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The contribution of the Digital Humanities to historical research in Central Vietnam : GIS & semantic web annotations

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Introduction

A regional study, focusing on the current provinces of Quảng Trị and Thừa Thiên-Huế in Central Vietnam, has been carried out within the framework of two international cooperation projects. Combining historical study and new technologies, this study traces the steps for a long-term understanding of the landscape in a region of prime historical interest. In a geo-historical perspective, it first presents the methodology put in place for the establishment of a Geographic Information System which will include the establishment and inventory of a corpus of cartographic documents and the first conclusions. Then the space in which regional history developed between the 2nd and 18th centuries will be described. Two themes will be detailed: the trade and the role of water in the construction of regional identity. Then, the tools presented will be exploited in an archaeo-geographic perspective to understand the landscape over the long term. Finally, the use of annotations will open new perspectives on the resilience observable in the landscape.

1. Methodology: at the crossroads of digital humanities methods

Ancient sources, archives, ancient texts, maps and plans, iconography, field documentation, and satellite photos, etc. constitute the basic material for historians and archaeologists to gain an understanding of complex phenomena and systems that inscribe varied human behaviours (interactions between actors on the territory, migrations, economy, choice of location and evolution of cities, etc.). Today, the data has become so exponentially massive that it becomes difficult for a single researcher to sort out what is useful for his research and what is not. This is actually the big data from the past¹. In addition to being spatio-temporal, the particularity specificity of these data lies in their non-homogeneity, their gaps, their multiple and multilingual sources, both qualitative and quantitative, displaying a loose structuring.

¹ Kaplan F., DiLenardo I., 2017, Big data from the past, Front. Digit. Humanit., 29 May 2017, <https://doi.org/10.3389/fdigh.2017.00012>.

In order to understand, exploit and visualize this type of big data, we will present here two methods resulting from this new aggregate of tools that we call the digital humanities² : Geographic Information Systems and the Semantic Web.

Semantic Web, GIS, & Digital Humanities

The spatialization of information, whether it is an image also called raster or vector geometries, offers infinite possibilities for analysis. The new field of data analysis makes it possible to query these data to extract answers that respond to research intuitions. For this to be possible, it is necessary to build databases and repositories that can be synthesized by means of processing and algorithms, and then offer either statistical analysis or multiple visualizations. This field, which is called data visualization, a field of data science³ (data visualization⁴ or data geovisualization⁵), initially intended rather for the hard sciences, is now largely available to the human and social sciences⁶.

Historically, the *spatial turn* movement⁷ in the 1980s enabled the human and social sciences to participate in the problems of the issue of time by integrating the exploration of phenomena highly dependent on space. The parameters of these analyses are based on the positioning of data on a territory and in relation to other objects in space. We can imagine, for example, how to account for the foundation and growth of urban centres and their presences strongly correlated to rivers⁸.

This turn also took place in human geography, whose data became increasingly qualitative⁹, leading to the creation of databases, like in demography¹⁰ or in archaeology¹¹¹². Geographic Information Systems (GIS) have made it possible to respond to this growing need in the creation, structuring and analysis of data. Thanks to GIS, it became possible to access information formalization tools that questioned both the geometric shape of spatial objects, which maintain links between them, and their semantics, *i.e.* the meaning and interpretation attributed to the data.

Today, a new turn is looming, that of the digital humanities, which offer new perspectives with the help of digital tools that have become more accessible, analytical methods based on spatial analysis, artificial intelligence learning methods and the data web.

This first section presents how, thanks to semantic Webs, data openness is increasingly becoming a crucial issue for research in Social Sciences and Humanities by

² Jones S. E., 2013, *The Emergence of the Digital Humanities*, Routledge.

³ Van der Aalst W., 2016, *Data Science in Action*, in *Process Mining* pp3-23, Springer, Berlin, Heidelberg

⁴ Grant R., 2018, *Data Visualization, charts, maps and interactive graphics*, CRC Press

⁵ Dykes J., MacEachren A.M., Kraak M.-J., (2005) *Exploring Geovisualization*, Elsevier

⁶ Shalin Hai-Jew, 2017, *Data Analytics in Digital Humanities* Springer

⁷ Withers, Charles W. J. "Place and the 'Spatial Turn' in Geography and in History." *Journal of the History of Ideas*, vol. 70, no. 4, 2009, pp. 637–658. JSTOR, www.jstor.org/stable/20621915. Accessed 10 Mar. 2020.

⁸ Dupâquier J., 1995, *Histoire de la population française*, Quadrige, Presses Universitaires de France

⁹ Martin O., et al., 2002, *Mathématiques et sciences sociales au cours du XXe siècle*, *Revue d'Histoire des Sciences Humaines* 2002/1, n°6

¹⁰ The site <http://cassini.ehess.fr> is a tool developed between the late 1990s and early 2000s by EHESS, Paris (France), which provides a historical demographic database.

¹¹ Davis, Jack L. *American Journal of Archaeology*, vol. 97, no. 2, 1993, pp. 357–359. JSTOR, www.jstor.org/stable/505664. Accessed 10 Mar. 2020.

¹² Mehrer, Mark, and Konnie Wescott. *Gis and Archaeological Site Location Modeling*. Boca Raton, FL: Taylor & Francis, 2006. Print.

publishing not only the source data of the research, but also the way these data can be processed and enriched by research knowledge, possibly through collaborative work.

Through the Oronce Fine platform, based on the Omeka-S tool, we will describe how research data may be enriched and enhanced. The corpus on which we are working represents a set of old maps of the region of central Vietnam collating a little more than 200 old maps (dating from 1490 to 1952), several dozens of aerial ortho-photographies from the years 1952-3, and finally hundreds of field photographs.

This process developed along several phases: 1. a descriptive and exhaustive work on the data: the documents must be inventoried in a precise manner; 2. a spatial integration of the documents that can be inventoried: this is the georeferencing of data, possible on topographic maps and aerial photos; 3. enrichment of the data, made possible by a more detailed knowledge of the corpus: lists of place names, people's names, concepts specific to the corpus (market, river, lagoon, river mouth, etc.) are created; 4. At the end of these phases, the enrichment of the data is made possible by the functionalities of the Oronce Fine platform: by connecting a point, a line, or a zone to reference systems (directories of places, authority records, bibliographic databases for example) on maps or simply to other documents of the corpus; 5. Finally, when data are connected together, it is possible to navigate in the corpus in a new way, but also to be able to analyse globally the form that this network of documents will take.

How can a heterogeneous corpus of data be enhanced?

Generally speaking, research in the human and social sciences when based on old sources from archives offers often incomplete data, with many gaps due to the historical hazards faced by the sources. These sources may be written in several languages, may come from a collection of data produced by several institutions with different data patterns, or from archaeological excavation campaigns for which the data created characterized by spatial or temporal imprecision. One thus speaks of heterogeneous data. The complexity of these data lies in the non-uniformity and non-generic nature of the data schemas, which makes it difficult to integrate them into databases.

To make it possible to analyse these data, it is necessary to be able to connect these data to one other. Indeed, the exploratory nature of the analysis often lies in the cross-referencing that can be made between sources. The problem is to be able to connect these data without re-integrating them in a common database, and therefore without touching the digital sources of the data, *i.e.* the database schemas, the data themselves, or the metadata.

This is the role of the semantic web and of repositories, which, through meta-models, allow these interactions between data models and go beyond the utopian vision of having standardized data schemas. The semantic web allows to decompartmentalize data silos and interconnect them.

This will be the subject of the next two sections, first by describing how inventories are made and then by describing what external repositories are.

Constitution of the cartographic / iconographic collection

There are two types of maps available to study the region: Việt maps and French maps. Comparison of the maps shows the evolution of the landscape over the centuries and serves as a basis to understand the settlement process.

A bibliographical research has led to the conclusion that the Việt then Vietnamese maps¹³ date from 1490 until today. The Viet maps have the particularity of bearing much information written directly on the maps, which are often quite schematic¹⁴. Each geographical sketch cannot be dissociated from the comments and explanations directly written on the document. Thus, the maps must be deciphered before being used, because they contain written information that is essential for any study on the resilience of the landscape. The Việt maps cannot be georeferenced as they display more a political and ideological reality than a geographical one. It is therefore advisable to use the cartographic sources according to the perception of the landscape presented.

For example, if we compare two maps published in the same year, 1883, we can clearly see that the lagoon landscape with the capital Huế and the openings to the sea are not represented in the same way, because the perspective was not identical. The French measured the territory; the Vietnamese described it. The Vietnamese map can only be used if the text written around and in the map, which specifies distances and geographical features, is included in the analysis.



Fig.1: Comparison of a French map and a Việt map from 1883.

Left: French map drawn up by the Geographical Service of Indochina (Archives Nationales d'Outre-Mer FRANOM Asie 106_01).

Right: Descriptive Geography of the Emperor Đồng Khánh (Ngô Đức Thọ et al. 2003).

The yellow circle marks the capital Huế. The orange circle in the North locates the channel known as Thuận An, the main access to the sea at that time. The orange circle in the South locates the lagoon of Cầu Hai, which opens onto the channel known as Tư Hiền; this is the only access that can be proven to have existed as early as the Cham period, as it is overlooked by a site dating from the 13th century.

Some Việt maps

Here are five map decks focusing on the provinces of Thừa Thiên-Huế and Quảng Trị. They have gathered to make reading easier. This selection of maps is not exhaustive, but it has been established according to its relative easy access.

On the *first known Việt map* dated 1490, and in addition to the names of the mouths, only the elements of the landscape that are important for the administration are

¹³ For a catalogue of Vietnamese maps, see Ngô Đức Thọ 2003

¹⁴ They follow the traditional Chinese mapping model Yee 1994: 35-70.

noted: the administrative districts. The old maps of 1490 presented in the *Atlas of the Hồng Đức time* represented thirteen regional units of the Lê Dynasty era.

The text going along with the map provided the number of villages by district: 88 for Vũ-xương, 60 for Đan- điền, 52 for Hải-lăng, 22 for Kim-trà, 69 for Tư- vinh, and 47 for Điện-bàn. In the administrative Việt system, the villages form the basis of the census, which in turn serves as the basis for taxation. But by the end of the 15th century very few Việt migrants had settled in the area and this inventory of villages probably served as a referential for the central administration. It indicated a relatively low population density in the region.

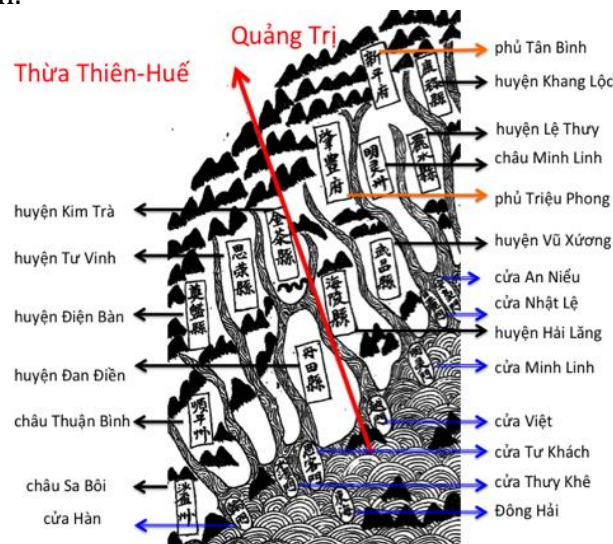


Fig.2: MAP 1. Hồng Đức Bản Đồ (Atlas of the Hồng Đức period) 1490 in Buu Cam et al. 1962: 46-8. Rivers act as natural boundaries between districts. The names of the districts are clearly indicated in cartouches. Thus, the prefecture (phủ) of Triệu-phong was formed by 6 districts (huyện): Vũ Xương, Đan Điền, Hải Lăng, Kim Trà, Tư Vinh, Điện Bàn and 2 other districts (châu): Thuận Bình and Sa Bôi.

Translation of recurrent elements: phủ province, prefecture; huyện district; môn or cửa mouth, estuary; hải gulf.

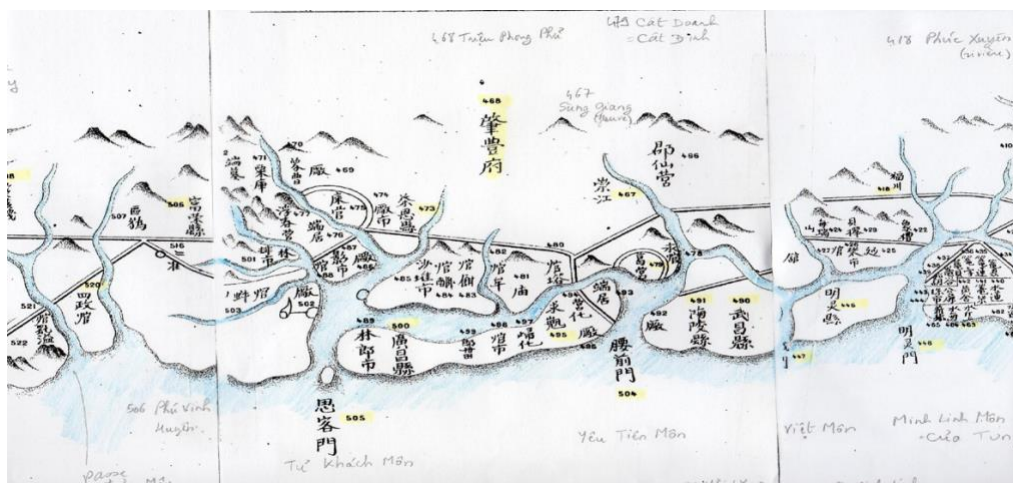


Fig. 3: MAP 2. Map of the region in the 16th century according to Dumoutier 1896: plates XVI, XVII and XVIII

Even though the second map used is not precisely dated, it indicates a condition of the territory between the early 16th and early 17th centuries. When Dumoutier

French maps

Maps from the French colonial period in Vietnam serve as a benchmark in the evolution of the landscape. The map set covering the period of the French colonization from 1875 to 1953, was executed by the National Geographic Service with the help of precise field surveys. These maps are kept at the National Geographic Institute (IGN-Paris) and at the National Overseas Archives (ANOM-Aix-en-Provence). Their staggering succession in time (1875, 1877, 1880, 1883, 1886, 1889, 1893, 1897, 1899, 1901, 1908, 1923, 1925, 1929, 1940 for the maps and 1952-53 for a set of aerial photos) allowed to conduct a first study of the landscapes demonstrating -their great evolution-, in particular that of the lagoons of Huế, the openings on the sea, and the modifications of the secondary hydrological network over time.

Assembling the 1908 1:25,000th maps can be seen at: <http://psig.humanum.fr/omeka-s/s/eclivi/page/mosaique>

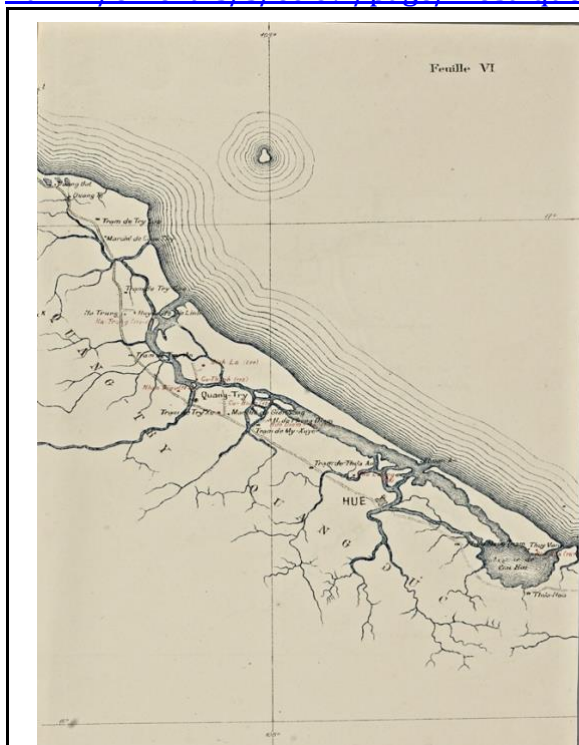


Fig.7: Map of the Archives Nationales d'Outre-Mer INDO-GGI_7981_01 of 1877

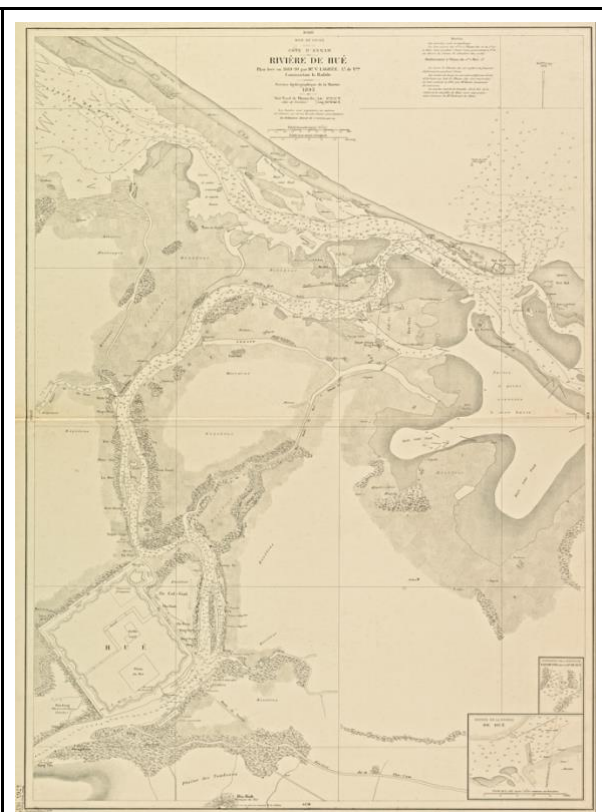


Fig. 8: Map of the Archives Nationales d'Outre-Mer FRANOM-CPA143_01 of 1889 showing the fortifications around the Thuan An Pass

These maps¹⁶ meet the geographical criteria of the present time i.e. they are georeferenced¹⁷ and therefore positionable on contemporary maps, allowing comparative studies of the evolution of the landscape thanks to the Geographic

¹⁶ The choice of maps used in this study is exclusive of all maps at a scale greater than 1:100,000, on which the only mention is "Campā" or "Cochinchine" without any detailed representation of the coasts or characteristic elements of the landscape does not allow their use in a Geographic Information System.

¹⁷ Georeferencing is a method that gives an image a cartographic repository, therefore a planar one, and offers the possibility of projecting it onto current cartographic repositories in order to obtain a diachronic analysis of objects and shapes from the past.

Information System (GIS). The georeferencing and vectorization of maps require a very long and minute work; it is the first step to form a Geographic Information System. An accurate georeferencing allows a precise analysis of the spatial dynamics. The GIS mapping process highlights the flexibility of the landscape, and helps to reconstruct the evolution of the landscape and to understand the process of colonization across centuries.

Inventorying source documents: a tedious but necessary task

These data take on a variable typology in the same field and the research is readily based on archaeological fields,¹⁸ on previous works,¹⁹ on prosopographic bases,²⁰ on courts archives,²² etc. In the case of research involving the spatialization of landscape elements or landscape forms that need to be recorded and compared in order to analyze their resilience, the typology of sources mainly concerns old maps and plans at variable scales, the most recent of which can be georeferenced, aerial or satellite photographs, and, finally, field photographs.

To begin with, the first task to be performed on such a heterogeneous corpus of data is to carry out a complete and exhaustive inventory of all the documents whose granularity, the archival unit, is the document. This inventory, although long and tedious, has several objectives:

- to understand the typology of the corpus,
- to arrange the corpus fragments by temporality (year of production of the map, major historical period, etc.),
- to have a global overview of the generators of the corpus documents,
- in case of documents of spatial nature, to understand the area of geographical coverage covered by the documents,
- to possibly draw up an inventory of the information contained in the documents: reference systems, cartographers, and engineers who collaborated in the map.

The research object thus created becomes data themselves superimposed upon the existing data. The data being the raw archival source, the data upon the data is a metadata, which is a form of interpretation as neutral as possible, matching several fields to enrich the source as new digital data available to perform a search by simple query.

¹⁸ Wells J. J., Kansa E. C., Kansa S. W., Yerka S. J., Anderson D. G., Bissett T. G., Noack Myers K., DeMuth R. C., Web-based discovery and integration of archaeological historic properties inventory data: The Digital Index of North American Archaeology (DINAA), *Literary and Linguistic Computing*, Volume 29, Issue 3, September 2014, Pages 349–360, <https://doi.org/10.1093/lc/fqu028>

¹⁹ Edelstein, D., 2016, *Intellectual History and Digital Humanities*, . *Modern Intellectual History*, 13(1), 237-246. doi:10.1017/S1479244314000833

²⁰ Michele Pasin, John Bradley, Factoid-based prosopography and computer ontologies: towards an integrated approach, *Digital Scholarship in the Humanities*, Volume 30, Issue 1, April 2015, Pages 86–97, <https://doi.org/10.1093/lc/fqt037>

²¹ Tamper M., Leskinen P., Apajalahti K., Hyvönen E. (2018) Using Biographical Texts as Linked Data for Prosopographical Research and Applications. In: Ioannides M. et al. (eds) *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection*. EuroMed 2018. Lecture Notes in Computer Science, vol 11196. Springer, Cham

²² Marc Renneville, Jean-Lucien Sanchez, Sophie Victorien. Criminocorpus. Un projet numérique pour l'histoire de la justice. *Digital Humanities Quarterly*, Alliance of Digital Humanities, 2018, 12 (1), <http://www.digitalhumanities.org/dhq/vol/12/1/000365/000365.html>. {hal-01762313}

ID	Name of the document	Filename	Temporal	Source	Assoc
1	Etude sur un portulan annamite du Xvème siècle par M.G. Dumoutier	3.Etude sur un portulan Annamite du XV siecle - Par M.G. Dumoutier.jpg	1500-1600	Dumoutier Gustave, 1896. « Etude sur un portulan annamite du X.3.Chu	
2	BAN DO - TOAN TAP THIEN NAM TU CHI LO DO THU	2.Ban do - Toan tap Thien Nam tu chi lo do thu.jpg	1600-1650	Buu Cam, Do Van Anh, Pham Huy Thuy, Ta Quang Phat, Trung Bu 2.Chu	
3	BAN DO - GIAP NGO BINH NAM DO	1. Ban do - Giap Ngo binh Nam do.jpg	1650-1700	Buu Cam, Do Van Anh, Pham Huy Thuy, Ta Quang Phat, Trung Bu 1. Chu	
4	DAO QUANG TRI	Dao Quang Tri.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
5	HUYEN DANG XUONG VA HUYEN HAI LANG	Huyen Dang Xuong va huyen Hai Lang.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
6	HUYEN MINH LINH VA HUYEN DO LINH	Huyen Minh Linh va huyen Do Linh.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
7	HUYEN THANH HOA	Huyen Thanh Hoa.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
8	PHU THUA THIEN	Phu Thua Thien.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
9	HUYEN HUONG TRA VA PHU VANG	Huyen Huong Tra va huyen Phu Vang.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
10	HUYEN HUONG THUY VA PHU LOC	Huyen Huong Thuy va huyen Phu Loc.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
11	HUYEN QUANG DIEN VA PHONG DIEN	Huyen Quang Dien va huyen Phong Dien.jpg	1883	Ngo Duc Tho, Nguyen Van Nguyen, Géographie descriptive de l'empereur	
12	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-017.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
13	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-018.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
14	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-019.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
15	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-020.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
16	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-021.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
17	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-022.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	
18	DICH BAN DO QUANG THAN DAO SU TAP PHAN QUANG TRI VA THUA TIEN	VHV.1375-023.jpg	1785	Nguyen Huy Quynh et Nguyen Huy Chuong, Quang Thuan Dao su Tap (19	

Fig. 9. Example of inventory of the sub-corpus of old maps.

This inventory carried out in a simple spreadsheet allows a powerful interoperability since the export is executed in CSV format (*comma separated values*). This format, as simple as it may seem, also guarantees the durability of the inventory data over time.

Semantic Web, Glossaries and Repositories

In order for this metadata to be understandable by different systems (programmatic interface: API, data harvesting by search engines: OAI-PMH), it is necessary for the inventory fields to be standardized by semantic web vocabularies.²³ For this purpose, we use the *Dublin Core* metadata vocabulary. The *Dublin Core*²⁴ aims "to provide a common core of descriptive elements that is sufficiently structured to allow a minimum of interoperability between independently designed systems."²⁵

Once the inventory has been carried out and stabilized, i.e. the quality is sufficient and contains no errors, a *mapping* operation should be carried out between the fields (column names) in the inventory file and terms or keywords from the *Dublin Core* vocabulary. The latter contains specific standardized terms that guarantee a strict correspondence and have a particular meaning. The following table gives some examples of the mapping we made between columns of the inventory table and fields of the *Dublin Core* glossary.

Terms in the *Dublin Core* glossary are prefixed by the term dc. Other vocabularies are used in the inventory, such as "Bibliographic Ontology" (BIBO) with the Map class in particular, which gives the term bibo:Map. The TimeOntology vocabulary is also interesting to formalize everything related to time: for example time::Duration.

If the glossaries make it possible to describe data internal to the platform, it is also possible to "hook" attributes to the inventory items from external repositories. This is particularly interesting when it comes to describing places or people.

Thus, an external repository is a web data resource whose database entities are perennial and accessible by a stable URI (Uniform Resource Identifier). It is therefore in reality a database that can be used as an authority record in various fields: initially created for libraries (see the VIAF repository²⁶), repositories were quickly introduced in biology (WikiPathways), biomedical chemistry (Semanticscience Integrated Ontology), and then extended to the Human and Social Sciences.

These repositories allow to connect datasets to one another, and just like the Web, it is possible to consider it as a view in the form of an interconnected data network.

²³ Ngomo AC.N., Auer S., Lehmann J., Zaveri A. (2014) Introduction to Linked Data and Its Lifecycle on the Web. In: Koubarakis M. et al. (eds) Reasoning Web. Reasoning on the Web in the Big Data Era. Reasoning Web 2014. Lecture Notes in Computer Science, vol 8714. Springer, Cham

²⁴ <http://dublincore.org/>

²⁵ Bibliothèque nationale de France, « BnF - Vocabulaires du web sémantique » [archive], sur www.bnf.fr

²⁶ Virtual International Authority File : <http://viaf.org/>

The geographic datasets are particularly important. In order to ensure connectivity of these spatially informed datasets, the repositories on which these data are based are referred to as gazetteers.

A gazetteer is a directory of place names, whose data can be structured and prioritized (e.g. according to administrative boundaries). The gazetteer that we mainly use is *Geonames*.²⁷ It is based on Wikipedia and is enriched daily by the community. For example, Hue is visible on the URI <https://www.geonames.org/1580240> and presents a view with its geographical coordinates, some background information (administrative division, population, etc.), but also alternative names in several languages, even ancient names.

Other geographical references exist: Getty as a generalist directory or Pléiades for ancient places. Finally, there is a generalist repository that we also use as an external resource: Wikidata, which is the semantic database linked to all Wikimedia projects, including Wikipedia.

What is of interest is to define concepts such as a model derived from a model of the world. Thus, for example, Đông Hà capital of the province of Quảng Trị presents a perennial link and links with other entities of a more general model. This page can be seen at: <https://www.wikidata.org/wiki/Q33343>. The identifier is a unique identifier and the page offers a translation in several languages. In the rest of the page, we see that the city of Đông Hà is linked to the generic class "Provincial city" and that the entity itself is linked to another entity to which it belongs: the province of Quảng Trị (<https://www.wikidata.org/wiki/Q36579>). By proceeding the exploration, we see that this one is in the geographical entity of Vietnam which belongs to the generic classes "country", "sovereign state", which is part of "Southern Asia", etc. Moreover, this repository will contain a link to other external repositories. We will therefore find links to the following repositories: VIAF, Freebase, Library of Congress, Whos on first and Geonames.

This way, a knowledge base of the world is built by a general model on which we can both build and justify inventories but which also serves to make inferences, i.e. computer queries that build new knowledge.

The corpus is online on the Oronce Fine portal

The complexity of a corpus gathering several hundred documents (maps and plans, field photos, archival documents) is not easy to handle and capturing all the parameters leading to the verification of intuitions or research hypotheses is a difficult operation.

At this stage, we are able to build a research object that presupposes all the previous steps before putting the iconographic documents online in a content management tool. This tool also allows the creation and management of a website to view the document collections (to date, 717 documents are available). For this project, there are four collections: ancient maps and plans (20 documents), contemporary maps (200 documents), orthophotographs (102 documents), and field photos (395 documents). All documentation can be seen at: <http://psig.huma-num.fr/pacha>. The collection is presented through a mosaic view at: <http://psig.huma-num.fr/omeka-s/s/eclivi/page/mosaique> .

²⁷ www.geonames.org

The construction of such a research object is related to, but not limited to, a precise theme concerning the analysis of landscape transformations, mainly around the question of water (mouths, paleo-medians), and what it entails.

For this reason, the following section will present the historical and archaeological research context of the area under consideration. Of course, the problem of *long durée* will be taken into account at the landscape level, and will be linked to the lines of research that emerged via the source documents. At the end of this section, we will be able to build a gazetteer of ancient and current toponyms specific to our field of study and to set up a methodology to start analyzing, in greater detail, the historical issues related to the change in the landscape.

2. The construction of a northern Cham space over the *Longue Durée*

This section aims at showing the historical coherence of the region as a research topic. By putting the textual documents into perspective, it is possible to follow their construction as a social space over the *longue durée*. The comparison of these data with the maps evidences their importance

Historical framework

In 192 CE, the assassination of the Chinese prefect of the Rinan commandery in Xianglin led to the birth of an independent chieftaincy in which we see a proto-Cham entity emerged, recognized by the Chinese as the Linyi or "city of the Lin" from the 3rd century onwards and with whom the Chinese traded. The Linyi may have distinguished itself from the other chiefdoms by its loose alliances with the Chinese. The Linyi is recognized by the Chinese as a constituted political entity. Its inhabitants are referred to as "barbarians," *Kunlun*, a term referring to "the black, frizzy-haired people of the South." The region of Hué was home to the seat of the Xianglin/Linyi from which the local chiefs extended their territory until the Chinese identified it at the end of the 5th century as "the Linyi Kingdom", a territory extending over the-current provinces of Quảng Trị and Thừa Thiên- Huế.²⁸ The northern city of Linyi, Oli (Ulik) (alias "Qusu"²⁹), has been described as "next to the mountains, where the thick forest reaches the clouds, the mist rises among and above them."³⁰ Evidence that the area was still wilderness.

From the 6th century onwards the first Cham kingdoms appeared with sculptures found in the places of occupation that seem to emanate from cult practices dedicated to

²⁸ Schweyer 2012 : 105.

²⁹ Personal communication from Li Tana, November 2018: « Ulik's earlier written form was no other than 區栗, numerous mentioned in the fourth century source *Shuijingzhu* and throughout the Chinese chronicles to the fifth century. In the early twentieth century, historians made a serious mistake interpreting the name "區栗" in Chinese script, and this erroneous misinterpretation persists to this day. The first character, "區" has two pronunciations, Ou and Qu (ô and Khu in Vietnamese). When it refers to a name it is read as Ou, as in the case of 區栗. Oli is thus a close record of the local name Ulik. When the *Shuijingzhu* was copied, the second character 栗, pronounced li, was mistakenly written as 粟, pronounced su. French scholars thus read the characters 區栗 as "kiu'-sou" (Qusu) in Chinese and "Khu Túc" in Vietnamese. Both characters were thus romanized erroneously. "Qusu" is a far cry from the phonetics of the city's name, Ulik, as pronounced in its original language. This mistake made the history of northern Champa even more confusing than it already is. Worst of all, it effectively disassociated the city from the region in which it was located. If, as the *Shuijingzhu* recorded, Oli was a city, then it would have been located in a region that was called by the same name as the Oli aromatics."

³⁰ *Shuijingzhu*, *juan* 36 in Li Daoyuan 1999.

the local spirits. Apparently, the Linyi was endowed with rich resources, which formed the basis of its prosperity.

A 5th-century Chinese source proclaims that the Linyi was "the port and way of all countries"³¹ indicating that the coasts offered multiple trade routes, by land and sea, and that it was best placed to connect the networks of mainland Southeast Asia to the shores of the South China Sea. Thus, exotic objects from Cambodia, Java, India, or elsewhere and brought to China, were repeatedly recorded in the Chinese Annals as being brought via Rinan, *ie* the Linyi.

From 618 CE, the Chinese Tang dynasty prevailed and became the powerful northern neighbour of the Chams for over two centuries. Historical documents are more abundant from the middle of the 7th century, showing a region entirely invested by the Chams, freed from the Chinese yoke. A local king named Kandarpadharma in the Chams inscriptions (C.96 VII of Mý Sơn³²), founded a capital, Kandarpapura, between 605 and 630, in the area of today's Huế. This capital is the current "citadel of the Chams" (*thành Lôi*) south of the Perfume River, not far from the current citadel of Huế. King Kandarpadharma introduced himself as "Lord of Champa" (*Campeśvara*) or "Lord of the Land of Champa" (*Campāprthivībhujā*).

In 645, Chinese texts³³ mentioned a king murdered by his minister, " along with all his male descendants". Only a nephew of King Kandarpadharma, named Jagaddharma, managed to escape and went into exile in the Khmer country, in Bhavapura, where he married a Khmer princess. Their son, Prakaśadhama, returned to claim his right to the throne during the second half of the 7th century. He made a citadel his capital, which he called Viṣṇupura "the city of Viṣṇu"³⁴, near the contemporary Cổ Thành in the province of Quảng Trị. Prakaśadhama imported viṣṇuism from the Khmer country into the Cham country.³⁵

The creation of structures linked to a political administration is made possible by the increase in wealth and a probable demographic surge. Thus, the development of irrigation systems in the King Prakaśadhama's Champa coincided with the strengthening of his authority and the need to feed a growing population. The demographic changes in Quảng Trị can be associated with the construction of irrigation works and canals that were first studied by Madeleine Colani³⁶ in the 1930s. The stone irrigation systems were re-studied by Lam Thi My Dung³⁷, and might be dating back to the 7th and 8th centuries. When thanks to his victories the king Prakaśadhama was finally recognized as king in the valley of the Thu Bon river (province of Quảng Nam, south of the province of Thừa Thiên-Huế), he received royal consecration (*abhiṣeka*) and took the name of Vikrāntavarman in 658 EC. His family remained the sovereigns at Viṣṇupura.

Little is known about the territorial occupation of this period. A few sites attest to a small territorial hold and therefore a present but sparse population. Few inscriptions have survived from this period, but they mention the great religions of Hinduism: śivaism and viṣṇuism. The construction of a temple (*kalan* in Cham) was a major social event, as each foundation increased the strength of the local elite.

³¹ Narrative of the *Linyi* in *Shuijingzhu* 水經注, juan 36.

³² Finot 1904 : 918.

³³ *Jiu Tang shu Ancient Book of Tang Dynasty*, 197.

³⁴ Southworth 2001 : 331.

³⁵ Dalsheimer & Manguin 1998 : 108-10.

³⁶ Colani 1940 *passim*.

³⁷ Lam 1993 : 76.

Under the Cham dynasty of Indrapura, the region of Quảng Trị and Thừa Thiên-Huế expanded. In 875, Indravarman's arrival as 'King of Kings' was remarkable, as this Tantric king Māhāyana encouraged the development of Buddhism in his kingdom. It is possible that the faith of the Cham king indicated political links with the Java dynasty Śailendra. The Cham inscription, C.149 of Nhan Biều³⁸ in the Quảng Trị province, mentioning a royal minister sent twice to Java on special missions to acquire "magical power", *siddhayātram*, offers arguments to this effect.

Inscriptions show that the region of Quảng Trị and Thừa Thiên-Huế was under the protection of King Indravarman. These territories were managed by members of the royal family native of the region; they were an integral part of the royal *maṇḍala* (circle of influence) whose satellites defined the royal territory.

In a Cham inscription dated 918 EC (C.148 Lai Trung³⁹), the 'Lord of Amarendrapura' is mentioned. Amarendrapura "the city of the gods" is synonymous with Indrapura, the name of the capital of the kings of the dynasty. This Lord was a minister of King Indravarman. The Cham city dating back to the same period can still be spotted on the ground. Today it is called Hoa Châu.

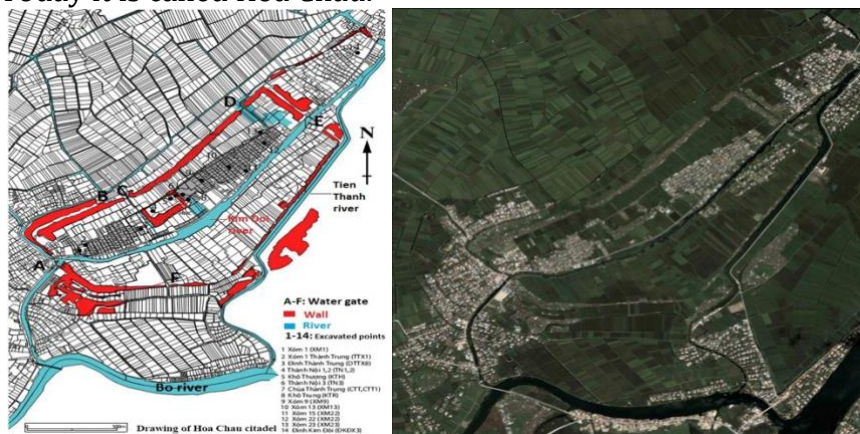


Fig. 10 The ancient Cham Amarendrapura/Indrapura city. Archaeological survey of the ancient Cham city Amarendrapura, nowadays called Hoa Châu. We can see its imprint in the landscape thanks to a Google Earth picture (right hand side).

During the 10th century, conditions were optimal for the territorial expansion of the Indrapura dynasty as the Chinese Tang dynasty was declining, while the Việts, located in the Red River delta, had not yet freed themselves from the Chinese yoke.

When the second king of the dynasty, Jaya Simhavarman, married a princess from the current provinces of Quảng Trị, Tribhuvanadevī, the whole vast plain of the current provinces of Quảng Trị and Thừa Thiên-Huế benefited from this wealthy dynasty. Most of the Cham sites built in the region date back to this period. The agricultural importance of the region can be recognized by means of a queen's foundation. The inscription C.113⁴⁰, of her foundation at Hà Trung dated back to 916 EC, describes the rich agricultural land around the sanctuary of śrī Indrakānteśvara in the 'city of Navap' (*nagara navap*). The fields are divided into three categories: the 'salty lands', which can go 'down to the sands of the great ocean'; the lowlands for rice fields are the 'lands for pricking out'; the highlands, the 'red lands' around Gio Linh and Vĩnh Linh, are the 'lands for planting'. Three types of production are thus materializing: salt, rice paddies, and other plantations. Still

³⁸ Huber 1911 : 299-311.

³⁹ Huber 1911 : 298-299.

⁴⁰ Huber 1911 : 298-9.

today, this region of Gio Linh is called "the three ascents" showing the development of the landscape by the Chams.

From the 11th century, the region was attacked by the Việts from the Red River Delta. The kings of Indrapura had essentially developed their expansionist aims towards the North, threatening the nascent Việts kingdom. The Việts Annals recounted the warlike relations with the Cham kingdoms during the first half of the 11th century. The *Đại Việts sử ký toàn thư*⁴¹, considered the first history book of the Việts, mentioned, as early as 1069, the district of Địa-Lý called the "Ô-Lý region" (in 1166 and 1285). In 992 there is also mention,⁴² of a road built by Lê Hoàn between the province of Hà Tĩnh and the "prefecture of Địa-Lý" as far as the excluded Cham territory.

The foundations of Cham temples were later abandoned in favour of the development of the defensive system, as evidenced by new citadels. The internal struggles between the Việts Lý and Trần dynasties (before 1225) were followed by an active campaign for the clearing and occupation of new lands. But this expansion was stopped by the Mongol invasions, which united the Việts and the Chams against this common enemy at the end of the 13th century. In 1285 a Cham king, Jaya Simhavarman, Prince Harijit, defeated the Mongols. He was the founder of the site of Linh Thái,⁴³ erected in the very south of the region of Thừa Thiên-Huế on a high hill overlooking the entrance to the pass of Cầu Hai and the mouth of the river Tư Hiền. In 1306, the victor over the Mongols married a daughter of king Trần Anh Tông (1293-1314), princess Trần Huyen, in exchange for the "territory of Huế", read the Việts texts. But the Cham king was assassinated in 1307 and the princess kidnapped by a Việts minister, who brought her back to her country of origin. This was the beginning of new wars between Chams and Việts. An unpublished inscription by Van Thê in the current province of Thừa Thiên-Huế, dated back to 1346 EC, mentions a "king of the Việts" (*yavaneśvara*)⁴⁴, who may have been defeated in the region. One ought to view this inscription as a sign that the region was still under Cham control in the 14th century. Any form of Việts tutelage over the region probably never existed at the time and the region only came definitively under the formal control of the Việts after 1471

The situation stabilized in favor of the Chams between 1360 and 1389, thanks to king Chế Bồng Nga,⁴⁵ from the region of Huế. The Chams plundered the Việts capital Thăng Long governed by the weakened Trần in 1371, 1377 and 1382,⁴⁶ taking spoils and

⁴¹ A list of accessible việts sources can be found in Dutton et al. 2012: 587-96 and an initial Western language catalogue is provided by Kiernan 2017: 134-5 and 180-1.

⁴² Ngô Đức Thọ 1983 vol. I : 193.

⁴³ Griffiths & Lepoutre 2016 : 244-246.

⁴⁴ Griffiths & Lepoutre 2016 : 206 note 29.

⁴⁵ In the absence of any Cham inscription from this king, the Cham name of this king is unknown. His name is only known from the Việts sources.

⁴⁶ It is written in the Việts sources, in 1362, that in the district of Hoá there is the citadel of Hoá- châu, which is a Cham foundation. In 1368, the territory of Hoá-châu is considered as a "border" (Bùi Quang Tung et al. 1990.: 51) between the Cham and Việts possessions and Cham King Chế Bồng Nga having worried the border region, a Việts minister is sent in 1376 to defend the Hoá district. In addition, "inhabitants of Thuận- Hoá came to deliver (to Việts) refugees from Champa" (The French translations provided here are taken from Bùi Quang Tung et al. 1990). But "the Chams persuaded people from Tân-bình (now Quảng Bình) and Thuận-Hoá to go and raid the provinces of Nghệ -an and Diễn-châu" in 1380, which is a way of saying that the Chams raided the Việts territories. It is certain that the region was still controlled by Chế Bồng Nga in the last quarter of the fourteenth century, making it impossible to stake out the territory.

prisoners and destroying the palaces and archives. There is obviously no question of Việts being present in the southern districts.

But King Chế Bồng Nga was assassinated in 1389-1390 by "a volley of cannon" in a naval battle (thanks to the treachery of one of his lieutenants who had indicated the ship of king Cham to the Việts gunners). However, the Đại Việts experienced an unprecedented crisis. The war had absorbed all the country's revenues and the new tax levies triggered the people's revolt. Yet the Việts had access to Chinese technology - and, in particular, gunpowder - at that period.⁴⁷ Thanks to this new technology, the Việts managed to outlive from one of the major crises in their history.

These episodes show that cultural and political exchanges intensified with the neighbouring Champa. For example, it was during this period that the Việts country was able to produce brown roofed ceramics produced in the Chams kilns of the present Bình province Định in central Vietnam. Their ceramics are a marker of intense communication in the South China Sea.

After the disappearance of King Chế Bồng Nga in 1389-90, the region is said to have suffered a Việts military presence, but under the leadership of Cham military leaders. The establishment of a new administrative system by Hồ Quý Ly at the end of the 14th century was the result of a military and political plan to integrate the region into the Việts sphere. However, it was after the Chinese invasion at the beginning of the 15th century that the intention to exhaustively catalogue the possessions of Đại Việts and the countries on the fringes was declared, based on the Chinese model.

The Ming invasion was above all the driving force behind a Việts migration towards the South. From the invasion of Đại Việts by the Ming in 1407, the South welcomed political dissidents. It was also a place of the banishment of those who were socially disrupted.⁴⁸ This Việts migration was probably not massive as the Annals book (*Thủy thiên bản*⁴⁹) recounts how a Việts family, the Bù family, came to settle in the region (village of Câu Nhi, district of Hải Lăng, province of Quảng Trị), at the beginning of the 15th century, when the region, on the margins of Đại Việts, was still controlled by the Chams. This text shows how a Việts group leader, a future village chief, came to settle in the region with the intention of staying there, since he carried along the remains of his ancestors to bury them in his new homeland. The text also states that the Việts migrants were concerned about their position as a "minority group".

After the victory over China and the death of Lê Lợi (1433), relations between the Chams and the Việts were again strained. The latter increasingly interfered in Cham affairs, even leading offensives on the then most opulent Cham capital, Vijaya, in the province of Bình Định, leading to its destruction in 1471.

The inhabitants of the region seemed to favour local peace, since after the defeat at Vijaya in 1471, "the troops of Thuận-Hoá captured (the Cham king) Trà Toài alive and presented him to the (Việts) king. ». Trà Toài remained under house arrest for 30 years at Thăng Long, and eventually died there. During the first quarter of the 16th century, the Chams suffered from the political instability of the Việts country. Under Le Uy Mục (1504-1509), nicknamed the "demon-king", the court sank into infighting. The instability of the government favoured the rebellion of the great lords and several peasant revolts broke out. In 1509, one of the children of King Trà Toài stole his father's ashes and managed to

⁴⁷ *Minh Shi History of the Ming Dynasty* 92 : 2264 et 89 : 2176-77 in Laichen 2006 : 75-6.

⁴⁸ Like in 1474 : Li 1998 : 22.

⁴⁹ Personal communication from Director of VICAS- Huế, Trần Đình Hằng, in August 2014, after a 1997 publication : Nguyễn Hữu Thông "Bức tranh dân cư vùng Thuận Hóa đầu thế kỷ XV qua văn bản *Thủy thiên tự*": 124-5, to which I only had access by means of a photocopy.

escape from Đại Việt to return to Champa. Many Cham slaves also escaped. The Việt king's ministers argued that these were a general revolt of the Chams. The king then ordered that the Chams in and around the Việt capital be massacred without any trial. After this massacre of 1509, there was no more mention of the Chams communities of Đại Việt in the official texts, nor of the migration of the Việt populations towards the South.

Lord Nguyễn Hoàng arrived in the region from 1558 to escape the political tensions that threatened his life and his clan in the North. He first settled in Ái Tử,⁵⁰ by the river in the district of Vũ Xương, now the province of Quảng Trị. For 13 years, he pacified the region and managed to establish his authority. His success attracted covetousness and the generals Mạc decided to destroy his emerging power. Legend has it that the genius of the river Ái Tử appeared to him and helped him to defeat a general Mạc. The Lord Nguyễn recognized a Cham goddess in this local genius and built a pagoda (chùa Bà) to thank her. In 1570 he moved his capital to Trà Bat,⁵¹ not far from Ái Tử, but to a more favourable site, next to a Cham monument. He succeeded in being accepted⁵² by the population, which was still predominantly Cham, and he sent spies to the other districts to "know the geography". He moved his capital⁵³ to Cát Doanh/Dinh Cát, which he fortified in 1600. He made a pact with the locals and succeeded in fighting the supporters of the Mạc.⁵⁴

The noble exiles who followed Nguyễn Hoàng in 1558 represented a group of about 1,000 men. Without representing a notorious migration, they formed a Việt elite in Cham land. This military and political entourage helped him to rule over this new region, soon to be called Đàng Trong "the region of the interior", which remained loyal to the Lê, who opposed Đàng Ngoài "the region of the exterior", where Mạc reigned as rebels against the legitimate dynasty. The choice to root a new centre of power, to locate it in a region, allowed the new governor to strengthen his position in a "local scene".⁵⁵ On a land that was not overpopulated, they enriched themselves with the customs of the Chams, for example by adopting the habitat on stilts that avoided the devastating effects of floods (which Alexander of Rhodes witnessed in the 17th century) or by not forbidding marriages with Cham women, contrary to what was practised in the North.

When disastrous harvests caused famine in the North in the second half of the 16th century,⁵⁶ the protected area was the scene of a new wave of immigration. Similarly, in

⁵⁰ «On the sandy hill of Ái Tử» Cadière 1906 : 95. 144 Lê, Đức Thọ 2012 : 127-33.

⁵¹ Lê Đức Thọ 2012 : 127-33.

⁵² « He struck an alliance with the local populations thanks to his policy of loving the army and the people, valuing the heroes and reducing chores and rents.». Anonymous 1558-1888, vol. I.

⁵³ Catherine Churchman in Dutton *et al.* 2012 : 159 "The duke was very pleased and decided to use virtuous government to conquer that place."

⁵⁴ "In 1572, supporters of the Macs, who had come to attack Nguyễn Hoang, the young founder of the dynasty of Nguyễn, newly arrived in his stronghold, were defeated by him and the survivors were sent to the region of Con-Tien, that is to say to the Red Lands of Gio-Linh, where they founded 36 villages.(...) in 1572, the rich Red Lands of Gio-Linh were not left fallow, but (...) they were cultivated and the country was inhabited. (...) Nguyễn Hoang seems to have carved out his kingdom from a largely Cham population; there was still, at that time, in all these provinces, only an Annamite minority; moreover, if the population of the Red Lands of Gio-Linh had been Annamite, how could Nguyễn Hoang have sent there, to dispossess it, the followers of the Macs who were indeed Annamites? "(Cadière in Colani 1940: 207-210). At the time of French Indochina, the Việts (population coming from the Red River Delta) were called Annamites (the inhabitants of Annam, a Chinese term designating conquered territories and meaning "the pacified South").

⁵⁵ Kelley 2015 : 119.

⁵⁶ Li 1998 : 29-30.

the 17th century, the war between the Trịnh and the Nguyễn caused a new wave of immigration.

When descendants of the Nguyễn clan claimed, centuries later, that "their ancestors originated from O Châu", official historians integrated all the ancient historical accounts into the official narrative of the new court and recounted how the Cham spirits of the land claimed the presence of a new ruler on their land. Even emperors Nguyễn from Minh Mạng in 1820, and especially under Đồng Khánh (1885-1889), accumulated titles, imperial patents and fervent descriptions of the goddess Po Nagar / Thiên Y A Na.⁵⁷ The Vietnamese longing for assimilation is based on the idea of a power fundamentally rooted in the soil, in relation to the guardian spirits. The veneration to the female Cham spirits seems to have been first organized by Nguyễn Hoàng, in order to appropriate the forces of the place and to make them beneficial. It also enabled him to incorporate ethnic diversity (i.e. the arrival of Việts) into the territorial continuity. Thus, the population accompanying the new governor, a minority initially, became a majority over decades of presence.

The functioning of the local economy over a lengthy period of time

This section provides elements to understand the functioning of the exchanges in the region of Thừa Thiên-Huế and Quảng Trị, insisting on the structuring role of water - whose importance is measured by studying maps -, while identifying the actors of the exchanges and the modifications of the social landscape through the establishment of borders. It presents some hypotheses regarding the regional landscape and the place of humans.

Role of water

The physical environment of mainland South-East Asia, along trade routes, shows that States developed along the coastline, similar to the island environment in the sense that the relations between the different kingdoms existed mainly by sea. For example, the Cham kingdoms or Đại Việt were part of the maritime trade network connecting South-East Asia with India, China and the Islamic world. The sea thus created the links between the different communities of Southeast Asia. But if the unifying role of the sea by means of trade has been studied, highlighting the "island" functioning of the different kingdoms open to international maritime trade,⁵⁸ thanks to each valley being open to the South China Sea, the fuelling of this trade with products from the mountains is not sufficiently documented. Although the civilization of Sa Huỳnh has been little studied in the region of Thừa Thiên-Huế and Quảng Trị, North-south trade along the coasts of present-day Vietnam has clearly existed for a long time. It questions the links between mountain people and the plains, the functioning of exchange networks, and, finally, the relative issue between steps and margins.

The river network in the region is dense. Rivers flowing directly into the sea are mainly to be found in the province of Quảng Trị, with the river Bến Hải flowing north into the South China Sea (now called the East Sea in Vietnam) at the mouth of the Tùng River, and further south, the river Quảng Trị, into which the river Cam Lộ flows and which ends at the mouth of the river Việt. The river Ô Lâu marks the boundary between the two provinces. In the current province of Thừa Thiên-Huế, two rivers flowed from the high plateaus, the Perfume River, or sông Hương, and the Bồ river. This province has the peculiarity today of not having rivers flowing directly into the sea, but all the rivers join

⁵⁷ Taylor 2004 : 32.

⁵⁸ Like Reid 1988 *passim* or Li 1998 : 59-98.

lagoons. The Bồ river, in the north, flows into the Perfume River, which crosses the Tam Giang lagoon to reach the mouth Thuận An. In the South, the lagoon Cầu Hai drains some rivers and opens to the sea at the mouth Tư Hiền. In the past, the most important river in the O-Li region was the river Bồ. Originally from Laos, it was large enough to allow navigation, linking the salt production sites to the mountainous areas. The Perfume River, or Sông Hương, was not mentioned in the 15th-century Ming Gazette. In this source, the main river in the province Thừa Thiên- Huế was the Bồ river,⁵⁹ on which the citadel of Hóa Châu was built by the Chams in the 9th or early 10th century. Japanese archaeologist Nishimura and Vietnamese researchers excavated this site between 2007 and 2012 and found numerous Cham objects in the north of the citadel, the residential area. Today, the valley of the Perfume River is the only one to reach the highlands, bordered by National Road 49.



Fig.11: Schematic presentation of the northern Cham region. Positioning of the main Cham archaeological sites along the rivers.

From the 7th-8th centuries onwards, the trade-related wealth allowed for diversification of tasks and geographical stability. Agricultural production, in the north of today's province of Quảng Trị, with the complex irrigation system of Gio Linh and the land use planning in the neighbouring district of Vĩnh Linh, represents a stage in the development of a political entity, as it is based on the cooperation of several communities. From Madeleine Colani's findings,⁶⁰ one can infer that the builders of the land around Gio Linh and Vĩnh Linh were able to adapt their technology to the geographical constraints, but also that their development techniques were specific to a particular subgroup of the Austronesian population. Above all, this group showed a strong sense of organization: they had warehouses near the river mouths, serving as a link between merchants from the sea and people from the mountains exchanging goods. The development of irrigated land gradually created large areas of permanent agricultural land, allowing a greater concentration of both agricultural and urban populations.

⁵⁹ *Ngan-nan tche tche yuan* : 56 «The Bồ river is in the Bồ Đài district. It originates in Laos. It runs east from the district office to the shallow sea (Phá Tam Giang), it also flows to the river Tam Kỳ in Hóa Châu. It is deep enough to allow navigation by boat. » Translation from Tana Li.

⁶⁰ Colani 1940 : 11, 13-4, 39-40, 48, 210.

On the first Việt known map Hồng Đức Bản Đồ dated 1490, rivers act as natural boundaries between districts. They have no names, while the mouths (*cửa* or *môn*) are identified, probably because they were important for shipping.

Bronson's model and trade

The framework of upstream/downstream linkages was formalized by Bennett Bronson by using a functional model called the *Riverine System Exchange Model*.⁶¹ His hierarchical model, known as dendritic, adapts to the geography of the valleys that drained products from the highlands to the coastal ports. According to this model, the products to be exchanged came from the mountains (E, F) to reach local markets (C, D), from where they were transported to the regional market (B), the political and social centre of the region, and from there, some of them would supply the national and international market (A).

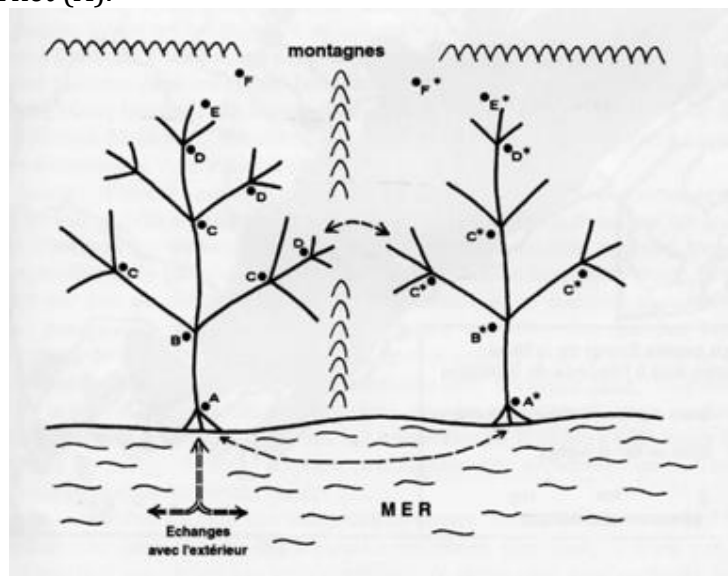


Fig.12: Bronson dendritic scheme slightly modified by P.-Y. Manguin, 2000⁶²

Bronson's model, although it was not originally created for the Chams, seems to be able to fit the Cham valleys. Kenneth Hall⁶³ explored this possibility by comparing the founding Chams kingdoms to Java and other island states, with each Cham valley containing a kingdom (*nagara*) that can be considered more or less autonomous.⁶⁴ He explained the political and economic networks of the Cham kingdoms using Bronson's model, calling it a "river trading network".⁶⁵ According to this model, a trading network system had a coastal trading centre, usually located at the mouth of a river, and remote upstream centres that were the hubs for products from more distant parts of the river's watershed. These products were made by people who lived in mountain villages or upriver. Each Cham *nagara* had its own river exchange system. Thus, the characteristic of Cham city states can be seen as a network of loose, yet interdependent, alliances between a series of urban centres, but whose very nature was politically and economically unstable. Political authority was concentrated in urban centres not far from the coast, centres of *nagara* that shifted over time.

⁶¹ Bronson 1977 : 42 fig. 1.

⁶² Manguin 2000 : 163 fig. 2.

⁶³ Hall 2011:22-29.

⁶⁴ Taylor 1992 : 154 considers the Cham valleys to be « island-clusters ».

⁶⁵ Hall 1985.

Whether this model is suitable for the Cham country is still a matter of debate. The best analysis of this model has been presented by William Southworth,⁶⁶ who discusses the individual points of Bronson's model, and whether they correlate with the Cham country. Southworth concludes that Bronson's model does not summarize the changes observed across the Cham country over time, particularly the transition to greater centralization during the 9th to 12th centuries. This is the period when the term *Bhūmī Campā* "land of Champa" appeared in the inscriptions. The "Land of Champa" can be understood by means of the political analysis scheme in concentric halos (*maṇḍala*) devised by Wolters.⁶⁷ In the case of Champa, the spatial model of this politico-religious construction consisted of three concentric halos, or zones of influence, with a first halo, the political centre occupied by a king in his capital, a second halo, the periphery under the control of the king's vassals, and a third halo, the margins of central power, bordered by "open" borders. The multiple "kings' circles" with these numerous rulers form an open political structure. Schweyer⁶⁸ proposed to adapt Wolters' concept of *maṇḍala* to better describe the specificities of the ancient Cham space based on the specific vocabulary of Cham inscriptions. Thus, the expression of *Bhūmī Campā* "the land of Champa" is a notion open to interpretation that can be considered as a historical model to describe the polyethnic space of the ancient Champa civilization, open to trade. Then, the centres (A= ports/warehouses and B= Cham capital), through the chief towns controlled by the king's vassals (C= Cham regional capitals), were linked to the margins (D= cities at the margins of a Cham kingdom, E= cities/mountain markets and F= place of production). We also note that by separating the places of agricultural production along the river valleys from the places of production of products for trade in the high plateaus, the Cham political-social system did not depend on a single socio-ecological system, and thus strengthened its capacity for resilience.⁶⁹

Passageways to the highlands: the example of the Cam Lộ valley

By studying Bronson's model, the importance of river valleys as trade routes is highlighted. Some data are available on the overland trade routes that fuelled trade. Lê Quý Đôn, in the *Phủ biên tạp lục*, in 1776, provides details of places of exchange between the high plateaus and the plain. For example: "Cam-Lộ in the upper river Đieu, near the tribal communities of Laos... Tribe members often brought goods to Cam Lộ for exchange. One elephant could carry 30 bags of rice." He also demonstrates the importance of the market for trade between the plain and the highlands: "Further west, you will see the tribal villages that lived and farmed in this area. Foreign merchants often bring salt, fish sauce, dried fish, iron goods, bronze pots, silver, and other items to this area to exchange for rice, chicken, buffalo, cloth, and other forest products, and then hire elephants to transport goods to Cam Lộ's market ».

Salt was an essential part of the trade between lowland and upland areas, and trade was based on the barter system.⁷⁰ Salt was a natural resource listed by Viêts, and was all the more important as it was subject to taxation. Jacques Dournes mentioned that these

⁶⁶ Southworth 2011:115.

⁶⁷ The theoretical science of *maṇḍala* is treated in the *Arthashastra* of Kautiliya, VII. Wolters (1999) provides the first significant analysis of the different types of regional developments given to this Indian model. This idea is drawn from the "galactic states" of Tambiah 1976.

⁶⁸ Schweyer 2006.

⁶⁹ Macrae 2016 : 94.

⁷⁰ Bartering was all the easier in ancient times, since the Cham country, like the Khmer country, was a "society without money". Lustig 2009 : 88.

roads linking the highlands to the plains were identified by the mountainous people as the "salt roads".⁷¹

An important trade route was found in the Cam Valley Lô, province of Quảng Trị. Trade with the highlands had been taking the same routes for centuries. Along this valley there are many traces of Cham sites dating from the 10th century, which seem to mark the date of the development of trade and attest to the prosperity of the valley. One can find the sites of Kim Đầu, An Xuân, An Bình, Lam Lan, Dinh Xá, Trương Xá and Đông Hà.



Fig. 13: Chams sites along the Cam Lô valley.

Despite the relatively large number of Cham sites, access to the valley upstream did not appear to be militarily locked. Only one ancient citadel has been identified in the area, Thành Cổ Lũy, which protected the northern access to the plain.

In fact, the border post of Ai Lao (passage to the highlands) and the "circle" (đạo) of Cam Lô (...) were created by Emperor Gia-Long (1802-1820). In 1828, Minh-Mênh incorporated them into his empire by organizing them into prefectures (phủ), and districts (huyện or châu), whose administration remained entrusted to their customary chiefs. Between 1827 and 1828, the nine districts of the prefecture of Cam Lô were erected.⁷² It seems that it was not until the 19th century that the passage to the highlands was closed by a border post. The establishment of fixed frontiers created a gap between the mountains and the plains, whereas the *Bhūmi Campā* previously did not generate any physical border.

The construction of a citadel guarding the valley of Cam Lô seems to date, however, from the time of the Lords Nguyễn. It appears on a map from the second half of the 17th century, marking tensions with the Trịnh during the second quarter of the 17th century, when the great wall of Đổng Hới was built. The valley of Cam Lô has remained an obligatory passage in the exchanges with the high plateaux. It can be seen that in the 17th century the valley was both a place of exchange with a market, located along the river, and a place watched over and protected by a stronghold, called the citadel. The presence of a citadel shows that the area was brought under control - a control that is probably due to the conflicts of the Nguyễn against the Trịnh. However, this military control does not seem to be interfering with commercial activities, since the "Cam Lô market" is still present along the river that joins the river of Quảng Trị flowing into the sea at the Việt mouth.

⁷¹ Dournes 1950 : 3-47.

⁷² Nguyễn Thê Anh 1997 : 158-162.

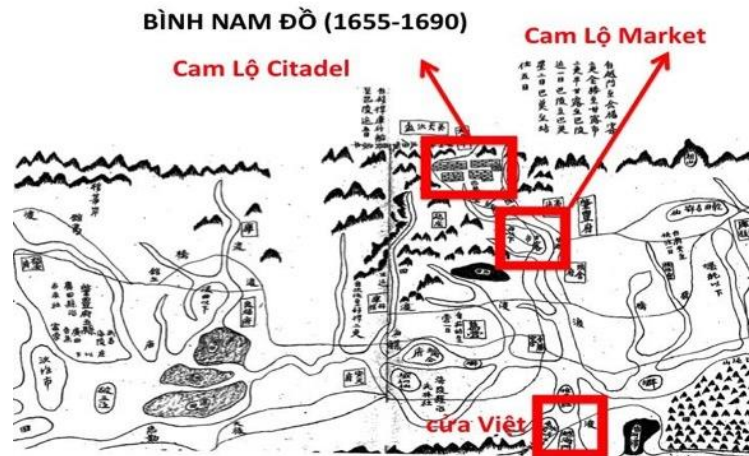


Fig. 14: GIÁP NGỌ BÌNH NAM ĐỒ, excerpt.

This detail from a map of the second half of the 17th century shows the locking of the Cam Lộ valley by a citadel.

The Cam Lộ valley made it possible to control the passage of men and goods between the sea - identified at the mouth "Việt" - and the high plateaus. The easiest and most important trade route of the whole Annamite chain (Trường Sơn) passed through the Ai Lao pass to reach the sea. This road remains the main access of Laos to the ocean. The ancient road that went along the valley is now the National Road No 9; it has become an international highway that allows the transit of goods from the Vietnamese coast to Laos and Thailand. As a result, it has made the old trade routes between the mountainous people and the people of the plains completely useless, since what used to take several days now takes only a few hours by truck.

A polyethnic space

The *Bhūmī Campā* "Land of Champa" was a polyethnic area that developed close relations with the highlands, on which they depended for their economy. The Chams recognized the social system of the people of the mountains. The regional dynamic functioned through roads and river routes. Even today these trade routes are known to the local population as the "salt route". The Cham centres played two important roles.⁷³ Firstly, they were integrated in the production of food for subsistence and to equip international traders, who used coastal ports to replenish their supplies. Secondly, they provided important links between the highlands, where exotic goods and raw materials were traded to the coast for export. In the west of present-day Vietnam were a series of mountain tribes, some of whom were linked to the Chams. The highlands were important for the supply of forest and other products for international trade, as well as for providing refuge.⁷⁴ The old system was heterarchic (political-social organization in the form of a network of cooperation without subordination), recognizing the importance of the margins as well as their autonomy from the political system.

In the history of the making of the states of South-East Asia, an important part of the scientific literature continues to maintain the image of a persistent opposition between, on the one hand, the populations of the plains and valleys, bearers of civilization, and, on the other hand, the "mountain peoples" ("tribes", "minorities"), who have remained on the margins. For the Chams, the margins were a kind of no man's land between two *maṅḍala*, at the limit of their zone of influence; for the Việts, they could be

⁷³ Hall 2011: 67, 76-77.

⁷⁴ Hall 2011:78 ; Lockhart 2011:30.

potential areas of settlement when demographic pressure was too great, while for the mountain people, nomads, the notion did not make sense. Jacques Dournes⁷⁵ invented the notion of "High Champa" to designate the high plateaus of Central Vietnam populated by the Jarai "which are Chams" - at least, from the 15th century onwards.

Today poorly integrated into the national scheme, the minority mountain population has nevertheless played a major role in the construction of trade and the country's wealth. Thus, rather than being in opposition to the populations of the plains, mountain societies were somehow internal margins.

The Chams recognized the mountain people. Some ethnic groups are mentioned in Cham inscriptions. For example, several inscriptions refer to the "mountain people" (*Kirāṭa*, *Kirendra* and *Mleccha*) - whose ethnic names can be recognized, the Vṛilah and the Radhé (*Randaiy*) - and especially locate them in "the land of the mid/interior multitude" (*nagara Madhyamagrāma* or *Maddhamagrāma*). They recognize them as kings.⁷⁶ The first references to these highlanders were mainly military from the 11th century onwards, with mention of political conflicts. The Chams endorsed the social organization of the mountain people with their words and ethnocentrism, naming "king" a probable tribal chief. Similarly, the mountains formed a different ecological environment from the kingdoms of the plains, and the Cham system of *maṇḍala* only functioned up to the limits of its own ecological system.

In ancient times, the societies inhabiting the forest and mountain regions on the steps of *Bhūmi Campā* and the Chams lived in a rhythm of interdependence and structured cooperation. The Marche regions were intermediate spaces between politically constituted kingdoms, but they were above all areas of encountering and interpenetration of cultures. The northern region of the Cham country was a Marche zone for the Viêts of the 15th-16th centuries and yet they were not impenetrable zones, far from centres of power. The mountain people were at the margins, but they were not marginal, since they were an essential link in the economic chain of the region. The highlands played an essential role in the construction of the Cham kingdoms. The Chams owed their wealth to their involvement in the maritime silk route, but they attracted foreign merchants with products from the highlands.

Even if the Cham inscriptions mentioning the mountain people refer only to the Chams kingdoms in the South, it can be assumed that this social structure was found in the North. Thus, the existence of links between the Katu and the Chams is documented in ancient times through rock inscriptions from Samo,⁷⁷ in the upper valley of the Thu River Bôn in the neighbouring province of Quảng Nam. Although their links are poorly documented and rather informal, the evidence of a Cham presence in Katu country proves the existence of very ancient links between the upstream and downstream valleys flowing into the highlands.

Nowadays, the mountain people with whom the people of the plain were in contact are not well known on the Vietnamese side. They are mostly in the present Laotian territory.⁷⁸ One study has shown that the region neighbouring the present Quảng Nam

⁷⁵ Dournes 1970.

⁷⁶ *kirāṭarāja* "king of the mountain people" in C.101 B l. 3 and 6 (Finot 1904 : 963-966), *kirāṭeśvara* "Master of the des mountain people" in C.43 B l.1 or *mahnākirendra di maddhamagrāma* "great king of the mountain people" in C.43 A l. 20 (Lepoutre 2019).

⁷⁷ Three inscriptions (C.199) that may date from the 7th century at Hien (formerly Samo) attest to contacts between the Katu and Chams. Wittayarat 2004-2005: 14-17 tried to decipher them. It mentions a buffalo and a gift to a local genius.

⁷⁸ This territory was once Khmer, see Maître 1912 : 455-456.

has benefited from exchanges with the Katu,⁷⁹ a Mon-Khmer-speaking population, since ancient times. The exchanges towards the region of the current provinces of Quảng Trị and Thừa Thiên- Huế were carried out with the provinces of current Laos. This shows that the ancient territories are not found within the modern borders and that the Chams drew a considerable part of their wealth from the products exchanged in the highlands.

The mountain people with whom the Chams traded in the provinces of Thừa Thiên-Huế and Quảng Trị have been little studied, in contrast to the mountain ethnic groups of South Vietnam. They are essentially three ethnic groups: the Katu or Cơ Tu, the Brou/Bru or Vân Kiều and the Tà Ôi, found along the northern Annamese Cordillera (Dãy Trường Sơn), between today's Vietnam and Laos. In reality, they are minorities speaking a language belonging to the Mon-Khmer group known as "Katuic", very close linguistically; they were slash-and-burn farmers.

The agricultural practises of these mountain populations did not create environmental imbalance, as they lived in an interdependent interaction: trees were felled for food and aromatic woods, and for burning in a process of shifting cultivation, but population pressures were low enough to allow for routine regeneration. However, before the colonial period and plantation agriculture and mechanized logging, a major change affected the environment. It was the rapid growth of commercial agriculture after the 16th century that encouraged deforestation and, as a result, the decline of large mammals, especially elephants and rhinos. Even more importantly, it was the overpopulation of the *Kinh* on the highlands from the last quarter of the 20th century onwards that visibly altered the entire landscape physiognomy⁸⁰ and ancestral practises. The highlands extending west of the region of Thừa Thiên-Huế and Quảng Trị experienced a drastic demographic change between 1976 and 1990, when a massive colonization of 6 million Kinh (the majority Vietnamese ethnic group from the plains) settled down there, exceeding the number of inhabitants of the highlands.

In ancient times, these populations, at the margins of politically more structured states, had apparently gained integration into the internal margins of these kingdoms. The functioning of the *Bhūmi Campā* did not generate any physical borders. The borders, though permeable, were more social, pitting, for example, the Indianized kingdoms using writing and Sanskrit against the mountain peoples of oral traditions. The modern notion that spaces should be controlled by a country ethnically or historically linked to it, has left many highland ethnic groups behind, and they have found themselves scattered among several states. This is the case of the group of languages known as the Katuic languages, which covers most of the ethnic groups that fuelled regional trade.

The recognition of the "margins" of *Bhūmi Campā* "the land of Champā" seems to have been acquired, as early as the 10th century, more certainly from the 15th century, and even more convincingly from the accession to the throne of Champā of King Po Romé (1627-1651), who, although of Churu mountain descent, became king of the Chams of the plain and their allies. Linguistic and ethnographic evidence shows that the Cham country was not an ethnically uniform political space, but that it was nourished by socio-economic

⁷⁹ Tran Duc Sang 2004: 71-86.

⁸⁰ Mcelwee 2008: 99-103 describes the economic practices implemented by the *Kinh* of the plains over the last fifty years, who come directly to exploit the forests and pick up exotic woods by truck to sell them on the markets of Đông Hà and Huế. The sensible exploitation of forest products has given way to a destructive deforestation imposed on the mountain populations who, in fact, can no longer practice slash-and-burn agriculture. Their traditional agriculture has been declared "destructive" by the Vietnamese authorities, who are trying to duplicate the flooded rice cultivation of the plains in a totally unsuitable landscape.

relations built over the *longue durée*. The reign of Po Romé marked a turning point in the process of interaction with the highlanders, since as a highland man he was deified in the last Cham temple built in the 17th century, the Bimong Po Romé, at Hậu Sanh, Ninh province Thuận. Po Romé had three wives, a Rhade, a wife Cham Awal (Muslim) and a Việt princess, a sign that he relied on his personal relationships to build his multicultural political base. His successor, Po Saut, was the son of his Rhadé wife. The next fourteen Cham kings were all Churu. And it was the Koho and Rhade (or Raglai) peoples who became the custodians of the "treasures of the Cham Kings".

With the disappearance of the *Bhūmī Campā* at the end of the 15th century, however, the social structures, the backbone of society, remained in place. It is not known how local society functioned in the 16th century, but it can be assumed that the economic and social networks, which were established over the long term, endured. The regional dynamic functioned through the roads that allowed the networks to reach the highlands; overland roads complemented the rivers in the creation of the network of exchanges between the highlands and the lowlands, known to the local population as the 'salt route'. It was on this road network that border posts and taxation points were established.

The notion of frontier: border post and taxation

The network of upstream-downstream exchanges in central Vietnam is a model of multi-ethnic coexistence in the region, in which each link had its own importance. In pre-modern times, the region was a melting pot of cultures unique in Vietnam, a place of interaction between highlands and lowlands, between North and South. The dynamic between the highlands and the plains seems monodirectional, as the Chams, then the Việts, seem to have been the sole interlocutors with the traders in international trade. But recent surveys show that the absence of written sources is the only reason for this understanding, because more than one-way relationships, in the interest of the people of the plains, there is a network of interactions that functioned over the *longue durée*.

It seems that the dichotomy between uplands or highlands and lowlands or plains took shape locally around the seventeenth century and took root between the nineteenth and twentieth centuries when the concepts of state-like geographical areas took shape. A region at the margins of Việt central power became the site of historical events that put it at the centre of history in the late 16th century. But it is Vietnamese irredentism to see the arrival of Việt populations in the region as just one step in the "March towards the South". Modern history has revisited pre-modern history by minimizing the rupture brought about by the Nguyễn⁸¹ and favouring a reading of dynastic continuity that denies historical truth.

Lê Quý Đôn clearly mentioned a system of taxation at the end of the 18th century. Thus, in the district of Minh Linh, there is evidence of a significant production of salt,⁸² in a well marked area. Several sources⁸³ explain how salt became, under the Nguyễn, a means of controlling the populations of the highlands, traces that the salt trade is a basis

⁸¹ The interpretation of Li 1998:99 that a new social, cultural and physical environment has created "a new way of being Vietnamese" seems to me distorted because of official historical sources. These sources have reinvented the lives of the men who came to migrate to the region. I have explained above why it seems to me that we have had more to do with a "chamisation" of the Việts than a "Vietnamisation" of the Chams from a socio-cultural point of view.

⁸² Lê Quý Đôn 1776 : *Xã Xuân Mỹ huyện Minh Linh hàng năm phải nộp 168 giạ muối thuế và 50 giạ muối lễ*.. The distinction between two kinds of salt (muối) "thuế" ("salt tax") and "lễ" ("salt ceremonies") appears to generate two types of taxes.

⁸³ Guérin *et al.* 2003.

for exchanges with the highlands and lowlands (and a means of control). Later, Jean Le Pichon⁸⁴ reports a katu song that refers to the French as "the (new) Masters of Salt".

Archeo-geography: the landscape over the *longue durée*

This section of archaeo-geography explores the notion of environment in history through the study of maps and texts to define the landscape in which civilizations evolve. This research, using Geographic Information Systems in History, should allow an eco-historical study of pre-modern times in the present provinces of Quảng Trị and Thừa Thiên-Huế, focusing on history and landscape over the *longue durée*. By focusing on river axes (vectors of relations between high plateaus and plains) and on lagoons (the final link in the chain of economic exchanges), the environmental study will provide a local response to a question that is initially more global in nature, concerning the adaptation of a society to its geographical and climatic environment over the *longue durée*. Through this contextualized work of multi-layered times and societies, it becomes possible to identify how the local becomes the expression of the global. For we know something about Champa's maritime history, but we know little about how its coasts and rivers were connected and how they have changed over time, and whether these changes in the landscape have had an impact on Champa's maritime fortunes in any way.

Evolution of river mouths and impact on human settlements

A study of the old maps allows further work to be done on the high mobility of the mouths in the region and the consequences for the populations.

On the first known map, from the end of the 15th century, only three mouths are identified for the whole region; two mouths (Minh Linh and Việt) are located in the current province of Quảng Trị and the mouth Tư Khách, in the south, in the current province of Thừa Thiên-Huế. The northern part of the region seems both open towards the highlands and well protected, which justifies the implantation of Lords Nguyễn in this part of the territory in the 16th century. The district of Đan-điền (today Quan-Điền) takes the form of an island surrounded by the waters of two rivers flowing into the sea, one at the mouth Việt, the other at the mouth Tư Khách, generating a lagoon, called the lagoon of Hải Lãng.⁸⁵

It seems possible to locate the five ancient Cham citadels of the region on this 1490 viet map and to understand their strategic position on the banks of the great rivers of the region, without ever being by the sea, which would expose them too much in the event of piracy attacks. Thus, close to the mouth of Minh Linh, where the river Bên Hai ended, stood the citadel of Thành Cổ Lũy (village of Vĩnh Giang, district of Vĩnh Linh), which proves the antiquity of this access to the sea. Opening on the mouth Việt, the two ancient Cham citadels up the river Hải Giang, Thành Thuận Châu and Cổ Thành, ancient *Viṣṇupura* (district of Triệu Phong), watched over, on the one hand, the access to the sea, whereas the other citadel surveyed the access by land leading to the mouth Tư Khách. Finally, the mouth Tư Khách was supervised by means of the citadel of *Amarendrapura* (today Hoa Châu) and the river Đại Giang (today's Perfume River) by way of the citadel of Thành Lôi.

⁸⁴ Le Pichon 1938 : 403-4. "The great chief of the French has come ... (...) He is the Master of salt: we want to be his friends, because he will give us buffaloes to eat and trade will be easy. We drank from the same jar together: our *gu'al* will be his, for he is rich and strong. Yes we want to be his friends!"

⁸⁵ One can read in *Ô Châu cận lục* in the middle of the 16th century that "the lagoon of Hải Lãng is linked to the East to a large port (trường/dài cảng) and to the West to mountains".



Fig. 15: Hypothetical positioning of the Cham citadels on the Việt map from the end of the 15th century. The ancient Cham citadels (1 to 5) still occupy strategic functions that survey the main waterways. Each one is considered as a spatial object that can be exploited by specific treatments (geometric or semantic).

This hypothetical projection of the ancient Cham landscape on a Việt map, even if it cannot be validated by any Cham visual document, accounts for the situation of the different Cham citadels. For example, they were founded in order to monitor and protect access to the region by waterways; a configuration that reinforces the presumed importance of trade in the development of the Cham kingdoms.

Other maps make it possible to follow the evolution of the landscape - and its validation in toponyms - through time. Four other maps, one from the 16th/early 17th century,⁸⁶ the second from the mid-17th century,⁸⁷ the third from the late 17th century,⁸⁸ and the fourth from 1785⁸⁹ may shed light on the landscape of the region. They are oriented North-South, without taking into account the actual North-West/South-East orientation.

The first map, although not precisely dated,⁹⁰ shows the state of the territory between the 16th and early 17th centuries. The landscape changed profoundly over the course of a century, with the opening of a new mouth called the Mouth (Cửa) Eo Trước⁹¹. According to the Nguyễn Annals,⁹² the Eo Mouth opened in 1404, closed in 1467, reopened in 1504, closed during the 17th century, reopened in 1740, and closed definitively in 1897. In 1814, Emperor Gia Long named it Thuận An. The lack of mention

⁸⁶ See fig. 3.

⁸⁷ See fig. 4.

⁸⁸ See fig. 5.

⁸⁹ See fig. 6.

⁹⁰ Dumoutier 1896 dates this map to the end of the 15th century.

⁹¹ It's transcribed into *Yêu-Tiên-Môn* at Dumoutier nr 504 p. 40.

⁹² *Đại Nam nhứt thống chí (Imperial Geography of Annam)* quoted in Đào Thái Hành 1914 : 243.

of ancient Cham capitals or citadels suggests it can be dated back between 1504 and the early 17th century.

The second map, from the 2nd quarter of the 17th century, shows how the landscape evolved, with the four mouths, the widening of a lagoon between the Eo and Tư Khách mouths and, above all, the creation of a closed lagoon south of the mouth Tư Khách.⁹³

The third map, dating of the second half of the 17th century, shows significant changes⁹⁴ in the landscape. The Nguyễn Annals attest to the closure of the Eo mouth in the 17th century, yet it is still mentioned on this map. However, a closer examination shows that the mouth called Eo on this map is positioned south of the lagoon called Tam Giang, that is to say at the mouth of the river of Huế. Thus, while the Việt textual sources mention the opening and closing phases of the Eo mouth,⁹⁵ memory has not retained its exact position on the coast and, while the original Eo mouth - access to the capital Nguyễn of Dinh Cát- closed (during the 17th century), a new pass was created about twenty kilometres further south and was named after the one that had closed. The disappearance of the mouth of the river Eo in its original position, a direct outlet of the river that led to the capital (Dinh Cát) of the first Lords Nguyễn in the present province of Quảng Trị, led to a change in the centre of power and caused the capital to move southwards in 1626. The other notable change in the landscape in this third map is the opening to the south of the lagoon that had begun to form, thus creating a new access to the sea.

The fourth map confirms the profound changes of the previous century with the closure of all direct access to the sea of the former province of Triệu Phong (now the province of Quảng Trị) and the formation of a second lagoon open to the south of the region. The shift of toponyms in accordance with the changes in the openings is confirmed with the Eo mouth in the extension of the Perfume River, which will only change its name to become the pass of Thuận-An in 1814 and the mouth Tư Khách, also called the mouth Tư Hiền, to the south of the lagoon of Cầu Hai.

A parallel arrangement of the four maps makes it possible to better visualize the representations given to the changes in the landscape over time.

⁹³ This stretch of inland water is described on the map as “Nước dồn về, bên trong khá rộng” (*The water accumulated, the interior was quite wide*).

⁹⁴ This map is also the first to provide practical indications about mouths; for example, the Việt mouth was described as “deep” (*Biển cửa Việt, sâu*), the Eo mouth as “moderately deep” (*Cửa Eo biển, sâu vừa*), and the Tư Khách mouth, although deep, needed navigational guidance (*Cửa biển Tư Khách, ở giữa cạn, hai phía nam bắc sâu* “Tư Khách mouth, in the middle of the land, two deep south-north sides”).

⁹⁵ Đào Thái Hành 1914 : 243 : “Two centuries before our time, there were two different mouths on the coast of Thuận : Cửa-Eo on the border of the village of Hoá-Quản and Cua-Sut on the territory of the village of Thai-Dương-Hạ. The first mouth was wide, deep and dangerous; it was later called the bar of Thuận-An; the second was narrow and not deep enough for navigation. A few years before the restoration of Our Great and Illustrious Gia-Long (1800), the mouth Cửa- Sut opened a little wider than before; but it was still impassable to large tonnage boats. It was in the ninth year of Thành -Thái (1897) that the mouth Cửa-Eo, bar of Thuận-An, was completely invaded by alluvium and that the mouth of Cửa-Sút of the village of Thai-Dương-Hạ was reopened wide to vessels of all sizes. This is the port of Thuận-An today (note 2: The name Thuận-An was given to Cửa-Eo by S. M. Gia Long in the third year of his reign (1814)).”

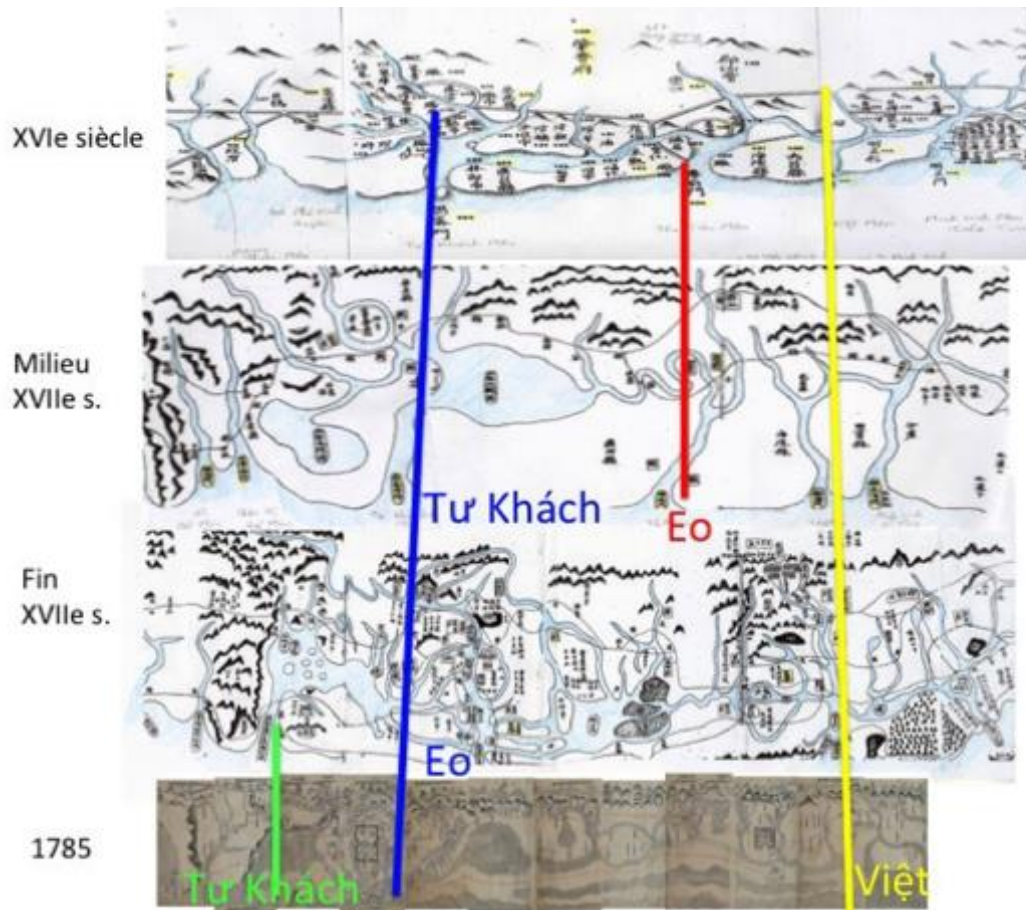


Fig. 16: Diachronic presentation of the four maps from the end of the 16th to the end of the 18th century. We can see that the closure of the Eo (Eo Trước) mouth to the North is taken into account and moved to the South of the Tam Giang lagoon, provoking the displacement of the mouth Tur Khách to the South of the new lagoon that opened to the sea.

The evolution of the landscape appears to have had a direct impact on human settlements; these natural phenomena have changed the geopolitics of the region, most likely resulting in the relocation of the Nguyễn capitals. Thus, the Nguyễn Lords have regularly changed sites for the location of their main towns⁹⁶ throughout the region, perhaps depending on their gradual acceptance by the local populations, most probably, according to the evolution of the landscape and the accessibility of their capitals. Thus, Nguyễn Hoàng settled down in the current province of Quảng Trị, in Ái Tử from 1558 to 1570, in Trà Bát from 1570 to 1600 and in Cát Doanh/Dinh Cát from 1600. It disappeared in 1613. His son, Nguyễn Phúc Nguyễn, remained in Cát Doanh until 1626,⁹⁷ when he moved to Phước Yên, in today's province of Thừa Thiên-Huế. His successors remained in the south of the region, settling down in Kim Long between 1636 and 1687, in Phú Xuân from 1687 to 1712, in Bac Vong from 1712 to 1738, and finally returning to Phú Xuân from 1738 to 1775.

⁹⁶ *Bulletin des Amis du Vieux Hué*, Index 1, 1925 : 85

⁹⁷ When, in 1625, Father A. de Rhodes recounts his first stay at the Court "in the province of Hoà", he does not give a name to this capital: *Voyages et Missions* 1884 quoted in Cadière 1939 : 67.

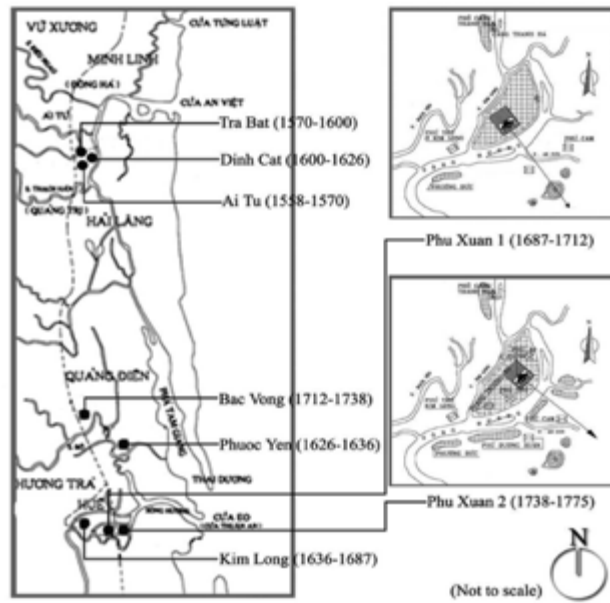


Fig. 17: Diagram of the main Việt capitals in the region of Thuận-Hóa, 1558 to 1775.

It was precisely in the middle of the 17th century (1636-1687) that the change of capital (to Kim Long) of two Nguyễn kings took place. In 1626, the capital of Đinh Cát in the present-day province of Quảng Trị was transferred to the province of Thừa Thiên-Huế, first to Phước Yên, near the river Bồ (Quảng Điền, Thừa Thiên) for about ten years, and then to Kim Long (Hương Trà, Thừa Thiên), on the banks of the Perfume River. The great rivers spotted at the end of the 16th century drew a whole network of islands which, on its back bank, offered a possibility of circulation and protection for boats and people. The lagoons that are so characteristic of the region of Huế today were created, playing multiple and complementary roles, as communication routes and forms of territorial control, political and social control and, finally, control of natural resources.

This study is therefore a rich source of information, since it makes it possible to link transformations of the landscape visible on ancient maps to environmental phenomena and to observe their consequences on humans. The particular attachment to the hydrographic network, which bore the entire local economy and structured politics, has made it possible to demonstrate that the various Nguyễn capitals followed environmental modifications, thus validating the hypothesis of human adaptability to landscape modifications.

The rapid evolution of the landscape has had direct consequences on the policy of the Nguyễn capitals. The kings were thus victims of the whims of the openings and closures of the river of Huế, or the Perfume River. The river flows into a lagoon, which opens out to the sea in three different ways, depending on the period, at Hoà Dâu, at Thuận An, and at Thai Dương- Hạ.

For each pass, there are written testimonies in Sino-Việt allowing us to understand the evolution of each pass. Thus, the pass known as "Thuận An" (named Eo until 1814) opened in 1404, closed in 1467 and reopened in 1504 ... Closed again... Reopened in 1740, to finally be definitively closed again following a tidal wave in 1897. A certain confusion reigns in the way of naming these passes; thus, the opening on the sea that was created in 1897 - which is the one that still exists today - is today called the estuary of Thuận An, even though it is formally located in the village of Thai Dương-Hạ. And the Thai Pass Dương-Hạ, opened in 1467, closed in 1504, and was eventually reopened to become the main opening to the sea since 1897.

The maps show how resilient the landscape is and how swiftly⁹⁸ openings to the sea could change, leading to significant changes in communication routes and thus trade. For example, the closure of Thuận An weakened the defensive system of the Việt Emperor, thus facilitating the French colonial presence.

An 1883 French map shows all the fortifications that protected the pass of Thuận An (opened between 1740 and 1897). In 1882, emperor Tự-Đức had the works of Thuận An, which defended the entrance to the Huế river, reinforced. On the aerial photos of 1952, this same pass is closed and we can see the opening of two passes to the North, at Hoà Duan and Thai Dương Hạ, showing the uselessness of the defensive works.

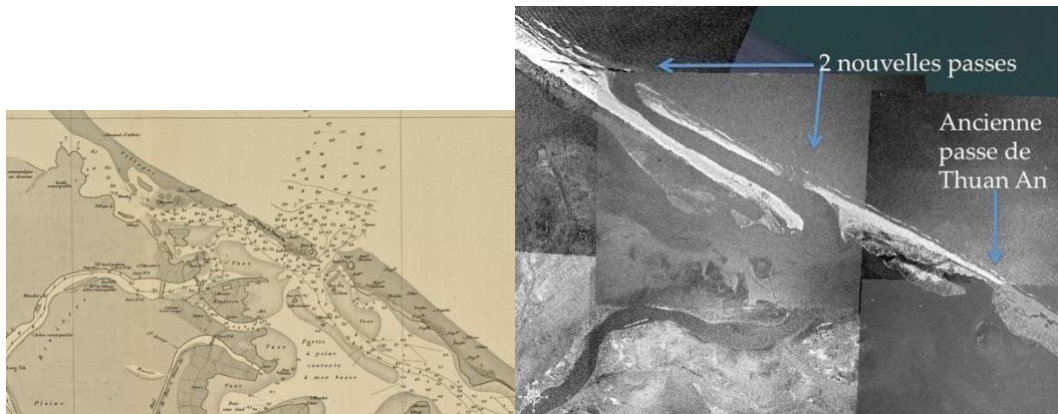


Fig. 18 : The pass from Thuận An to the mouth of the Huế river.

Left: Detail of a French map from 1883 showing the fortifications built in 1882 by Emperor Tự-Đức (Archives Aix FRANOM_Asie-106_01)

Right: Montage of aerial photos from 1953 on which the pass of Thuận An closed in favour of the Hoà Duân and Thai passes Dương Hạ.

This first study of landscapes demonstrates the very high mobility of landscapes, in particular on the evolution of the lagoons of Huế, the openings to the sea, and the modifications undergone by the secondary hydrological network over time. The comparative study on the settlements of the Cham citadels and the Việt cartography demonstrated the great mobility of the landscape. Moreover, the hydrographic network has undergone major changes over time. One observes the disappearance of the Eo mouth, access to the Nguyễn capital of Dinh Cát, which has resulted in the relocation of the capital -and the whole Court- further south. It has been mentioned that the closure of this mouth forced the secondary network to reshape itself: the river Ô Lâu, at the edge of which the presence of several Cham sites proves its ancient role, by flowing into the Tam Giang lagoon, has lost its role as a vector of trade. Moreover, the reading of satellite images

⁹⁸ The testimony of Pierre Poivre in 1750 (Cordier 1887) indicates that the mouths can close quickly. Thus, when he speaks of the capital (the current Huế), he wrote: "This capital is located four miles from the sea in a large plain bordered to the south by small mountains. The river (...) flows into the sea through two main mouths that used to be harbours, but in recent years sandbanks and bars have been formed there that prevent smaller vessels from entering and make it difficult for even the country's own ships to enter.....» Cordier 1887: 11. But in 1750, a pass re-opened: "Continuous rain, great flood. The waters rushing from the mountains into the river flooded the whole plain and flowed so fast that their current dragged a sandbank that closed the mouth of the river and prohibited boats from entering this port, which is closest to the Court and most convenient for the exit and entry of an infinite number of boats that carry the tributes of all the provinces of the Kingdom every year to Hue. This is great news for the King and for all Cochinchina because this port greatly shortens the boats' journeys. Previously they were obliged to navigate five or six miles further up and faced many dangers. » *idem* 33.

most likely indicates the location of the ancient Eo mouth and makes it possible to reconstruct the ancient hydrological network.

Paleo-meanders and human settlements

In the secondary network, the ancient communication routes are disappearing. For example, the ancient Cham citadel of Thành Châu (locally called Ve Nghia), dating from the 10th century, was crossed - like all the ancient citadels - by an arm of the river. It is no longer watered today by any river, but it is possible, thanks to the reading of old parcels of land by photo-interpretation, to reconstruct its fossil meanders.

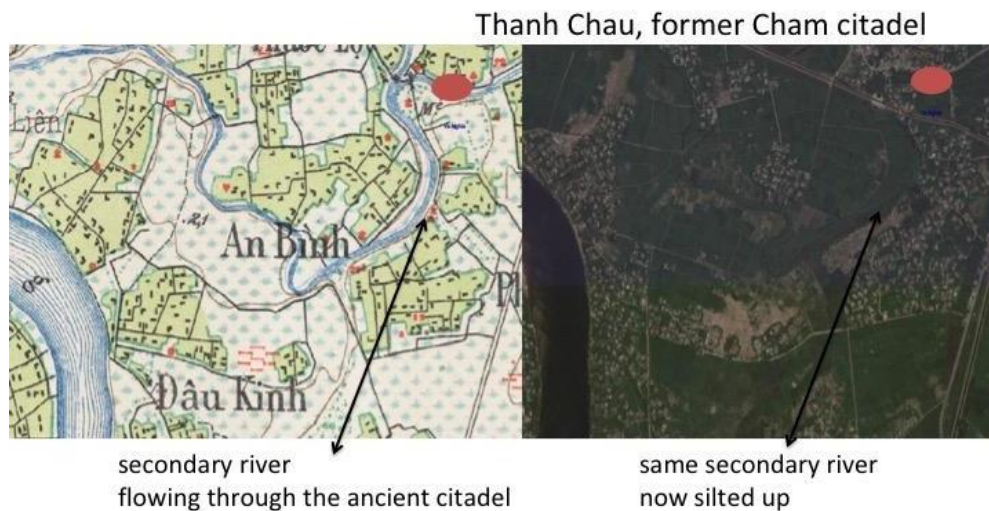


Fig. 19: Comparison between an early 20th-century map and a satellite picture taken in the early 21st century, performed in an attempt to produce a theoretical map of the ancient waterways that used to flow around an ancient Cham citadel at Thành Châu, Quảng Trị province. Image by Anne-Valérie Schweyer after images courtesy of Institut Géographique National, maps 1:25,000 Nr 23 West_1908, and Google view.

In the province of Quảng Trị, a significant erosion and sedimentation dynamic can be observed: the numerous traces of paleo-channels reveal a landscape in constant evolution. The mobility of riverbeds has probably had a significant impact on the urbanized riparian areas. The consequences of river dynamics on certain historical sites can be envisaged in the deltaic plain sector. The case of the Cổ Thành Cham citadel sheds light on this point. Located at the boundary between the shales, limestones, and sandstones of the hills, and the alluvial deposits of the deltaic plain, the example of the river Quảng Trị/Thach Han illustrates part of the past and current river dynamics.

Observation of the river channel - and more specifically of two meanders - reveals an east-west lateral shift of the riverbed in this sector. A sedimentation zone has formed in the convexity of the meander and an erosion phenomenon has occurred in its concavity. The river underwent numerous morphological changes both related to the underlying bedrock, but especially to the high flows during intense rainy episodes or typhoons. This dynamic has changed in recent decades, partly due to the construction of two dams, built in the second half of the 20th century, one of which is located about 12 km from the site of the former citadel of Cổ Thành. Although the current dynamics of the river probably have nothing to do with those that existed before the dams were built, the probability that the site of Cổ Thành could have been submerged in the riverbed Quảng Trị/Thach Han is conceivable. The available data suggest that this historical site was located on the right bank of the river, where the erosive currents during floods are greatest (meander

concavity). The oldest plans available (1908 and 1950) make it possible to define the probable paleo-channel layout. Examining these plans reveals traces of paleo-channels, ancient passages of the river channel. The following dynamics can be observed: a progressive abandonment of these river's arms by sedimentation effect in the convexity of the meander, and a lateral erosion of the right bank leading to a progressive east-northeast shift of the river bed.



Fig. 20: Determination of the paleochannels (red dotted line) around the ancient citadel of Cổ Thành by means of ancient plans (1908 and 1950).

Aggravated by its geographical location at the immediate foothills, this sector is a privileged place where the flows at the outlet of the gorge are powerful and the erosive force important, especially during major floods. This situation has endangered the site of the citadel of Cổ Thành. Consequently, the sites of Nhan Biều and Cổ Thành, now separated by the river, must have belonged to the same archaeological ensemble, around a 10th-century citadel. On the other hand, the site of Đa Nghi, now on the same side of the river as Nhan Biều, was, slightly elevated, located close to the ancient course of the river.

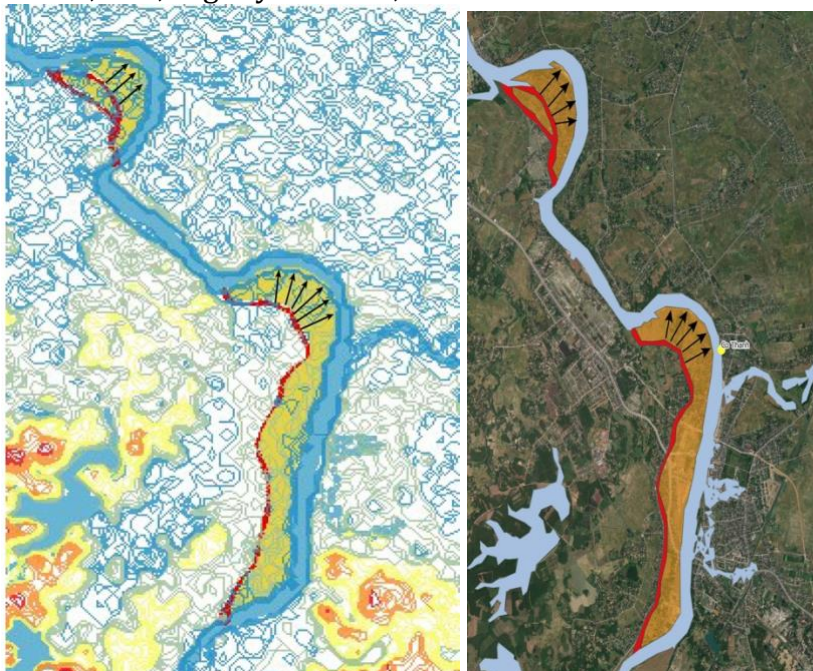


Fig. 21: Ancient supposed dynamics of the river Quang Trï in 3D view with altimetry (28 left) and in plan (28 right) with sedimentation on the left bank (orange zone) and erosion on the right bank (black arrows show erosion dynamics). The riverbed may have migrated from the

supposed paleochannels (in red) to the current riverbed (in blue). This shift would have resulted in the disappearance of the former citadel of Cổ Thành (the yellow dot on the plan view).

The dynamics of the river probably accelerated in the last decades of the 20th century with the construction of two dams in the upstream part of the watershed.

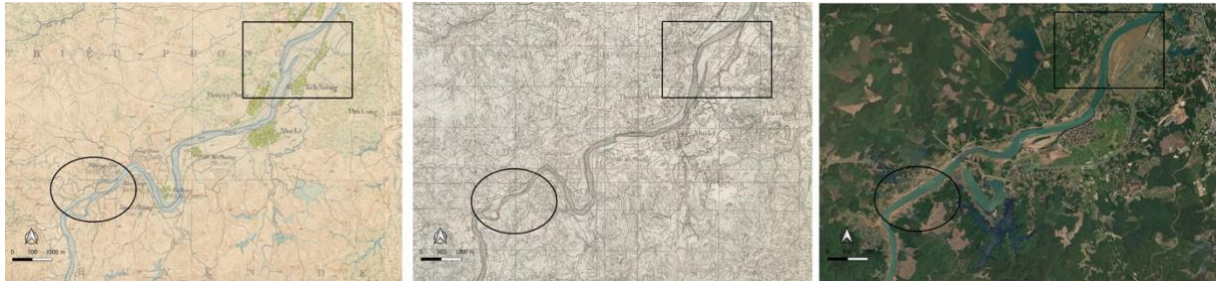


Fig. 22: Comparative maps (1908, 1950 and 2020) showing the impacts of dam development on the river morphology, upstream of Cổ Thành. The black circles show the transition from a braided system to a much more linear system after the dam was built. Downstream of the dam, a change in the course of the river can also be observed: in the black rectangles, the course of the paleochannels has now disappeared and the sedimentation zone has been filled in.

These two examples aim to demonstrate the importance of a study of stream's paleo-meanders in long-term landscape shaping. The extreme mobility of landscapes in the Anthropocene seems to be due to natural phenomena as much as to human intervention.

3. Integration and analysis of thematic data

In the first part of this paper, a corpus of cartographic documents and a large corpus of field photographs were identified. These, after a detailed inventory, it allowed to identify more precisely the underlying issues of the Cham economy or the displacement of capitals through cartographic documents. A classical morphological analysis reveals the complexity of the territory.

In this part, we will describe how to establish a Geographic Information System, by questioning the limits of georeferencing, and how a GIS can be integrated into the semantic web. Finally, through document annotations and the construction of a network of documents, other methods of data analysis are proposed.

How GIS fits into the semantic web

Maps and plans have a spatial characteristic that is necessarily associated with a reference frame that has been defined by its author. Generally speaking, it is common to say that maps dating from before the second half of the 18th century do not have a geometric reference frame (triangulation network, topographic surveys, etc.). It is therefore difficult to associate them with a geographic or cartographic coordinate system that can be associated with a current reference frame. However, if they do not have a mathematical referential, these maps have other referential forms which are often landmarks existing in the landscape at the time: rivers, mountains, intersections, singular trees, remarkable buildings. This is for example the case of the maps of the *Atlas of the*

Hồng Đức period (1490) to the maps The descriptive geography of the Emperor Đồng Khánh of 1883.

For European or French maps of the end of the 19th century that meet the criteria of geodetic reference frames, the absolute coordinates are linked to imaginary lines that are meridian and equator. Moreover, this reference frame constitutes a system of geographical coordinates that must be transformed into a cartographic coordinate system. The spherical coordinates are then transformed into planar coordinates. This is called a projection of coordinates which allows, by a mathematical operation, to obtain a two-dimensional rendering that can be displayed on a sheet of paper.

These maps -computerized digitized images- can then be georeferenced, thus can be positioned on contemporary maps, allowing comparative studies to study the evolution of the landscape thanks to the Geographic Information System (GIS).

Georeferencing, the first step in reconstructing data from the past, is the operation of assigning a reference coordinate system to a cartographic document. Although this operation is now well mastered, several algorithms exist. The simplest perform a simple homothety (translation, rotation, scaling of an image on a current map), other algorithms are more complex and one can compare an image to a fabric whose corners are tried to be drawn in different directions in order to make the print correspond to a current cartographic reality. Regardless of the method used, a residual error of a few meters to several tens of meters always exists on an old map that has been georeferenced: the fault lies with the old surveying methods but also with the georeferencing algorithms that cannot reconcile local and global views.

The second step in the work of reconstructing old data is vectorization based on georeferenced maps and plans. A vector data is a computer object that can be stored in a database. It has geometric information, i.e. a spatial or primitive geometric shape (point, line or polygon) and semantic information, i.e. attributes that are associated with the shape.

The georeferencing and vectorization of maps requires a very long and meticulous work; it is the first step to build a Geographic Information System. Precise georeferencing allows a precise analysis of the spatial dynamics, the GIS mapping process highlights the flexibility of the landscape and helps to reconstruct the evolution of the landscape and to understand the settlement process through the centuries.

Towards systematic georeferencing?

The georeferencing method allows the overlapping of old maps and plans in image format with a current repository, such as Google Maps satellite images, or raster plans with a vectorized base, such as *OpenStreetMap*⁹⁹. Overlaying allows an easy comparison of elements from two temporalities: for example, to understand the evolution of the morphology of a city over 100 years by comparing topographic maps or aerial views. It is then possible to visually observe how the main axes have been reinforced, how buildings have become denser or how new districts have been created on the ruins of buildings that were doomed to disappear.

To perform these analyses, the first method consists in playing with the transparency of layers in GIS tools to mix two different views or layers such as a current map and an old aerial photo. However, this tool alone is not enough and several other methods have been developed to be able to co-visualize data supported in two different

⁹⁹ <https://www.openstreetmap.org/>

layers. For example, national geoportals now offer visualizations that mix two different sources that can be selected from a defined dataset.

The French IGN geoportal¹⁰⁰, which hosts several georeferenced historical maps, has a section called "time travel"¹⁰¹ that offers these exploration possibilities:

- a division of the horizontal or vertical view into two sections that can be moved, see figure 23.1.
- or a magnifying glass that allows you to display the layer covered by a top layer as you move the mouse, see figure 23.2.



Figure 23.1: A two-part view of the same area with two orthophotographs, one recent on the left and one from the 1950s on the right.



Figure 23.2: view with a magnifying glass following the mouse with the same information: recent and old orthophotograph.

Cadastral documents are also interesting to georeference in order to understand at a local scale how parcels may have aggregated or separated. One can then understand, thanks to georeferencing, how a territory may have evolved.



Figure 24. Two views presenting on the left a mixed aerial photography view on which the lines of the current cadastre have been overlaid in black lines, on the right the old cadastre from the Napoleonic cadastre (beginning of the 19th century).

In spite of this, georeferencing suffers from several problems that can limit the analysis if it is based only on the method of superimposing layers. Indeed, georeferencing is based on a distortion of old maps and plans and can accumulate several errors:

- the error due to the age of the map: the relative imprecision of objects mapped on old maps due to topographic survey methods that have gradually improved over time, but which, before 1750, were often drawings, more than maps;
- the drawing and graphical techniques of the past did not allow a precise capture of objects in space;

¹⁰⁰ <https://www.geoportail.gouv.fr/> only in French, at this stage.

¹⁰¹ <https://remonterletemps.ign.fr/>

- the quality of document scanning necessarily imposes an approximation of the objects on the map (quality of the document which can be distorted and then pixelated);
- the limits of the deformation method: a mathematical deformation function is applied globally on the map from control points present in both the past and the present. The computer image is stretched so that the points of the past correspond to the points of the present reference frame. It is impossible to apply a distortion that minimizes the error of all control points.

Thus, the accumulation of these errors, when viewed in detail, results in errors ranging from a few meters to several hundred meters, depending on the techniques used and the viewing scales. Figure 25 shows the same crossroads, but once the Napoleonic staff plan has been superimposed on an aerial photograph, there is an error of more than 50 meters.



Fig. 25: A superimposed French staff plan with a paneled view shows a positioning error of an old crossroads of more than 50 meters. In addition, the plan on the right shows a rather large pixelation when the zoom is high, which hinders precision work.

Thus, if georeferencing documents from the past is a first step towards understanding the evolution of the territory, it is not sufficient and shows limits, both historical and technical, when it comes to connecting identical objects through time.

When georeferencing is not possible...

Some documents whose creation date is before the middle of the 18th century for European maps, georeferencing is technically possible, but with such deformations that it becomes very difficult to exploit them scientifically. We then speak rather of a positioning of a map than of georeferencing. Figure 26 shows a georeferencing test of the 16th century map of the provinces of Quảng Trị and Thừa Thiên-Huế on a current reference frame (satellite images of the area). The georeferencing control points and transformation parameters distort the map without adapting to the physical reality.



Figure 26: Example of georeferencing of a 16th century map (*according to Dumoutier 1896 : plates XVI to XIX*) on a current satellite image background. The offset of the map with respect to the coastline shows the importance of the error.

A distinction must be made between topography and topology. In the case of old maps, the topography (mathematical model for cartography based on a triangulation of space respecting distances and angles) was not yet complete. This type of map was a vision of the territory that essentially respected a form of topology (i.e. the relationships between the forms of the territory: below, below, close) without having information that could correspond to current data. The Oronce Fine platform that we use will allow us to overcome this drawback thanks to the semantic annotations and the web of data that we described in the first part.

How can we analyze this data and what can we expect from it?

In this last part we will show how it is possible to exploit the semantic annotations on maps. To this end, it is necessary to create a gazetteer, a directory of place names for which an inventory has been drawn up beforehand from the translations of the texts written on the maps. Finally, there are several possibilities for analyzing the maps from the annotations: graph analysis.

Document annotations and the construction of a document network

The first step is to design a directory of place names based on a translation of the toponyms visible on twenty old maps. This translation leads to a critical record of place names but also to a typology of these places. This inventory is thus divided into two parts: a gazetteer (a directory of place names: for example 丹田縣 huyện Đan Điền or 營葛 Dinh Cát, etc.) and a thesaurus of place types (an exhaustive list of the types of places encountered: for example Do bridge, Quang guesthouse, Cua mouth, etc.). These two notices contain 422 toponyms and 47 types. These "items" in the Omeka-S sense are respectively concepts, with for one the "Place" typology, for the second the "Conceptual Object" typology.

By construction and as we described in the first part, these "Place" or "Conceptual" objects are when possible attached to a wikidata and/or geonames URI.

From qualitative to quantitative: graph analysis

The annotations then form the links between the documents so as to form a graph (G), in the sense of graph theory¹⁰², where all the objects hosted on the system (maps, orthophotographs, field photos, but also conceptual objects and places) will be vertices (V) of the graph G, the annotations being links or edges (E). Formally, a graph G can then be written mathematically as follows: $G = \{V, E\}$ where V is a list of vertices and E a list of edges (E). The elements E and V also carry a typology characterizing them. Thus, a vertex (pl. vertices) is characterized by all its metadata (name, type, spatialization, etc.) as well as the annotations will be qualified by a typology of the link (a value, a type of link, a geometric form, a level of uncertainty). These aspects respect the W3C recommendations¹⁰³.

The interest of this approach and of this model of annotations on documents is twofold. The first possible exploitation of this system is to build a new model for the visualization of iconographic collections. This visualization allows you to navigate between documents by clicking on the annotations made directly on the images, but also to have a global view of them by switching to a representation in the form of a network of interlinked documents (see figure 27).

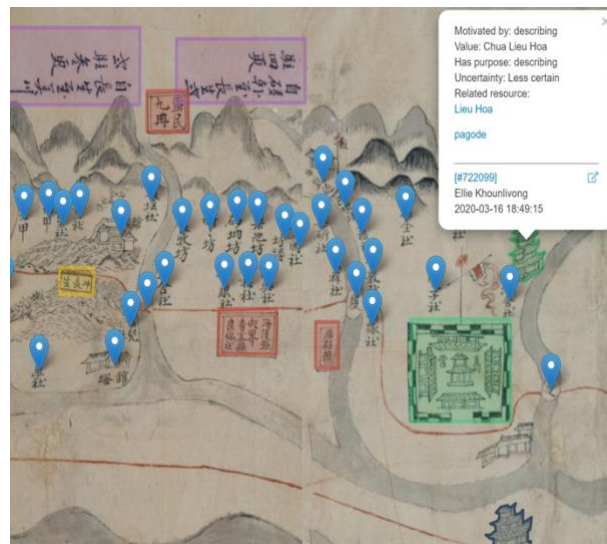


Fig. 27: The visualization of the map " QUẢNG THUẬN THUẬN ĐẠO SỬ TẬP " of 1785 shows annotations (here points or polygons). One can click on each of them. Here a click on the shape of Chua Lieu Hoa points to two other objects: the toponym Lieu Hoa and the conceptual object pagoda.

The second possibility is to be able to understand the links between documents through annotations by mobilizing the tools of graph theory by interrogating the network with measures (centrality, accessibility, etc.) or transformations (clustering, simplification, etc.). Thus, a visualization of the network in which the position of the vertices is generated by the Force Atlas algorithm¹⁰⁴ from the links they have between

¹⁰² Graphs & HyperGraphs, Claude Berge, North-Holland Publishing Company, 1973

¹⁰³ <https://www.w3.org/TR/annotation-model/>

¹⁰⁴ ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software, Mathieu Jacomy, Tommaso Venturini, Sebastien Heymann, Mathieu Bastian, PLOS ONE, June 2014, Volume 9, Issue 6, <https://doi.org/10.1371/journal.pone.0098679>

them. The principle of the algorithm can be described by a physical analogy of the components of the graph where the vertices are represented by particles of the same charge, attracting or repelling each other, and the edges are similar to springs stretching and compressing each other.

Complete network of annotations from the project collection. There are 1267 annotation links that link 670 vertices, including 220 maps, 50 concept objects and 400 place names. (See the dynamic version <http://psig.huma-num.fr/pacha-network2/>). In orange are the vertices/nodes that represent maps, in dark blue are the annotations on the maps, the dots in light blue are the representations of conceptual objects and places.

Several observations can be made from this representation:

1. the map vertices/nodes (orange) that share common concepts will tend to get closer,
2. some map vertices/nodes (oranges) centralize more annotations than others: the two maps from the early 17th century (*Giap Ngo Binh Nam Do*) and the late 17th century (*Tuan Tap Thien Nam Tu Chi Lo Do Thu*) clearly have concepts in common and are similar,
3. some conceptual vertices/nodes (light blue) also centralize an important set of annotations, this is the case of the "village" concept or the "mouth" concept marking the predominance of these concepts in the maps.

Nevertheless, the density of this representation is such that it is difficult to extract exploitable results. By its very nature, a graph is a tool that can be simplified using various algorithmic methods. In this case, it is possible to select only those objects that have a neighboring connected to concepts. The rest of the article then focuses on describing a progressive simplification of the graph that will allow to keep only the model inherent to the links that have been set up in this work.

We can provide a simplified visualization of the graph for which we have made invisible the annotations not connected to conceptual objects or place names. The rendering of the graph thus presents fewer links. Moreover, we can display a symbology on the vertices/nodes according to their typology. we have removed the annotations that are not connected to concepts or place names. We visualize in light green, map objects, in light orange, conceptual objects, in dark orange, places, in dark blue, the values of the annotations, and finally in dark green, conceptual objects shared with other collections (Hàn, Laos). See the dynamic version <http://psig.huma-num.fr/pacha-network-concepts/>

On this visualization, it is possible to observe that, by the phenomenon of bringing the vertices/nodes closer together through the simulation of a physical phenomenon, the maps of the 16th (*Dumoutier 1896*) and 17th centuries (*Toán tập Thiên Nam tứ chí lộ đồ thư* and *GIÁP NGỌ BÌNH NAM ĐỒ*) become quite central while being quite close together. Indeed, the latter share concepts that can be found on both sides, including a common administrative grid, while the maps of the 18th (*QUẢNG THUẬN THUẬN ĐẠO SỬ TẬP*) or 19th century (*Descriptive Geography of the Emperor Đồng Khánh*) show a different basic administrative conception.

The analysis of the morphology of the graph is also interesting. First of all, we notice conceptual objects that centralize a large number of annotation type objects. This is, of course, the case of map objects that support annotations, but it is especially the case of the conceptual object village (xã). The latter, shared over several maps, becomes the most central object. There is also an internal/external morphology:

- If we consider only the conceptual objects, we see that other vertices/nodes are quite central, like military camp, markets, province. While the latter are

administrative elements, the former are places that seem to be important and well connected to several maps and annotations.

- Other vertices/nodes are naturally positioned at the periphery of the graph and are either off-centered concepts or maps. This is the case of external clusters such as bridges, lodges, and forests.

Assuming that a map is a chosen representation of what one wishes to show explicitly, these mapped spaces seem to reflect a strong administrative grid structured around important places (province, districts, villages, markets, military camps), and whose external clusters can be reference points for the map reader.

A final simplification of the graph confirms this hypothesis. If we remove the map vertices/nodes that by definition centralize the majority of links, we obtain a simplified form of the graph that shows a view of the links between annotations and concepts. A further simplification of the graph by removing the map objects provides a clearer view of the links between concepts. Conceptual objects are visualized in light orange, places in dark orange, places in dark blue, annotation values, and finally in dark green, these are conceptual objects shared with other collections (Hàn, Laos). (See the dynamic version <http://psig.huma-num.fr/pacha-network-concepts-low/>)

On a closer view, we identify:

1. some large and well-connected clusters: villages first, provinces, districts, markets, mouths.
2. some outer clusters: bridge, swamp, lake, beach, pagodas and temples.
3. some rare isolated (unconnected) clusters: bay, road, isolated places not identified as a village, sandbank, caves.

Here we see the district and market concepts that have links with more distant concepts, such as villages, mouths, provinces, and chief towns.

From an archaeological and anthropological point of view, we can see quite clearly that the maps show an important hierarchical construction for this period. Human structures of a commercial type such as markets are clearly articulated around the concepts of village while often naming the market as belonging to a province, a district or a village. One might think that warehouse-type places are part of this phenomenon. The notion of warehouse (*kho*) being quite general, one could think that these structures take on a more military than commercial role for this period and are therefore articulated differently.

Conclusion

The analysis method implemented here is based on graph theory, it relates maps linked together by concepts and toponyms that are linked by annotations. This method offers the possibility of a synthetic representation in the form of networks that can be explored and/or simplified according to the hypothesis/intuition to be highlighted.

This form of modeling, if it seems to move away from classical research methods, nevertheless allows to show interesting results while questioning the cartographic object from the 16th century onward while connecting concepts that have a spatial and/or historical reality.

Faced with the map, one wonders whether it relates to the historical reality of the territory or rather to a conceptual and topological view of places as a synoptic or mental map, i.e. a spatialized arrangement of selected places reflecting a chosen reality. If it is clear that the places present are necessarily important, the conception of the map also questions the instrument of power it can be to offer a subjective vision of the territory.