The Cartographic Journal

Map of Tlacotalpa by Francisco Gali, 1580: an early example of local coastal chart in Spanish America.

--Manuscript Draft--

Manuscript Number:	CAJ422R1
Full Title:	Map of Tlacotalpa by Francisco Gali, 1580: an early example of local coastal chart in Spanish America.
Article Type:	Refereed Paper
Keywords:	Early coastal chart, Spanish America, sixteenth century, map comparison, Tlacotalpa, Gali, Mexico.
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Abstract:	In the last third of the sixteenth century, the Spanish Crown launched a project to create a map of the New World. Regional maps would be obtained, which, referenced through a system of meridians and parallel arcs, would comprise a complete map of the continent. The mechanism devised for this purpose was that of surveys, known as the Relaciones Geográficas (Geographic Relations). Each town would be sent a questionnaire with more than 50 questions, that should also be completed with a map of the region. The majority of these maps, known as pinturas, lacked field measurements, and therefore also lacked both scale and geographical coordinates. Only a few cases were created following the standards of European cartography. Among these are the maps made by Francisco Gali. In this paper, we study the map of Tacotlalpa, one of the first examples of local nautical charting in Latin America.
Funding Information:	

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In the last third of the sixteenth century, the Spanish Crown launched a project to create a map of the New World. Regional maps would be obtained, which, referenced through a system of meridians and parallel arcs, would comprise a complete map of the continent. The mechanism devised for this purpose was that of surveys, known as the *Relaciones Geográficas* (Geographic Relations). Each town would be sent a questionnaire with more than 50 questions, that should also be completed with a map of the region. The majority of these maps, known as pinturas, lacked field measurements, and therefore also lacked both scale and geographical coordinates. Only a few cases were created following the standards of European cartography. Among these are the maps made by Francisco Gali. In this paper, we study the map of Tacotlalpa, one of the first examples of local nautical charting in Latin America.

Keywords: Early coastal chart, Spanish America, sixteenth century, *Relaciones Geográficas*, map comparison, Tlacotalpa, Francisco Gali, Mexico.

INTRODUCTION

From the early days of the colonization of the Americas, the Spanish Crown needed to ascertain and represent the new overseas territories for control and demarcation purposes. Another reason for mapping the discovered lands was to settle disputes between the kingdoms of Spain and Portugal as a result of the Treaty of Tordesillas.

During the sixteenth century, Spanish colonial cartography consisted of two broad categories of maps. The large-scale or cosmographic representation of the continent along its coastlines. These nautical charts had as main object the aid in navigation to the Indies. They were closely linked to the development of astronomy and to the systems of measurement of longitude and latitude. At first, these cartographers were mainly concerned with the definition of the coastlines of the New World (its eastern profile) and of the general shape of its territory.[1] Most of these nautical charts

were drawn in Seville by the cartographers and cosmographers of the *Casa de la Contratación* (House of Trade). They were compiled from the sketches of the navigators, who represented the regions they were exploring, without conform to Ptolemy's geographical concepts (Figure 1).

Figure 1. *Dibujo de la costa del golfo de México desde la península de Florida hasta Nombre de Dios* (Sketch of the coast of the Gulf of Mexico from the Florida peninsula to Nombre de Dios). Alonso Álvarez de Pineda? 1519. Archivo General de Indias, Sevilla [AGI, MP-Mexico,5].

However, as time went by, other mapping groups emerged: regional and local maps. Then began the development of a detailed cartography of the interior, its territorial divisions, geographical features, mountain ranges, rivers, lakes, roads and main towns, with the corresponding toponymy. This diverse group comprises representations of territory ranging from pre-Hispanic indigenous tradition, to maps and plans that made native painters and officials for the Spanish Crown, in the great project of the *Relaciones Geográficas*.

In the last third of the sixteenth century, the instrument that was designed to carry out the project of the representation of the New World was that of surveys. Each town or community would be sent a questionnaire to be answered by the local colonial authorities. These questionnaires, known as the *Relaciones Geográficas* (Geographic Relations) of the XVI century, contained questions regarding geography, topography, place names, indigenous languages, demographics, mineral resources, housing, commerce, religious institutions, and plants.[2] The responses to the questionnaire were composed by a wide variety of authors. A few of them had formal European training, but many seem to have been extemporary mapmakers, and some retained a purely indigenous style (Buisseret 2007).

On the *Relaciones Geográficas* questionnaire, the creation of a map was requested of the region or town, as appropriate. When the town was coastal, then the shape and design of its ports and jetties were requested; for the islands, a map covering these same features was required. The number of questionnaires sent to the New World remains unknown, not all were answered, nor did all surveys comply with the request to attach a map.

In the majority of cases, cartographic documents were not preceded by measurement and data collection in the field, nor the subsequent planimetric survey to scale. One reason for this was that the people who made these documents were not mapping experts. The colonial authorities commissioned maps from local Spanish, Creole, and indigenous artists, who were, in general, unaware of European topographic and cartographic techniques.

One of the survey questions that were often left blank or drew an incomplete response was that which requested the height or elevation of the pole. This indicates to us the lack of human and material resources for measurements to be made and for consequently accurate representations to be drawn of the places described. The existence of only a few exceptional cases corroborates this statement. In this way, the data was completed in the *Relación* of Tepeaca, in which Andres de la Vega, pilot of the Spanish route to the Indies and Tecamachalco resident, intervened and took the measurements corresponding to the region with an astrolabe (Berthe, Breton and Lecoin 1991). Astronomical measurements were also performed to obtain the coordinates of places for the creation of the map of the *Relación Geográfica* of Zapotitlán, made to scale by its mayor, Captain Juan de Estrada, who was a nautical and cosmography expert (Alvarez 1989). Another case is that of the maps constructed by the navigator, explorer, cosmographer and cartographer, Francisco Gali, on behalf of several mayors

responsible for the completion of the *Relación Geográfica* questionnaires of their towns. These officials, rather than entrusting the creation of maps to a local artist, took advantage of the talents of Gali, a mariner with knowledge of cartography, who was passing through those territories on his way to the Pacific coast. On the subject of Gali, the Archbishop Viceroy of Mexico wrote to King Philip II, 'he was the most honourable and worthy man there was in this America' and that, in matters of cosmography and seamanship, he could compete with the choicest of Europe (Hipólito 1819). The first author who classified these maps within the category of nautical charts was Robertson (1972). Subsequently, others have also noticed the uniqueness of these cartographic documents within the corpus of the *Relaciones Geográficas* Tait (1991), Berthe, Breton and Lecoin (1991), Mundy (1996), Kagan (2000), Padrón (2004), among other authors.

BIOGRAPHICAL NOTES

Francisco Gali is a unique and enigmatic character. Little is known about him before his appearance in the Americas. Although many historians agree on his date of birth, 1539, and the majority put the event in Seville, a few authors point to other Spanish cities. Other sources suggest an Italian origin. Moreover, his name appears in historical sources in many different ways: Francisco Gali, Galli, Gualle o Guelle. As if this were not enough, two of his manuscript maps feature the signature of Francisco Stroza Gali.[3] If, in all ancient sources, the *Archivo General de Indias* (General Archive of the Indies) being the first, the name Francisco Gali or Galli is featured, then why would he add the name Stroza to his signature on those maps? This is one of the mysteries that remain unanswered.

As for his position, this also differs according to historical sources: pilot, pilot of the *Carrera de Indias* (the sea link between Spain and the Indies), chief pilot, captain,

commander in chief. It seems clear that he was a marine expert and, according to the documents of the *Archivo General de Indias*, on his death he held the post of captain.[4]

Neither is there unanimity with respect to the place where he died (Acapulco or Manila), although on this issue, documents do exist that settle the issue by establishing Manila (Philippines) as the place where death suddenly struck him down in early 1586 (León 2001).

It has also been written that he probably belonged to the family of *alarifes* (prominent master builders) established in Seville, although no document has been found to accredit this claim. Nothing is known about his time in Seville, how he was trained as a mariner, nor, most importantly, how he acquired skills as a cartographer. It has also been written that he arrived in *Nueva España* (New Spain) and resided in the colonial town of Tlacotalpa (now Tlacotalpan in Veracruz State). Although certain sources indicate that, during his stay in Tlacotalpa, Gali created its urban layout (Alvarez 1989). No evidence has been found to support this idea, and it can be concluded that possibly the urban layout of the Veracruz population has been confused with the map created by Gali for the *Relación Geográfica* of Tlacotalpa (Figure 3), where, instead of the map of the town, a nautical chart is developed that covers a wide region of more than 220 km of coastline, from Punta Gorda to mount of Minzapa.

Despite the limited number of maps in our possession that were produced by Gali (two signed and an attributable third), historical documents refer to him not only as a marine expert, but also as a cartographer and cosmographer. However, Francisco Gali is known worldwide for his transpacific journeys. He had already made several trips across the Pacific before March 1583 when, commissioned by Pedro Moya de Contreras, archbishop of Mexico and interim viceroy of New Spain, he left for Manila with two ships from Acapulco. He arrived in Manila in June and, after staying in the

Philippines for one year, Gali left for Macau, on the southern coast of China, in June 1584. From Macao, on July 29, Gali began the trip back to Nueva España, disembarking at the starting port, Acapulco, in January 1585 (Portillo 1982). With this background, Moya de Contreras thought of him as an ideal person to carry out an expedition of exploration of the north-western Pacific shore in order to investigate and trace the coastline. In addition, Gali had a mission to find a port that would serve as a naval station for colony ships from Manila heading towards Peru. In addition, he had to check whether the coast of the Americas was linked to that of Asia, by means of the supposed strait of Anian (Northwest Passage). With this mission set by Moya de Contreras, Gali left Acapulco again in March 1585 and arrived in Manila almost three months later, on 20 June 1585. There, waiting for vice-regal orders for their return, he realized that their ships were unsuitable for the return journey due to their unseaworthiness; he proposed building ships that would be more suitable for the crossing. In the midst of this enterprise, he died suddenly in January 1586.

On his transpacific voyages, Francisco Gali explored the archipelago islands of Hawaii, the coast of California and the Bay of San Francisco. He was the first explorer to sight this bay, although he did not cross it, and hence its discovery has historically been attributed to Gaspar de Pórtola in 1769 and to Juan de Ayala, who was the first to cross the bay on his schooner. On recounting his voyages, in 1585 Gali wrote *Viaje, descubrimientos y observaciones desde Acapulco a Filipinas, desde Filipinas a Macao y desde Macao a Acapulco*, (Voyages, discoveries, and observations from Acapulco to the Philippines, from the Philippines to Macao, and from Macao to Acapulco). The manuscript was sent to the Viceroy, but for reasons unknown, it fell into the hands of Jan Huygen van Linschoten (1563-1611), a Dutchman who published it in his language as *Defeat of the Indies* (Amsterdam, 1596, 1614, 1626). English (London, 1598) and

German translations were also published in the same year, and later in Latin (The Hague, 1599) and French (Amsterdam, 1610, 1619 and 1638). The whereabouts of the Gali original remain unknown, thereby forming yet another of the mysteries surrounding the biography of this character.

In the first half of 1580, Francisco Gali was travelling through the Strait of Tehuantepec to pass overland from the Atlantic coast to the Pacific Ocean, probably on an official mission to the Far East, as he is known to have done on several occasions. It was during this trip, when taking the opportunity of passing through several coastal towns where mayors were busy trying to answer the survey questions of the *Relaciones Geográficas*, that they commissioned the marine and cartographer expert to make maps of their regions. The mayors drew on Gali's capability to create the map that they had to include in their survey; he was a professional in his element, a sailor who passed through their ports, and who succeeded in submitting a graphic response to the king's questionnaire: a nautical map (Mundy 1996). There were three *Relaciones Geográficas* in which Gali intervened as a cartographer: Tlacotalpa (February 1580), Coatzacoalcos (April 1580) and Tehuantepec (September-October 1580). In Figure 2 these three places have been located. The first two maps are signed by the author, while the map of Tehuantepec remains anonymous, although it bears an unmistakable resemblance to the other two charts by Gali. However, being incomplete, this map merited little credit, especially since it was clearly not the product of the same measurement techniques applied in the other two pieces of work in the Gulf.[5] While for Barbara Mundy (1996) this map is simply a sketch, perhaps a preliminary draft that was to be perfected later by observation and measurement but could never be finished, Alexander Tait (1991) states that it is merely a copy of a chart made by a rather clumsy artist.

Figure 2. Location of the area depicted on the Gali's map in current satellite image. They have located Coatzacoalcos and Tehuantepec, where Gali also made a map for the *Relaciones Geográficas*.

RELACIÓN DE TLACOTALPA Y SU PARTIDO (RELATION OF TLACOTALPA AND ITS ADMINISTRATIVE AREA) [FEBRUARY 1580]

The *Relación* of Tlacotalpa or Tlacotlalpa (now Tlacotalpan, in State of Veracruz, Mexico), belonging to the Bishopric of Tlaxcala, was carried out from 18 to 22 February 1580, with its mayor, Juan de Medina, taking the leading role. The editor of the survey was the royal scribe Juan de Molina. The informants were two Indians, inhabitants of the town. In the text of the *Relación*, the term *Tlacotlalpa* is used, while the place name employed on the map is *Tacotalpa* (Manso 2012). The region is located on the coast in the Gulf of Mexico. The text of the *Relación* and its accompanying map, created by Francisco Gali, have been conserved. Both can be found in Madrid. According to the text of the *Relación*, in the local language –náhuatl-, *Tlacotalpa* means starting land, which refers to the town that was originally founded in pre-Hispanic times on a river island in the Papaloapan River, as shown on the map.[6] In 1580, Tlacotalpa had five *estancias* (smallholdings) under its jurisdiction: Atlizintla (now Alvarado), Tlazintla, Chuniapa, Tlapazula (now Tlapazola) and Ahuateopa (now Aguateupa) (Paso 1905). In the text of the *Relación*, Gali is described by its mayor as someone who 'has travelled and taken all latitudes and the locations shown here'. Through the contents of the *Relación* it is also known that, in order to create the map, Gali visited some of the coastal sites.

Map of Tlacotalpa

This is a manuscript map drawn on bond paper measuring 43x31 cm in black ink and illuminated with a watercolour wash (Figure 3). The map was drawn on two sheets

joined in the middle. The upper half, where the legend is, was cut in a trapezoidal shape, mimicking the shape of the animal skin parchment on which Cosmographers made portolans and nautical charts during the XIII, XIV, XV and XVI centuries. It is oriented with a compass rose, which occupies the central part of the map. On this manuscript, there is a legend in which the latitudes of the ten locations represented are related. Its graphical scale is in leagues. If a longitude of 634.170 cm is taken for geographical league, then the resulting scale for the map is 1/431.408 (Manso 2012). The mayor of Tlacotalpa, Juan de Medina, added a hand-written inscription on the map underneath the league scale, proudly assigning the authorship thereof to Francisco Gali, thereby authenticating this map as one of the few in the corpus of the *Relaciones* whose author is irrefutably known (Mundy 1996). The inscription indicates that Francisco Stroza Gali made the map 'as a person who has walked and probed all heights and parts contained herein'. Next to the signature of Mayor Medina, Gali has placed his own signature, dating it as 5 February 1580. Gali also conducted surveys to measure the depth of the water in certain areas; these depths are indicated in writing on the map.

The map represents an extensive coastal region located in the southwest of the Gulf of Mexico, adjacent to the Strait of Tehuantepec (Figure 2). It ranges from Punta Gorda, a reef to the northeast of the present city of Veracruz, to Pan de Minzapa, a high mountain near the coast, belonging to the volcanic mountains of the Sierra de los Tuxtlas, which served as a beacon to ships. The style is clearly that of a nautical chart due to the minutely detailed representation of the contours of the coastline, the course of the rivers, coastal lagoons, and brackish estuaries, and also of the islands and reefs residing off the coast, particularly in the area of San Juan de Ulúa, where the city of Veracruz would later be settled. The hinterland is hardly represented at all, (it is largely flat since it is virtually at sea level), except the layout of a few roads that connect towns

and the mountainous area to the right of the map. In this area, there are some mountainous undulations that increase towards the east. They are the first foothills of the Sierra de los Tuxtlas, a volcanic mountain range that runs along the Veracruz coast of the Gulf of Mexico.

In the mouths of some rivers, in reef areas and in the channels formed off the coast between the flooded sandbanks, the water depth is indicated. The coastline is outlined in minute detail, as well as numerous coastal lagoons and sounds formed between the mouths of rivers. Gali used shading by means of short fine lines to emphasize the coastline and riverbanks. The water of the coast and rivers is represented with a green watercolour wash. The various lagoons between the coast and the rivers that flow into it are shaded by means of dots; a convention that is also used to indicate the sandbanks and reefs in the sea. The relief of the mountains is represented by their profiles (hill in the side view), which are shaded in a similar way to the coastline, with fine-line stripes in an effort to give the illusion of volume, by means of the shadow effect that a light from the west would produce on the hills. The towns, farms, and inns (stopping places for travellers) are represented by a house (two buildings are drawn for Tuxtla) illuminated in pink, with a gabled roof, and even a chimney in some cases. The buildings sit on the shaded profile of one or more hills. Moreover, a number of roads, represented by a fine line, link some of the towns, and also these towns with certain places on the coast.

Figure 3. *Relación Geográfica* map of Tlacotalpa. Francisco Gali, 1580. Source: Royal Academy of History, Madrid.

Methodology for the planimetric analysis of the map

For the planimetric study, work has been carried out with a scanned image of the map in high resolution. This image has been processed with a CAD program.[7] This has allowed

us to make a restoration of the original image, whereby all the elements that compose the map are redrawn and the information obtained is organized into different layers: contour lines (coastlines, rivers, lakes and islands), relief, houses, roads, legends, shading, etc. (Figure 4). This also allows us to analyse and compare the underlying information into the map, abstracting it from the pictorial image which it is immersed.

Although it would not be correct to evaluate a manuscript map of the sixteenth century exclusively in terms of its accuracy, since it contains other values, a comparative study of the map of Gali with a recent basis map has been made.[8] For this purpose, we analysed the map by using the MapAnalyst software (Jenny and Hurni 2011).

Figure 4. *Relación Geográfica* map of Tlacotalpa. Redrawn version.

Planimetric analysis of the map

Table 1 shows the geographical coordinates of latitude as indicated in the map legend for ten places in the region under study. These coordinates are compared with those obtained by means of Google Earth™ for the same places. In all cases, the measurement, which was most likely taken by Gali with his marine astrolabe, is greater than the actual latitude: the maximum deviation is of 1º 20' and the minimum of 48'. The northernmost place represented on the map is Punta Gorda, whose latitude is 19º 14,5' 49". The most southerly place represented on the map is Pan de Misapa, whose latitude is 18º 20' 17". Therefore, the maximum latitude covered by the map is 55' 2".

Although latitude was determined by astronomical observations (during the day by meridian altitude of the sun, at night by measuring the altitude of Polaris), the relative error of the deviation indicated in Table 1 has been calculated based on the min / max latitude coordinates covered by the Gali's map. In absolute terms, the errors

committed by Gali in the measurement latitudes could be due to an instrumental error. In the late sixteenth century, we can find in America coastal charts latitude errors up to 3° (Cerezo 1994).

Table 1. Latitudes recorded by Gali and indicated in the map legend

	Toponym		Latitude		Gali's error	
Nº *	Gali's map legend	Its modern counterpart	Map Legend	Google Earth	Deviation	Relative error **
14	sant Juandeolua	San Juan de Ulúa	18º 12' N	19º 12'	-1º 00'	-109,02%
36	punta deanton niçardo	Punta Antón Lizardo	18º 8' N	19º 03'	-0º 55'	-99,94%
42	boca de aluarado	Boca de Alvarado	17º 52' N	18º 47'	-0º 55'	-99,94%
40	Roca partida	Roca Partida	17º 22' N	18º 42'	-1º 20'	-145,37%
18	tacotalpa	Tlacotalpan	17º 48' N	18º 36'	-0º 48'	-87,22%
19	taliscoja	Tlalixcoyan	18º 0' N	18º 48'	-0º 48'	-87,22%
21	tustla	Santiago Tuxtla	17º 15' N	18º 27'	-1º 12'	-130,83%
17	tlacintla	Saltabarranca	17º 30' N	18º 35'	-1º 05'	-118,11%
05	guateupa	***	17º 50' N			
20	tapacula	***	17º 50' N			

* The identification numbers correspond to those indicated in redrawn version of map (see Figure 10).
** Relative error of the deviation based on the max / min latitude covered by the map.
*** Both villages were subject to Tacotalpa, but then disappeared. Today there is no vestige of them.

Table 2 shows the comparison of a number of distances taken on the map in the direction parallel to the coastline (northwest-southeast) with the measurements obtained from a 'modern' map. It is striking that the second largest longitude on the map between two control points, San Juan de Ulúa-Punta de Zapotitlán, presents the minor relative error of 1.3%. However, a similar segment in terms of the situation of control points and the longitude thereof, such as the one from San Juan de Ulúa to Roca Partida (cape), yields a high relative error of 22.1%. From the analysis of the data obtained for the longitudes in the direction parallel to the coastline, it can be deduced that, although in general the measured distances on the map are greater than the actual distances. There are also cases where the opposite is true; no pattern exists for the error, neither in magnitude nor in the sign (positive or negative).

Figure 5. Control points and segments to compare distances and calculate errors.

Table 2. Distances between control points in the northwest-southeast direction (parallel to the coastline)

Nº ∗	Segment	Distance on the map	Actual distance	Difference	Relative error
14-35	San Juan de Ulúa-Pan de Minzapa	161,5 Km	182,3 Km	-20,8 Km	-11,4%
14-39	San Juan de Ulúa-Punta de Zapotitlán	155,6 Km	157,7 Km	-2,1 Km	-1,3%
14-40	San Juan de Ulúa-Punta Roca Partida	139,8 Km	114,5 Km	25,3 Km	22,1%
14-42	San Juan de Ulúa-Boca de Alvarado	69,1 Km	61,7 Km	7,4 Km	12,0%
42-40	Boca de Alvarado-Punta Roca Partida	74,2 Km	61,7 Km	12,5 Km	20,3%
14-36	San Juan de Ulúa-Antón Lizardo	30,2 Km	24,0 Km	6,2 Km	25,8%
36-42	Antón Lizardo-Boca de Alvarado	39,3 Km	38,8 Km	0,5 Km	1,3%
36-40	Antón Lizardo-Punta Roca Partida	111,9 Km	91,3 Km	20,6 Km	22,6%

∗ The identification numbers correspond to those indicated in redrawn version of map (see Figure 10).

In Table 3, a comparison is performed similar to that in Table 2, with the difference that the segments analysed are now perpendicular to the coastline (northeast-southwest). Although apparently in this direction the relative errors obtained are similar or even lower than those of Table 2, the fact is that the shape of the coastline is compressed in the northeast-southwest direction, as can be seen in Figure 8. Gali represented the mouth of the Alvarado River and the whole system of coastal lagoons in its surroundings as displaced into the Gulf of Mexico some 6.5 km, thereby compressing the concave shape of the coast. Francisco Gali may have based this map on an existing nautical chart in order to obtain a pattern from the coast, upon which he made adjustments and corrections with the measures he had personally taken (Mundy 1996).

Table 3. Distances between control points in the northeast-southwest direction (perpendicular to the coastline)

Nº ∗	Segment	Distance on the map	Actual distance	Difference	Relative error
14-19	S. Juan de Ulúa-Taliscoya	56,1 Km	47,5 Km	8,6 Km	18,1%
36-19	Antón Lizardo-Taliscoya	29,9 Km	29,8 Km	0,1 Km	0,3%
02-18	Alvarado-Tacotalpa	26,7 Km	22,4 Km	4,3 Km	19,2%
15-18	Siquiapa-Tacotalpa	13,8 Km	12,7 Km	1,1 Km	8,7%

∗ The identification numbers correspond to those indicated in redrawn version of map (see Figure 10).

Finally, in Table 4, the distances between some of the towns represented on the map are compared. As in the results in the other comparisons, the differences vary from

a negative value up to the positive values that yield relative errors ranging from 2.5% to 36%. In Figure 5, they are plotted and compared all segments whose data shown in Tables 2, 3 and 4.

Table 4. Straight line distance between populations (*)

Nº **	Segment	Distance on the map	Actual distance	Difference	Relative error
14-21	San Juan de Ulúa-Tuztla	136,2 Km	128,6 Km	7,6 Km	5,9%
14-02	San Juan de Ulúa-Alvarado	64,9 Km	61,7 Km	3,2 Km	5,3%
14-18	San Juan de Ulúa-Tacotalpa	91,2 Km	82,6 Km	8,6 Km	10,4%
18-21	Tacotalpa-Tuztla	52,1 Km	50,5 Km	1,6 Km	3,2%
19-21	Taliscoya-Tuztla	100 Km	97,5 Km	2,5 Km	2,6%
02-21	Alvarado-Tuztla	74,1 Km	59,8 Km	14,3 Km	23,9%
18-07	Tacotalpa-Ingenio del Marqués	42,2 Km	31,0 Km	11,2 Km	36,1%
19-02	Taliscoya-Alvarado	29,9 Km	30,2 Km	-0,3 Km	-1,0%
42-18	Boca de Alvarado-Tacotalpa	22,9 Km	21,1 Km	1,8 Km	8,5%

* Only some routes have been compared because it has not been possible the exact location of places, because they have disappeared and there are no references to its old location.

** The identification numbers correspond to those indicated in redrawn version of map (see Figure 10).

In addition to the previous analysis, map geometry has been analysed using MapAnalyst, a digital tool for determining the planimetric accuracy of historical maps. We have made two comparisons. One with the eight places whose latitudes were determined by astronomical observations and which are listed in the map legend. Then another comparison was made using 18 points that could be located on a reference map. In the first comparison (Figure 6) the map has a global scale of approximately 1:379.900. The global rotation is around 32 degrees in counter clockwise direction, the standard deviation is ±6.416 m and the mean position error is ±9.073 m.

Figure 6. Distortion grid and displacement vectors on Gali's map. Eight control points have been used, corresponding to places whose latitudes are listed in map legend. Each mesh corresponds to a surface of 5000 by 5000 meters in the new reference map. Produced by MapAnalyst.

In the second comparison (Figure 7) the map has a global scale of approximately 1:438.300. The global rotation is around 28 degrees in counter clockwise direction, the standard deviation is ±10.358 m and the mean position error is ±14.649 m.

Figure 7. Distortion grid and displacement vectors on Gali's map. Eighteen control points have been located on a reference map. Each mesh corresponds to a surface of 5000 by 5000 meters in the new reference map. Produced by MapAnalyst.

FINAL CONSIDERATIONS

Of the maps and plans that accompanied the survey of the sixteenth-century *Relaciones Geográficas* that have survived, the vast majority failed to meet the characteristics of scientific mapping. In such a vast corpus, hardly any examples were made to scale, nor were measurements often taken in situ, nor were many astronomical observations performed, which were essential operations to attain cartography in line with the European standards of the time.

In this context, an exceptional figure emerges: an important, trained and capable character, the captain and cosmographer, Francisco Gali (Morales 2001). The method used by Gali to create these maps was certainly compatible with the techniques used at the time to make large-scale maps of the coast, and therefore the maps made for the *Relaciones Geográficas* are sufficiently detailed to be used in coastal navigation. As regards the representation of the terrain in these maps, on having been drawn according to the canons of nautical charting (Morales 2001), focus was centred on those aspects useful for navigation, without especially addressing any particular geographical features of the interior.

In the case under study of the map that accompanies the *Relación* of Tlacotalpa, Gali wrote the record of the latitudes of ten places in the map legend, and due to an error in transcription or instrumentation, their readings suffered a deviation of between

48’and 1º 12’; these mistakes were later avoided in the map of Coatzacoalcos (Mundy 1996, Price 1957).

On collecting data to create the map, for the measurement of the angle of elevation of the sun and the North Star, Gali probably used the compass and the marine astrolabe; instruments often used in navigation in that period (Mundy 1996). To verify this even further, whenever there was sufficient space on the document, Gali drew a compass rose in the centre of the map. In addition, he trimmed the rectangular sheet of paper like an animal-skin parchment used for medieval and renaissance nautical charts.

The map of the *Relación* of Tlacotalpa (1580) is a nautical chart which, in great detail, shows the coastline, estuaries, bays, lagoons and rivers, and indicates the water depth in some areas. However, it is not surprising that, in this work by a mariner, the locations of the inland towns present greater errors than those detected for positions on the coast. From the results obtained on the comparison of the latitudes recorded on the map with current latitudes, it follows that the error in almost all cases is similar, and hence it is reasonably likely that the error is due to a failure of the measuring instrument. For an experienced mariner like Francisco Gali, the determination of the latitude, both onshore and offshore, was a procedure that he most certainly should have known. One could also consider the hypothesis that, since he was only passing through those lands, Gali was unable to devote sufficient time to carry out the measurements with greater precision.

To draw the map of Tacotalpa, Gali possibly used the latitudes determined by astronomical means, as well as a series of measurements of directions and distances - with the help compass- both at sea and on the land. In addition, he had to make notes about the landforms and measured with a probe the depth in different parts of the coast, as well as in lagoons and the mouth of some rivers.

Figure 8. Gali's map versus current satellite image. Based on the displacement vectors calculate by MapAnalyst.

From the planimetric map analysis, it follows that, in the region of Tlacotalpa, Gali could not measure the positions of the inland towns since the distances are compressed along the northwest-southeast direction, that is, perpendicular to the coastline, as can be observed when it is compared with a satellite image of the area (Figure 8). The planimetric deformation of the map, compared to a current version, leads us to think that Gali took insufficient measurements or that they were carried out too quickly. It could also be due to his having used an existing outline of the coast that already had these deformations, thereby limiting the author of the map to completing the information through the addition of places and the detailing of geographic features. This conjecture posits Bárbara Mundy (Mundy 1996) is quite plausible since Francisco Gali, as pilot and captain, probably had copies of the *padrón real* (master map) obtained at the House of Trade in Seville before departing for their trips to overseas, especially when he was commissioned by the viceroy of New Spain to explore the coast of Baja California. Unfortunately, there are no surviving any copy of the *padrón real* because the secrecy of cartography produced and controlled by the Council of the Indies.

On observing how thoroughly Gali delineates the coast, it can be seen that he makes a very faithful representation as to the shape, leaving a striking resemblance in some areas between his sixteenth-century map and current maps (Figure 9). However, despite this detailed observation of coastal profiles, the distances present major differences with respect to current maps, which may well have been caused by the lack of in situ measurements and by the impossibility of determining longitude in the sixteenth century.

The results obtained with MapAnalyst suggest that Gali drew his map based on points whose latitudes determined by astronomical observations. Possibly the rest of points situated them on the map by partial measurements made by direct observation in the field. In the two cases analysed, using eight and eighteen control points respectively, it is observed that the deformation and the displacements increases towards the southeast corner (to the right of the map), where it is maximum.

Figure 9. Gali's map versus current satellite image. Details.

As can be seen in Figure 9, despite the distortion of angles and distances, in some places the coastline delineated on the Gali's map is quite similar to the present coastline. The exception is found in the area where the current city of Veracruz and San Juan de Ulúa sits. In 1580, when the map was made, Veracruz occupied a location more north of the present one, in lands located outside the area represented in the map. The islet of San Juan de Ulúa became over time an artificial peninsula to connect its fortress with the port of Veracruz.

Table 5 it shows the transcription of the legends and inscriptions of the map, grouped by category (toponyms, landforms, rivers, etc.). The first column indicates an identification number that corresponds to the redrawn version of map (Figure 10).

Table 5. Map's inscriptions

Nº	Toponym	Its modern counterpart (inscription's translation)
01	Ato del marqués	El Marqués?
02	Alvarado	Alvarado
03	Caxiapa	Village disappeared
04	Estancia de Juan Sarmiento	(Livestock ranch)
05	Guateupa (Aguateupa)	Village disappeared
06	Hacienda de Pedro López	(Farm)
07	Ingenio del marqués	Paso del Ingenio
08	Isla Blanca (1)	Missing island
09	Isla Blanca (2)	Missing island
10	Isla Verde	Isla Verde (island)
11	Marqués	Village disappeared
12	Mitanquautla	Metlangutla or Mictlancuauhtla. Village disappeared

13	Sacrificio	Isla Sacrificios
14	San Juan de Olua	San Juan de Ulúa
15	Siquiapa (Chuniapa)	Village disappeared
16	Spiche	Espiche or Hospichán, probably Oxichan, village disappeared
17	Tacintla (Tlazintla)	Saltabarranca
18	Tacotalpa	Tlacotalpan
19	Taliscoja (Taliscoya)	Tlalixcoyan
20	Tapacula (Tapachula?)	Village disappeared
21	Tustla	Santiago Tuxtla
22	Venta de Buitrón	Veracruz city center (Venta: inn, hostelry)
23	Venta de Ramírez	(Venta: inn, hostelry)
24	Xaruco	Village disappeared
Nº	Landforms	Its modern counterpart (inscription's translation)
25	Anegadas	(Marshy sea-coast)
26	Anegada del medio	(Marshy sea-coast)
27	Cabeza del varado	Small island in the reef system of Veracruz, off the shore of Antón Lizardo
28	Laguna	Laguna Mandinga Grande (Lagoon)
29	Laguna	(Dried lagoon?)
30	Laguna de la Sierra con 4 pies de agua	Laguna Sontecomapan or San Andres lagoon (It has 4 feet of water depth)
31	Médano blanco	(Médano: sandbank)
32	Médano gordo	(Médano: sandbank)
33	Monte de carnero	Monte de Carneros. Hill near the port of San Juan
34	Ostial	(Entrance to a ship canal)
35	Pan de Misapa (Minzapa or Minzapan)	Ancient volcano, currently San Martin hill. It was a very high mountain, near the coast, that served as a beacon for the boats.
36	Punta de Antón Niçardo	Antón Lizardo (cape)
37	Punta de Lagarto	Laguna Punta Lagarto (lagoon)
38	Punta Gorda	Entrada a Punta Gorda (cape)
39	Punta de Zapotitlán	Punta de Zapotitlán (cape)
40	Roca Partida	Roca Partida (cape)
41	Stero (estero)	(Marshy ground)
Nº	Rivers (inscription)	Its modern counterpart (inscription's translation)
42	Río de Alvarado (con 16 pies de agua y pueden entrar naos de 150 toneladas)	Río Papaloapam (It has 16 feet of water depth where vessels of 150 tons can enter)
43	Río de Cañas (con 12 pies de agua)	Río Cañas (It has 12 feet of water depth)
44	Río de Medellín (con 3 pies de agua)	Río Jamapa (It has 3 feet of water depth)
45	Río de Belgara	Arroyo (stream) Vergara
Nº	Others inscriptions	inscription's translation
46	Aquí se perdió la nao de Justiniano	Justiniano boat was lost here
47	El batel	Skiff
48	Embarcadero	Jetty
49	Palo	Skiff
50	Por este canal 32 pies de agua	On this canal 32 feet of water
51	Por este canal 40 pies de agua	On this canal 40 feet of water

Figure 10. *Relación Geográfica* map of Tlacotalpa. Redrawn version. Detail.

Acknowledgements

The author would like to thank anonymous reviewers for their valuable comments and ideas that helped to shape and restructure the paper into its current state; and to Magda Huerta for her invaluable help with the paleographic transcription.

Notes

1 For more information in English, see Sandman 2007.

2 The questionnaire was published as a Royal Cedula in San Lorenzo de El Escorial on May 25, 1577 under the title of *Cédula, instrucción y memoria para la formación de las Relaciones y descripciones de los pueblos de Indias*.

3 Among the authors that use the surnames Stroza Gali are: Howard F. Cline, 1972. Rene Acuna, 1982. Jean-Pierre Berthe, 1991. Barbara Mundy, 1996. Richard L. Kagan, 2000 and Ricardo Padron, 2004; among others. In the documents found in the *Archivo General de Indias* the name used in all cases is Francisco Gali, like in classical historiography of the time.

4 AGI, FILIPINAS, 18A, R.5, N.30. Carta de la Audiencia de Manila con 31 puntos.

5 However it does contain references to geographical coordinates, so the legend contained in the top of the map, the author wrote: 'The whole coastline is of this view and a height of northern latitude sixteen fair degree'.

6 Over time, the site of the town of Tlacotalpan had moved to its current location, somewhat farther north, on the banks of the river Papaloapan, at the confluence with the river San Juan; so, the riverine town ceased to occupy the river island to settle permanently on the mainland.

7 We have used Cad-Earth™ and AutoCad™.

8. In its context, the map of Tlacotalpa has many interesting aspects, such as its meticulous style in the representation of geographic features. The information that the author adds to the map by means of the legends should also be highlighted, such as bathymetric depth of the areas where this information is vital for coastal navigation.

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Table 1. Latitudes recorded by Gali and indicated in the map legend.

Table 2. Distances between control points in the northwest-southeast direction (parallel to the coastline).

Table 3. Distances between control points in the northeast-southwest direction (perpendicular to the coastline).

Table 4. Straight-line distance between populations.

Table 5. Map's inscriptions.

Figure 1. *Dibujo de la costa del golfo de México desde la península de Florida hasta Nombre de Dios* (Sketch of the coast of the Gulf of Mexico from the Florida peninsula to Nombre de Dios), 1519. [AGI, MP-Mexico,5] Source: Archivo General de Indias, Sevilla.

Figure 2. Location of the area depicted on the Gali's map in current satellite image. They have located Coatzacoalcos and Tehuantepec, where Gali also made a map for the *Relaciones Geográficas*. Image prepared by the author.

Figure 3. *Relación Geográfica* map of Tlacotalpa. Francisco Gali, 1580. [RAH, C-028-017] Source: Royal Academy of History, Madrid.

Figure 4. *Relación Geográfica* map of Tlacotalpa. Redrawn version. Image prepared by the author.

Figure 5. Control points and segments to compare distances and calculate errors.

Figure 6. Distortion grid and displacement vectors on Gali's map. Eight control points have been used, corresponding to places whose latitudes are listed in map legend. Each mesh corresponds to a surface of 5000 by 5000 meters in the new reference map. Produced by MapAnalyst.

Figure 7. Distortion grid and displacement vectors on Gali's map. Eighteen control points have been located on a reference map. Each mesh corresponds to a surface of 5000 by 5000 meters in the new reference map. Produced by MapAnalyst.

Figure 8. Gali's map versus current satellite image. Based on the displacement vectors calculate by MapAnalyst. Image prepared by the author.

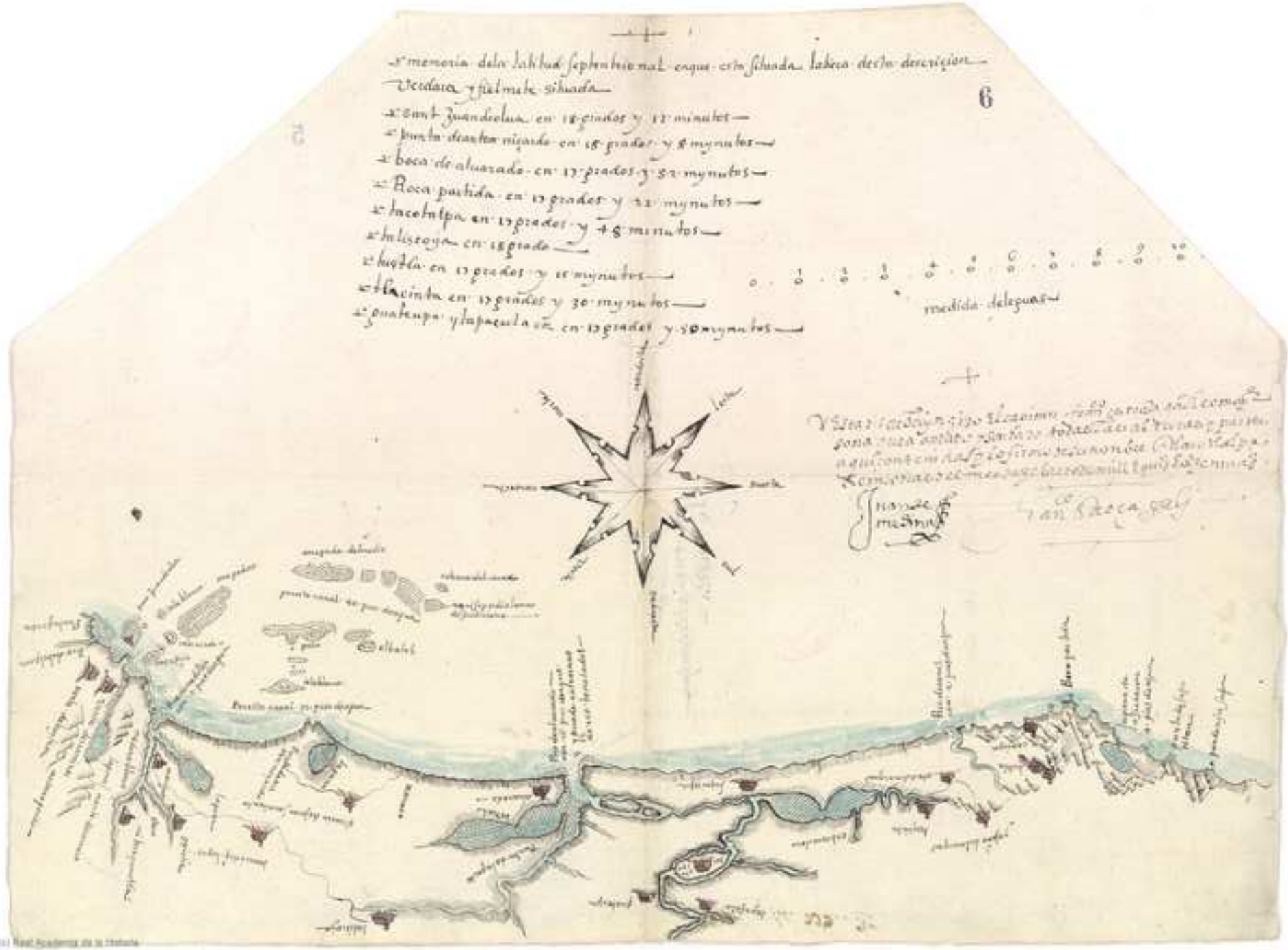
Figure 9. Gali's map versus current satellite image. Details. Image prepared by the author.

Figure 10. *Relación Geográfica* map of Tlacotalpa. Redrawn version. Detail. Identification numbers are shown.

Colour figure

Colour figure

Colour figure



Colour figure

memoria de la latitud septentrional en que está situada la tierra de esta descripción verdadera y fielmente situada

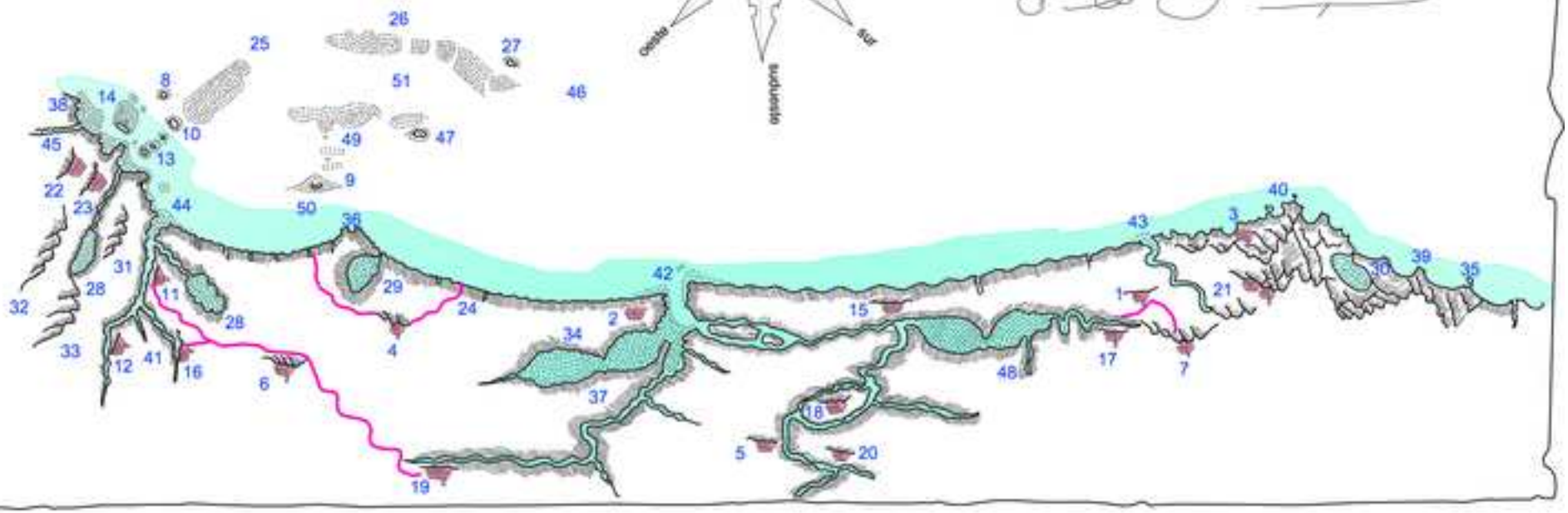
* san juan de olua en 18 grados y 12 minutos --
* punta de anton nicardo en 18 grados y 8 minutos --
* boca de alvarado en 17 grados y 52 minutos --
* Roca partida en 17 grados y 22 minutos --
* tacotalpa en 17 grados y 48 minutos --
* taliscoya en 18 grados --
* tustla en 17 grados y 15 minutos --
* tlacintla en 17 grados y 30 minutos --
* guateupa y tapacula en 17 grados y 50 minutos --

1 2 3 4 5 6 7 8 9 10

medida deleguas --

norte nordeste leste sureste sur suroeste oeste noroeste

Esta descripción la hizo el capitan francisco sttroza gali como persona que ha andado y sondado todas las alturas y partes aqui contenidas firmo de su nombre Tlacotlalpa
cinco de febrero de mil quinientos ochenta



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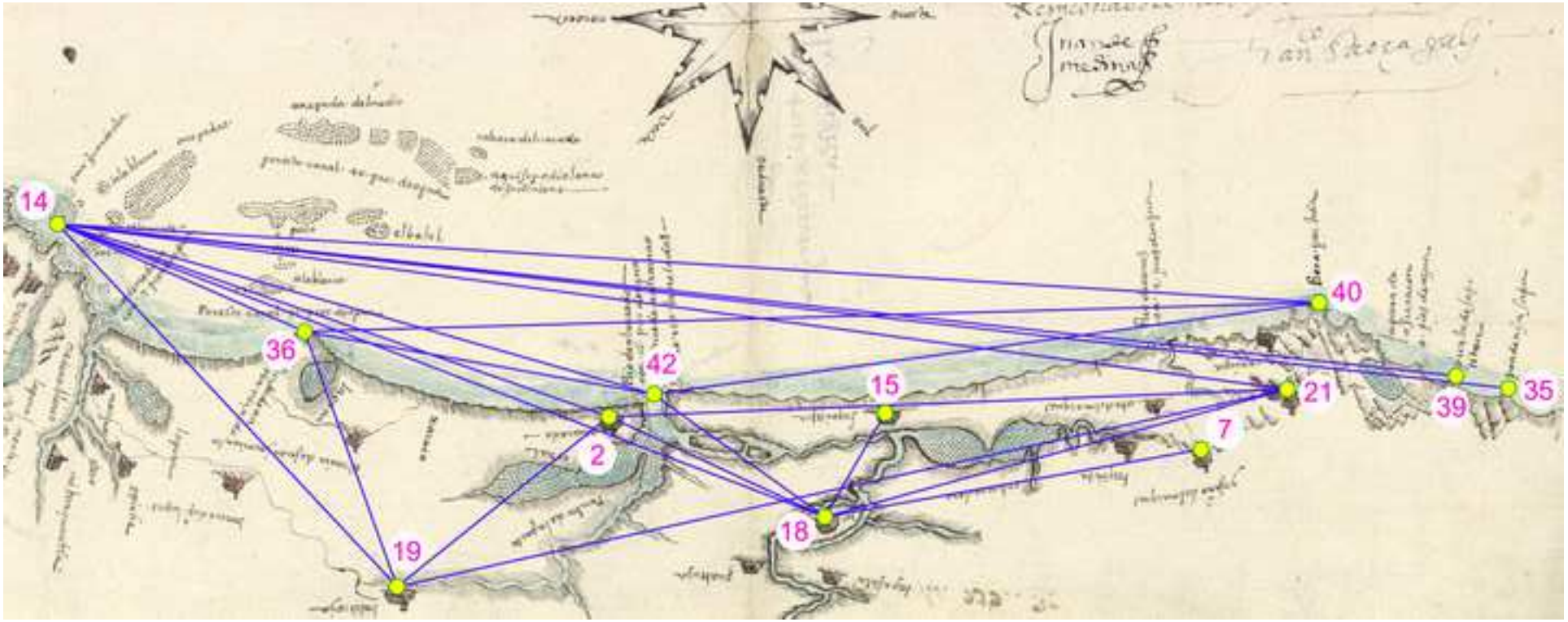

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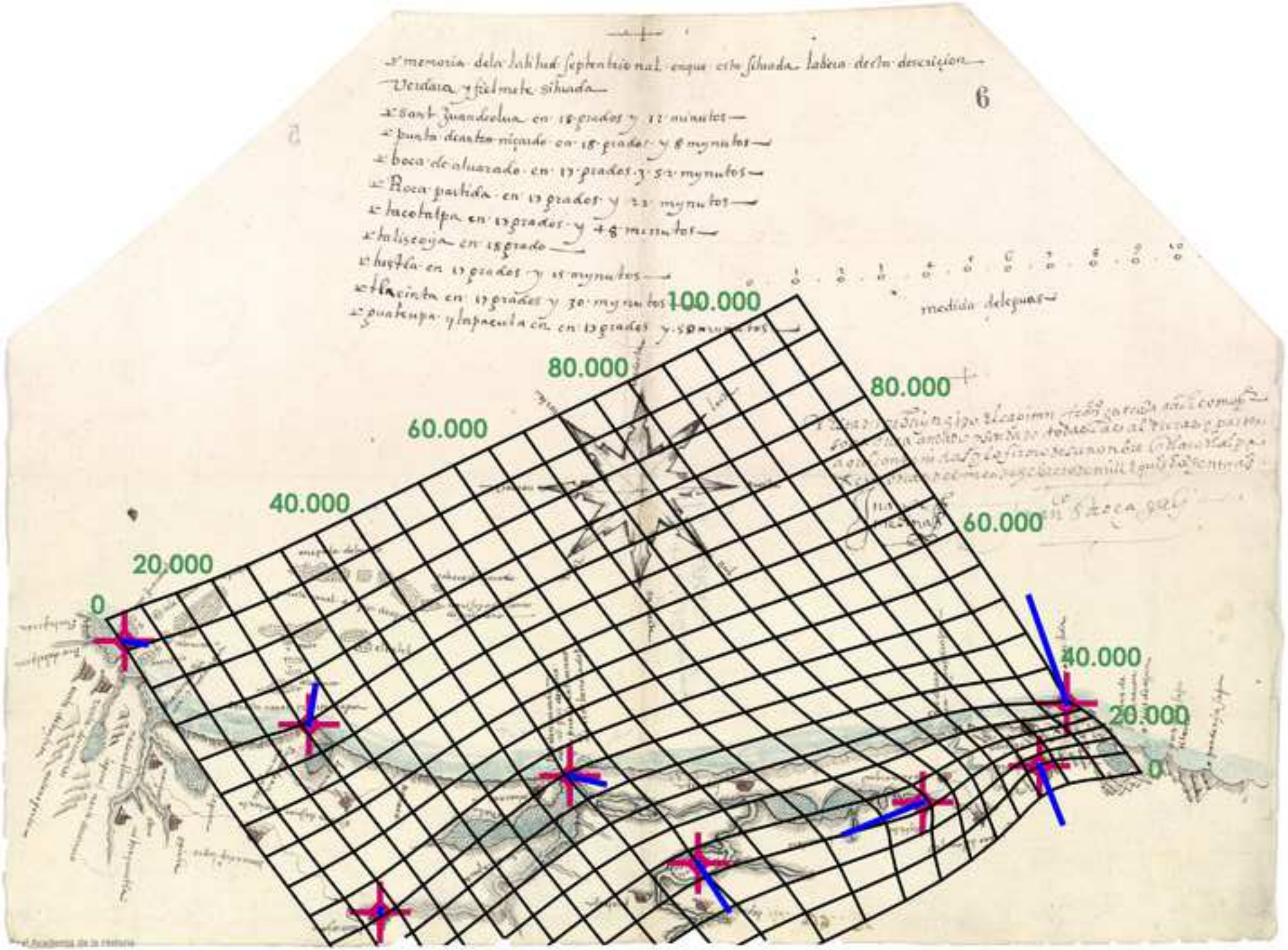

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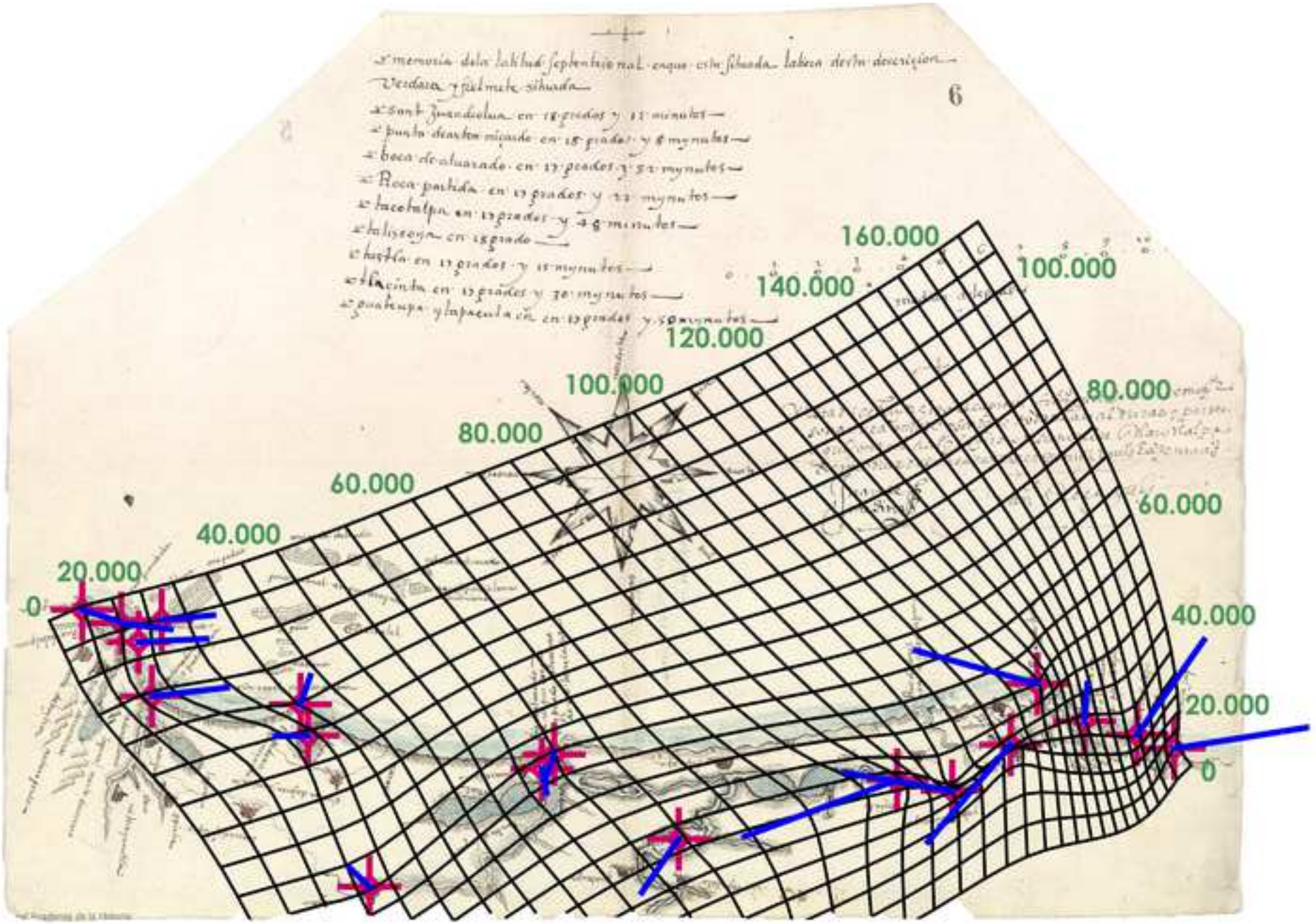

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