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ORIGINS OF THE TWO-DIMENSIONAL RELIEF REPRESENTATION ON SOME SPANISH AMERICAN MAPS IN THE SIXTEENTH CENTURY

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I. INTRODUCTION

From the beginning of cartography to the discovery and systematization of the contours in the eighteenth century, the land-relief is represented by the usual cartographic convention of hill profiles. Figures like Cruquius, Bauche, Ducarla or Dupain-Triel were the precursors of the scientific method to represent terrain and its relief on the same map. During the Spanish conquest and colonization of America, many regional maps were made in the sixteenth century. In this vast corpus, we have found some examples in which can be seen methods for depicting terrain that do not follow the usual pattern at the time of hill profiles. The study of these methods reveals a striking similarity to the techniques used by to represent the terrain relief two centuries later by the contours. Maps discussed in this article show the originality of representing terrain relief with a different from the commonly used method. Do not try to represent the mountains in profile view, or oblique perspective of a high perspective or bird's-eye view; but intuitively seem to want to represent the relief in a plan view.

II. OBJECTIVE AND METHODOLOGY

The objective of this paper is to show that the studied cartographic documents can be, to some extent, an empirical or intuitive anticipation of modern surveying methods used for the representation of landforms that developed nearly two hundred years after these maps were drawn. In a post-Harley context, our focus is not on a social, philosophical or ideological history of the map. Harley himself wrote, 'My reading of the map is not technical one (this already has a voluminous literature) but a political one'. Current cartographic production has as a premise to provide an accurate picture of the Earth's surface. However, this should not mean that the study of old maps focuses on the comparison of these cartographic documents with contemporary representations, in terms of topographic accuracy, conformity with

represented space and conventions are concerned. This approach focuses on study of cartographic documents but also as an expression of geographic knowledge of a particular time.

The methodology used in our research starts with a first phase of localization of the cartographic documents of interest to us for the proposed objective. We then proceeded to a second phase, the individual analysis of each graphic document, in terms of both their physical characteristics and their contents. For the analysis of each image, we start from a brief historical survey of it, placing it in its proper spatiotemporal context. The basic rule of historical method is that documents can only be interpreted in their context. The rules applies equally to maps, which must be returned to the past and situated squarely in their proper period and place.

In a second step, we proceeded to the individual analysis of each map, taking care of both their physical characteristics and their contents. Thanks to modern techniques of scanning in high resolution images, we have been able to make a thorough examination of each map, analysing details that hardly could be seen working with the original document. There has been a work of redrawing each map, according to different levels of study: landforms, hydrography, relief, settlements and populations, vegetation, roads, place-names, etc. This also allows us to analyse and compare the underlying information into the map, abstracting it from the pictorial image in which it is immersed.

III. BACKGROUND OF CONTOUR LINES

The scientific representation of terrain altimetry is considered to have begun with the discovery of contour lines. The precedents of relief depiction by contour lines do not come from land surveying but rather from representations of hydrography beds. Therefore, it can be said that contour lines appear chronologically before bathymetry that topography.

The earliest representation of isobaths discovered so far is found in a manuscript map, dated 1584, of the Dutch surveyor Pieter Bruinss. This map, quite astonishing for its time, shows a 7-foot depth line off Het Spaarne, near Haarlem. The map represents a section of Spaarne, a partly channeled river in North Holland that connects Ringvaart's canal with a branch of the canal of the North Sea. This document is considered the first bathymetric representation because it contains a dashed line connecting points of equal depth.

A century and a half later, in 1730, another Dutchman, Nicolaus Samuelis Cruquius (1678-1754), represented the bed of the Merwede estuary in the confluence of the Maas and Waal rivers. In 1738, this method was used by French engineer Philippe Bouache (1700-1773), who drew a bathymetric map of the English Channel based upon previous practices used by navigators to measure the seabed using probes that measured differences in levels below water level, drawing a line on a map connecting points of equal measure. These precedents correspond to the planimetric representation of the depth of hydraulic beds. In 1771, Du Carla created the first contour map of an imaginary island –and finally, in 1791, Dupain-Triel compiled the first contour map of an existing land surface, that of France.

Therefore, except for the case of Leonardo da Vinci, it is commonly accepted that the planimetric representation of the earth's surface did not begin until the end of the eighteenth century. However, there is strong evidence that in the cartography produced during the discovery and colonization of America, empirical methods were used for relief depiction –in

plan view–, as in the works of Leonardo in Tuscany, these can be considered precedents of modern methods for depicting terrain that use a graphical system to represent land relief on a horizontal plane. In chronological order, these cartographic documents are the map of Captain Diego Palomino, 1549; *Relación Geografica* map of Huehuetlán, 1579; and *Relación Geografica* map of San Miguel and San Felipe of the Chichimecas, dated 1580.

IV. SKETCH MAP OF CAPTAIN PALOMINO'S CONQUEST, 1549

The map of Palomino represents, with acceptable accuracy, the hydrography of the region discovered by the author and is designed as a sketch. The map has an unusual orientation because the East-West direction coincides with one of the diagonals of the drawing, which is represented by the figures of the sun in the upper right corner and the moon in the opposite corner. The plan of the town of Jaen, which Palomino re-founded and named in honor of his hometown, is aligned with the cardinal points. The Spanish towns, Indian villages and the sparse vegetation present on the map are represented by elevation (profile). Jaen and Guancabanba, the two most important towns of the region, are represented differently than the others. Jaen and Guancabanba are represented by the plan of a walled enclosure with an oval form, inside of which the elevation of an important church or cathedral is drawn on a basement with three towers topped by pyramidal roofs. To represent the towns the author of the map seems to have used a sketch of each village instead of a sign or convention, as we found in many cases in the cartography of the era, where they function as metonymic signs: church = town of Spanish, hut = village of Indians.

To represent the orography, Palomino uses sinuous lines -usually open- around the hydrographic network and populations. Principal curves and construction or auxiliary curves are distinguished. Construction curves are drawn with a tenuous fine line. We do not find any signs about the representation of relief through hill profiles, the most usual convention used in Cartography from its origins.

The sinuous lines move away from the banks of rivers in the direction of the flow of water. The curves that occupy the upper reaches of the mountains are closed lines, unlike those found lower, along the rivers, which form long, winding open forms. In some areas, construction lines have been drawn in the form of open curves, no doubt for more patent terracing of land.

It is necessary to admit that the procedure designed by Diego Palomino has no uniformity; he draws the elevation of the buildings, huts, and boats in different directions on the horizontal plane of projection. The practical absence of terrestrial ways, striking on the map of Palomino perhaps because communications were carried out mainly by river. This map showed an absence of stylistic features particular to native manuscripts, it seems that the author did not have any influence of the pre-Hispanic traditions to represent the territory.

V. RELACIÓN GEOGRÁFICA MAP OF HUEHUETLÁN, 1579

The map describes the region that contains the town of Santo Domingo Huehuetlán and the town's subject villages. The author drew the hydrographical network in a dark brown color, constituted by a main river (also named Huehuetlán) as well as numerous streams and

tributaries that feed them in an environment of rugged relief and lush nature. It is known that a noble Indian, Don Juan Hernández, added the Spanish inscriptions on this map. They indicate the names of the subject towns and describe the topography of the region. This corresponds to mountainous territory due to its location next to the Sierra del Tentzo, which is part of the Sierra Madre Oriental, and its relief is determined by the presence of southern mountain ranges of the neo-volcanic axis. The inscriptions identify the names of 18 villages subject to Huehuetlán's jurisdiction: San Miguel, San Juan, Santa Marta, Santa Maria Magdalena, and San Augustín, among others. Although there is no graphical or written indication of the orientation of the map, the situation of the villages, suggests that it is oriented to the north. According to the *Relación* text, in the region had a gypsum quarry and was abundant limestone, used in building construction. The map shows in two places an accumulation of rocks shaped mound, which probably corresponds to situation of respective quarries. One is near the village of San Agustín and the other in the vicinity of Santa Ana.

The village of Huehuetlán is represented on the map by drawing the simple church of his Dominican convent. This church is located in the central left part and is drawn with its elevation next to the plan of the atrium –double line drawn to indicate the thickness of the wall -, both in red. A network of red roads connects this head church with the subsidiary parishes, represented by a drawing identical to that of the Dominican church but smaller and in black ink, with its corresponding toponymy in Spanish and, in some cases, with comments in Nahuatl. The signs for villages are shown proportionally to the rank of the places concerned. Here, the representation of the paths presents certain peculiarities because they are plotted as a single line in red. Those that seem to be main ways are presented with greater thickness, including footprints in black, a convention typical of the indigenous cartography.

This geographical view proposed a generic understanding of the topography surrounding of villages specified in the texts, and respond to the representation of territorial space, where the head town and subject villages are depicted. This is the model we see on the *Relaciones Geográficas* maps, with settlements nucleated and ranked in a hierarchy of *cabecera* (head town) and subjects. Schematic elements are used to structure the whole, as roads, rivers, mountains, and buildings that, metonymically, come to identify the different urban enclaves. Sometimes the hierarchy are specified with increasing of details or elements. On these maps, communities are organized by and around a central religion, and they reveal this by their iconography, in which communities are symbolized by churches. From the perspective of our study, the representation of the terrain and its relief is interesting because it does not used the usual hill profiles in the indigenous and Spanish cartography of the colonial epoch.

To represent the relief have been drawn sinuous lines that surround the riverbeds and inflections of land. In some cases these curves are closed within the limits of the map, creating areas that are colored with different shades of brown that may differentiate the highlands of the lowlands, or the wasteland of the forested (these both hypotheses are compatible). Either ways, the terrain is shown in a manner consistent with the latest European techniques. This open and closed lines system has divided into zones the territory: some areas are colored in light brown and the others with the same dark color. These colored

dark brown areas are filled with graphics as we have been from earliest times, so-called 'fish scales', 'molehills', or 'sugar loaves' have been used to represent relief. As Leonardo was already doing, the innovation of this artist was the use of different shades of color to denote changes in elevation.

VI. RELACIÓN GEOGRÁFICA MAP OF SAN MIGUEL AND SAN FELIPE, 1580

This map shows the geography of the Valley of the San Miguel River, from its sources to San Francisco Chamacuero, as well as the reality of this conflict area, bordering the Chichimeca Indians. The richly colored map, represents the terrain with brown and green shades; rivers, springs and streams in blue. The villages of San Miguel el Grande and San Felipe, the town of San Francisco Chamacuero, areas of the fields, the roads by a single red line, with ranches and the forts guarding them, as well as nomadic Indians hunting cattle and the Spanish who fought them during the wars of conquest. Along the way are represented in profile view, but they are in different orientations with respect to the horizontal direction; Spanish wagons pulled by oxen, protected by soldiers on foot and on horseback, armed with harquebuses. The quality of the border region, which were frequent clashes with the Chichimecas; is evidenced in the drawing of the Indians armed with bows and arrows, located at the crossroads and possible confrontations places. In the mountain passes of Nieto and Chamacuero, we find one each Indians executed by hanging. Along the mountain pass of Chamacuero it is the drawing of the decapitated heads bleeding Franciscan friars who were assaulted by the Chichimeca Indians in the stream of Chamacuero, today Comonfort.

The map is oriented with the figures of two suns indicating the East and the West. This feature, together with the absence of glyphs and indigenous conventions, supports its Spanish authorship, although the technique used is a mixture of Spanish and indigenous styles. A genuinely indigenous feature of this map is that in addition to representing landforms, villas, and ways in the region, it tells a story of the Franciscan friars who were attacked and decapitated by Chichimecas Indians in the stream of the Chamacuero.

The orography of the area is mostly flat, although it is crossed by mountains of medium altitude in its extreme East and West as well as in the center of the territory. The main stream through the region is the Laja River, whose origin is depicted on the map in the middle left (West) and surrounding the elevation that occupies the lower central part of it: the mountainous area of Guanajuato; describing a meander that disappears from the map on the Southeast. In addition to the Laja River, other minor streams are represented. In one of these, the stream of Charco del Ingenio (middle right of the map), was installed the first water mill mentioned by the colonial authority, was built by friars, which preserves the ruins.

The terrain is represented by a series of curves that enclose areas, which are colored on their edges and often also in the interior. Although in the top of the map these curves may seem to represent mountains in profile view, in the rest of the map the winding route of these lines, alternating convex and concave parts on all directions, we think that we can discard this hypothesis. This convention is reinforced by the use of color with gradients and shading to create a sensation of volume. In the central part of the map area, near the village of Santa Catalina and the river of the same name, we find an indigenous *tepetl* symbol, used in the

indigenous cartography for the hill or mountain. A simple line in red is used to represent the roads, whereas for the rivers and streams, a double line with a blue interior is used.

The buildings, vegetation, fauna and human figures are drawn in elevation, view from the side. The Spanish are drawn with armor, firearms and horses with blankets, protecting the ways and cattle, whereas the Indians carry bows and arrows. Three conventions are used to represent the inhabited places. For the towns of San Miguel, San Felipe and San Francisco, a simple church or house with a slender gable roof topped by a cross and semicircular arch entrance. The ranches and farm are represented by a simple house with a flat roof, in elevation view, sometimes with arch entrance. Finally, the drawing a hut made of woven material and hemispherical shape represents Indian villages. Crude drawings of a type of hut used by the Chichimecas can be seen on this map.

VII. CONCLUSIONS

Delineation of the continuous three-dimensional form of the land has always been one of the most challenging problems in cartography. As we have been from earliest times, so-called 'fish scales', 'molehills', or 'sugar loaves' in profile or, at best, oblique views have been used to represent relief.

Although of different dates, places and authorship, these three maps made during the sixteenth century and representing various Spanish American regions show the originality of representing terrain relief with a different from the commonly used method. Do not try to represent the mountains in profile view, or oblique perspective of a high perspective or bird's-eye view; but intuitively seem to want to represent the relief in a plan view. To do this, and with some differences between the three maps, the method used consists of representing the terrain relief through wavy lines with inflections similar to those of the terrain, which implies some knowledge of their morphology and the ability to draw it by a succession of sine curves with alternating concave and convex forms. This method of representing the relief in horizontal projection is completely different from the method of hill profiles, such as those used throughout the history of cartography.

The interesting thing –the amazing thing– of these three maps is that, contrary to what he did Leonardo on the maps of Tuscany, they are not meant to represent the relief by their actual appearance, as the landscape would look in an aerial photograph. However in an intuitive way they use a system of sinuous lines, viewed from above, that try to become a non-pictorial conventional sign to represent the features of terrain. By contrast, in the representation of those other elements that are not part of the relief, such as buildings, people, trees and plants; instead of using conventional signs, used their actual appearance, seen in elevation drawing, from the side.

This intuitive way of expressing terrain shape in a single horizontal projection could be an empirical precedent of what centuries later called 'method of approximate contour lines or figurative curves'. This procedure achieves represent the terrain and its relief in a single orthogonal projection. This allows a fairly good approximation to the real relief of the area represented, but without any numerical indication of altitude or elevation of land. On maps studied, although attempts have been made to represent relief by a system of sinuous curves, has not been done following a strictly technical criteria, but rather intuitive.

Interestingly, in these three cases, we observe that the method used to represent the relief in horizontal projection coexists with the elevation representation used for vegetation, buildings, and the figures of people and animals that are superposed on horizontal plane of projection in different directions, as if viewed from the side at ground level (profile).

In terms of the representation of the towns in these maps, map of Palomino uses the sketch of the layout of buildings, houses and huts; we do not know if they correspond to the actual image that had those places. However, without a doubt is different in the way human settlements are represented in the other two maps, using conventional signs: a house or a church. In the first case, the number of buildings, houses or huts indicates the expansion of the city, town or village. While the second is the size of the conventional sign, which indicates the importance, or size of the place that represents.