

# Artificial Intelligence, Computational Approaches, and Geographical Text Analysis to Investigate Early Colonial Mexico

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## Summary

The application of digital technologies within interdisciplinary environments is enabling the development of more efficient methods and techniques for analysing historical corpora at scales that were not feasible before. The project Digging into Early Colonial Mexico is an example of cooperation among archaeologists, historians, computer scientists and geographers, engaged in designing and implementing methods for text mining and large-scale analysis of primary and secondary historical sources, specifically the automated identification of vital analytical concepts linked to locational references, revealing the spatial and geographic context of the historical narrative. As a case study, the project focuses on the *Relaciones Geográficas de la Nueva España* (Geographic Reports of New Spain, or RGs). This is a corpus of textual and pictographic documents produced in A.D. 1577-1585, which provides one of the most complete and extensive accounts of Mexico and Guatemala's history and the social situation at the time. The research team is developing valuable digital tools and datasets, including (a) a comprehensive historical gazetteer containing thousands of georeferenced toponyms integrated within a Geographical Information System; (b) two digital versions of the RGs corpus, one fully annotated and ready for information extraction, and another one suitable for further experimentation with algorithms of Machine Learning, Natural Language Processing, and Corpus Linguistics analyses; and (c) software tools that support a research method called Geographical Text Analysis (GTA). GTA applies Natural Language Processing based on deep learning algorithms for named entity recognition, disambiguation, and classification to enable the parsing of texts and the automatic mark-up of words referring to place names that are later associated with analytical concepts through a technique called Geographic Collocation Analysis. By leveraging the benefits of the GTA methodology and resources, the research team is in the process of investigating questions related to the landscape and territorial transformations experienced during the colonisation of Mexico, as well as the discovery of social, economic, political and religious patterns in the way of life of Indigenous and Spanish communities of New Spain towards the last quarter of the sixteenth century. All datasets and research products will be released under an open-access licence for the free use of scholars engaged in Latin American Studies or interested in computational approaches to history.

## Keywords

Artificial Intelligence, Natural Language Processing, Geographical Text Analysis, GIS, Digital Humanities, Colonial Mexico, Historical Datasets, Gazetteers, sixteenth-century, Relaciones Geográficas de Nueva España.

## Digging into Early Colonial Mexico: The Project

[\*Digging into Early Colonial Mexico\*](#) (DECM) is a project funded by the [\*Transatlantic Platform of Social Sciences and the Humanities\*](#) through three research councils: ESRC-UK; FTP-Portugal; and CONACyT-Mexico. It includes the participation of archaeologists, historians, geographers, and computer scientists, based at [\*Lancaster University\*](#) (UK), [\*INESC-ID\*](#)-University of Lisbon (Portugal), and the National Institute of Anthropology and History (Mexico).

This project started in 2018 with two main objectives: (a) answering important historical questions related to the process of the colonisation of New Spain; and (b) advancing the processing and analysis of historical sources by bringing together theories, methodologies and techniques from the Humanities and a range of data-driven sciences. The project takes advantage of recent breakthroughs in Machine Learning (ML), Corpus Linguistics, Natural Language Processing (NLP), and Geographic Information Sciences. It aims to automate the identification and analysis of information in one of the most essential sixteenth-century Mexican historical corpus, namely the *Relaciones Geográficas de Nueva España* (Geographic Reports of New Spain, RGs hereafter). The corpus, produced between 1577 and 1585, contains 168 reports (almost one million words), plus 78 pictorial maps in Indigenous or Spanish-Indigenous styles.

The project focuses on investigating technical challenges and questions, such as:

- To what extent computational approaches can advance the analysis and investigation of historical material?
- How can Artificial Intelligence methods facilitate the identification, extraction, and cross-reference of information from primary historical sources to expand research in history and historical archaeology?
- How can language technologies and geospatial analysis facilitate answering historical questions?
- How can annotation and semantic analysis techniques be used to investigate the sixteenth-century territorial representations (Indigenous maps) accompanying the *Relaciones Geográficas*?

The project also seeks to investigate historical questions, such as:

- To what extent did prehispanic forms of spatial organisation survive in the last quarter of the sixteenth century?
- How did the introduction of European forms of organisation, including the movement of settlements and ethnic groups, transformed the geopolitical and social organisation of native populations in America?
- How did the Spanish colonial authorities portray and use information about the newly conquered territories and people?

Although these are not the only questions to explore, the project's main ambition has been to transform how historians and archaeologists might approach the study of textual, and to a certain extent, image collections. Besides, the research team is producing a series of free open data digital resources, some of which are already available online, while others will be released in 2021. These include:

- 1) *The DECM Corpus*: A digital corpus of the texts of *Relaciones Geográficas*, including a machine ready version, an expert-annotated sample of documents that can be used as the gold standard for assessing the quality of future NLP and ML models, and an automatically annotated version of the entire corpus ready for text mining.
- 2) *The DECM Ontology*: A selection of analytical categories, specifically tailored for the annotation and mining of information in historical texts related to the colonial history of Mexico and Central America.
- 3) *The DECM Historical Gazetteer*: A digital directory of historical places of Mexico and Guatemala from primary sources, as well as information collected from comprehensive studies on the political, religious and administrative units of the Viceroyalty of New Spain. A subset called *The DECM Sixteenth Century Gazetteer* includes toponyms mentioned in two main primary sources: the *Relaciones Geográficas* and the *Suma de Visitas de los Pueblos de la Nueva España* (1548–1550). The gazetteer includes 71 main files with geographic information of colonial jurisdictions (*provincias, alcaldías, corregimientos, diócesis*) and thousands of historical cities, towns, villages, and other places. This is integrated into an interoperable model (Linked Places format) containing geographic coordinates of nearly 4000 thousand historical locations with their name variations, which accounts to a total of 14,654 entries. The dataset also includes 30 tables with additional historical information related to toponyms, languages, repositories, maps, etc.
- 4) [\*DECM: Creating a sixteenth-century gazetteer of Mexico\*](#): An online story-map explaining the creation of the DECM historical gazetteer.
- 5) [\*The 'Subaltern Recogito' Dataset\*](#): A digital annotated version of the pictographic maps included in the RGs.
- 6) [\*The 'Subaltern Recogito' Ontology\*](#): A tailored schema for annotating and mining information from sixteenth-century Mexican maps.
- 7) [\*Mesoamerican Pathways\*](#): An online resource for public engagement that narrates local histories through cartographic maps.
- 8) [\*Geographical Text Analysis Software\*](#): An online tool to carry out spatial queries from the annotated texts and their accompanying gazetteer. This software is being designed to process any annotated corpora so that other research teams can use it in future projects.

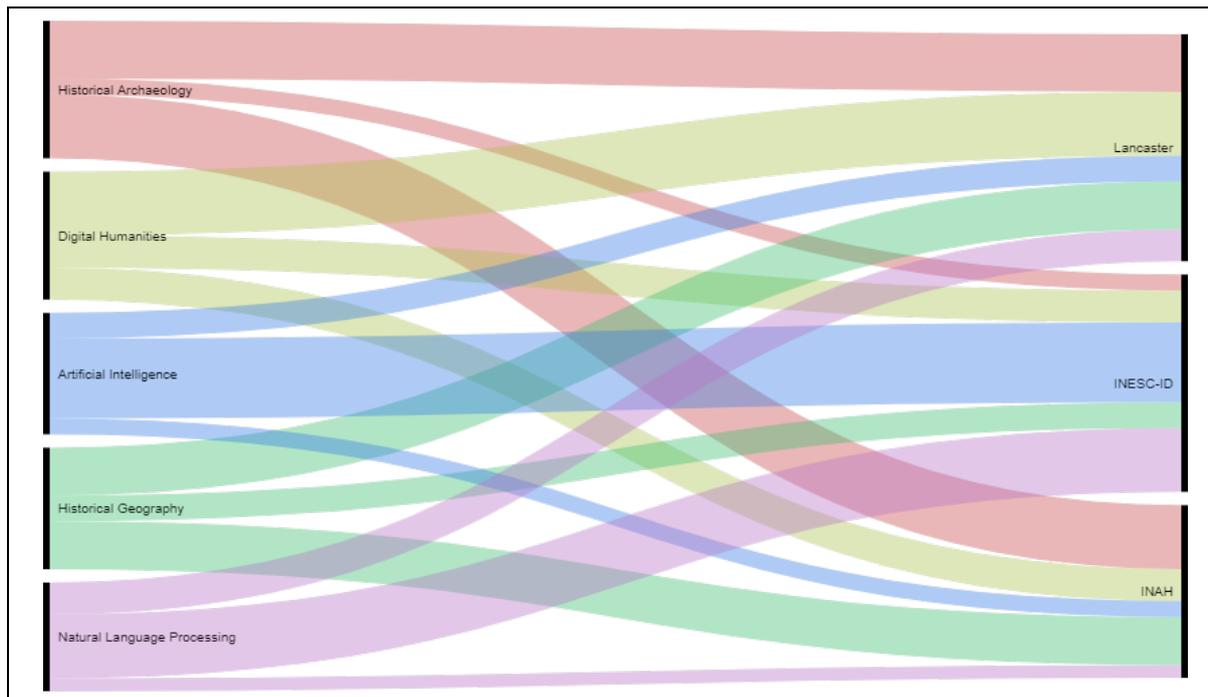


Fig. 1 The project applies an interdisciplinary model where the three teams work closely together. The team at Lancaster University leads the research related to historical geographies and GIS. It is also the Digital Humanities lead, focusing on the connexions between the three groups. The team at INESC-ID leads the Machine Learning and NLP research while working in close collaboration with Lancaster to integrate geographic information. The team at Templo Mayor-INAH conducts historical research working in partnership with Lancaster and Lisbon to create datasets and develop historically based technological methods.

## Historical Background: The sixteenth-century *Relaciones Geográficas de Nueva España* (the Geographic Reports of New Spain)

### The creation of the Geographic Reports of New Spain

The collection of manuscripts and pictographic documents known as *Relaciones Geográficas de la Nueva España* (1577-1585) is considered one of the essential sources of knowledge about the history, geography, culture, religion, and economy of Indigenous and Spanish communities of New Spain in the last quarter of the sixteenth century. From conception to production, the corpus was shaped by a unity of intent and a territorial coverage not seen in any other contemporary collection. Its span facilitates comparative historical research across small, medium and large areas.

The compilation of RGs constitutes one of the most successful chapters in a long list of enquiries commissioned by Castilian monarchs, avid to learn about their subjects at the other end of the world. These started with a royal instruction addressed to Colón before his fourth voyage (1502), in which the Catholic monarchs ordered to register specific data from the newly discovered lands. Decades later, when the colonisation process was underway, Emperor Charles V continued the task using Spanish conquistadors as informants. In 1533, for example, he enacted a *Cédula Real* (royal instruction), ordering Pedro de Alvarado to

prepare a report on Guatemala that should include geographical representations (*pinturas*) and relevant information for the governance of that province.<sup>1</sup> Even more remarkable are Hernando Cortes's letters reporting the extraordinary events of the Conquest of Mexico-Tenochtitlan. Also, formal investigations were ordered by Charles V to high-level intellectuals like Alonso de Santa Cruz (1505-1567), cosmographer of the *Casa de la Contratación* in Seville. This government agency was charged with overseeing trade and travel between Spain and the colonies, for which it controlled the production of navigation charts and New World maps. Santa Cruz's position in this institution gave him the opportunity to undertake a massive project to assemble an atlas with descriptions of all the territories known to European explorers since 1400, of which only a portion known as *Islario General de Todas las Islas del Mundo* was completed at the time of his death in 1567.<sup>2</sup> The *Islario* contains 111 maps spread into four sections. The fourth one, dedicated to the New World, includes maps and descriptions of the island of Tenochtitlan, the Yucatán Peninsula, Tierra del Labrador, Virgin Islands, La Española, Cuba, Jamaica, Gulf of Panama, the coast of Brazil, and Río de la Plata, among others.<sup>3</sup> For this and other projects, Santa Cruz used published information and benefited from witness accounts coming from residents and travellers to the New World. Santa Cruz requested backing to obtain this first-hand information in 1546, 1548 and 1563 to the Council of Indies, an institution with enough authority to order the compilation of data by residents in the colonies and travellers. The hope was to obtain data as specific as recording distances and bearings between geographic locations, something necessary to establish a more accurate measure of longitude. This information was highly desirable as it would help to draw more accurate maps, showing the New World in relation to Europe.<sup>4</sup> Santa Cruz's studies on longitude were published in a book, but the problem remained unsolved.<sup>5</sup>

The efforts of collecting information were even more substantial during the reign of King Phillip II. He needed to survey his European possessions and the viceroyalties of New Spain and Peru. New Spain included Mexico, Guatemala, and since 1569 the Philippines, while Peru covered most parts of South America. Juan de Ovando y Godoy, a jurist, member, and eventually President of the Council of the Indies (1570-1574), emphasised the idea that to consolidate a good government, the Crown needed detailed and constantly updated information.<sup>6</sup> He embraced this challenge by sponsoring several expeditions to the New World and designing formal questionnaires to learn the colonies' history and geography. One of the most remarkable expeditions sent to New Spain was led by the naturalist Francisco Hernández de Toledo between 1570 and 1577. He and his team collected great botanical, medical and scientific information.<sup>7</sup>

Another of Ovando's projects started in 1569, asked officers across the Indies to compile a 37-chapter survey to obtain detailed descriptions of the New World provinces, including recordings of bearings for navigation. Responses did not reach Spain as expected, and towards 1571 he designed a new enquiry, this time containing 200 questions addressed to civil and ecclesiastic authorities in New Spain.<sup>8</sup> These high-level officials lacked the local knowledge, time or will to respond, so the reports reaching Spain were too scarce, and none has survived.<sup>9</sup> These failures led to new attempts in 1572 and 1573 when he added procedural instructions known as *Ordenanzas para la Formación del Libro de las Descripciones de Indias*.<sup>10</sup> This document explains how to respond to 135 questions on multiple aspects of life in the Indies, especially natural and moral history, legislation, local government, the

establishment of religious orders, population in urban and rural spaces, matters of *hacienda* and taxation, cosmography, and geographic descriptions.<sup>11</sup> All this knowledge was to be organised in a single book commissioned to Ovando's Secretary, the distinguished intellectual Juan López de Velasco, who has been recently appointed (1571) Principal Royal Chronicler-Cosmographer of the Indies.<sup>12</sup> López de Velasco used the scarce reports obtained in 1569, 1572 and 1573 for his book *Geografía y Descripción Universal de las Indias*, completed in 1574, but not published until 1849.<sup>13</sup> Further attempts were made in 1574 and 1575, but they did not have much success.<sup>14</sup>

In 1577, López de Velasco finally devised a successful questionnaire that contained only 50 questions. A crucial difference with previous enquires was that the target respondents were not the highest authorities in the colonies but lower-level officers with knowledge of the situation in actual cities and towns due to their close contact with the communities that the answers were supposed to describe. This seems to be the reason why the compilation of a substantial corpus of *Relaciones Geográficas* was finally accomplished. Another crucial decision was requesting the elaboration of maps specifically for the purpose of representing the spatial organisation of towns. This enquiry was set in motion through a *Cédula Real* by The Council of Indies –the strongest possible official support– and sent to the viceroyalties of New Spain and Peru in a printed document known as *Instrucción y Memoria*, which explains how and what questions needed to be answered (Fig. 2). After being received by the viceroyalty authorities, the instructions were passed onto local governors of main district-size jurisdictions (*corregimientos* and *alcaldías mayores*), who in turn, sought appropriate informants (mainly old members of the Indigenous nobility) to provide the answers. Most of the time, the native informants responded in their local language (Nahuatl, Otomi, Pame, etc.), so an interpreter and Spanish writer (*escribano*) was necessary to write down the answers.<sup>15</sup> The resulting *Relaciones Geográficas* arrived in the Iberian Peninsula between 1579 and 1585, though sadly, they were never used to support governmental or administrative decisions, as originally intended. In particular, the pictographic maps were primarily drawn in Indigenous style and did not fulfil López de Velasco's expectations or the Spanish authorities.

Nevertheless, Antonio Herrera y Tordesillas (1549-1625) and Antonio León Pinelo (1595-1660) used the corpus in their historical projects. After that, the documents remained untouched in the Escorial's archive and were dispersed during the following centuries to different institutions. Only at the end of the nineteenth and beginning of the twentieth centuries were rediscovered by historians Marcos Jiménez de la Espada (1831-1898), and then by Francisco del Paso y Troncoso (1842-1916) in his celebrated *Papeles de Nueva España* (1905-1946).<sup>16</sup>

Since then, a myriad of scholars has found priceless information on New Spain's society. Seminal research has been conducted by Moreno Toscano<sup>17</sup>, Cline<sup>18</sup>, Gerhard<sup>19</sup>, Gruzinski<sup>20</sup>, Mundy<sup>21</sup>, Bravo-García<sup>22</sup> and other scholars. The publications by Cline systematised all available information on the history of the corpus, providing the first complete inventory and classification of the documents that with minor changes (e.g. Acuña 1982-1988), it is still used today.<sup>23</sup> Moreno Toscano, used the complete textual information of the RGs to perform a matrix analysis oriented to reconstruct the economic geography of New Spain.<sup>24</sup> Gerhard used it as one central source for his ground-breaking works on Mexican historical geography, which synthesised the available knowledge on history, territorial organisation, and ethnic

composition of every province existing in central and northern Mexico from the sixteenth to the eighteenth centuries.<sup>25</sup> Between 1982 and 1988, Acuña edited and translated in 10 volumes the vast majority of RGs, while Mercedes de la Garza published those for Yucatán in 1983.<sup>26</sup>

Gruzinski approached the corpus by studying how the contrasting, sometimes conflicting worldview of conquistadors and native peoples shaped the questionnaire's responses, pointing out interesting details about the transformation of the collective imaginary in New Spain society.<sup>27</sup> More recently, Mundy analysed the surviving maps to identify continuities and changes of the indigenous cartographic tradition during the colonial period, and McDonough studied indigenous technologies as portrayed in the corpus.<sup>28</sup> Single documents of the *Relaciones* have also been the focus of historical research.<sup>29</sup> All these studies have proven the enormous value of these textual and cartographic documents for regional and local studies. Unfortunately, historians still face some difficulties to mine data due to the long time needed to cross-link information among the many documents or to a lack of tools for uncovering non-explicit knowledge hidden in the subtext of the answers to the questionnaire. This motivated the development of Big Data approaches for studying the *Relaciones Geográficas*.

## Instructiō, y memoria, de las relaciones que

se han de hazer, para la descripcion de las Indias, que su Magestad mandó hazer, para el buen gouerno y ennoblecimiento de ellas.



Primera, los Governadores, Corregidores, o Alcaldes mayores, a quien los Vireyes, o Audiencias, y otras personas del gouerno, embiaren estas instrucciones, y memorias impresas, ante todas cosas haran lista, y memoria de los pueblos de Españoles, y de Indios, que viere en su jurisdiccion, en que solamente se pongan los nombres de ellos escriptos de letra legible, y clara, y luego la embiaran a las dichas personas del gouerno, para que juntamente, con las relaciones que en los dichos pueblos se hizieren, la embien a su Magestad, y al consejo de las Indias.

Y distribuyan las dichas instrucciones, y memorias impresas por los pueblos de los Españoles, y de Indios, de su jurisdiccion, donde viere Españoles, embiando las a los concejos, y donde no, a los curas si los viere, y sino a los religiosos, a cuyo cargo fuere la doctrina, mandando a los concejos, y encargando de parte de su Magestad, a los curas y religiosos, que dentro de vn breue termino, las respondan, y satisfagan como en ellas se declara, y les embien las relaciones que hizieren, juntamente con estas memorias, para que ellos como fueren recibiendo las relaciones, vayan embiandolas a las personas de gouerno que se las vieren embiado, y las instrucciones y memorias las bueluan a distribuir si fueren menester por los otros pueblos a dō de no las vieren embiado.

Y en los pueblos, y ciudades, dō de los Governadores, o Corregidores, y personas de gouerno residieren, haran las relaciones de ellos, o encargar las han a personas inteligentes de las cosas de la tierra, que las hagan, segun el tenor de las dichas memorias,

Las personas a quien se diere cargo en los pueblos de hazer la relacion particular de cada vno dellos, responderan a los capitulos de la memoria, que se sigue por la orden, y forma siguiente.

Primera, en vn papel a parte, pōdran por caueca de la relacion que hizieren, el dia, mes, y año de la fecha de ella: con el nombre de la persona, o personas, que se hallaren a hazerla, y el del Governador, y otra persona que les viere embiado la dicha instruccion.

Y leyendo atentamente, cada Capitulo de la memoria, screuirá lo que huuiere que dezir a el, en otro capitulo por si, respondiendole a cada vno por sus numeros, como van en la memoria, vno tras otro, y en los que no huuiere que dezir, dexarlos há sin hazer mención de ellos, y pasaran a los siguientes, hasta acuar los de leer todos, y responder los que tuuieren que dezir: como queda dicho, breue y claramente, en todo: afirmando por cierto lo que lo fuere, y lo que no, poniendolo por dudoso: de manera que las relaciones venganciertas, conforme a lo contenido en los capitulos siguientes.

Fig.2 First page of the instructions to fill in the 1577 questionnaire that was sent along with the royal mandate. With permission of LLILAS Benson Latin American Studies and Collections, The University of Texas at Austin.

### The Geographic Reports Corpus

The fifty questions in the *Instrucción y Memoria* aimed at gathering comprehensive material related to the geography, history, languages, and social organisation of each major jurisdiction of New Spain. The original Spanish version has been published in the most

important editions of the corpus<sup>30</sup>, and a translation into English by Clinton R. Edwards, is found in Cline<sup>31</sup> and Mundy<sup>32</sup>.

Table 1 summarises the topics covered in the enquiry (a similar one in Spanish is found in Bravo-García).<sup>33</sup> It is worth noticing that questions 1 to 8 requested information on towns inhabited by Spaniards, while questions 9 to 16 focused on indigenous settlements. The remaining 34 questions were equally applied to Spanish and Indigenous settlements.

<b>Questions</b>	<b>Information asked</b>
1-2	<ul style="list-style-type: none"> <li>• Native names of towns, districts, and provinces, along with translations into Spanish.</li> <li>• Historical data of Spanish settled areas, including dates of discovery, personal names of important people (discoverers, conquerors), etc.</li> </ul>
3-4	<ul style="list-style-type: none"> <li>• General climate and geography.</li> </ul>
5	<ul style="list-style-type: none"> <li>• Demographics, such as population figures and causes of any variation through time in the numbers of subjects; the languages spoken in the region, plus opinions on the way of life, intelligence, moral character, and inclinations of the Indians.</li> </ul>
6-8	<ul style="list-style-type: none"> <li>• Information on latitude and celestial observations.</li> <li>• Distances between each city or town occupied by Spaniards.</li> <li>• Condition and characteristics of transport routes, roads and paths.</li> </ul>
9 and 13	<ul style="list-style-type: none"> <li>• Name of each Indigenous town and translation into Spanish, data on the history, size and languages spoken in the area.</li> </ul>
10-12	<ul style="list-style-type: none"> <li>• Landscape description of native towns.</li> <li>• Maps or plans of Indigenous settlements.</li> <li>• Distances between Indigenous towns and between these and their nearest head-towns.</li> </ul>
14-16	<ul style="list-style-type: none"> <li>• Native history, including information about previous political organisation, forms of religion, war, means of subsistence, diseases.</li> <li>• Previous political status of Indigenous towns, whether they were conquered before the Spaniards' arrival, to which jurisdiction they used to pay tribute, etc.</li> <li>• General information on physical geography, important orographic features, their names and translations into Spanish.</li> </ul>
17-21	<ul style="list-style-type: none"> <li>• Type of settlement, data on the health of local population, the most common remedies for diseases.</li> <li>• More specific details on mountains, rivers, water sources, focusing on the possibilities for exploitation through mining, large-scale irrigation, etc.</li> <li>• Lakes, lagoons, fountains and anything remarkable about them.</li> <li>• Volcanos and any other 'admirable works of nature'.</li> </ul>
22-26	<ul style="list-style-type: none"> <li>• Names of plants, trees, and their produce; whether they were native or imported and useful in any way.</li> <li>• Grains, seeds and garden plants, vegetables and availability of other resources including olive oil, wine, wheat, barley, silk, and cochineal.</li> </ul>
27	<ul style="list-style-type: none"> <li>• Native and imported animals and how well they breed and multiply in the area.</li> </ul>

28-30	<ul style="list-style-type: none"> <li>• Mineral and metal resources, including gold, silver, and other veins that can be exploited.</li> <li>• Deposits of precious stones and any other esteemed material that might exist.</li> <li>• Existence of resources, such as salt, and techniques available for exploitation.</li> </ul>
31-32	<ul style="list-style-type: none"> <li>• Form and construction of houses, building materials, home types, origin of construction materials, etc.</li> <li>• Existence of fortresses and strongholds.</li> </ul>
33	<ul style="list-style-type: none"> <li>• Information on trade, classes of commerce, exchange ways, data on tribute items and payments.</li> </ul>
34-37	<ul style="list-style-type: none"> <li>• Ecclesiastic organisation and architecture of the area.</li> <li>• Information on to which diocese the town belongs, distance and directions to the nearest religious seat (monastery, church or parochial building) and ease of travelling to such centre.</li> <li>• Data on any existing hospital, college, and pious institution.</li> </ul>
38-47	<ul style="list-style-type: none"> <li>• Maritime and coastal information such as depth of bays and tides, description of offshore islands, landfalls, and whether these were fit for navigation, or to be used as ports.</li> <li>• Report on the ease for obtaining basic resources such as fresh water, firewood, salt, etc.</li> <li>• Names of islands, shapes, forms, and all natural resources in them.</li> <li>• Drawing maps or sketches of such islands, ports and bays</li> </ul>
48	<ul style="list-style-type: none"> <li>• Information on areas depopulated by Spaniards and reasons for abandonment.</li> </ul>
49	<ul style="list-style-type: none"> <li>• Anything remarkable in terms of nature that might be worth knowing.</li> </ul>
50	<ul style="list-style-type: none"> <li>• Signature and names of the people involved in collecting the information.</li> </ul>
Table 1. Information asked for in the 1577 questionnaire of the <i>Relaciones Geográficas</i>	

The RG reports describe county-size administrative jurisdictions known as *alcaldías mayores* and *corregimientos*, where communities were hierarchically organized into head-towns (*cabeceras*) and dependants (*sujetos*). In large territories, subordinate towns could, in turn, have their own *sujetos*, becoming de facto second-level *cabeceras*. As Spain's instructions did not specify how to structure the reports, they took different formats. These were classified by Cline as "simple", "composite", and "complex".<sup>34</sup> Most reports are "simple" in the sense of containing information about a single *corregimiento*, while others integrate responses from two or more jurisdictions. In the latter cases, some respondents decided to list at the beginning the settlements belonging to two or more *corregimientos*, and then answered the questions for each jurisdiction separately. This resulted in several *relaciones* joined in a "composite" document. In other cases, the questionnaire items were responded to one by one, but within each chapter, a separate paragraph was dedicated to each jurisdiction creating a "complex" report.<sup>35</sup>

In 2020, a total of 168 textual reports had been identified. These comprise nearly a million words that describe the situation in 415 main *cabeceras* and almost 4 thousand smaller towns,

villages or mining settlements, spreading over more than half the territory of New Spain circa 1577-1585.

There are also 78 pictographic representations of the jurisdictions attached and described by some of the textual reports. These *pinturas*, conventionally called maps, were drawn in indigenous or hybrid Spanish-Indigenous styles and constitute in itself one of the most valuable collections to understand Mexican pictographic tradition, as the seminal study by Mundy demonstrates.<sup>36</sup>

The original manuscripts and maps are spread across four institutions:

- [The General Archive of the Indies in Seville](#) (Spain)
- Serie antropológica / Universidad Nacional Autónoma de México. Instituto de Investigaciones Antropológicas 45, 53-4, 58-9, 63, 65, 70 [The Royal Academy of History in Madrid](#) (Spain)
- [The Latin American Collection of the Benson Library at the University of Texas](#) (USA)
- The University of Glasgow (UK)

Although much information can be found in these documents, the answers' precision and extension vary enormously. The "complex" *Relación de la Ciudad y Provincia de Tezcoco* - authored by Juan Bautista Pomar (1535-1601), son of the daughter of an Acolhua king and a Spanish colonist- answers only twenty questions but the extension (160 folios of which 149 survive; 26, 218 words) and accuracy of the content, particularly in answers 14 and 15, goes far beyond the expectation of the survey.<sup>37</sup> In fact, instead of writing a bureaucratic report, Pomar provides a complete history of the ancient kingdom of Acolhuacan and focuses much less on geography or practical matters. Indeed, the answer to question 18 (orography of the region) is covered in 71 words. For modern ethnohistorians, this constitutes an invaluable source of knowledge on Prehispanic Mexico and one of the best examples of mestizo historiography. On the other end, the "simple" *Relación de las Minas de Cimapan* answers also twenty questions, but deal with the topics in 1739 words.<sup>38</sup> There is a more extreme case in the *Relación de Samahil and Calotmul* (Yucatan), in which Rodrigo Álvarez –an old conquistador and *encomendero*- writes 398 words about his deteriorated physical condition instead of answering the questionnaire.<sup>39</sup> Fortunately, it is most common to find reports like the "complex" *Relación de la Alcaldía Mayor de Meztitlan y su Jurisdicción* (14 manuscript folios; 6966 words), in which Gabriel de Chavez, *alcalde mayor* of a frontier district located between the central valley and the gulf coast of Mexico, gathers in his twenty-three answers, considerable knowledge on prehispanic priesthood activities, religion (including a drawing and explanation of the Nahua calendric system), plus information on politics, government, law, customs, nourishment, natural resources, territorial organisation and an orographic map, one of the few in European style.<sup>40</sup>

The computer-readable corpus produced by the DECM project was derived from the 54 RGs from Yucatan transcribed and initially published in two volumes by De la Garza<sup>41</sup>, plus 114 RGs edited by Acuña<sup>42</sup> in 10 volumes. The latter contains 12 RGs from Nueva Galicia, 17 from Michoacán, 34 from Mexico, 15 from Tlaxcala, 34 from Antequera (i.e. Oaxaca) and 2 from Guatemala. This version is complemented by another computer-readable edition, corresponding to the RGs published by Del Paso y Troncoso in *Papeles de la Nueva España*.<sup>43</sup>

It is worth noticing that, beyond the core material, the DECM project also incorporated other historical documents relevant to Mexico's geographic history. Two examples are: *La Suma de la Visita de los Pueblos*, and *The Libro de las Tasaciones de Pueblos de Nueva España., Siglo XVI*, which add essential population statistics, taxation figures, and economy data within a geographic framework from surveys done by Spanish officials in New Spain in the 1550s, that is two decades before the compilation of the RGs.<sup>44</sup> Plans are also underway to add unpublished documents from several branches of Archivo General de la Nación (Mexico City), especially the *Ramo de Tierras, Indios, Congregaciones, Indiferente virreinal, and Mapas, Planos e Ilustraciones*. These would provide context to events that occurred since the 1530s and after the 1580s.

## Creating computational methods and datasets for the analysis of historical documents

### Geographical Text Analysis

One of the project's main objectives has been to develop techniques to identify, extract, cross-reference, and analyse the corpus information in a semi or automated way. Big Data approaches are efficient for those purposes, enabling the recognition of data patterns from which scholars can solve questions that have been difficult or impossible to answer in the past due to the sheer scale of information.<sup>45</sup> The idea of applying these techniques in the Humanities has been around for several years, particularly in approaches like the so-called "distance reading" proposed by Franco Moretti in the field of Literature.<sup>46</sup> The key behind distance reading is that, using computational methods, the researcher can discover in a short time unsuspected information contained in thousands of documents, abbreviating a task that would typically take any researcher many years to complete. The motivation for adopting this approach in the DECM project is to promote in history and archaeology (spatially-focused disciplines by nature) an extended version of distant reading that allows the discovery of geographies and spatially related data patterns in historical narratives. To this end, the DECM Lancaster team has been working for several years on the development and refinement of the methodology called Geographical Text Analysis, or GTA.<sup>47</sup> GTA blends techniques from Natural Language Processing (NLP), Corpus Linguistics (CL), Machine Learning and Geographic Information Systems (GIS). GIS focuses on identifying, manipulating, and analysing spatial information, specifically georeferenced data that can be mapped and spatially analysed.<sup>48</sup> NLP uses Machine Learning algorithms to teach a computer how to perform complex tasks, like recognising semantic categories in large amounts of written or spoken natural language.<sup>49</sup> Machine learning systems also have the ability to learn and improve their own artificial knowledge through automatic means.<sup>50</sup> Corpus Linguistics is also a computational theoretical and methodological approach that supports the study of linguistic phenomena in corpora.<sup>51</sup>

GTA's essence is to use a combination of methods and techniques from these fields to expedite the identification and querying of data from large text collections, regardless of whether these are primary or secondary sources. GTA comprises several steps that can be summarised as follows:

- Firstly, using NLP techniques such as Named Entity Recognition (NER), the corpus is parsed by the computer to automatically identify and annotate proper nouns, including

names, place names, and institutions. This step can be augmented by annotating any other category of information relevant for historical research (names of plants, animals, domestic utensils, tools, architectural buildings, etc.). The selection of these categories is described in an ontological model that references information such as cosmogony, economy, and natural resources, among many others.

- After the corpus is fully annotated, a second step called geoparsing can be carried out. Place names identified in the corpus are matched with the geographic coordinates derived from a historical gazetteer. Thus, a major task for the DECM team has been to compile and create the first digital sixteenth century gazetteer of New Spain.
- Once the corpus has been annotated and geoparsed, a further stage consists of implementing "collocation analysis". In corpus linguistics, collocation refers to sets of words that appear together, co-occurring next to each other more often than it could be expected by chance alone. This method facilitates the discovery of significant regularities or patterns in the use of words within corpora. GTA extends this notion to geographic collocation analysis, which allows the identification of geographic references that are related to any word of interest in the corpus, or to any concept annotated in accordance with the ontology established in step 1. This allows discovering "words in context" and the identification of spatial patterns.
- The final stage consists in the mapping of annotated, georeferenced and collocated information with GIS, as well as the application of advanced methods of spatial analyses.

The method allows faster and more comprehensive mining of complex historical evidence along with spatial references in the texts, permitting the creation of subsets of data that can then be used to carry out spatial analyses in GIS or other software. For instance, the researcher might want to know how the writers of the RGs portrayed essential events such as epidemics, as well as their spread over different regions of New Spain. In cases like these, the query engine of the GTA software can extract all sentences of the corpus that mention diseases, either by asking for the general entity "disease", as defined in the ontology, or by querying a specific keyword like *cocoliztli* (the Nahuatl name of a particular epidemic). The textual information would then appear in a tabular form along with a map showing the places where instances of diseases were found. The table's rows would contain each instance of the entity or keyword (in this case *cocoliztli* -the query can include spelling variations of the word) and a fragment of the text where it appears (Fig.3). By exploring the table and the map together, the researcher may discover unexpected information patterns that are not mentioned explicitly in the text.

The GTA software uses metadata associated with the table, such as document ID, name and date of the RG, as well as a link to the HTML file of the transcribed document. This allows the automatic navigation and link to the text where the mention of the concept of interest is found, facilitating the switch between distant and close reading of the historical sources. With this information, further analyses can be carried out with, for instance, Geographic Information Systems and/or Network Analysis software, among others.

TextID	Pos	Location	X	Y	ContextLeft	Entit	Entity	Entity	ContextRight
6_RG_Mi	158	Atengo	-99.33	20.176	fue grande en los tiempos pasados. Y la causa de su despoblación fue el gran	Health	Disease	cocolizte	que hubo en esta Nueva España,
7_RG_Mi	642	Culhuacan	-99.11	19.338	más, y con enfermedades que han tenido, y en especial de pestilencias, que e	Health	Disease	COCOLIZTE	, se han muerto. Es pueblo funda
10_RG_N	1322	Ameca	-104	20.548	de las laderas de las sierras donde estaban poblados, empezaron a enfermar	Health	Disease	COCOLIZTLI	, que quiere decir "peste", que lo
6_RG_Mi	2137	Atengo	-99.33	20.176	y que no suele haber enfermedades en ellas, si no es después que entró el	Health	Disease	cocolizte	, y a esto no saben el remedio qu
3_RG_An	3443	Papalotlcp	-96.88	17.842	que se causaba su muchedumbre por causa de tener muchas mujeres un hom	Health	Disease	cocoliztle	(que significa "pestilencia") que t
2_RG_An	10498	Atlatuacca	-96.83	17.532	dar razón de qué enfermedad es la que más les fatiga, más de decir el	Health	Disease	Cocolistle	, que es, nuestra lengua, "enferm
6_RG_Mi	10742	Cempoala	-98.67	19.915	en edificios y labores. Por fin, antiguamente habían mucha cantidad de gente	Health	Disease	cocoliztles	los tienen muy apocados y se vai
6_RG_Mi	10759	Cempoala	-98.67	19.915	tienen muy apocados y se van acabando. Y, antiguamente, no sabían lo que e	Health	Disease	cocoliztle	. Estos cuatro pueblos están pob
6_RG_Mi	10862	Tlaquipan	-98.75	19.943	por ser frío; otros enferman de cámaras de sangre, y ahora enferman y muen	Health	Disease	cocoliztle	y de tabardetes. Cúranse con yea
5_RG_Tli	11736	Texalocan	-98.25	18.637	antiguamente, solía haber en él dieciséis mil vecinos, y se murieron en el tiem	Health	Disease	cocoliztle	que hubo ahora hará unos treint
2_RG_An	12615	Miaguatlan	-96.6	16.329	un tributario. Es tierra muy sana, fría y seca, y así, en las enfermedades y	Health	Disease	cocolixtles	(que los indios llaman "pestilenci
8_RG_Mi	21337	Tezcoco	-98.88	19.506	y españoles hicieron para ello las diligencias posibles para atacar ese mal que	Health	Disease	cocoliztli	ezalahuac, que quiere decir "pes
8_RG_Mi	21518	Tezcoco	-98.88	19.506	ordinarios, con que se valen el día de hoy. De manera que para solos los	Health	Disease	cocoliztles	no han hallado remedio. Y, si al f
9_RG_Mi	26238	Cuzcaquau	-103.6	18.598	indios. Y el día de hoy han venido a muy gran disminución, por muy grandes	Health	Disease	COCOLIZTES	y mortandades que en ellos ha h
5_RG_Tli	26919	Cholula	-98.3	19.058	los saca de sentido. Es pueblo sano, salvo cuando generalmente sucede algun	Health	Disease	cocoliztli	, v. así, hav muchos indios que pa

Fig. 3 GTA Output example. The table shows the context to the left and to the right for each of the times the 'Entity' requested is identified in the RGs (in this case, the disease *Cocoliztli*). It also shows not only the file and the location where the sentence comes from but also the place name that can be associated with the disease and its coordinates.

## Artificial Intelligence and Geographical Text Analysis

NLP methodologies driven by artificial intelligence have been developed with modern datasets. Therefore, they have proven to be very effective in analysing texts written in a single contemporary language, especially English. However, their application to historic corpora composed in pre-modern languages can be challenging.<sup>52</sup> This is the case of the *Relaciones Geográficas*, which besides being written in sixteenth-century Spanish, possess the additional challenge of being multilingual. Indeed, the RGs reports are peppered with terms in 69 different native languages. Therefore, the DECM project is carrying out experiments to develop a Machine Learning model suitable for this kind of pre-modern, multilingual corpora.

### 3.2.1 Implementing Natural Language Processing for the annotation of the corpus

One of the keys for implementing GTA is tagging the words of historical interest in the corpus, so that the search engine can retrieve them easily when historians need it. A basic level of automatic annotation is achieved by implementing Named Entity Recognition techniques (NER), that is, computer-aided identification of proper nouns referring to places, people, institutions and dates mentioned in the corpus. These categories are useful, but more sophisticated historical analysis can be achieved by recognising and annotating words and expressions belonging to more complex analytical categories, such as "activities", "natural resources", "cultural artefacts" and many others considered relevant for analysing the corpus. By tagging words belonging to an entity called "disease", for example, a researcher would quickly locate the distribution of *cocoliztli*, the epidemic that decimated New Spain's population between 1571-1576 (Fig 4).



Fig. 4 Example of annotated corpus

Furthermore, the concept of 'location' was defined in such a way as to accommodate not only geographic data but also other types of spatial information. For example, once a historian has extracted all occurrences of toponyms such as "Mexico", his/her search might go further to determine its "type of settlement" (city, town, village), or the "class of jurisdiction" to which it belonged. To do that, we implemented a series of spatial categories as labels under the entity called "Location". These act as attributes of the primary entity that can serve text mining purposes, but they can also provide more atomic information for Machine Learning models. In the same manner, the ontology contains entities and labels to identify dates; different types of events, animals, activities, ethnic groups, social classes, languages, architecture, events and measurements; plants, food, cultural artefacts, and health, as well as information on cosmogony, routes of transformation, kinship, and climate.

In summary, The DECM ontology is a dictionary that provides the exact definition of 21 entities and labels appropriate for the analysis of complex concepts in the corpus (Table 2). These are defined and linked to DBpedia. Therefore, the annotation schema can be augmented in the future and reused by other research teams.

Entity	Labels	Ontological definition
Person	female/male, title, profession, saints, deities	<a href="http://dbpedia.org/page/Person">http://dbpedia.org/page/Person</a>
Date		<a href="http://dbpedia.org/ontology/date">http://dbpedia.org/ontology/date</a>
Institution	civil, ecclesiastical	<a href="http://dbpedia.org/page/Institution">http://dbpedia.org/page/Institution</a>
Location	Settlement type, geographic	<a href="http://dbpedia.org/ontology/location">http://dbpedia.org/ontology/location</a>

	feature type, toponym, imaginary, ecclesiastic jurisdiction, civil jurisdiction	
Activity	agriculture, warfare, economy, mining, domestic, female/male, ritual, social, civil, politic	<a href="http://dbpedia.org/ontology/activity">http://dbpedia.org/ontology/activity</a>
Animal	insect, mammal, reptile, bird, amphibian, aquatic, domesticated	<a href="http://dbpedia.org/ontology/animal">http://dbpedia.org/ontology/animal</a>
Plant		<a href="http://dbpedia.org/page/Plant">http://dbpedia.org/page/Plant</a>
Food		<a href="http://dbpedia.org/page/Food">http://dbpedia.org/page/Food</a>
Natural resource		<a href="http://dbpedia.org/page/Natural_resource">http://dbpedia.org/page/Natural_resource</a>
Cultural artefact	house goods, commodity, clothing, weapon, tool, ritual	<a href="http://dbpedia.org/page/Cultural_artifact">http://dbpedia.org/page/Cultural_artifact</a>
Architecture	religious, civil, domestic	<a href="http://dbpedia.org/page/Architecture">http://dbpedia.org/page/Architecture</a>
Health	illness, remedy	<a href="http://dbpedia.org/page/Health">http://dbpedia.org/page/Health</a>
Route of transportation	terrestrial, aquatic,	<a href="http://dbpedia.org/ontology/RouteOfTransportation">http://dbpedia.org/ontology/RouteOfTransportation</a>
Climate		<a href="http://dbpedia.org/page/Climate">http://dbpedia.org/page/Climate</a>
Ethnic group		<a href="http://dbpedia.org/page/Ethnic_group">http://dbpedia.org/page/Ethnic_group</a>
Social class		<a href="http://dbpedia.org/page/Social_class">http://dbpedia.org/page/Social_class</a>
Language		<a href="http://dbpedia.org/page/Language">http://dbpedia.org/page/Language</a>
Measurement	Price, weight, population, distance, size	<a href="http://dbpedia.org/page/Measurement">http://dbpedia.org/page/Measurement</a>
Table 2. The ontology defines the entities, DBpedia links to these definitions and the labels per entity that can be used to annotate these documents. In addition, it also contains examples of the concepts to annotate (this is not shown in this table, but the ontology can be accessed here).		

Once a sample of documents is annotated with this ontology, it can be used as a training dataset for Machine Learning to automatically identify these concepts in previously 'unseen' documents.

## The DECM Corpus and its versions

The project has produced two digital versions of the RGs corpus: one in simple text format and another one annotated automatically with the NLP model and an expert-annotated sample (gold-standard) to use in other machine learning experiments. An ontology was adopted to annotate the corpus. The release of these resources is expected in 2021.

### 1. [The DECM Machine Ready Corpus:](#)

This version includes text only files (.txt) containing each of the 10 volumes originally edited by Rene Acuña (1982-1988), the 2 volumes edited by Mercedes de la Garza (1983), the *Papeles de Nueva España* edited by Del Paso y Troncoso (1905-1946), the *Suma de Visitas de los Pueblos de Nueva España* (Del Paso y Troncoso 1905), a file with the original text of the Crown mandate (*Instrucción*), and metadata for this collection. This version contains only the original text of each of the RGs as transcribed by the scholars, excluding any editorial note, commentary, or historical work. This can be therefore used directly for corpus linguistics analyses, visualisations, etc.

### 2. [The DECM Gold Standard Corpus:](#)

This version contains a sample of the RGs manually annotated by multiple researchers with the software of our industry partner, Tagtog. This corpus has been used to carry out the NLP and ML experiments, and the files are available in JSON and TSV format. Texts and annotations compose these files. This is also accompanied by the DECM ontology, which explains the entities and labels used. This corpus can be used for further experimentation with Artificial Intelligence methods.

### 3. [The DECM Machine Annotated Corpus:](#)

This is the version of the entire RG corpus automatically annotated using the ML models trained with the DECM Gold Standard Corpus. The files are available in JSON and TSV format, and it also contains the file for the DECM Ontology. This corpus can be further used for quantitative and qualitative research and advanced analyses using text mining techniques, corpus linguistics, and other methods such as Geographical Text Analysis.

### 4. [The DECM Ontology:](#)

This is the ontology used to annotate the corpus of the RGs. It is constituted by 21 entities and labels marking important social, political, territorial, and economic information. A series of guides were also produced for the process of annotation. The ontology and rules are available in Excel format.

## Developing a geographic resource for historical and archaeological research

As explained before, the second component of GTA is a gazetteer. This can be thought of as a geographic dictionary, where the main components are toponyms and their corresponding coordinates. While the concept behind is simple, the problems of creating historical gazetteers are well known.<sup>53</sup> Related to our region of study, historical geography is a well-researched subject, and some atlases have been created for the colonial period.<sup>54</sup> The works cited by Peter Gerhard and Howard Cline, have been crucial to advance the study of the territorial organisation at a larger scale in early colonial Mexico. Nevertheless, there has

never been an attempt to create a fully dedicated sixteenth-century gazetteer of the whole country. To do so, our project took geographic information from primary and secondary sources and carried out dedicated research to find and clarify historical details of thousands of toponyms.

The secondary sources consulted were the works on historical geography published by Gerhard Cline, Tanck de Estrada et al., and Moreno Toscano.<sup>55</sup> These were used in the first instance to disambiguate historical places and as a basis to create a first version of the gazetteer. This resulted in 3 GIS initial layers, mainly from the geographies included in Gerhard's works and Moreno Toscano. Besides, multiple digital resources, including the GeoNames geographical database, the Getty Thesaurus of Geographic Names, and others created by the Mexican institutions INEGI and CONABIO, were also used in the process of disambiguation.

We then created indexes from the primary sources with the geographic information (i.e. all the place names) contained in a) the 10 volumes of RGs as transcribed by Rene Acuña; b) the 2 volumes of RGs as transcribed by Mercedes de la Garza; and c) *La Suma de la Visita de los Pueblos de Nueva España* by Del Paso y Troncoso.<sup>56</sup> Using these indexes, the team proceeded to create a workflow to identify places and assign spatial information as explained elsewhere.<sup>57</sup>

As with other areas of Geographic Information Retrieval, the creation of historical gazetteers presents several challenges. For the identification of sixteenth-century geographies, there were two main problems to tackle: *place reference identification* and *place reference disambiguation*.<sup>58</sup> The first one refers to challenges associated to changes in language over time, including spelling variations. The second refers to assigning the correct coordinates to a particular place, which might include issues related to ambiguity in language, such as different places sharing the same name. As it can be imagined, particularly for the early colonial period, historical, political, social changes and events affected the settlement pattern and the historical continuation of places. As such, changes in towns and villages' locations and names were not uncommon. While locating the places that experienced historical continuation might be relatively straight forward, the introduction of Spanish names and the profound transformations in the territorial organisation from the *encomiendas* and the introduction of the changes experienced due to the *reducciones de indios*, make this task particularly hard. While at the beginning of the project, our expectation was to make use of more automated techniques, and the use of secondary sources was of significant help in the creation of the gazetteer, the reality was that substantial historical research was also required to create this resource (Fig. 5). Nevertheless, the effort was necessary and worth it. We believe that this resource is unparalleled in terms of quality, and it will help many generations of scholars interested in Latin American, archaeologists and historians in the years to come.

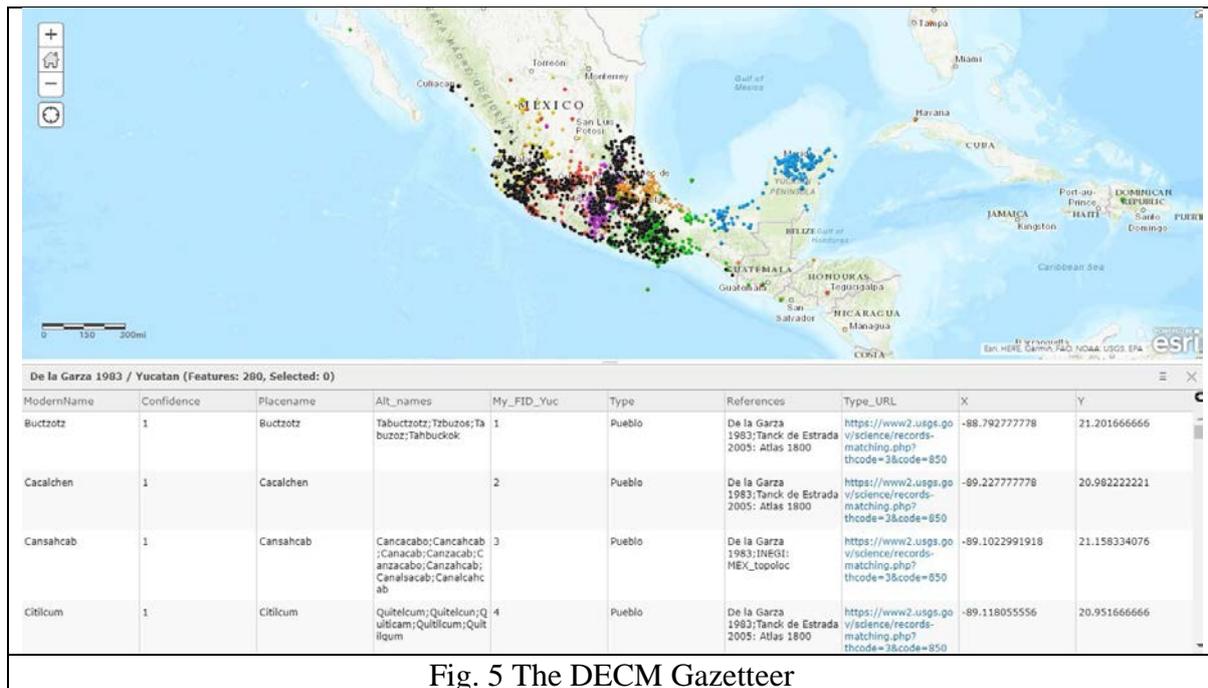


Fig. 5 The DECM Gazetteer

### The DECM Historical Gazetteer

The gazetteer was created through the process explained above. It contains information for 14,654 toponyms, plus 70 layers of GIS information and 40 tables of additional geographic, political or administrative historical information created through research by the project, and/or digitised from secondary sources. To guarantee the dataset's interoperability, the database followed the Linked Past Places format (LPF). The dataset will be made available through the project's [Github repository](#), the World Historical Gazetteer, the Pelagios Network, and mapping tools such as Recogito.

The dataset contains important geographic and historical information, including coordinates, toponyms and their alternative spellings, possible historical relationships among these, the original native language in which they were recorded and bibliographic references, among many others. The gazetteer will be released in two versions plus a registry of all information created, and both resources will be available in LPF, CSV files, and GIS shapefiles from the project's repositories as follow:

#### 5. *The DECM Gazetteer:*

This version includes all the researched historical toponyms contained in primary and secondary sources. The information is organised by RG volume. It also includes layers and tables of historical information digitised and/or created by the project from secondary sources. All these are accompanied by metadata, including the DECM Gazetteer Registry.

This set is composed by a) all toponyms with coordinates, mentioned and disambiguated from the primary sources (13 volumes) and secondary sources (3 volumes); b) 30 geographical layers of additional historical information derived from secondary sources; c) 32 tables with other important historical information related to the RGs; and d) the DECM Gazetteer Registry.

6. [The DECM sixteenth-century Gazetteer:](#)

This version constitutes a subset of the main DECM Historical Gazetteer, including only the toponyms mentioned in the RG reports and the *Suma de Visita de los Pueblos*, providing a clear window into the period when these were recorded (1548–1550/1577–1585).

This dataset contains the toponyms with coordinates, mentioned and disambiguated for each RG volume and the *Suma*; plus, the 30 geographical layers and 32 tables as explained above and the DECM Gazetteer Registry.

7. [The DECM Gazetteer Registry:](#)

This is a record for quick reference of all the files available in the gazetteer.

## Conclusion: The future of historical research with digital technologies on early colonial Mexico

With the creation of these datasets and the development of Geographical Text Analysis, many possibilities open to research multiple geographic scales, bringing a diversity of disparate types of information in an interplay between distant and close reading. For example, the DECM research team is exploring new and traditional questions related to settlement patterns and territorial organisation of New Spain in the sixteenth century. Although some of these questions have been studied in exciting and valuable ways in the past, bringing together previously inexistent geographic data and the capacity to cross-link and reference information with a large volume of textual historical sources will, without doubt, lead to the discovery of new knowledge.

Thanks to the creation of the digital gazetteer, novel toponym studies and advanced spatial analyses can be carried out. This, in combination with the extraction of information from the corpus at a large scale, would facilitate the investigation of aspects of colonial history, such as:

- a) Meaning and linguistic variation of place names, like the addition of Spanish Saints' names to Indigenous toponyms.
- b) Territorial and political changes, both in administration and geographies over time.
- c) Physical geography including landscapes, flora, fauna and climate.
- d) Cultural and social issues such as health, customs, architecture, languages, material culture and some elements of cosmogony and religion.
- e) Political history including aspects of the governmental structure and territorial organisation at the time, war, and narratives about historical events and the conquest.
- f) Economic endeavours including information on the availability and use of natural resources and cultural artefacts, agriculture, cattle raising, and other important activities such as mining and taxation.

Two examples of this are the case studies the project team is starting to carry out, where we are using large-scale textual and spatial analyses. The first significant case study will use advanced spatial analysis to take advantage of the unique datasets created by the project.

Mesoamerican archaeology in Mexico has a long tradition. While detailed settlement pattern analyses have been carried out investigating for some parts of the country how the different ethnic groups approached living, adapting, and conceiving their symbolic views of the landscape, many others remain less well studied. This is the case, for instance, of many of the areas of Central Mexico, where settlement patterns for some parts of the Basin during the diverse periods before and after the arrival of the Spanish have been well investigated, while others remain less well understood.<sup>59</sup> With the defeat of the Aztec Empire at the hands of the Spanish and their Indigenous allies, the fall of the Triple Alliance that controlled and influenced great part of Mesoamerica saw the partial collapse of its networks and its radical transformation, along with a profound change in the ideological value of resources, and eventually a transformation of the market and its economy. The introduction of new diseases provoking the epidemics that decimated the Indigenous settlements, and the establishment of the Christian religion, triggered massive population movements and socio-cultural transformations along with the new political alliances and disputes between the native nobility and the Spanish newcomers. This led to profound changes in society, politics, and territory. Although the restructuration of landscapes and settlements responded to the new order's ideas, many indigenous conceptions remained. The creation of the *República de Indios* took place using as a basis the previous native territorial order and organisation to a certain extent, where the native leaders held political authority over their jurisdictions.<sup>60</sup> During the first part of the colonial period between the establishment of the legal government of Hernando Cortés in 1522 almost to the arrival of the Viceroy Antonio de Mendoza in 1535, the establishment of the *encomiendas* followed closely the shape of the territorial organisation and the tributary provinces established by the Triple Alliance, at least in central Mexico.<sup>61</sup> However, the regional and political organisation suffered from constant shifts amongst the struggle between the ruling native nobility and the Spanish *encomenderos*.

Previous to 1550, the Spanish towns were ruled by *cabildos* being increasingly overseen by *alcaldes mayores* that had a similar function as the *corregidores*. While many of the main Indigenous towns were established as *cabeceras* and retained their local organisation and rulers, most named *alcaldes* were *conquistadores* and colonisers. These treated the lands they governed as short-term *encomiendas*, incurring in numerous abuses.<sup>62</sup> The introduction of the *corregidores* between 1531 and 1535 responded to the necessity of the Crown to establish a firmer local order, where aided by the native nobility, newly appointed *corregidores* (some of which were previous *encomenderos* and first settlers) acted as administrators, civil and criminal judges. They were also in charge of tax collection, covering the four main aspects (*gobierno, justicia, guerra, and hacienda*) under which all the New Spain territories were organised.<sup>63</sup> At his arrival in 1535, Antonio de Mendoza proposed to reduce the number of *alcaldes mayores* and substitute them for carefully selected officials. The Council of Indies took on board a modified version of this plan. Between 1550 and 1570, New Spain was divided in around 40 provinces, each ruled by an *alcalde mayor* in charge of the suffragan *corregimientos*.<sup>64</sup>

By 1570 all *encomiendas* belonged to a *corregimiento*, creating a territorial picture composed at the local level of many civil jurisdictions ordered by *alcaldías mayores* (around 70) and *corregimientos* (more than 200) with vast numbers of native and Spanish towns.<sup>65</sup> Although in theory the *corregimientos* were well delimited in terms of size and ordered in contiguity with other neighbouring *corregimientos*, in comparison to dispersed or mountain regions,

more precise distinctions were made in places with larger population density such as the Valley of Mexico and Toluca.<sup>66</sup>

The reality is that the actual geographic extension of many of the local territorial entities, including the *corregimientos* and many of the thousands of towns, has never been entirely clarified (Del Vas Mingo 1999: 72 Gerhard 1972: 22-28).<sup>67</sup> In addition, the degree to which native spatial arrangements remained since Mesoamerican times until the end of the sixteenth century and beyond remains to be fully understood for many of the regions within New Spain. The Spanish misunderstanding of the inner workings of the *altepetl* (the Mesoamerican form of political-territorial and socio-religious organisation) and the consequent translation of its institutions (such as the *calpolli*) to Spanish forms of spatial understanding has enormously complicated this task, and much research remains to be tackled in order to clarify the extent and the ways in which the *altepetl* was transformed during the colonial period.<sup>68</sup>

With new and more precise geographic information on how the territorial arrangement of *cabeceras* and *sujetos* took place at the time of the RGs provided by the DECM sixteenth-century gazetteer, a new opportunity has opened to:

- a. Clarify and possibly establish better the extent or *términos* of the *cabeceras*, *sujetos*, and *pueblos*, and
- b. Shed further light to changes in settlement patterns and the extent to which these happened between the Late Postclassic and the end of the sixteenth century.

Regarding the first, we can start exploring this through GIS analyses including the data recorded by the project regarding *cabeceras*, *sujetos*, *pueblos*, *estancias*, etc., combined with the information that is available in the historical maps and texts from the RGs, primary sources such as the *Títulos Primordiales y Títulos de Tierras y Pueblos*, *Composiciones de Tierras*, the *Suma de Visitas de los Pueblos de la Nueva España*, and other important works such as the *Geografía y Descripción Universal de las Indias* written by Juan López de Velasco, as well as the many historical documents surviving related to legal disputes, etc.

Regarding the second, it is known that before the arrival of the Spanish, Mesoamerican groups favoured a settlement pattern composed of dispersed settlements that could be located in a diversity of altitudes, including high mountains that obeyed military and symbolic purposes.<sup>69</sup> With the introduction of the *República de Indios*, the *congregaciones* were designed in the Spanish tradition. They aimed to gather the native population from entire regions into single and accessible locations. The epidemics facilitated this process since it was difficult for people to survive in towns with only a few remaining members, and after the great *cocoliztli* epidemic of 1545, many *congregaciones* emerged. However, many prehispanic settlements remained occupied until the time of the RGs (1577-1580), and many survived intact up to the 17<sup>th</sup> century.<sup>70</sup>

The central office of archaeological and monument records (DRPMZA) at the National Institute of Anthropology and History (INAH), has made an extraordinary effort to collect a GIS database that compiles all geographic information of archaeological sites recorded for the Mesoamerican periods. Using the DECM sixteenth-century gazetteer and this dataset, new advanced settlement pattern analyses can be carried out, looking to understand more in-depth how these changes took place.

The second case study will aim to create a more nuanced picture of the governmental structure and political network between 1577 and 1585 of the regions included in this corpus of RGs. As explained, the Royal mandate asked both *alcaldes* and *corregidores* to answer the questionnaire, providing in the process some information on their administration. Past research about the political organisation of the government of New Spain, has shed light into some of the processes through which these posts were assigned. This has also delved into the important role that *alcaldes* and *corregidores* played as provincial authorities, and the precarious position in which many of them found themselves due to low wages and the expenses that came with the post, usually leading these figures to look for alternative forms of income legally or otherwise, and which in many cases ended in corruption.<sup>71</sup> Towards the second half of the sixteenth century, most of these posts' appointments for the provinces were made by the Viceroy. These were assigned according to the services that the person had provided to the Crown. However, in many occasions, these were dictated by relationships either of friendship, kinship, or convenience of all the involved.<sup>72</sup> This led to an interesting network of relationships that was captured to a certain extent in the RGs. In these documents, there is information about the *alcaldes*, *corregidores*, *adelantados*, *conquistadores*, *indios principales*, and other important figures in each region. In some cases, the RGs also recorded information about their kinship. There has been excellent research about the origins and general establishment of the institution of *Alcaldías Mayores*.<sup>73</sup> Also, regional research had enormously contributed to the knowledge of these institutions.<sup>74</sup> Nevertheless, the identification of people holding major and minor posts, and that participated in the capture of the RGs, as well as the analysis of the networks they established, has the potential to assist in the research about the governmental structure towards the end of the sixteenth century. The years between 1570 and 1580 can be thought of as a period when the Spanish Crown is starting to intervene more strongly, both in the general government and the local ruling. This period, therefore, can be seen as a time of experimentation where rules and institutions were introduced, while others disappear or are consolidated.<sup>75</sup> In this sense, a more detailed picture of this network might facilitate our understanding of these changes. Moreover, by furtherly cross-linking this information with available research and primary sources such as the wide variety of *juicios* that were carried out against the *alcaldes* and other public figures, or even the sermons that some of the priests made looking to admonish them, additional insights into the ways *alcaldías* and *corregimientos* worked during this period are expected to be obtained.<sup>76</sup>

Finally, we are also working with Artificial Intelligence techniques to annotate and extract information from the maps that accompanied the *Relaciones Geográficas* (Fig. 6).

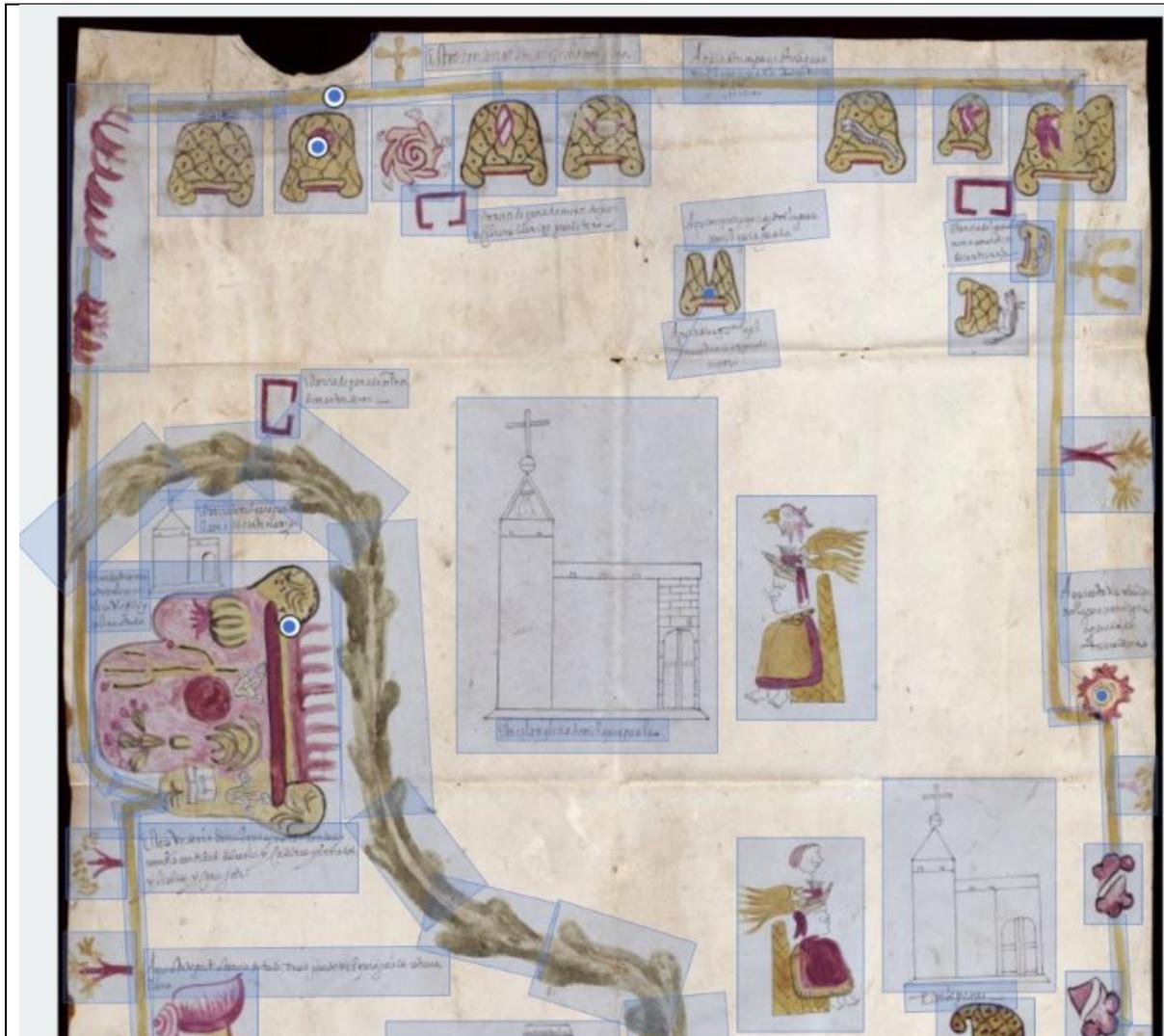


Fig. 6 Annotation example of the map of Atengo-Misquiahuala. With permission of LLILAS Benson Latin American Studies and Collections, The University of Texas at Austin.

Some of the results from the project [Subaltern Recogito](#) are already available at the repository of the University of Texas at Austin.<sup>77</sup> While we have achieved some advances on this front, the challenges that image processing pose, along with the inherent historical complexities of these maps and their limited number, inevitably means that progress on this front is slower. Nevertheless, we believe that in combination, the datasets and the ideas presented here will be a fertile ground for research and discussion in the years to come.

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small grant from Pelagios Commons. We would like to thank the DECM team for all their work and support.

## Discussion of the Literature

As the RGs can cover a great variety of topics related to life before and during the sixteenth century, it is fair to say that vast numbers of scholarship looking to understand life in Mesoamerica and the early colonial period have made use of the RGs. In this sense, it would be impossible to list all the research that has relied on the information that these reports provide or to cover the hundreds of articles and chapters devoted to them. Nevertheless, there have been scholars that have dedicated significant pieces of research to the RGs. In this discussion, we focus mainly on these.

Some of the first transcriptions and editorial work of the RGs, was carried out between the end of the 19<sup>th</sup> and the beginning of the 20<sup>th</sup> centuries by Francisco del Paso y Troncoso in the collection called '*Papeles de la Nueva España*'. Although initially eight volumes were planned, only six were published in 1905. This corpus compiled 49 RGs that corresponded mainly to the centre's geographic areas and south of Mexico, including those in the *arzobispado de México*, and the *diócesis de Oaxaca, Tlaxcala, Mexico* and *Michoacán*. The '*Colección de Documentos Inéditos de las Posesiones de España en Ultramar*' published in 1898 by the *Real Academia de la Historia*, included the *Relaciones de Yucatán* in volumes 11 and 13. After this, necessary research using the texts and the maps of the *Relaciones* would take place. For instance, using the map of the *Relación de Teozacoalco* (Oaxaca) towards 1949, Alfonso Caso would make the connexion between the dynasties shown in the Mixtec codices with those in the colonial map, establishing with it the basis to understand Mixtec genealogies and the identification of essential toponyms and places. Other contemporaries of Caso, such as Antonio Peñafiel and Mary E. Smith, would also make significant contributions to the interpretation of toponymic and name glyphs, among many other aspects. Later on, in 1964, Howard Cline would publish his study of the RGs and establish these documents' typological classification. An extended version of this study, including a catalogue, was published in the guide to ethnohistorical sources of the 'Handbook of Middle American Indians' (vol.12) in 1972. Along with other landmark chapters in this Handbook, Cline's classification is still followed today and constitute crucial references for any scholar looking to engage with the RGs. Around the same time, Peter Gerhard also carried out another two indispensable works to study colonial historical geographies, focusing especially on the content of the RGs: 'A Guide to the Historical Geography of New Spain', and 'The Southeast Frontier of New Spain'. In this research, Gerhard used the RGs among many other primary sources to produce a substantial atlas that constitutes an invaluable starting point to understand the territorial organisation of New Spain.

In parallel, studies regarding the pictorial documents accompanying the RGs were also taking place. For instance, Joaquín Galarza established a method to analyse pictorial elements from Mesoamerican and colonial maps and codices. His work would lay the foundation for the systematic study of *codices* and *pinturas* alike.<sup>78</sup> In 1972, Donald Robertson published a catalogue of the RG maps in the 'Handbook of Middle American Indians' (vol. 12), and then in 1975 with John B. Glass, would carry out a comprehensive census of Mesoamerican and Colonial pictorial documents also published in the Handbook series (vols. 14 and 15). This last census included Mesoamerican codices, the RGs maps, the Techialoyan codices, pictorial

catechisms and falsified documents known up until then. The maps of the *Relaciones* received attention as part of the documents catalogued as cartographic manuscripts.

Between 1982 and 1986, Rene Acuña published his '*Relaciones Geográficas del Siglo XVI*' in 10 volumes. These compiled and transcribed all the RGs known corresponding to the regions of Guatemala (vol. 1), Antequera (vols. 2-3), Tlaxcala (vols. 4-5), México (vols. 6-8), Michoacán (vol. 9) and Nueva Galicia (vol.10). This edition included a transcription standardised to modern Spanish and short studies accompanying each *Relacion*. In 1983, Mercedes de la Garza published a study and transcription of the '*Relaciones de Yucatán*', with a second edition in 2008. Since then, there have been numerous studies focusing on individual *Relaciones*, maps and other similar documents, looking to understand the social, politic, and economic aspects portrayed in the RGs and the corpus as a whole. To mention only a few, in '*La Colonización de lo Imaginario*' (1988), Serge Gruzinski used the RG corpus to understand the changes that took place in the Mesoamerican oral and writing traditions. In the same research, he also reflects on how as an empire instrument, the *Relaciones* asked the Indigenous communities to think of themselves in a European light. In '*Territorialidad y Paisaje en el Altepétl del Siglo XVI*' (2006), Federico Fernández Christleb and Angel Julián García Zambrano, compiled a variety of studies resulting from the project '*La Organización del espacio urbano en la Nueva España*'. This critical project based at UNAM used the *Relaciones* corpus, among other evidence, to shed new light on the *Altepétl* and the territorial organisation between 1519 and 1620. In '*Territorio, poblamiento y arquitectura. México en las Relaciones geográficas de Felipe II*' (2007), Rafael López Guzmán presents important aspects barely studied, such as the measurements used, the architecture of New Spain and its materials, among many others. In 'The *Relación de Michoacán* (1539-1541) and the Politics of Representation in Colonial Mexico', Angélica Afanador-Pujol carries out a much needed extensive analysis of this document, uncovering the responses and strategies of the Indigenous groups that created it facing the colonial authorities.

There have also been studies dedicated to the maps. Some of these constitute essential readings for those interested in colonial cartography and the different dimensions of these spatial depictions. In 'The Mapping of New Spain' (1996), Barbara Mundy carried out the first substantial study of the maps of the RGs collection. Looking to understand the general context of creating this corpus, the study covered a vast number of topics. These included the Spanish imperial ideology of mapping, the history of the questionnaire, the Indigenous tradition of mapping, and the analysis of individual maps in the corpus. Although in '*El Realismo Circular*' (2005), Alessandra Russo focused mainly on the maps of the *Ramo de Tierras* at the General Archive of the Nation in Mexico (AGN), her study complements that of Mundy, and it provides new insights to materials less well studied than the maps of the RGs. Among the most recent publications dedicated to the *pinturas*, 'Trail of Footprints' (2014) by Alex Hidalgo, also used the map collection at AGN to carry out an exciting reflection looking to delve further into the context and people that created the maps, as well as their use within the Spanish Empire.

Although most studies use either the primary sources or the edited *Relaciones* mentioned here, more recently, studies focusing on other aspects such as historical linguistics have also emerged. In '*Las Voces del Contacto*' (2015), Eva Bravo García has published the most recent palaeographic edition of the 23 RGs located at the Archive of the Indies. In this edition,

Bravo García carries out a study looking to analyse the linguistic contact process between Spanish and the Indigenous languages. We hope that a similar approach is taken with the rest of the corpus at some point.

## Primary Sources

According to Cline, for New Spain, 189 texts and 91 maps have been recorded (1972c: 196). This gives 283 items from which 25 texts and 15 maps are lost, and 8 texts and 23 maps remain unpublished. These numbers were traced mainly from 4 surviving colonial documents compiling RG's lists and inventories, and the details of this can be consulted in Cline (1972c: 195-197). Although the Philippines were considered part of New Spain, no RG's corresponding to this territory have been found in the 1577-1586 series. This is also the case for northern areas located in the modern United States, including Florida, Texas, and California, and other parts of the Southwest and northern Mexico (Cline 1972c: 193).

The volumes of *Relaciones Geográficas de Siglo XVI* edited by René Acuña and published by UNAM have been made available in Epub (.epub) format at [UNAM's repository](#). Besides, the Digging into Early Colonial Mexico project, with UNAM's permission, has also released the entire corpus of the RGs in plain text (.txt) to facilitate searches and other computational and linguistic approaches. This includes the volumes by Acuña, the two volumes edited by Mercedes de la Garza dedicated to the *Relaciones de Yucatán*, and the *Suma de Visita de los Pueblos por orden alfabético* edited by Francisco del Paso y Troncoso. These corpora and further information about these versions can be consulted in the [DECM Github repository](#). The original edition of the *Papeles de la Nueva España* and *Suma de Visita de los Pueblos* by Francisco del Paso y Troncoso, is available at the [Internet Archive](#).

Along with the texts, the maps of the RGs survive mainly in three collections: the *Archivo General de Indias* (AGI), the *Real Academia de la Historia* (RAH), and the Lilias Benson Collections at the University of Texas at Austin. Although these maps were created in response to this specific questionnaire, many other similar cartographic materials were made in the sixteenth century. A variety of these are located in collections worldwide, and a major one survives in the *Ramo de Tierras* at the *Archivo General de la Nación* in Mexico.

Finally, it is worth mentioning that although this article focuses on New Spain, the effort of the creation of the *Relaciones Geográficas*, covered territories well beyond. For instance, the *Relaciones Geográficas de Venezuela* and the *Relaciones Geográficas de Perú* can be consulted in the publications by Arellano Moreno (1964) and Jiménez de la Espada (1965). Finally, for those interested in the process of creation of the questionnaires that led to the formation of the RGs, the '*Cuestionarios para la formación de las Relaciones Geográficas de Indias, Siglos XVI/XIX*', edited in 1988 by Francisco Solano and Pilar de Ponce, constitute invaluable material, as it contains studies by multiple authors, but also the transcriptions of many of the *cedulas reales*, *decretos*, and *instrucciones*, among other documents, that were used to request information and that contributed to the creation of the RGs across the colonial period.

## Links to Digital Materials

There are many other important sources, historical collections, and resources related to the RGs and New Spain's geographies. Some of these are Mesoamerican and Colonial codices that mention the places, toponyms, and histories that the RG covers, as well as historical

documents related in a variety of archives. In addition to this, digital technologies and the field of Digital Humanities are also enabling vital interdisciplinary research that allows both humanities and science fields to make significant contributions in their areas. Some digital projects, libraries and collections specific to the RGs, and related to Mesoamerican and Colonial material can be of great use for scholars interested in these topics. We present here only some:

[PARES -Portal de Archivos Españoles](#). This is an invaluable resource to consult and access the digital collections from all archives in Spain, including the AGI and RAH.

[Llilas Benson Latin American Collection](#). The Nettie Lee Benson collections are invaluable resources for the study of Latin America. Essential for this article's subject is the [Early Maps collection](#) and the [García Icazbalceta collection](#), which contains the 43 original RGs and 37 maps at the University of Texas.

[AGI -Archivo General de la Nación, México](#). This is the principal archive of Mexico. It holds an extensive collection of colonial documents divided into a diversity of topics. Among the most relevant to the subject of this article are Indios (58); Tierras (110); Tributos (113); Alcaldes Mayores (5); Congregaciones (31), among many others.

[BDMX -Biblioteca Digital Mexicana](#). This is another invaluable digital resource that provides access to the materials of some of the most important archives and institutions in Mexico and abroad including: the Archivo General de la Nación; Archivo Histórico del Estado de Tlaxcala; Benemérita Universidad Autónoma de Puebla; Llilas Benson Latin American Collection (Texas); Biblioteca de Mexico; Biblioteca Palafoxiana; Biblioteca Russell; Centro de Estudios de Historia de México; Instituto Nacional de Antropología e Historia; Mapoteca Manuel Orozco y Berra; El Tecnológico de Monterrey; Real Biblioteca (Madrid); Universidad de las Américas Puebla; and Universidad Iberoamericana.

[TEMOA -Contextos Alfabéticos del Nahuatl](#). This is a unique resource and collaboration between UNAM, INAH, the BNM and others. It contains the palaeography of dozens of historical texts in Nahuatl and their translations to Spanish.

[TLACHIA -Contextos Pictográficos del Nahuatl](#). This is a resource connected to the above, which was also published by UNAM and others. Tlachia constitutes a database or pictorial dictionary with detailed analyses by experts, containing hundreds of glyphs in Mesoamerican and Colonial codices.

[Visual Lexicon of Aztec Hieroglyphs](#). This project by the University of Oregon and edited by Stephanie Wood is a similar resource to Tlachia. The Visual Lexicon contains detailed analyses of glyphs in a wide variety of codices.

[Amoxcalli](#). One of the earliest digital projects offering the study and digitisation of the *Fondo Mexicano* of the National Library of France. Directed by Luz María Mohar Betancourt, CIESAS dedicated several years during the '90s to compile and provide digital access to this invaluable collection. It contains the original or facsimile documents, palaeography and translation to Spanish.

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- <sup>5</sup> Santa Cruz, *Islario General de Todas Las Islas Del Mundo*.
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- <sup>14</sup> M. T. Cáceres Lorenzo, 'Tipos de Relaciones Geográficas En El Siglo XVI', *Crítica Hispánica* 35, no. 1 (2013): 45–66.
- <sup>15</sup> Cline, 'The Relaciones Geográficas of the Spanish Indies, 1577-1586', 347.
- <sup>16</sup> Francisco del Del Paso y Troncoso, *Papeles de Nueva España*, vol. 1, 3–7, Segunda Serie: Geografía y Estadística (Madrid: Sucesores de Rivadeneyra, 1905).
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- <sup>18</sup> Cline, 'The Relaciones Geográficas of the Spanish Indies, 1577-1586'; Cline, *Handbook of Middle American Indians, Volume 12*.
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- <sup>20</sup> Serge Gruzinski, *La colonización de lo imaginario: sociedades indígenas y occidentalización en el México español, siglos xvi-xviii*, trans. Jorge Ferreiro, 1a reimpr, Sección de obras de historia (México: Fondo de cultura económica, 1993); Serge Gruzinski, *The Aztecs: Rise and Fall of an Empire*, New Horizons (London: Thames and Hudson, 1992).
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<sup>24</sup> Moreno Toscano, *Geografía económica de México (siglo XVI)*.

<sup>25</sup> Gerhard, *Geografía histórica de la Nueva España, 1519-1821*.

<sup>26</sup> René. Acuña, *Relaciones Geográficas Del Siglo XVI*, 1a ed., 10 vols, Serie Antropológica / Universidad Nacional Autónoma de México. Instituto de Investigaciones Antropológicas 45, 53-4, 58-9, 63, 65, 70 (Senate House Libraries, University of London: Universidad Nacional Autónoma de México, Instituto de Investigaciones Antropológicas, 1982), [https://books.google.com/books/about/Relaciones\\_Geogr%C3%A1ficas\\_Del\\_Siglo\\_XVI.html?id=XuQ0834CgVAC](https://books.google.com/books/about/Relaciones_Geogr%C3%A1ficas_Del_Siglo_XVI.html?id=XuQ0834CgVAC).

<sup>27</sup> Serge Gruzinski, *La colonización de lo imaginario: sociedades indígenas y occidentalización en el México español. Siglos XVI-XVIII*, 2016, 77–103.

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<sup>31</sup> Cline, *Handbook of Middle American Indians, Volume 12*, 12:234–37.

<sup>32</sup> Mundy, *The Mapping of New Spain: Indigenous Cartography and the Maps of the Relaciones Geograficas*, 227–30.

<sup>33</sup> Bravo García, *Las voces del contacto*, 8.

<sup>34</sup> Cline, 'The Relaciones Geograficas of the Spanish Indies, 1577-1586'.

<sup>35</sup> Cline, 348; Cline, *Handbook of Middle American Indians, Volume 12*, 12:191.

<sup>36</sup> Mundy, *The Mapping of New Spain: Indigenous Cartography and the Maps of the Relaciones Geograficas*.

<sup>37</sup> René. Acuña, *Relaciones Geográficas Del Siglo XVI. México, Tomo III.*, 1a ed., vol. 8, Serie Antropológica / Universidad Nacional Autónoma de México. Instituto de Investigaciones Antropológicas (Universidad Nacional Autónoma de México, Instituto de Investigaciones Antropológicas, 1986), 23–113.

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