of any culture. Klaudios Ptolemaios or Ptolemy (c. 100 – c. 170) compiled the “Graeco-Roman” geographical knowledge about the world of the 2nd century in his *Geography*. From a historical and geographical point of view, his collection is a unique source of investigation. In Europe, the *Geography* was rediscovered in the early 15th century. This paper wants to account for questions on geographical knowledge existing in the ancient Mediterranean and in 15th and 16th century Europe about the Arabian Peninsula, the then so-called *Arabia Felix*. One aim of this approach is to investigate what kind of toponyms in this area we preserved through the *Geography* and how this knowledge was received by early modern geographers and mapmakers in their Tabulae modernae (or novae). Linked Open Geodata is used for comparing two different sorts of maps and its toponyms of certain areas of the Arabian Peninsula. QGIS is applied to make similarities visible between the antiquity and the early modern period by creating different georeferenced and transformed layers. Traditional historical methods and new technologies are brought together. On the one hand, methods from historical geography are employed. On the other hand, open data methods are used to compare already known locations from historical and archaeological research and make it possible to discuss solutions in localising places, which are unknown in modern times but were localised and are mentioned by Ptolemy or in a Tabula moderna. The application of GIS to current historical research allows a collaborative workspace in which historical issues can be visualized and discussed more efficiently.

Keywords:
Historical Geography, Georeferencing, Gazetteer, Ptolemy, QGIS.

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INTRODUCTION

How can historical work benefit from a digital approach? How may georeferencing and transforming an old map help to find historical places when sources differ from each other? How is a comparison of old maps possible? To provide answers to these questions QGIS[1] is employed for georeferencing and transforming a map which is based on Ptolemy’s *Geography* and a Tabula moderna (or Tabula nova) from the 16th century. Pelagios, Pleiades and iDAI.gazetteer are used for comparing toponyms, which are mentioned by Ptolemy or were found in the maps. The focus lies on visualising characteristics and differences of the maps and on stating benefits and limits which were encountered while georeferencing and transforming these two sorts of maps.

The primary question is whether georeferencing and transforming a Ptolemaic map brings us a benefit for that kind of research. There are convincing arguments that state it does not. Ptolemy’s measuring processes are not completely clarified. We know that Ptolemy had used very few astronomical measure points which function as reference points (*themelioi*) for the vast majority of its toponyms. Ptolemy’s measurement methods cause three phenomena: *overmapping*, *inversion* and *doubling* [Tupikova et al. 2014]. That means that the application of

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[1] QGIS, version 2.14.22

statistical methods to a Ptolemaic map on a global level implicate a high degree of potential for error. Hence, the spline-based transformation type *Thin Plate Spline* (TPS) is chosen which allows flexible local compensation vectors to attain data in the form of local rates of contortions, also known as rubber-sheeting. TPS does not work parametrically but calculates between the locations of the control points and the corresponding locations in the reality. Due to the fact that global approaches are doomed to failure the focus lies on local proportions of a regional map and the relations between the control points and the suitable real points.

Especially the difference between a Ptolemaic map and a Tabula nova is investigated. For this reason, it is important to know what kind of differences exists between both types of maps. Therefore, knowledge about the respective historical backgrounds of the maps is important. Against this background georeferencing and transforming the maps can show if their shape fit in reality or not. Both processes combined may help to compare maps better and easier. Furthermore, how to georeference and transform an old map with QGIS is explained. A number of papers about georeferencing old maps has already been published [e. g. Balletti 2006; Boutoura and Livieratos 2006], but the software which is used, changes over time. With QGIS there is an open source software with a big active community available, hence historians and archaeologists may use it several years or even longer for free. A short tutorial on QGIS and old maps exists [Volkmann 2014], but only with screenshots. This paper is a contribution to an expandable research about the Arabian Peninsula as an object of investigation in the context of georeferencing and transformation.

PTOLEMY'S *GEOGRAPHY*

At first, we have to clarify what kind of source Ptolemy's *Geography* is and why this achievement is important for historical geography. The *Geography* contains almost 8000 toponyms of locations all over the now so-called Old World. Among them are cities, villages, capes, bays, river mouths, mountains, lakes, legionary camps and islands. For some regions, like the Mediterranean, many of these toponyms have already been identified. For example, nearly two-thirds of the locations of the books about Europe and about Turkey to Mesopotamia, are already determined. But for book 6 and 7, which are about Assyria to Sri Lanka, most of the toponyms are still not localised. Arabia Felix, which is in book 6, only has 17 toponyms out of 290, which are said to be securely localised [Stückelberger and Graßhoff 2006]. That means that the vast majority of the toponyms of the Arabia Felix is still not detected. One of the problems are Ptolemy's sources. Besides the geographical data from Marinus of Tyre, Ptolemy used astronomical calculations, itineraries, logbooks, trip logs and reports from merchants. He had to match this data into his own mathematical and geometrical concept [Geus 2013].

Before the first Ptolemy editions were printed most of the maps in Europe were *mappae mundi* or Portolan charts. Ptolemy was the first to give instructions on how to create a world map and regional maps of the Old World, with grids of parallels and meridians, giving a scientific way of interpreting the earth. He gives instructions on how to create a world map and the at least 26 maps of regions [Geus and Tupikova 2013]. With the translation of Ptolemy's *Geography* in 1406 from Greek into Latin the rediscovery and the spreading of the book started. In 1406 Jacobo d'Angelo translated the *Geography* from Greek into Latin. Also, the possibility of printing books and maps enabled an easier availability of the work. Until 1600, 31 different Latin and Italian editions with maps were published [Meurer 1991]. This demand for Ptolemy's work determined its great influence on geography. Although Ptolemy's circumference of the earth (in latitude) is too small and Ptolemy's length of the oecumene (in longitude) is too long (which is why Columbus might have thought, his journey to east-Asia or Japan will be completed in a shorter period of time than it was in fact), the maps of the Ptolemy editions mark the origin of modern maps as we know them.

Ptolemy's parallels (latitudes) are nearly right, but the meridians (longitudes) are wrong, because the Zero meridian (Ferro Meridian) was based on the most western position of the oecumene, running through El Hierro (Ferro), the most western of the Canary Islands. This specific distinction can be easily calculated with the current Zero meridian (Greenwich meridian) resulting in a difference of nearly 18° in longitude. In contrast, Ptolemy's circumference of the earth is too small, while the length of the oecumene is too long, 180° instead of nearly 120° [Stückelberger and

Mittenhuber 2009]. Both of these factors cause immense distortions. That is one main reason why generations of scholars and scientists have been searching for numerous places several times without success.

PTOLEMAIC MAPS AND TABULAE MODERNAE

Maps as sources of investigation have specific characteristics and can pose obstacles. They are depictions of the time of their origin. Furthermore, the distance of time, destructions of places and new constructions have changed toponyms and the human geography in a wider sense. Meanwhile trade routes added up to the pool of geographical information. One can see trade as a motor of travelling and of the reception of geographical knowledge in general and especially for Arabia. Making the Ptolemy editions, both texts and maps, was a working process which crossed numerous borders. For example, Clerics from Mainz and Cologne worked together with Florentine scholars for the Bologna edition from 1477. In Rome, a Netherlandic mapmaker worked together with monks from Verona for the edition from 1478 [Theatrum 1963-1966].

The maps, based on Ptolemy's *Geography* [Theatrum 1963-1966], are similar to each other (despite the differences in their appearance). Of course, they are, because the mapmakers followed Ptolemy's instructions and his gazetteer. But there exist differences in their styles, like in contrasting and shading. Also, there are differences in drawing coastlines or islands. But generally speaking they correspond well with each other (Fig. 1). The Ptolemaic maps have more differences with the Tabulae novae, but that also depends on the specific Tabula nova at hand.

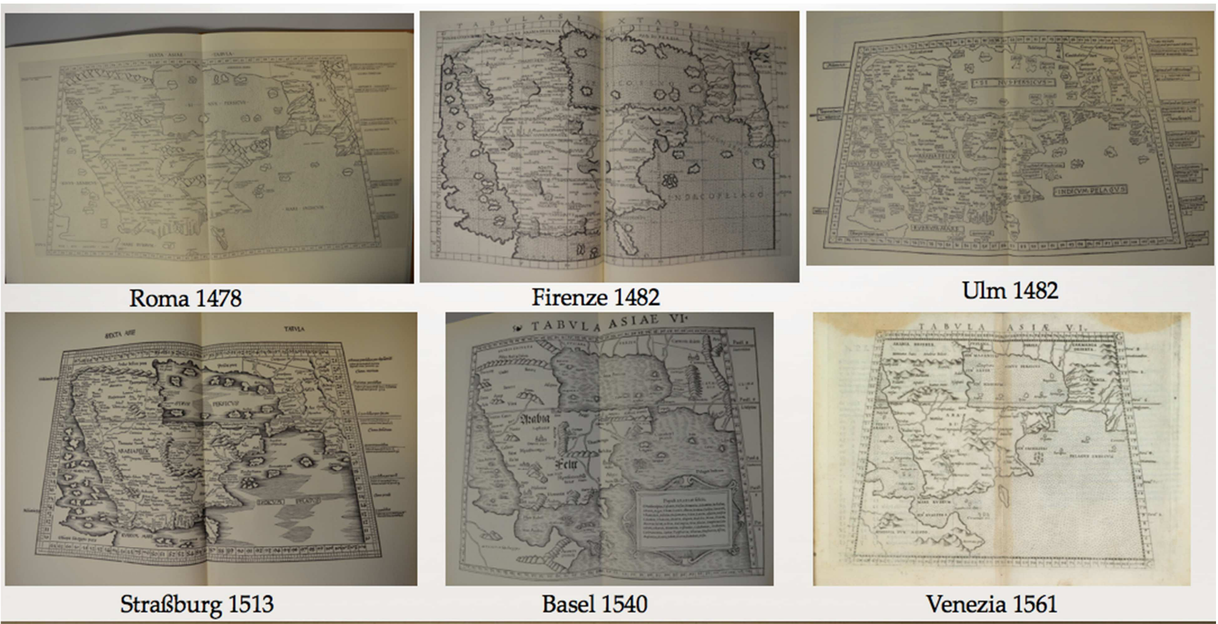

Fig. 1. Ptolemaic maps showing the Arabian Peninsula (Arabia Felix), the 6th map of Asia in book 6, from six different printed Ptolemy editions.

Arabia Felix in the Venetian edition of Ptolemy's *Geography*

Two maps from the Venetian Ptolemy edition are the objects of investigation. One is based on Ptolemy's *Geography* (Tabula Asiae VI.) and the other is a Tabula nova (Arabia Felice Nuova Tavola), a version of the first modern map of the Arabian Peninsula. Since the first printed Tabula nova was published in the Ptolemy edition of Florence in 1482, it had become common to print both, maps which are based on the *Geography* and modern maps.

One can easily spot that the shapes of the peninsula differ from each other, as well as the coastlines and the locations of the islands. At a first view on both maps from Venice (Fig. 2) differences in the shape and orientation of the peninsula, the Red Sea and the Persian Gulf become obvious. Different map shapes are deployed but with nearly the same coordinates. While the Ptolemaic map shape is trapezoid the Tabula nova is rectangular. The meridians are the same but the parallels are dissimilar to a little extent. The Ptolemaic map starts with the parallel three and the Tabula nova with five in the south. As a consequence, the coordinates for the places differ from each other on the map while the text of the *Geografia* [Ptolemaios et al. 1561] lists the prior coordinates from Ptolemy which correspond with coordinates from the Tabula Asiae VI. but not with those from Arabia Felice Nuova Tavola. That confirms the thesis that the author of the text and the author of the map usually had not been the same person [Horst 2008]. Furthermore, mistakes like in the inscription were not unusual.

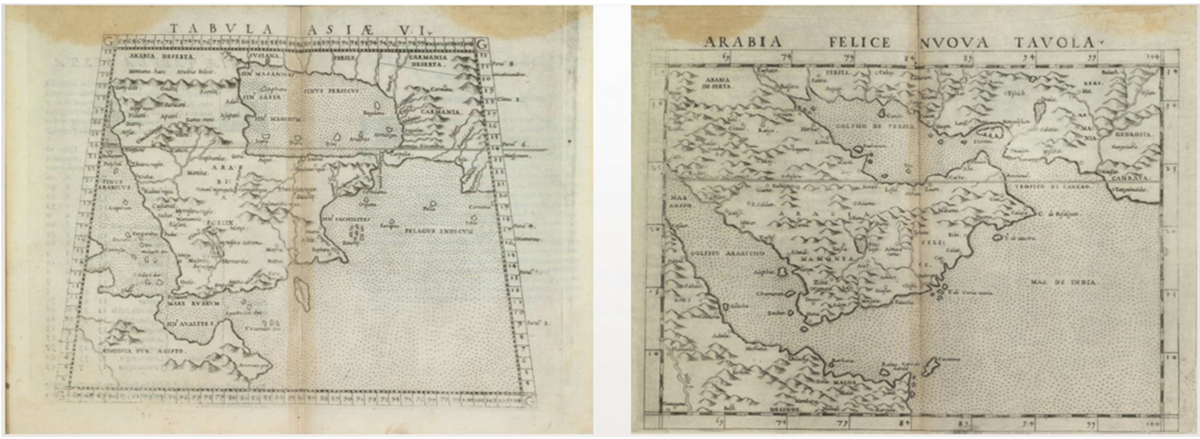

Fig. 2. Both maps depict the Arabian Peninsula, the Ptolemaic view (left) and the contemporary view (right). Both originated from the Venetian Ptolemy edition of 1561.

When we look at the map more closely, we find evident differences. The mountains in the north serve as a suitable example. In both maps they are different and both wrong. The mountains do not exist in this location, as you can see on a map from Google Earth (Fig. 3). Such an imprecise localisation of mountains in early maps is not uncommon. Without a sufficient knowledge about the interior of the peninsula, which the mapmakers did not have, this kind of result is unsurprising.

Another difference between the maps that points out is the shape of the Persian Gulf. A map from Google Earth shows the right shape of the Persian Gulf. The depiction of the Persian Gulf in the Tabula nova is closer to reality than it is on the Ptolemaic map. This “new” depiction of the Persian Gulf marks a distinctive growth of geographical knowledge. In this case the geographers of the 16th century had known significantly more about the Persian Gulf than Ptolemy (Fig. 4). Nevertheless, one has to take into account the changing shape and size of that water throughout the centuries.

Fig. 3. Both maps depict a mountain in the north of the Arabian Peninsula. The Ptolemaic map (left) depicts mountains, which end in the Red Sea in the West and end in the Persian Gulf in the East, like a straight line. The Tabula nova (right) does not depict the mountains this way but its depiction is a bit nearer to reality (below).

Fig. 4. The shape of the Persian Gulf differs obviously on the three maps. While the Persian Gulf on the Ptolemaic Map (left) looks much broader than the real shape of it, the Tabula nova (right) comes closer to the real shape (below).

Also, the change of the location of the island Socotra between the Ptolemaic and the modern map (Fig. 5) enables a better understanding of the maritime region in the south of Arabia. However, to some extent the mapmakers had vague or incomplete pieces of information about distances and geographical positions. This is due to the fact that most of the data which is shown on the maps stems from reports from sailors and traders, which are not primarily made to reflect the physical reality. Their reasons to make maps found on matters of navigation and politics, both in antiquity and in early modern times. While Ptolemy focuses on the best possible solution for a transformation of the 3D-earth to a 2D-earthmap in the most accurate way possible, most of the authors of his sources and the authors of the sources of the early modern geographers did not prioritise it.

In many cases the external (meridians, parallels, scale, transformation) and the internal (toponyms, coastlines, etc.) geography of the early modern maps or nautical charts often do not fit together. Magnetic declination and difficulties arising from unknown methods of specify meridians were chief causes in this context. This internal-external problem was mentioned by the mathematician and astronomer Pedro Nunes (1502-1578) which shows that this issue was a subject of interest during that time but without having found a solution [Gaspar and Leitão 2017].

Fig. 5. The location of Socotra changed from the Ptolemaic Map (left) compared to the Tabula nova (right). The accurate location of this island is closer to Somalia than to the south coast of Arabia (on top).

European Maritime Expansion

Why are the Ptolemaic map and the Tabula nova so different to each other? The 15th and 16th century represents a time of discoveries and maritime expansion. Especially the Portuguese discovered coastlines, cities, capes, bays and islands in the Indian Ocean and Persian Gulf. The circumnavigation of Bartolomeu Dias of the Cape of Good Hope in 1488 should be mentioned, also Pero da Covilhã’s Journeys into the Persian Gulf between 1487 and 1492 should be pointed out, as well as Vasco da Gama’s voyage to India in the late nineties. Madagascar were discovered in 1500 and Hormuz was occupied in 1515. In 1523 António Tenreiro went from Aleppo to Basra [Russell-Wood 1992]. It is important to mention that it was often not allowed to share maps with each other without the permission of the particular ruler. However, the knowledge they had conveyed became part of the European perception of these regions of the world. The 15th and 16th century was a time of journeys and discoveries which brought new geographical reports to some cities and persons in Europe.

The Arabian Peninsula or Arabia Felix

The Arabian Peninsula is an interesting region because not many Europeans went in to this place in all times. Due to its physical geography, it was and it is not facile to pass through the peninsula. However, through reports from merchants, who bartered at the Red Sea, the western coastlines of Arabia are relatively well known. But whereas lore about the coast and its cities was at hand (with faults in distances and shapes of the whole peninsula), knowledge about the interior was lacking. Understandably the interior of the Arabian Peninsula was not well known because of the difficulty in transitioning through the region [Glaser 1890].

Therefore, there exist difficulties with the 6th map of Asia. The places are not easy to localise: Not only cities but also mountains and rivers and even coastlines. Mountains did not change their position (maybe metres but not kilometres) but some of them were not very well known by Europeans, neither in antiquity nor in the 15th or 16th century. Cities can be destroyed by pillages and can be destroyed forever or can be rebuilt in another place. Ruins of them can be visible over centuries, but only one big desert sand storm can hide them until the moment the sand leaves this area again. Rivers can change their course. Ptolemy mentioned several river mouths, which might have changed their position several times in 1300 or 1800 years.

GEOREFERENCING AND TRANSFORMING OLD MAPS WITH QGIS

Why is there such a complex procedure required? Most of the data which is shown on the maps comes from reports from sailors and traders. To some extent we have imprecise information like distances and geographical positions. Itineraries are earmarked navigation aids and they are not made for reflecting the physical reality.

Several steps exemplified on the maps from the Ptolemy editions are required: List the locations of a current edition of Ptolemy’s *Geography* [Stückelberger and Graßhoff 2006], which have been proven. Compare these locations with the old map you want to georeference. Then, take a shapefile as the foundation of the following work. Compare these locations with the data bases and digital maps of Pelagios and Pleiades or iDAI.gazetteer. After adding all proven locations QGIS will calculate the georeferencing and transformation.

The proven toponyms as an ossature

To get reliable results in the georeferencing process relatively proven toponyms from the old map are wanted. Unfortunately, there exist only a few securely proven toponyms in the 6th map of Asia, the Arabian Peninsula. However, as much of the proven toponyms as possible should get georeferenced. A list (Table 1) shows the proven toponyms based on the current Ptolemy edition [Stückelberger and Graßhoff 2006]. Of course, toponyms can change over the years. That is why ancient names of places can be different from those of the following centuries. Only seven of the 17 proven locations are depicted in the Tabula nova (Table 2).

After comparing the toponyms from the current Ptolemy edition with the toponyms in the Tabula nova from Venice, only six assured control points and one unassured point (Gezem) are available for georeferencing. The more control points available the better will be the result. Hence, proven toponyms from the map which are not mentioned by Ptolemy are required. Therefore, the islands Baharam (Bahrain), Cacotora (Socotra), Zuchor (Jabal Zuqar), Alephar (Farasan island) and Ailocho (Halib) as well as the cites Taema (Tayma) and Balsera (Basra) are added. Thus, we have 14 control points while one of them, Gezem, will be identified once as Mocha and another time as Jizan.

Table 1. The proven toponyms of Arabia Felix

Ancient name	Ptolemaic parallel	Ptolemaic meridian	Modern name	Modern parallel	Modern meridian
Baitios (Baitiros) potamos ekbolai	20° 40'	69° 30'	Wadi Baisch – river mouth	17° 05' 36" (?)	42° 25' 19" (?)
Mouza emporion	14° 00'	74° 30'	Mauza / al-Muchā/ Mokka	13° 19' 13"	43° 15' 16"
Arabia (Arabias) emporion	11° 30'	80° 00'	Aden	12° 48'	45° 2' 1"
Syagros akra	14° 00'	90° 00'	Ras Fartak	15° 38' 07"	52° 13' 25"
Kryptos limen	21° 30'	92° 40'	Muscat / Maskat	23° 36' 51"	58° 35' 27"
Hiera Helios akra	23° 30'	87° 20'	(Ras Oman) / Ras al Hadd / Ras al-Dschinz	22° 31' 19" / 22° 25' 53"	59° 47' 42" / 59° 46' 57"
Klimax	16° 00'	76° 30'	Dschabal Isbil / Jabal Isbil (a mountain)	14° 34' 22"	44° 40' 43"
Katara	23° 20'	79° 30'	Katar	25° 16' 10"	51° 12' 46"
Makoraba	22° 00'	73° 20'	Mekka	21° 25' 21"	39° 49' 34"
Naskos (Nako) metropolis	20° 40'	81° 15'	Al-Bayda (former Naschq)	13° 59' 28" (16° 10' 44")	45° 34' 12" (44° 29' 39")
Mara (Maraba) metropolis	18° 20'	76° 00'	Marib	15° 25' 22"	45° 20' 15"
Sabbatha (Saubatha) metropolis	16° 30'	77° 00'	Schabwa	15° 22' 8"	47° 1' 25"
Sapphara metropolis	14° 30'	78° 00'	Zafar	14° 12' 50"	44° 24' 10"
Harmouza polis	23° 30'	94° 30'	Hormus	27° 4'	56° 27'
Karpella akra	22° 10'	94° 00'	Ras al-Kuh	25° 48'	57° 18'
Badara	20° 10'	103° 00'	Gwadar	25° 7' 35"	62° 19' 21"
Karmana metropolis	29° 00'	100° 00'	Kirman / Kerman	30° 17' 13"	57° 4' 9"

Shapefile as a foundation for the old map

At first a shapefile (Fig. 6) is needed as a foundation for the map, which is about to get georeferenced. The public domain map dataset Natural Earth provides the opportunity to download functional background maps respectively public domain modern GIS data. It is free to use for any type of project. After importing that shapefile into QGIS, the plug-in Georeferencer needs to be started.

Table 2. The toponyms from table 1, which can be found in the Tabula nova from Venice 1561

Modern name	Modern parallel	Modern meridian	Name in the Tabula nova
Wadi Baisch – river mouth	17° 05' 36" (?)	42° 25' 19" (?)	–
Mauza / al-Muchā/ Mocha	13° 19' 13"	43° 15' 16"	Gezem*
Aden	12° 48'	45° 2' 1"	Aden
Ras Fartak	15° 38' 07"	52° 13' 25"	Fatacha
Muscat / Maskat	23° 36' 51"	58° 35' 27"	Calaya
(Ras Oman) / Ras al Hadd / Ras al-Dschinz	22° 31' 19" / 22° 25' 53"	59° 47' 42" / 59° 46' 57"	Capo de Rasalgate
Dschabal Isbil / Jabal Isbil (a mountain)	14° 34' 22"	44° 40' 43"	–
Katar	25° 16' 10"	51° 12' 46"	–
Mekka	21° 25' 21"	39° 49' 34"	Lamech
Al-Bayda (former Naschq)	13° 59' 28" (16° 10' 44")	45° 34' 12" (44° 29' 39")	(Magiareb, Cittá Regale?)
Marib	15° 25' 22"	45° 20' 15"	–
Schabwa			–
Zafar	14° 12' 50"	44° 24' 10"	–
Hormus	27° 4'	56° 27'	Hormus
Ras al-Kuh	25° 48'	57° 18'	–
Gwadar	25° 7' 35"	62° 19' 21"	–
Kirman / Kerman	30° 17' 13"	57° 4' 9"	–

Then a raster file is needed, which is the old map. At this point it has to be decided on a transformation type. In this case TPS is the best choice. Due to the fact that it is a highly flexible transformation method, capable of compensating for strong geometric errors locally, with the disadvantage that it is also extremely sensitive for changes in the set of referencing points, control points preferably from all areas of the map are needed. Then control points can be added. The coordinates of modern locations can be found in Wikipedia or Google Earth (Fig. 7).

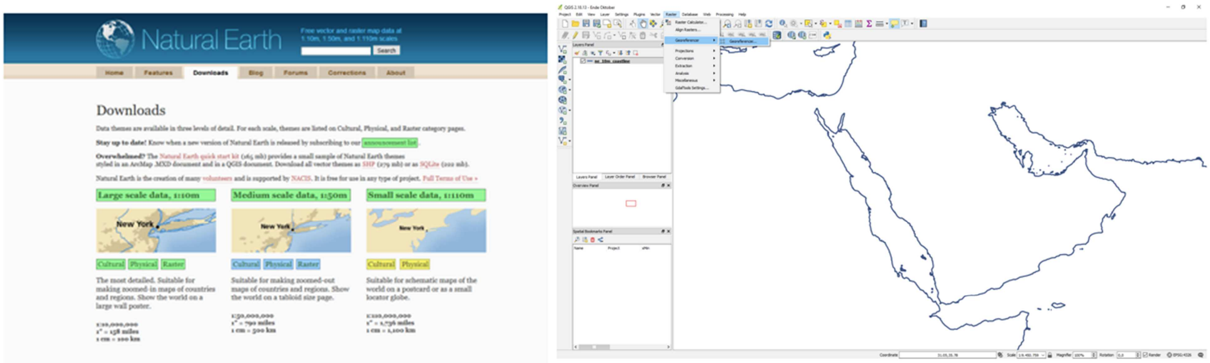

Fig. 6. Left: The map dataset Natural Earth provides shapefiles for base layers. Right: The world map from Natural Earth in large scale as a shape layer in QGIS.

For ancient places which do not exist these days, e.g. iDAI.gazetteer or Pelagios are very helpful tools. They help to find coordinates for the places, which are named in the Tabula nova. Pelagios works with Pleiades, which is a community-built gazetteer of ancient places, and the Digital Atlas of the Roman Empire, by Lund University. Searching directly in Pleiades is also possible. Some places differ from each other and some places can be found in one gazetteer but cannot be found in a different one, e.g. Hormuz can be found in the iDAI.gazetteer, but not in Pleiades (Fig. 8). The harbour city Mouza (nowadays probably Mocha) is shown in Pelagios in the interior of the peninsula while the Barrington Atlas locates this place on the coast [Talbert 2000]. The variety of the data, which is collected by the gazetteers, should be taken into account while searching for places. Due to the fact that the data bases of the gazetteers are still growing and changing currently and in the near future, coordinates and names for places should be enquired in all mentioned sources.

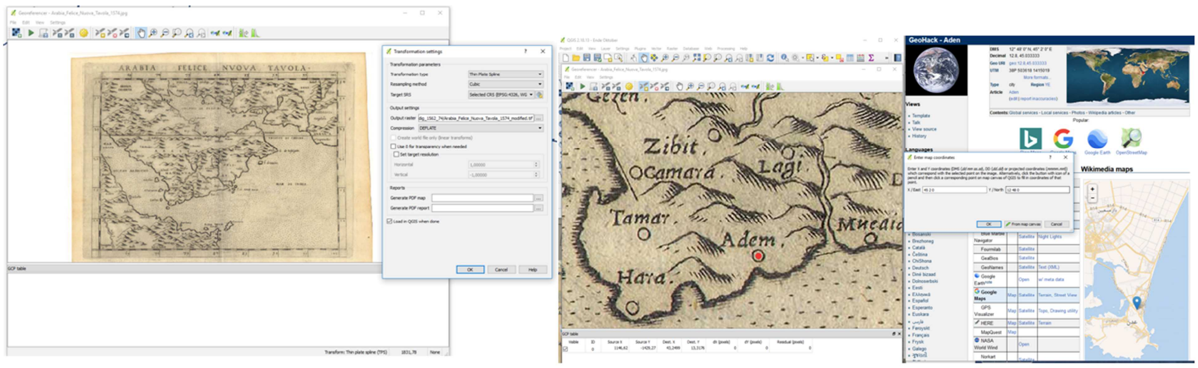

Fig. 7. Left: The transformation type is essential for the adjustment and comparability of the old map. Right: The setting of control points. In this case, Aden which is one of the seven proven toponyms (Table 2) is selected. Aden's coordinates can be found in GeoHack[2].

Moreover, the information in the Ptolemy editions differ from each other. While one edition [Ptolemaios et al. 1561] does not have a contemporary equivalent for the toponym Mouza, two other editions offer two different suggestions.

[2] https://tools.wmflabs.org/geohack/

The early modern edition identifies Mouza as Gezem [Ptolémée and Rosaccio 1599] which is depicted in the Tabula nova, and the current Ptolemy edition suggests Mauza for Mouza [Stückelberger and Graßhoff 2006]. The coordinates are also dissimilar. The various coordinates may result from different versions of the *Geography*, on which they are based. These distinctions result from the usage of different sources by the particular author. It can be shown with georeferencing that Gezem on the map is not Mouza but might be Jizan [Tibbetts 1978].

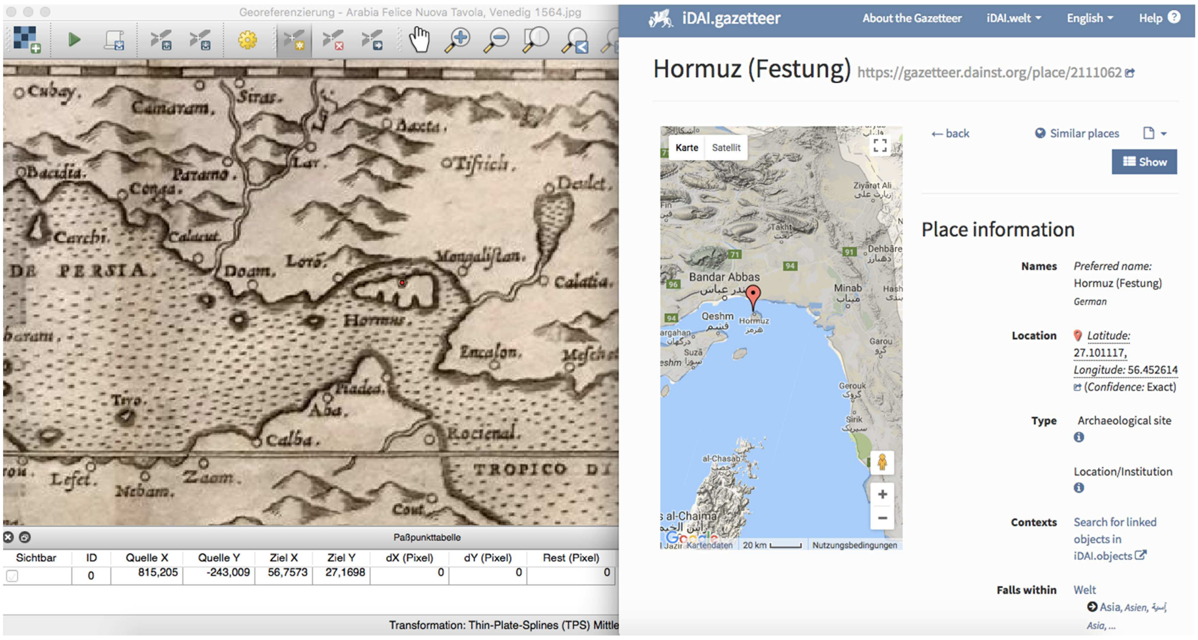

Fig. 8. Coordinates for toponyms contained in the old map (left) can be found in online gazetteers, e.g. iDAI.gazetteer (right).

After connecting the control points from the map with the background map via filling in the coordinates, the georeferenced and transformed Tabula nova appears (Fig. 9). The transformed maps have changed their shapes. The old maps can be easily compared with the background map from Natural Earth. It is evidently visible that the Tabula nova fits much better in the background map than the Ptolemaic map, for example considering the shape of the Persian Gulf or the location and shape of the Red Sea. Differences between the map based on Ptolemy and the Tabula nova can be demonstrated. But even the Tabula nova has regions with more and less distortions. And maybe locations can now be identified better. But there is no definite proof. Hence, an examination of every single region and place is inevitable.

Furthermore, one should attend to the high sensibility of the raster file. The shape of the georeferenced map can change fast in the transformation process. One has to be careful with the points, which are added in the georeferencing process (Fig. 10).

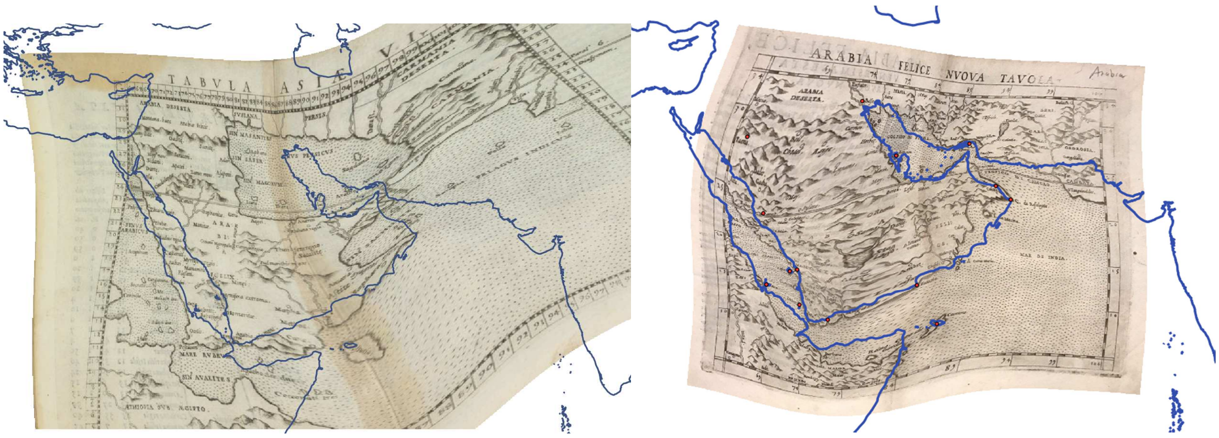

Fig. 9. The georeferenced and transformed Ptolemaic map (left) and Tabula nova (right). You can compare both old maps easily with the background map from Natural Earth, on which coastlines are coloured blue. The edge effect distortions on the Ptolemaic map are less in almost every part of the map but its shape does not fit in the real shape of the peninsula. The Tabula nova has a lot of edge effect distortions while fitting better in the real shape.

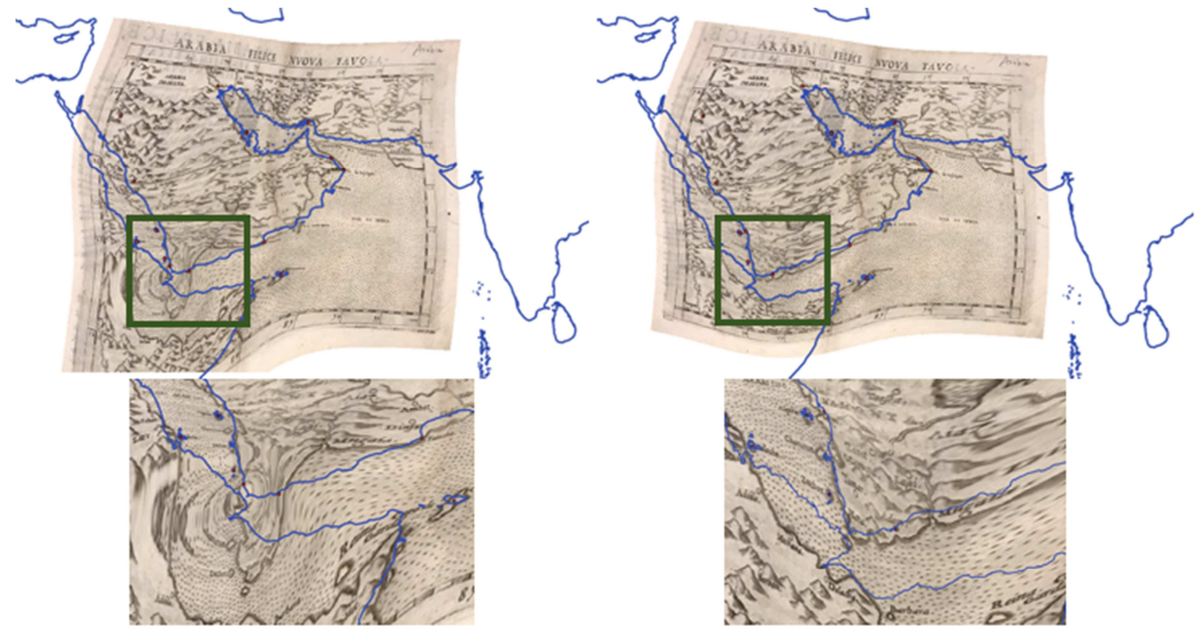

Fig. 10. Only one point more (top left) or less (top right) influences the shape of the layer (the georeferenced Tabula nova) to a great extent. The city Gezem, which is named in the Tabula nova and is supposed to be Mouza there, seems to be too far in the north to be Mouza, because this part of the Arabian Peninsula in the Tabula nova is stretched too far into the south (bottom left). Without taking the control point Gezem as Mouza, but instead identifying it as Jizan, the shape looks much more realistic (bottom right).

The example of Gezem and Mouza shows that places could also be excluded, if the addition of another point to the points for georeferencing and transforming would have a negative influence on the shape of the old map e.g. distort the result. If the mapmaker had identified Gezem with Mouza he would have put this city in the wrong place. In this case, Gezem seems to be Jizan because the shape of the transformed Tabula nova looks much more realistic.

The decision for taking places into account or not before starting the georeferencing and transformation process of an old map is already an interpretation of the historical source. Every set control point can change the shape of the transformed map. The more proven points that can be added in the beginning, the higher the probability for getting more reliable results [Balletti 2006].

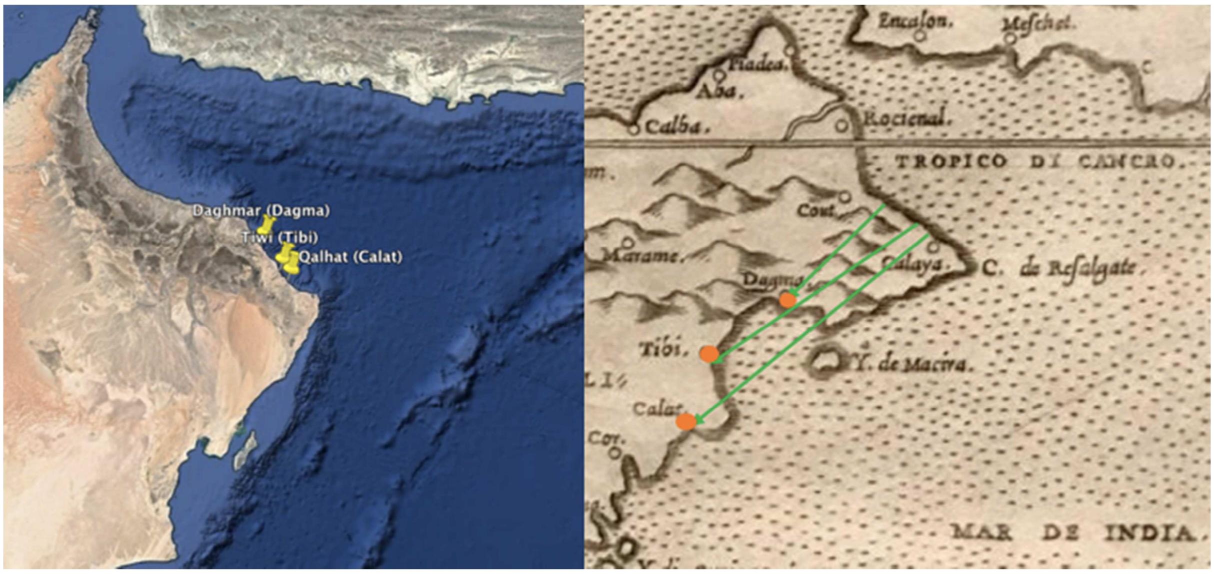

Fig. 11. The places Qalhat, Tiwi and Daghmar in the east of the peninsula seem to be depicted as Calat, Tibi and Dagmar in the right sequence but on the wrong coastline. Why are they located so far in the south on the Tabula nova? The place names might have been transcribed out of an itinerary or travel report. This example shows how difficult it is to justify locations and distances between places on the basis of place names.

Next steps could be the assessment of the relations between the control points to detect more details of the cartometry and the influence of the positions of the control points on affine transformations. Furthermore, the question is if topographical features such as the coastline can be assessed on the basis of known control points and if this process can promote interpretative gains. If the coastline is relatively accurate and some known points are used, this could lead to other places being positioned more accurately. But examples like the depiction of Calat, Tibi and Dagmar (Fig. 11) show how difficult it is to match information shown in a Tabula nova and places in reality.

The validity of the presented method is the approach on finding answers for questions on toponymy and cartometry via GIS. Georeferencing and transformation of maps can help with the interpretation of the maps' information. At last it should not be forgotten to return consistently to the original map.

CONCLUSION

The presented georeferencing process is a valuable methodology for comparing maps with each other. Local deformation and distortion show what the mapmaker may have known and what he did not know about regions and spatial relations and the location of places. Georeferencing and transforming maps provides a more precise interpretation and comparison of geographical knowledge or ignorance which is shown in the maps [Volkmann 2017]. In contrast, establishing the relationship between a Ptolemaic map or an early modern map implicates a high degree of potential for error on a global level. The focus ought to be on local analysing, especially, on relations between the control points and the real locations. Several proven places are needed in different areas of the map. Every georeferenced control point can change the shape of the transformed map so that one has to be very careful when selecting the locations. That is a particular problem of the spline function.

To sum it up, georeferencing and transforming is a very helpful implement to analyse old maps and identify places. However, in order to identify places, assumptions still have to be made and in many cases no evidence is given. QGIS is a valuable open source tool to lay old maps on top of modern maps. It allows to georeference and transform maps and to compare them. The active community working on and with that software provides an open workflow and an easy access.

The most promising ways of further research is on the one hand the comparison of toponyms in the works of modern historians and archaeologists with the toponyms on the maps. Comparing more maps with each other, taking more sources into account, ancient and younger, brings the research further. Finding and enquiring other historical sources like inscriptions in Arabia [Al-Sheiba 1987] through archaeological surveys may, of course, be beneficial. On the other hand, research on historical geography needs to know more about the practice of mapmakers throughout the specific centuries. Including Portolan maps into this comparison could also be possible. We can learn much more about the geographical understanding of different cultures during specific times by thinking about toponymy and how and where places were localised in old maps.

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REFERENCES

Abdallah Hassan Al-Sheiba. 1987. Die Ortsnamen in den altsüdarabischen Inschriften (Mit dem Versuch ihrer Identifizierung und Lokalisierung). *Archäologische Berichte aus dem Yemen*, IV (1987), 1-62.

Caterina Balletti. 2006. Georeference in the analysis of the geometric content of early maps. *e-Perimetron*, 1, 1 (2006). 32-42. http://www.e-perimetron.org/Vol_1_1/Balletti/Balletti.pdf.

Chryssoula Boutoura and Evangelos Livieratos. 2006. Some fundamentals for the study of the geometry of early maps by comparative methods, *e-Perimetron*, 1, 1 (2006). 60-70. http://www.e-perimetron.org/Vol_1_1/Boutoura_Livieratos/1_1_Boutoura_Livieratos.pdf.

Joaquim Alves Gaspar and Henrique Leitão. 2017. What is a nautical chart, really? Uncovering the geometry of early modern nautical charts. *Journal of Cultural Heritage*, 10 (2017).

Klaus Geus and Irina Tupikova. 2013. Von der Rheinmündung in den Finnischen Golf … Neue Ergebnisse zur Weltkarte des Ptolemaios, zur Kenntnis der Ostsee im Altertum und zur Flottenexpedition des Tiberius im Jahre 5. n. Chr. In *Geographia Antiqua*, 22 (2013), 125–143.

Klaus Geus. 2013. Wie erstellt man eine Karte von der Welt? Die Lösung des Ptolemaios und ihre Probleme. In Dietrich Boschung et al., eds. *Geographische Kenntnisse und ihre konkreten Ausformungen*. München:

Morphomata 5, 119–136.
Eduard Glaser. 1890. Skizze der Geschichte und Geographie Arabiens von den ältesten Zeiten bis zum Propheten Muhammad nebst einem Anhange zur Beleuchtung der Geschichte Abessyniens im 3. und 4. Jahrhundert n. Chr., 2. Berlin.
Thomas Horst. 2008. Die Altkarte als Quelle für den Historiker. Die Geschichte der Kartographie als Historische Hilfswissenschaft. *Archiv für Diplomatik* 54 (2008), 309-378.
Peter H. Meurer. 1991. Fontes Cartographici Orteliani. Das „Theatrum Orbis Terrarum" von Abraham Ortelius und seine Kartenquellen, Weinheim: Diss.: Berlin, Freie Univ., 1991.
Klaudios Ptolemaios. 2006. Handbuch der Geographie. Griechisch – Deutsch. Alfred Stückelberger and Gerd Graßhoff, eds. Einleitung, Text und Übersetzung, Index, 1 and 2. Basel.
Klaudios Ptolemaios. 2009. Handbuch der Geographie. Ergänzungsband mit einer Edition des Kanons bedeutender Städte. Alfred Stückelberger and Florian Mittenhuber, eds., Basel.
Klaudios Ptolemaios, Girolamo Ruscelli, Giuseppe Moleto and Vincenzo Valgrisi. 1561. La Geografia Di Claudio Tolomeo Alessandrino: Con Espositioni del medesimo, particolari di luogo in luogo, & universali sopra tutto il libro, et sopra tutta la Geografia, ò modo di far la descrittione di tutto il mondo. E con nuove et bellissime figure in istampe di rame, oue, oltre alle XXVI antiche di Tolomeo, se ne son'aggiunte XXXVI altre delle moderne. Con la carta da navigare, et col modo d'intenderla, et d'adoperarla... Et con una nuova et copiosa Tavola di nomi antichi, dichiarati co i nomi moderni, et con molte altre cose utilißime et necessarie, che ciascuno leggendo potrà conoscere; Con privilegio dell'Illustrissimo Senato Veneto, et d'altri Principi per anni XV; [dedicated:] Imperator Ferdinando Primo / Nuovamente tradotta di Greco in Italiano, Da Girolamo Ruscelli... Aggiuntovi un pieno discorso di M. Gioseppe Moleto. Ne quale si dichiarano tutti i termini & le regole appartenenti alla Geografia.
Claude Ptolémée and Gioseppe Rosaccio. 1599. Geografia di Claudio Tolomeo Alessandrino / tradotta di greco nell' idioma volgare italiano da Girolamo Ruscelli; et hora nuovamente ampliata da Gioseffo Rosaccio, […] con varie annotationi […] et una Geografia universale del medesimo, separata da quella di Tolomeo, […] et una breve Descrittione di tutta la terra, distinta in quattro libri […]. In Venetia, MDXCIX. Appresso gli heredi di Melchior Sessa.
Anthony J.R. Russell-Wood. 1992. A World on the Move: The Portuguese in Africa, Asia, and America, 1415 – 1808, Manchester.
Richard J. A. Talbert ed. 2000. Barrington Atlas of the Greek and Roman World. Map-by-Map Directory, 1, Princeton NJ.
Theatrum Orbis Terrarum. 1963-1966. A Series of Atlases in Facsimile, Amsterdam.
Gerald R. Tibbetts. 1978. Arabia in Early Maps: a bibliography of maps covering the Peninsula of Arabia, printed in Western Europe from the invention of printing to the year 1751. Cambridge.
Irina Tupikova, Matthias Schemmel and Klaus Geus. 2014. Travelling along the Silk Road: A new interpretation of Ptolemy's coordinates. Max-Planck-Institut für Wissenschaftsgeschichte (MPIWG Preprints; 465), Berlin. Retrieved January 9, 2018 from https://www.mpiwg-berlin.mpg.de/Preprints/P465.PDF.
Armin Volkmann. 2017. Geographische Informationssysteme. In Fotis Jannidis et al., eds. *Digital Humanities. Eine Einführung*. Stuttgart: 299-314.
Armin Volkmann. 2014. Georeferenzierung von historischen Karten mit QGIS – Ein Bilderbuch. Geo-referencing of historical maps with QGIS. *archäologiedigitale. Digitalbasierte Forschungen der Archäologie* (2014).

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