



**HAL**  
open science

## Abstraction in Archaeological Stratigraphy: a Pyrenean Lineage of Innovation (late 19 -early 21 century)

Sébastien Plutniak

► **To cite this version:**

Sébastien Plutniak. Abstraction in Archaeological Stratigraphy: a Pyrenean Lineage of Innovation (late 19 -early 21 century). Sophie de Beaune; Alessandro Guidi; Oscar Moro Abadía; Massimo Tarantini. *New Advances in the History of Archaeology*, Archaeopress, pp.78-92, 2021, 978-1803270722. 10.31235/osf.io/2pgak . hal-03338343v2

**HAL Id: hal-03338343**

**<https://hal.science/hal-03338343v2>**

Submitted on 9 Sep 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Abstraction in Archaeological Stratigraphy: a Pyrenean Lineage of Innovation (late 19<sup>th</sup>–early 21<sup>th</sup> century)

Sébastien PLUTNIAK 

École française de Rome and LISST-CERS (Toulouse, France)

[Preprint of: Sébastien Plutniak [2021], “Abstraction in Archaeological Stratigraphy: a Pyrenean Lineage of Innovation (late 19<sup>th</sup>–early 21<sup>th</sup> century),” in *New Advances in the History of Archaeology*, XVIII UISPP World Congress Paris, June 4-9, 2018, ed. by Sophie A. de Beaune et al., 978-16, Oxford: Archaeopress, pp. 78-92.]

## Contents

- 1 **The “Cartesian coordinate method” as a type of methodological innovation for which a single authorship is difficult to establish**
  - 1.1 Precursors of “pioneers” . . . . .
  - 1.2 A typical case of multiple discoveries . . . . .
- 2 **Laplace’s method was a new step towards formalising archaeological stratigraphy, the organisation of excavations and data recording**
  - 2.1 From a fieldwork practice to the publication of a formalised method . . . . .
  - 2.2 The components of Laplace’s stratigraphic method . . . . .
  - 2.3 Toward a conceptual analysis of the systematisation of archaeological stratigraphy . . . . .
- 3 **Laplace’s method as part of a trans-Pyrenean lineage of stratigraphic innovations**
  - 3.1 The spatial dissemination of Laplace’s method . . . . .
  - 3.2 A trans-Pyrenean lineage of stratigraphic innovation . . . . .

## Abstract

Methodological innovations have a special status in disciplinary histories, because they can be widely adopted and anonymised. In the 1950s, this occurred to Georges Laplace’s innovative use of 3-dimensional metric Cartesian coordinate system to record the positions of archaeological objects. This paper proposes a conceptual and social history of this process, with a focus on its spatial context, the Pyrenean region (Spain, Basque Country, and France). Main results of this research based on archives, publications, and

bibliometric data, include: 1) a critical discussion of the notions concerning authorship of such methodological innovations; 2) a presentation of the lesser-known aspects of Laplace's method, showing its contribution to the abstraction and formalisation of archaeological observations and data recording; and 3) the identification of an international Pyrenean intellectual lineage of innovation regarding stratigraphy and excavation methods, from the late 19<sup>th</sup> century to the early 21<sup>st</sup> century.

**Keywords:** archaeological methods, stratigraphy, authorship, geography of innovation, Pyrenees.

### Résumé

**L'abstraction en stratigraphie archéologique : un lignage pyrénéen d'innovations (fin XIX<sup>e</sup>–début XXI<sup>e</sup> siècle)**

Les innovations méthodologiques, pouvant être largement adoptées et anonymisées, possèdent un statut particulier dans les historiographies disciplinaires. Ce fut le cas du système de coordonnées Cartésiennes métriques employé dès les années 1950 par Georges Laplace pour enregistrer la position des objets archéologiques. Fondé sur ce cas, et accordant une attention particulière à son contexte spatial – l'espace international pyrénéen (Espagne, Pays Basque, France) – cet article propose une histoire conceptuelle et sociale de ce processus. Les résultats de cette recherche, basée sur les publications, des archives, et des données bibliométriques, comprennent : 1) une approche critique de l'attribution d'autorité dans le cas des innovations méthodologiques ; 2) l'analyse d'aspects plus méconnus de la méthode Laplace, et leur contribution au processus d'abstraction et de formalisation des observations et de l'enregistrement des données en archéologie ; 3) la mise en évidence, de la fin du XIX<sup>e</sup> siècle au début du XXI<sup>e</sup> siècle, d'un lignage pyrénéen international d'innovation.

**Mots-clefs :** méthodes archéologiques, stratigraphie, autorité, géographie de l'innovation, Pyrénées

### Resumen

**La abstracción en la estratigrafía arqueológica: un linaje pirenaico de innovaciones**

Las innovaciones metodológicas, que pueden ser ampliamente adoptadas y anonimizadas, tienen un estatus especial en las historiografías disciplinarias. Así, desde los años 1950, Georges Laplace ha utilizado un sistema de coordenadas métricas cartesianas para registrar la posición de los objetos arqueológicos. A partir de este caso, y prestando especial atención a su contexto espacial –el espacio pirenaico internacional (España, País Vasco, Francia)–, este artículo propone una historia conceptual y social de este proceso. Los resultados de esta investigación, basada en publicaciones, archivos y datos bibliométricos, incluyen: 1) un enfoque crítico del reconocimiento de la autoría en el caso de las innovaciones metodológicas; 2) el análisis de los aspectos menos conocidos del método Laplace, y su contribución al proceso de abstracción y formalización tanto de las observaciones como del registro

de datos arqueológicos; 3) la identificación, desde finales del siglo XIX hasta principios del siglo XXI, de un linaje pirenaico internacional de innovación.

**Palabras clave:** métodos arqueológicos, estratigrafía, autoridad, geografía de la innovación, Pirineos

## Introduction

Stratigraphic methods have a long and complex history as they have been subjects of debate in geohistory since the 18<sup>th</sup> century (Rudwick 2005, pp. 534-536), and then in emerging subdisciplines in geology, namely lithostratigraphy and biostratigraphy (Schweizer 2008). Today, these methods play a foundational and almost tacit role in archaeology, as reflected by the absence of entry on these methods in the 483 articles of a recent *Encyclopedia of Archaeological Sciences* (López Varela 2018). However, the development of these methods has been frequently commented on by archaeologists who are interested in the history of their discipline. They address two aspects in particular.

First, the characterisation of conceptual changes regarding time, focusing on the liminal relations between geology and prehistoric archaeology during the 19<sup>th</sup> century (Moro Abadía 2002, Hurel and Coye 2011) and on the 1920s controversial “stratigraphic revolution” in North American archaeology (Lyman and O’Brien 2006). There are multiple and ambiguous definitions of “stratigraphic excavation” in archaeological literature (Lyman and O’Brien 1999, pp. 57-61), but a working definition is nevertheless required for this paper. Here I use the differences highlighted by the authors to define *stratification* as the “presence of (generally) vertically discrete layers of deposition or excavation”, and *stratigraphy* as “an interpretation of the chronological meaning of layers” (Lyman and O’Brien 1999, p. 58). It is noteworthy that, in practice, the word stratigraphy is often used to refer to stratification. This involves a confusion (deliberate or unconscious) between physical reality and the process and result of a representation of this reality; in other words, that a stratigraphy is a model, more or less formalised, of a stratification. In this context, O’Brien and Lyman (2002) distinguished between *empirical* units and *ideational* (either theoretical or descriptive) units in archaeology. This rather elementary distinction is of particular importance because various methods and authors have been associated with “stratigraphic excavations” in historical studies without taking into consideration such conceptual distinctions.

Identifying prominent actors who contributed to this issue was the second focus of these studies. As emphasised by historians of science, disciplinary histories often used such “pioneers” as a means to legitimise a discipline<sup>1</sup>. Pioneers associated with stratigraphic methods can be categorised into two groups. First, those who are remembered for using these methods early in archaeology, including:

- William Pengelly’s (1812–1894) work in the Kents Cavern between 1858 and 1880 (McFarlane and Lundberg 2005).

---

<sup>1</sup>See the discussion of Lavoisier’s case for the history of chemistry and on the uses and functions of disciplinary histories in Bensaude-Vincent 1983.

- Flinders Petrie (1853–1942) for his excavation in 1890 at Tell el-Hesi in present-day Israel (Petrie 1891, cited by Negev and Gibson 2001, p. 228 and Gran-Aymerich 1998, p. 290).
- Jacques de Morgan (1857–1924), for the pseudo-stratigraphic method used during his excavation of the Susa site in Iran (de Morgan 1912, cited by Gran-Aymerich 1998, pp. 290–291).
- William Baker Nickerson (1865–1926) and Frederick Starr (1858–1933) for their excavations in the Midwest of the U.S.A during the 1920s (Browman 2013).
- Marthe Péquart (1884–1963) and Saint-Just Péquart (1881–1944) for their excavations in Brittany (M. Péquart and S.-J. Péquart 1928a,b, cited by Groenen 1994, pp. 109–111).
- André Leroi-Gourhan’s (1911–1986) early methodological handbook (Leroi-Gourhan 1950), and his horizontally expanded excavations at Arcy-sur-Cure (Leroi-Gourhan 1961) and Pincevent (Leroi-Gourhan and Brézillon 1966).

The second group of actors is characterised by being associated to an eponymous stratigraphic method, including:

- Mortimer Wheeler (1890–1976) and his excavation method (Wheeler 1954).
- Edward Harris (1946–) for his *Principles of Archaeological Stratigraphy* and his “Harris Matrix” (Harris 1979).
- Georges Laplace (1918–2004) and Louis Méroc (1904–1970) for their “*Méthode des Coordonnées Cartésiennes*”, published in 1954 and commonly called “*méthode Laplace*” or “*méthode Laplace-Méroc*” (Laplace and Méroc 1954a).

In literature, the “*méthode Laplace*” is commonly cited to refer to the innovative use of 3-dimensional metric Cartesian coordinates to record the positions of archaeological findings. This paper focuses on this case, which is of particular interest in advancing three arguments.

First, as a method which was first eponymised and then anonymised, it addresses the problem of authorship of methodological innovations.

Second, such an eponymisation comes with a conceptual oversimplification of the original proposition. The use of a 3-dimensional coordinate system was an important step in the use of abstraction in stratigraphy, which is considered as a method to represent archaeological stratification. Despite being reduced to one of its aspects, Laplace’s method was more, since it also dealt with standardising data recording and organising excavations. This requires a definition of the conceptual framework to address all the facets and complexities of the method.

Third, Laplace’s method was part of a series of innovations which were developed in and around the Pyrenean region during the 20<sup>th</sup> century. Its archaeological and bibliographic success has to be understood in the framework of Southwest European archaeology and, in particular, in the Pyrenees which was a key region for archaeology (figure 1). Laplace’s method is a relevant case to study the effect of spatial location on innovation in science.

This paper is based on publications, bibliometric data, unpublished archive materials, and interviews with researchers.

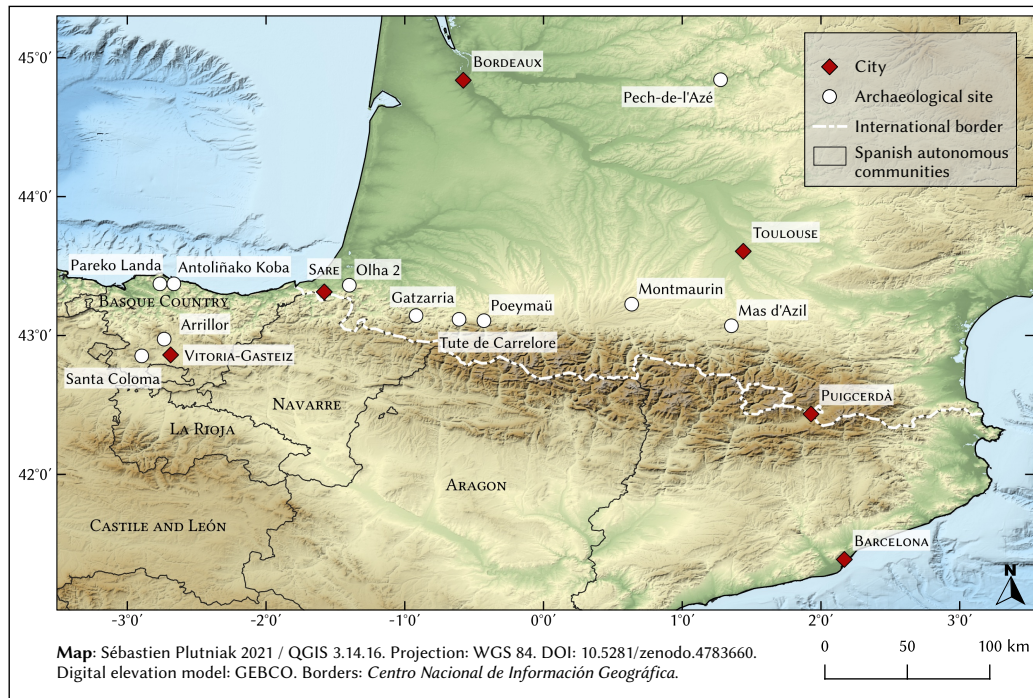


Figure 1: Map of the archaeological sites and municipalities mentioned in the text.

## 1 The “Cartesian coordinate method” as a type of methodological innovation for which a single authorship is difficult to establish

### 1.1 Precursors of “pioneers”

Laplace and Méroc are often credited as the authors of the “Cartesian coordinate method”. However, it is possible to identify previous uses of such a reference grid in archaeological excavations, prior to their 1954 paper; in other words, the precursors of these “pioneers” can be determined.

An early use of a 3-dimensional metric reference system was used in Switzerland in 1916. The geologists Auguste Dubois (1862–1923) and Hans Georg Stehlin (1870–1914) applied this method to excavate the Palaeolithic levels of the Cothencher Cave, near Neuchâtel ([Dubois and Stehlin 1933](#)).

Other examples can be found outside of Europe. In Mexico, Alfonso Caso Andrade (1896–1970) and Ignacio Marquina used a 3-dimensional coordinate system during their excavations of the pre-Colombian site of Monte Albán in 1931 and 1939 (figure 2). They described their method as follows:

The objects discovered in the gravestone are numbered, localised on a map, and recorded in an inventory, which are both realised during the

excavation. Each object is recorded in the inventory with its number, a brief description and its coordinates, namely its position in relation to the two walls of the grave which are chosen as coordinates axis. If the objects are not on the ground of the grave but have a higher position, one adds a third coordinate which gives the height in relation to the ground. (Caso Andrade and Marquina 1938, pp. 269-270.)

EXEMPLE :

<u>N<sup>o</sup></u>	<u>Description</u>	<u>Coordonnées</u>	<u>Observations</u>	<u>Croquis</u>
1	Vase de terre noire polie, à 3 pieds.	39 N × 25 E	Position norm.	
2	Assiette de terre couleur café.	40 N × 30 E	Renversée.	
3	Pierre sphérique de jade.	40 N × 30 E	Sous l'objet précédent.	

Figure 2: The method used to record the position of objects by Caso Andrade and Marquina 1938, p. 269.

Other cases come from Africa during the 1930s. For example Eric Axelson's (1913–1998) investigation in South Africa (Axelson 1938; see plans by Axelson reproduced in Fauvelle-Aymar 2012, figs 5 and 6, p. 133) and the surveys conducted by Oliver Myers (1903–1966) during the 1930s and 1940s in the Egyptian desert. Myers divided the space to be surveyed into squares using a virtual grid, and then used the count of remains by square to compute density contours and determine the spatial dispersion of remains (Myers 1950). It is not a coincidence that Myers collaborated with Petrie, author of the famous book *Inductive Metrology. Or, the Recovery of Ancient Measures from the Monuments* and pioneer statistical methods in archaeology (Petrie 2013). A final example is related to archaeological research in North Africa. Pierre Cintas (1908–1974) was a French colonial officer for archaeology in Tunisia (namely *Inspecteur des Antiquités*). From the 1930s he conducted many surveys and excavations in Tunisia, Algeria and Morocco. Explaining the method he employed for his excavation of the Punic sanctuary in Sousse (Tunisia), he wrote:

To excavate the *area* of a sanctuary is essentially to destroy it. [...] Looking for the objects included in the deepest layers requires the prior removal of the objects of the surface levels. In order to preserve, in spite of this destruction, a synthesis of the excavation, fixed coordinates were chosen, and meter by meter a survey of the position of all the objects encountered was carefully kept. A catalogue has been created. All objects were numbered and the same number was reported on the plans. The examination of these plans now allows us to situate immediately in space any monument coming from the excavation, both in isolation and in groups. (Cintas 1947, p. 3.)

Therefore, there are many examples of using metric coordinates in archaeological excavations prior to those of Laplace and Méroc. Further research would

probably identify other, and perhaps earlier, examples: e.g., Massimo Tarantini emphasised the case of Gian Alberto Blanc in the Romanelli cave (Tarantini, *infra*). Since earlier uses of the method have been identified, Laplace and Méroc's authorship of this method should be considered more carefully. However, regarding the case of Cartesian coordinates in archaeology –and also more generally– feeding priority conflicts is not an interesting aim for historians of science.

## 1.2 A typical case of multiple discoveries

There is no doubt that the use of Cartesian coordinates was a scientific innovation, but it was what type of innovation? Different categories of innovations can be distinguished: those concerning methodological procedures, the design of new instruments, and conceptual changes, for example. The processes leading to these innovations are not the same, and neither is the recognition different authors received for their “inventions”. Furthermore, some of these innovations are more likely to have been “discovered” multiple times. The importance of these multiple discoveries in the history of sciences (by different people at the same or different times) has been highlighted since the list of 148 duplicate independent inventions was published and analysed by William Ogburn and Dorothy Thomas (1922), and subsequently by sociologist Robert Merton who wrote an important paper promoting the statistical analysis and sociological theory of this question (Merton 1961).

In the case of a Cartesian coordinate grid to locate archaeological remains, Cintas, one of its “early adopters” made a crucial observation in an article about his excavation in the city of Tipaza in Algeria. He wrote:

I am tired, indeed, to listen to people around me arguing that the results of excavation depend on chance alone. It must be known: there is a method for research, just as there is, after the discovery, a technique for the excavation. This method has formal rules; rules that can be learned, if one lacks such intuition that one is unable to use them without this effort on the field, by the mere use of subconscious reasoning. These rules may change with the nature of the research to be undertaken, but none the less exist, rigid, absolute. (Cintas 1948, p. 264, my emphasis.)

For Cintas, excavations methods, including the precise localisation of findings, could be developed from intuitive logical principles that all scientists employ.

This view could be discussed in general but, regarding the use of a Cartesian coordinate grid in archaeological excavations, I argue that Cintas' statement is relevant. This localisation method is not an innovation which is “discovered”; it is rather:

1. The easiest and most obvious method to adopt if one aims to rigorously record spatial information.
2. A quantitative approach similar to methods in scientific fields which a pre-historic archaeologist would have consulted in the 1940s, namely: physical anthropology (e.g. the multidisciplinary *L'Anthropologie* French journal),



Quaternary geology, and classical archaeology (in which relatively accurate topographical plans were commonly made by architects). Furthermore, many prehistoric archaeologists had another profession which would have made them familiar with basic quantitative methods: physicians, engineers, and military officers, for example.

Regarding Laplace, this idea is supported by examining his files, and in particular, the forms he used to synthesise his notes, which included his knowledge in mathematics, arithmetic and geometry (figure 3). The methods he developed drew on this knowledge.

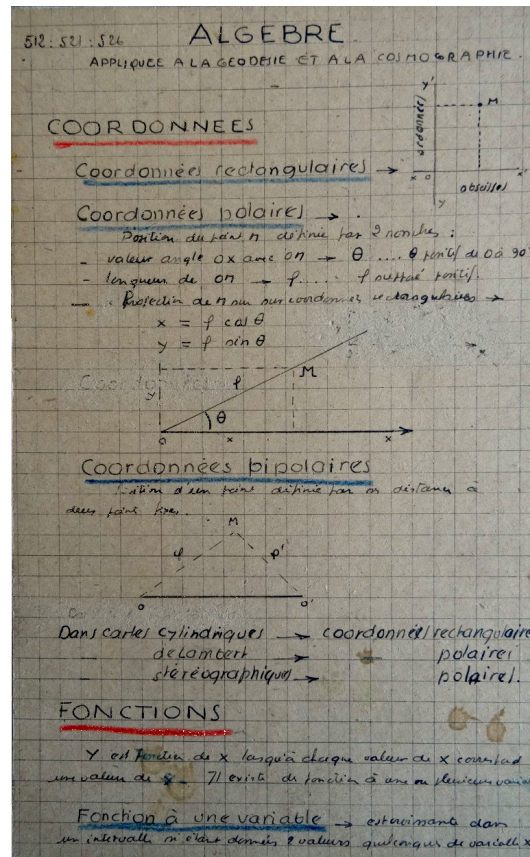


Figure 3: “Algebra applied to geodesy and cosmography”: an example of a card from Laplace’s files about Cartesian, polar, and bipolar coordinate systems. Source: the private files of Fabrizio Millesimi (Laplace’s nephew).

## 2 Laplace's method was a new step towards formalising archaeological stratigraphy, the organisation of excavations and data recording

### 2.1 From a fieldwork practice to the publication of a formalised method

Studies on the relationships between tacit and explicit knowledge in science emphasise the gradual difference between a practice, its objectification, and its systematised expression as a method (Collins 2010, pp. 157-164). Hence, using a spatial reference system, or theorising and writing about it, involves a process of making the system more explicit. From the simple use of Cartesian coordinates, Laplace developed a systematic and general method aimed at systematising and formalising stratigraphy in archaeology. In this section, I examine the chronology of publications related to this development, and the components of the method.

From 1947 to 1952, Laplace took part in excavations led by Méroc in the Montmaurin quarry (near Toulouse, Vialet 2019). There, he was exposed to the metric coordinate system used by Méroc. He immediately applied it in his own excavations, for example in 1948 in the Tute de Carrelore site (figure 4):

This publication is the first to report excavations carried out according to the method of applying a grid on the site and the precise notation of the position of each piece, recommended by L. Méroc. Its use is becoming more widespread in the 10<sup>th</sup> district of Prehistoric Antiquities. (Laplace-Jauretche 1949, p. 232<sup>2</sup>.)

From 1952, he used this system in the Gatzarria cave (Laplace 1964), and from 1953 in the Olha 2 cave, two sites in the northern Basque country.

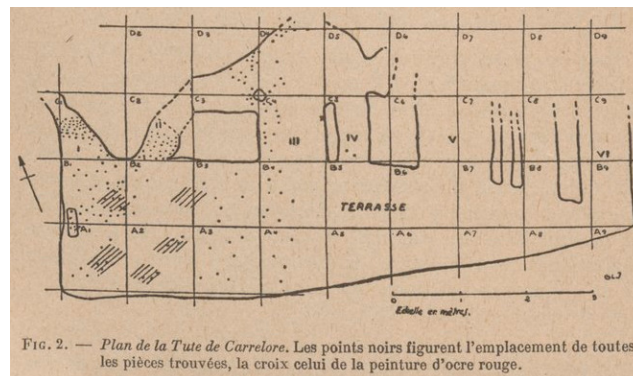


Figure 4: Graphic representation of the Cartesian grid used during the excavation of the Tute de Carrelore site by Laplace. The dots show the location of the objects uncovered (Laplace-Jauretche 1949, p. 228).

In 1954, Laplace and Méroc published two short articles together in the *Bulletin de la Société préhistorique française* (BSPF). They presented the method using

<sup>2</sup>From 1949 Laplace authored his publications as Laplace-Jauretche (adding his first wife's surname); from 1958 onward, he authored as Laplace.

examples from the Montmaurin, Gatzarria, and Olha 2 sites. Although they published together, Laplace actually wrote the first entitled “Application of Cartesian coordinates to the excavation of an archaeological deposit” (Laplace and Méroc 1954a) and Méroc wrote the second (“Complement to our note on the application of Cartesian coordinates to the excavation of an archaeological deposit” (Laplace and Méroc 1954b). Indeed, in a letter sent to François Bordes (1919–1981), Laplace emphasised that his own methodological proposition, initially based on Méroc’s method, had become quite different (Laplace 1954).

Some twenty years later, in 1970, Laplace was invited by the Basque archaeologist Jesús Elósegui Irazusta (1907–1979), editor of the *Munibe* journal, to contribute to a special issue in honour of José Miguel de Barandiarán y Ayerbe (1889–1991) (Laplace 1970). Laplace, who did his earliest archaeological surveys in the northern Basque country with Barandiarán in 1947, accepted and proposed a revised presentation of his method (Laplace 1971).

In summary, traces of Laplace’s method include these three publications, which are complemented by the field notes he and his collaborators wrote in the excavation sites throughout France, Spain, and Italy where the method was applied. It is important to stress that what the “Cartesian coordinate method” refers to partly changed over time, due to a series of revisions and its multiple applications.

## 2.2 The components of Laplace’s stratigraphic method

Sáenz de Buruaga identified three components to summarise Laplace’s method: 1) the division of the surface with a grid; 2) the localisation of the objects; and 3) a procedure to excavate the sediments (Sáenz de Buruaga 1991, pp. 85–90). I propose a slightly different analysis which distinguishes four components:

- The use of a **device**, namely a *physical grid* which visually divides the excavation space, but also defines various abstract spatial entities such as plans, squares, and axes (figure 5).
- The **quantification** of distances between objects, using a metric reference system (figure 6).
- The conceptual distinction between observed and reconstructed stratigraphy. Laplace specifically distinguished between “stratigraphic profile” and (objects’) “position diagrams”.
- A method for **naming** spatial entities and recording archaeological objects.

Laplace’s method considered the excavation volume to be composed of various spatial entities, including *squares*, *subsquares*, and *layers*, constructed from different axes and plans. Later, he also defined a “*taille*” as “the sediment slice between two horizontal planes at a distance of 1 decimetre” (Laplace 1971, p. 228). A systematic method was employed to name these entities. For example, a layer is named by the acronym of the apocope of the words in its description in natural language: “cbci”, for example, stands for “*couche brune à cailloutis inférieur*” (“lower brown layer with gravel”). There is a standard description of colours using a geological reference chart, the *Code expolaire*, which is an alternative to the well-known

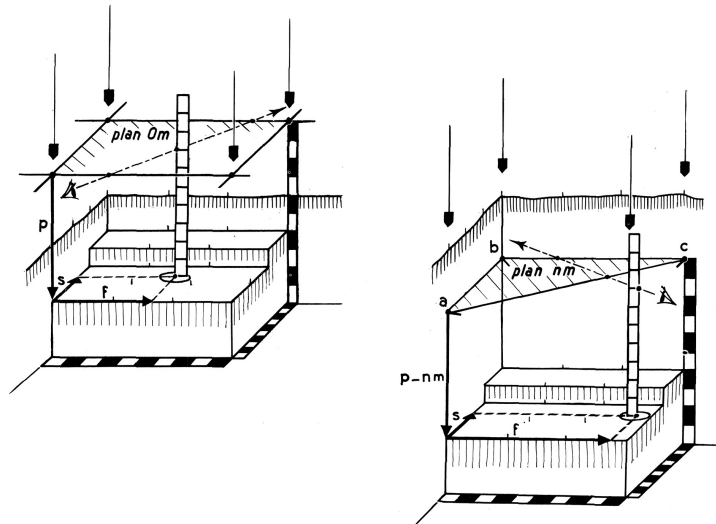


Figure 5: Illustration of two methods to record the location of an object during an excavation: above the surface level with reference to the plan  $Om$ ; below the surface, with reference to the plan of the  $nm$  triangle (Laplace 1971, p. 228)

couche	carré	n°	x	y	z	nature	Observations
II	B7	594	152	72	27	éclat silex	brisé dans le gisement, base du foyer F2.
II	B7		154	55	44	plaquette calc. (12 × 25 × 40)	Horizontale, base F2.
II	B7	595	156	60	72	dent <i>Equus</i>	contact c. III.
III	B7		170	25	44	galet	éclaté par gel.

Figure 6: Example of a field recording form (Laplace and Méroc 1954a, p. 62).

Munsell code (de Cailleux and Taylor 1963). By generalising this standardisation for all spatial information, Laplace proposed a systematic method to record the location of each sampled object during an excavation. Qualitative information (the sedimentary properties of the spatial entities) and quantitative information (Cartesian coordinates of the located object) were combined in alphanumeric sequences, e.g., “Gat D7 4 (9) 36.72.85 cbcif”, stands for an object located at  $z=36$  cm,  $x=72$  cm,  $y=85$  cm in the inferior *taille* number 4 of sub-square 9, square D7 of the Gatzarria site.

In summary, this method involved different types of information and different levels of abstraction. An analysis of this method would benefit from a more general analysis of the conceptual constructions underlying the various stratigraphic methods developed throughout the history of archaeology.

### 2.3 Toward a conceptual analysis of the systematisation of archaeological stratigraphy

Mid-20<sup>th</sup>-century methodological propositions on stratigraphy are an interesting starting point to define such a general framework of analysis: during this period there was intense concern for the precision, standardisation, and formalisation of the ways scientists expressed their observations and analytical procedures. Based on the comparison of five stratigraphic methods, according to five criteria, this section presents an orientation for future research (Table 1).

Table 1: Comparison of various formalisations of stratigraphic information used by archaeologists in the 19<sup>th</sup> and 20<sup>th</sup> centuries (N.L. stands for “natural language”).

	Piette	Myers	Méroc	Laplace	Harris
Publication date	1880s	1950	1930s	1954	1979
Entity to locate	points	surfaces	points	pts, surf., vol.	volumes
Naming of spatial entity	N.L.	none	N.L.	coding	coding
Spatial dimensions	1	2	3	3	1
Use of measurement	yes	no	yes	yes	no
Qualitative spatial relation	no	yes	no	no	yes

This table shows how unsatisfactory a general analysis of the history of the stratigraphic methods in archaeology would be if it is seen as a change from a “qualitative” to “quantitative” approach, or as an increase in the number of spatial dimensions recorded. Even if the idea of increasing abstraction might be qualified, one must consider that the introduction of a more abstract approach (as Laplace’s generalisation of the use of Euclidean space) did not imply that more analogical methods of graphic representation were abandoned. For example, Laplace’s “position diagram” is a plot of the findings according to their Cartesian coordinates; reading this diagram is similar to reading a stratigraphic profile, even if it shows something which cannot be directly observed in the field. Similarly, Philippe Sabatier and Jean-Louis Voruz, who participated in the seminars organised by Laplace during the 1970s, later developed a method coined *verticalisation des données planimétriques* and applied it to the Gardon cave in Bourgogne (Sabatier 1995).

In other words, it is possible to adopt a research agenda which aims to record the history of abstraction in scientific practices and to apply it to the case of stratigraphic methods in archaeology. Such a study should also take into account the historical conditions (spatial and temporal) in which these methodological innovations were developed. The last section of this paper focuses on a series of stratigraphic innovations developed in the Pyrenean region over a period of about one century.

### 3 Laplace's method as part of a trans-Pyrenean lineage of stratigraphic innovations

This section first focuses on the dissemination of Laplace's method throughout the Pyrenean region, and finally argues for the existence of a *trans-Pyrenean lineage of stratigraphic innovations*.

#### 3.1 The spatial dissemination of Laplace's method

##### 3.1.1 Reasons for an effective diffusion

During the 1950s, in addition to its use in Montmaurin, the “Cartesian coordinates” method was used in other excavations sites in the Southwest of France. There are four main reasons for this:

1. At the time Montmaurin was one of the few large prehistoric excavations in France, that many people joined to practice the most advanced methods; Laplace participated from 1949 to 1952 and Bordes in 1949 and 1951.
2. Méroc was influential as he was the *Directeur de la 10<sup>e</sup> circonscription des Antiquités préhistoriques* from 1947 to 1970 and responsible for managing prehistoric archaeology in this part of France.
3. The method was published in one of the most important journals for prehistoric archaeology (BSPF).
4. Laplace was also involved in many other excavations in the Southwest of France, in the Béarn and the Basque country, as well as in Dordogne, which increased the potential diffusion of the method.

##### 3.1.2 From Southwestern France to North Africa and back

In 1950 and 1951 Bordes excavated the Pech de l'Azé cave in Carsac-de-Carlux, Dordogne. He benefited from the help of Laplace and Ernest Gobert (1879–1973), who all applied the Cartesian coordinates method: “The excavation was conducted using the method of locating each piece by three Cartesian coordinates, the ground having been ‘cut’ into 1-metre cubes.” (Bourgon and Bordes 1951, p. 523). Pierre Boucher (1909–1997), a former collaborator of Laplace in the northern Basque country, also contributed to this excavation (Boucher and Peyran 2013, Ebrard 2013).

Gobert, who specialised in prehistoric archaeology, was also a public officer (*Inspecteur des Antiquités préhistoriques*) responsible for this field of research in Tunisia. There, he frequently collaborated with Cintas (mentioned previously). Later, Laplace conducted fieldwork and also collaborated with Gobert in Algeria (1953 and 1954), and in Tunisia (1954 and 1955). It is most likely that they shared their experiences on excavation methods, especially since Laplace had contributed to debates on methodology, as evidenced by his survey archives (Plutniak 2017a, pp. 123–124).

### 3.1.3 The typology seminars at Arudy

Laplace's method was also disseminated by the excavations he led (in particular at Gatzarria, Olha 2, and Poeymaü sites), and the annual seminar he organised from 1969 to 1989 in Arudy (a small town where the Poeymaü site is located). Entitled “*Séminaires de Typologie d'Arudy*”, these meetings attracted up to 50 participants mainly from France, Italy, and Spain (Plutniak 2017c, pp. 126-141). They presented and discussed methodological and theoretical work related to prehistoric archaeology, but also encompassing applied mathematics, linguistics, and computing. The contents of these works were published in the *Dialektikê* bulletin. Note that articles in this bulletin did not deal directly with the Cartesian coordinate method. However, in the late 1970s and early 1980s, Laplace generalised the same approach to the analysis of lithic objects and published a sophisticated set of metrology and statistical methods (Laplace 1977, Laplace 1982). Looking at the distribution of the number of participants in these seminars, we observe that during the 1980s the number of Spanish participants, and Basque ones in particular, notably increased (Plutniak 2017b, pp. 521-522).

### 3.1.4 Reception in Spanish-speaking countries and the *Krei* group

The diffusion of the Cartesian coordinate method was particularly wide-spread in Spanish-speaking countries, in Spain in particular. This supports the idea of the Pyrenean region as a key region for the development of archaeological methods.

In 1956, two years after the publication of the Laplace-Méroc paper, the Spanish and Mexican archaeologist José Luis Lorenzo Bautista (1921–1996) published an annotated translation of this paper (Laplace and Méroc 1956). This translation was republished in 1991 in a volume in honour of Bautista (Laplace and Méroc 1991). Furthermore, it is noteworthy that Laplace published the revised version of his method in the Basque journal *Munibe* (Laplace 1971). In 1973, the Catalan archaeologist Francesc Martí Jusmet (1946–) published a translation into Spanish in a hydrology and karstology journal (Laplace 1973).

At a more general level of analysis, through a bibliometric analysis, Spain is observed to have been critical in the diffusion of the method (figure 7). The language of the texts which cite the two major publications on the method were analysed, assuming they reflect the geographical location where the texts were produced. The analysis shows that Laplace and Méroc 1954a was mainly cited in the French literature until the late 1990s, whereas Laplace 1971 was rarely cited. The reception of Laplace 1971 was almost exclusively Spanish, and references to Laplace and Méroc 1954a only increased after the late 1990s. This late reception in Spain has already been emphasised (Estévez Escalera and Vila i Mitjà 1999, p. 67). Estévez and Vila were Catalan archaeologists who contributed to the renewal of archaeological theory and methods in Spain after the Francoist period, participating in Laplace's seminars in Arudy on a regular basis. Besides Catalonia, the southern Basque country was the second and main place in Spain where Laplace's method was received.

The collaborations Laplace made with southern Basque country archaeologists date back to the immediate post WWII era. At that time, Laplace worked with José Miguel de Barandiarán who was exiled in Sare, a northern Basque village. Laplace

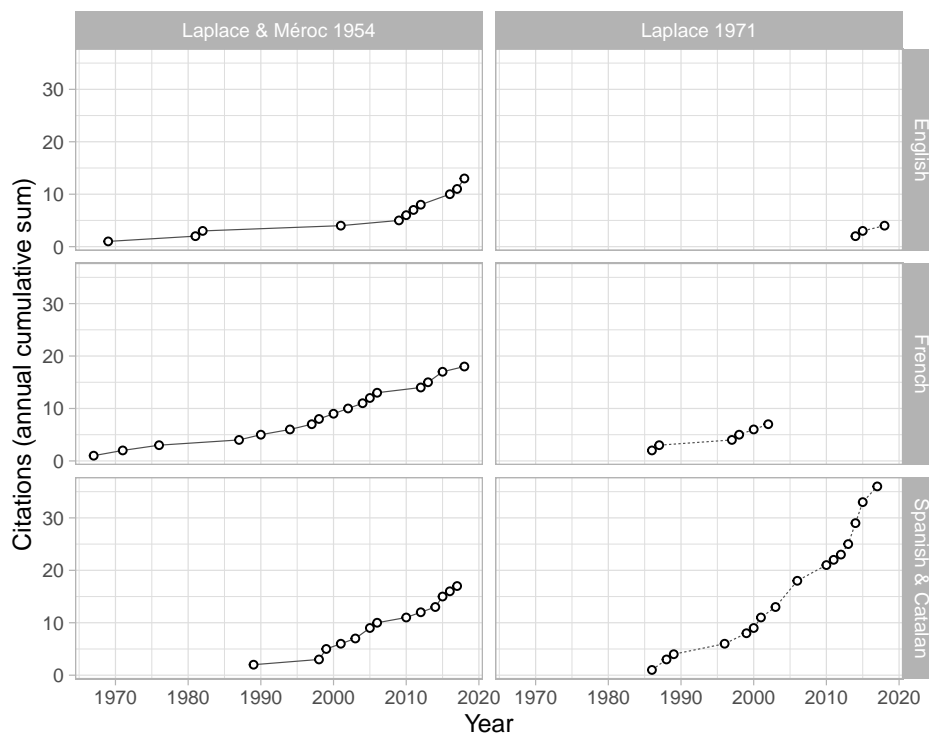


Figure 7: Annual cumulative sum of [Laplace and Méroc 1954a](#) and [Laplace 1971](#) citations between 1967 and 2018 (data: *Google Scholar*).

was also involved in various Basque and Pyrenean scientific societies during the 1950s ([Plutniak 2017c](#), pp. 122-123). Thirty years later, part of the young post-Francoist generation of southern Basque country archaeologists found the renewal they had been looking for in Laplace’s seminar. In return, Laplace also gave lessons at Vitoria-Gasteiz University in 1983, 1985 and 1986.

Andoni Sáenz de Buruaga played a notable role during this time. He was one of the closest and last collaborators of Laplace and he completed his PhD on the results of Laplace’s excavation in Gatzarria ([Sáenz de Buruaga 1991](#)). In 1996, he set up a research group in Vitoria called *Krei. Círculo de Estratigrafía Analítica* (“Circle of analytical stratigraphy”) which edited an eponymous journal from 1996 to 2015. The group was dedicated to using and enhancing Laplace’s methodological propositions, in particular stratigraphy. The method they created, coined “analytical stratigraphy”, was explicitly considered as “a deepening of Laplace’s system” about stratigraphy ([Sáenz de Buruaga 2006](#), note that the collective volume in which this text was published was dedicated in honour of Laplace). This method detailed two tools for representing stratigraphy: 1) an alphanumeric code system (figure 8) –called “analytical formulas”, based on the coding system developed by Laplace to code lithic objects; and 2) an organisation chart inspired by Harris’ “matrix”. The development of this method was closely related to the sites excavated by the *Krei* group in the southern Basque country, in particular the Cueva de Arrillor (Múrua-Zigoitia), Antoliñako Koba (Gautegiz-Arteaga), Pareko Landa (Sollube), and Santa Coloma (Apricano) sites (for a comprehensive list of the 30 sites interpreted by the “analytical stratigraphy”, see [López Quintana and Sáenz](#)



de Buruaga 2015, pp. 65-66).

[AlaR] = [Ala] = [Lam] = [Lmc] = [Armb] = [Armc {Armc-h}] = [Ara] = [Armkl  
 {Armkl-h}] = [Ara2 {Ara2-cr}] = [Arrk] = [Agp] = (Aras) = [Arrk2] = [Ara3 {Ara3-  
 cr}] = [Arrk3] = [Agp2] = (Aras2) = (Arrk4) = [Ara(m)4 {Ara(m)4-cr}] = [Arrk5  
 {Arrk5-h}] = (Agp3) = [Ara5 {Arr}] (=) {Ara5-cr1} {Ara5-cr2} = [Arrk6] = (Agp4) =  
 [Ara6 {Ara6-cr}] = [Ara6 = <Zi-Ara6>] = [<Hs-Amk> = Amk] [Arrk7 {Arrk7-h}] =  
 (Agp5) = [Ara7] ...

Figure 8: An “analytical formula” representing the stratigraphy of the Cueva de Arrillor. The sign [] represents the stratigraphic structure, = the superposition of structures, {} the inclusion of structures, \_ the structure in the case of composed expressions, () the structures with uncertain relations (Ormazabal 1996, p. 34).

### 3.2 A trans-Pyrenean lineage of stratigraphic innovation

Historical studies of science can address various spatial units of analysis. National borders are a very common choice to study scientific activities in a country or scientific relationships between different countries. Concerning the history of stratigraphic methods, such a national-based perspective is illustrated by studies on the U.S.A (Lyman and O’Brien 1999, Browman 2013), or Italy (Guidi and Tarantini 2017). Here I focus on the Pyrenean region and opt for a different definition based on the geophysical properties of a territory. In this context, the relevance of considering the Pyrenean territory in itself is also supported by a long-standing history of exchanges between archaeologists in this area. This is illustrated by a series of scientific conferences, including the *Congresos de Estudios Vascos* organised by the scientific society *Eusko Ikaskuntza* (from 1918 to the 18<sup>th</sup> conference in 2018; see Larronde 2003), the *Congresos Internacionales de Estudios Pirenaicos* (from 1950 to the 7<sup>th</sup> and last conference in 1983), or the series of *Colloqui Internacionales d’Arqueologia de Puigcerdà* (from 1976 to the 15<sup>th</sup> and last conference in 2011 – note that the 14<sup>th</sup> conference was dedicated in honour of Laplace; see Mercadal i Fernández 2009).

In this context, the series of stratigraphic innovations developed in or around this mountainous region is striking and includes the following:

- 19<sup>th</sup> century work with a particular focus on stratigraphy: that conducted in Ariège by the geologist and palaeontologist Jean-Jacques Pouech (1814–1892), and by Édouard Piette (1827–1906).
- Later in Ariège, the excavations conducted by the Péquart couple between 1935 and 1944 in the Mas d’Azil cave (M. Péquart and S.-J. Péquart 1941).
- Research made by Méroc in the 1930s and especially his excavation in Montmaurin from 1948.
- From the 1950s to the late 1980s, Laplace’s work, mainly in the Béarn and in the northern Basque country.

- From the early 1990s, the collective developments of the *Estratigrafía Analítica* by the *Krei* group in the southern Basque country.

Some actors and methods of this series were strongly related, while others had no direct relationships. However, all researchers were aware of the existence of former works. For this reason, they constitute an “intellectual and research lineage”, in the sense the sociologist Andrew Abbott gave to this term to analyse the developments of the various branches of sociology in the U.S.A. (Abbott 2001)<sup>3</sup>.

## Conclusion

In the historiography of archaeology, regions associated with the development of stratigraphic methods in 20<sup>th</sup> century generally include the U.S.A. in the 1930s, the Soviet area, northern France (with Leroi-Gourhan’s excavations, inspired by Soviet methods), and Great Britain in the 1960s. My aim in this paper was not to claim the importance of the Pyrenean region over the other regions, but to show how an intellectual lineage of scientific innovations can grow through the common ground authors share by working in the same territory.

This paper also contributes to recent interest on the history of stratigraphic methods, stressing the need for a careful use of the concepts regarding the authorship of methodological innovations. Furthermore, several perspectives for future research have been proposed: 1) the stories behind and between each component of the trans-Pyrenean lineage should be addressed in more detail within a socio-historical perspective; and 2) the framework for the conceptual analysis of the various formalisations of stratigraphy should be refined and applied to an extended set of methods.

## Acknowledgements

This research was made with the support of the collective project *PAVO – Préhistoire Ancienne de la Vallée d’Ossau*. I thank Fabrizio Millesimi and François-Xavier Chauvière for the information they shared with me; Claire Manen for her help in accessing some publications; and Massimo Tarantini, Jean-Marc Pétilion, and François Fouriaux for their useful suggestions on previous versions of this paper.

## References

- Abbott, Andrew [2001], *Chaos of Disciplines*, Chicago (Ill.): University of Chicago Press, xvi–259 p.
- Abbott, Andrew [2016], *Human Nature in Processual Thinking*, Chicago (Ill.): The University of Chicago Press, pp. 16–32, xvi–311 p.

---

<sup>3</sup>Abbott had not refined the concept of lineage in his applications to the study of sciences, in which he only established an analogy with kinship lineages. Later he developed the concept, in relation to the ontology of personalities and social groupings, not with reference to intellectual lineages (Abbott 2016).

- Axelsson, Eric [1938], "Discovery of the Farthest Pillar Erected by Bartholomew Dias," *South African Journal of Science*, 35, pp. 417-429.
- Bensaude-Vincent, Bernadette [1983], "A Founder Myth in the History of Sciences? The Lavoisier Case," in *Functions and Uses of Disciplinary Histories*, ed. by Loren R. Graham, Wolf Lepenies, and Peter Weingart, *Sociology of the Sciences Yearbook*, 7, Dordrecht: D. Reidel, pp. 53-78, DOI: [10.1007/978-94-009-7035-9\\_3](https://doi.org/10.1007/978-94-009-7035-9_3).
- Boucher, Pierre and Ximun Peyran [2013], "P. Boucher (1909-1997) : Éléments d'une histoire de vie," in *50 ans d'archéologie en Soule. Hommage à Pierre Boucher (1909-1997)*, ed. by Dominique Ebrard, Mauléon-Licharre: Ikerzaleak, pp. 17-23.
- Bourgon, Maurice and François Bordes [1951], "Le gisement du Pech de l'Azé Nord. Campagnes 1950-1951. Les couches inférieures à Rhinoceros Mercki," *Bulletin de la Société préhistorique de France*, 48, 11-12, pp. 520-538, DOI: [10.3406/bspf.1951.2963](https://doi.org/10.3406/bspf.1951.2963).
- Browman, David L. [2013], "The Origin of the 'Chicago Method' Excavation Techniques: Contributions of William Nickerson and Frederick Starr," *Bulletin of the History of Archaeology*, 23, 2, pp. 1-9, DOI: [10.5334/bha.2324](https://doi.org/10.5334/bha.2324).
- Caso Andrade, Alfonso and Ignacio Marquina [1938], "La technique des fouilles au Mexique," *Mouseion*, 43-44, pp. 263-275.
- Cintas, Pierre [1947], "Le sanctuaire punique de Sousse," *Revue africaine*, 91, 410-411, pp. 1-80.
- Cintas, Pierre [1948], "Fouilles puniques à Tipasa," *Revue africaine*, 92, pp. 263-330.
- Collins, Harry M. [2010], *Tacit and Explicit Knowledge*, Chicago (Ill.): University of Chicago Press, 186 pp.
- De Cailleux, André and Gerard Taylor [1963], *Code Expolaire*, Paris: Édition N. Boubée et Cie, 20 pp.
- De Morgan, Jacques [1912], "Observation sur les couches profondes de l'acropole à Suse," in *Céramique peinte de Suse et petits monuments de l'époque archaïque*, ed. by Jacques de Morgan, *Mémoires de la délégation en Perse*, 13, Paris: Ernest Leroux, pp. 1-25.
- Dubois, Auguste and Hans-Georg Stehlin [1933], *La Grotte de Cotencher, station moustérienne*, *Mémoires de la Société paléontologique suisse*, Bâle: Société paléontologique suisse, 292 pp.
- Ebrard, Dominique [2013], "L'archéologue Pierre Boucher (1909-1997)," in *50 ans d'archéologie en Soule. Hommage à Pierre Boucher (1909-1997)*, ed. by Dominique Ebrard, Mauléon-Licharre: Ikerzaleak, pp. 25-29.
- Estévez Escalera, Jordi and Assumpció Vila i Mitjà [1999], *Piedra a piedra. Historia de la construcción del Paleolítico en la Península Ibérica*, BAR international series, 805, Oxford: Archaeopress, 355 pp.
- Fauvelle-Aymar, François-Xavier [2012], "La croix de Dias. Genèse d'une frontière au sud de l'Afrique," *Genèses*, 86, 1, pp. 126-148, DOI: [10.3917/gen.086.0126](https://doi.org/10.3917/gen.086.0126).
- Gran-Aymerich, Ève [1998], *Naissance de l'archéologie moderne. 1798-1945*, forew. by Jean Leclant, Paris: CNRS Éditions, p. 533.
- Groenen, Marc [1994], *Pour une histoire de la préhistoire. Le paléolithique*, L'homme des origines, Grenoble: Jérôme Millon, 603 pp.
- Guidi, Alessandro and Massimo Tarantini [2017], "The Emergence of Stratigraphic Archaeology in Mediterranean Europe. The Italian Case Study (1900-1950)," *Acta Archaeologica*, 88, 1, pp. 139-154, DOI: [10.1111/j.1600-0390.2017.12180.x](https://doi.org/10.1111/j.1600-0390.2017.12180.x).
- Harris, Edward C. [1979], *Principles of Archaeological Stratigraphy*, London: Academic Press, xiii-136 p.

- Hurel, Arnaud and Noël Coye (eds.) [2011], *Dans l'épaisseur du temps. Archéologues et géologues inventent la préhistoire*, Paris: Publications scientifiques du Muséum national d'histoire naturelle, 442 pp.
- Laplace-Jauretche, Georges [1949], "Gisement azilien de la Tute de Carrelore, à Lurbe (Basses Pyrénées). Découvertes et outillages," *Bulletin de la Société de sciences naturelles de Toulouse*, 84, pp. 227-236.
- Laplace, Georges [1954], *Letter to François Bordes*, Bordeaux: SRA de Nouvelle-Aquitaine.
- Laplace, Georges [1964], "Le problème de l'origine de l'Aurignacien à la lumière des fouilles de la Grotte de Gatzarria," *Bulletin de la Société des Sciences, Lettres et Arts de Pau*, 24, pp. 24-26.
- Laplace, Georges [1970], *Letter to Jesús Elósegui Irazusta*, Donostia: Aranzadi archives.
- Laplace, Georges [1971], "De l'application des coordonnées cartésiennes à la fouille stratigraphique," *Munibe. Revista de la Sociedad de Ciencias Naturales Aranzadi*, 23, 2-3: *Homenaje a D. José Miguel de Barandiarán*, pp. 223-236.
- Laplace, Georges [1973], "Sobre la aplicación de las coordenadas cartesianas en la excavación estratigráfica," trans. by Francesc Martí Jusmet, *Speleon. Revista española de hidrología, morfología cárstica y espeleología*, 20, pp. 139-159.
- Laplace, Georges [1977], "Notes de typologie analytique. Orientation de l'objet et rectangle minimal," *Dialektikê. Cahiers de typologie analytique*, 6, pp. 32-53, DOI: [10.5281/zenodo.2584046](https://doi.org/10.5281/zenodo.2584046).
- Laplace, Georges [1982], "Recherches sur le passage de la latéralité à la transversalité," *Dialektikê. Cahiers de typologie analytique*, 10, pp. 30-38, DOI: [10.5281/zenodo.2584235](https://doi.org/10.5281/zenodo.2584235).
- Laplace-Jauretche, Georges and Louis Méroc [1954a], "Application des coordonnées cartésiennes à la fouille d'un gisement," *Bulletin de la Société préhistorique de France*, 51, 1-2, pp. 58-66, DOI: [10.3406/bspf.1954.12427](https://doi.org/10.3406/bspf.1954.12427).
- Laplace-Jauretche, Georges and Louis Méroc [1954b], "Complément à notre note sur l'application des coordonnées cartésiennes à la fouille d'un gisement," *Bulletin de la Société préhistorique de France*, 51, 7, pp. 291-293.
- Laplace-Jauretche, Georges and Louis Méroc [1956], "Técnica de exploración arqueológicas. Empleo de las coordenadas cartesianas según G. Laplace-Jauretche y L. Meroc," trans. by José Luis Lorenzo Bautista, *Tlatoani*, 10, pp. 18-21.
- Laplace-Jauretche, Georges and Louis Méroc [1991], "Técnica de exploración arqueológica: empleo de las coordenadas cartesianas según G. Laplace Jauretche y L. Meroc," in *Prehistoria y Arqueología. José Luis Lorenzo*, ed. by Lorena Mirambell Silva, trans. by José Luis Lorenzo Bautista, México: Instituto Nacional de Antropología e Historia, pp. 19-30.
- Larronde, Jean-Claude [2003], "Histoire du VIIème Congrès d'Études Basques. Biarritz, 1948," in *VIIème Congrès d'Études Basques*, ed. by Jean-Claude Larronde, Donostia: Eusko Ikaskuntza, pp. 17-61.
- Leroi-Gourhan, André [1950], *Les fouilles préhistoriques. Technique et méthodes*, Paris: A. et J. Picard, viii-88 p.
- Leroi-Gourhan, André [1961], "Les fouilles d'Arcy-sur-Cure (Yonne)," *Gallia préhistoire*, 4, 1, pp. 3-16, DOI: [10.3406/galip.1961.1182](https://doi.org/10.3406/galip.1961.1182).
- Leroi-Gourhan, André and Michel Nacu Brézillon [1966], "L'habitation magdalénienne no 1 de Pincevent près Monterau (Seine-et-Marne)," *Gallia préhistoire*, 9, 2, pp. 263-385, DOI: [10.3406/galip.1966.1264](https://doi.org/10.3406/galip.1966.1264).
- López Quintana, Juan Carlos and Andoni Sáenz de Buruaga [2015], "Recorrido y reflexiones en torno al pensamiento analítico de Georges Laplace: movimiento, interdependencia y arquetipos en la construcción de una Arqueología científica," in

- Seis décadas de tipología analítica. Actas en homenaje a Georges Laplace*, Vitoria-Gasteiz, Nov. 13-15, 2012, ed. by Aitor Calvo, Aitor Sánchez, Maite García-Rojas, and Mónica Alonso-Eguíluz, Vitoria-Gasteiz: Facultad de Letras de la UPV/EHU, pp. 61-91.
- López Varela, Sandra L. (ed.) [2018], *The Encyclopedia of Archaeological Sciences*, 4 vols., Chichester, Oxford, and Malden: Wiley-Blackwell, liii–1909 p. DOI: [10.1002/9781119188230](https://doi.org/10.1002/9781119188230).
- Lyman, R. Lee and Michael J. O'Brien [1999], "Americanist Stratigraphic Excavation and the Measurement of Culture Change," *Journal of Archaeological Method and Theory*, 6, 1, pp. 55-108, DOI: [10.1023/A:1022976726447](https://doi.org/10.1023/A:1022976726447).
- Lyman, R. Lee and Michael J. O'Brien [2006], "American Stratigraphic Excavation," in *Measuring Time with Artifacts. A History of Methods in American Archaeology*, Lincoln and London: University of Nebraska Press.
- McFarlane, Donald A. and Joyce Lundberg [2005], "The 19th Century excavation of Kent's Cavern, England," *Journal of Cave and Karst Studies*, 67, 1, pp. 39-47.
- Mercadal i Fernández, Oriol (ed.) [2009], *Els Pirineus i les àrees circumdants durant el Tardiglacial. Mutacions i filiacions tecnoculturals, evolució paleoambiental (16000–10000 BP)*, XIV Colloqui Internacional d'Arqueologia de Puigcerdà. Homenatge al professor Georges Laplace Puigcerdà, Nov. 10-12, 2006, Puigcerdà: Institut d'Estudis Ceretans, 695 pp.
- Merton, Robert K. [1961], "Singletons and Multiples in Scientific Discovery: a Chapter in the Sociology of Science," *Proceedings of the American Philosophical Society*, 105, 5, pp. 470-486.
- Moro Abadía, Oscar [2002], "Towards a Definition of Time in Archaeology: French Prehistoric Archaeology (1850-1900)," *Papers from the Institute of Archaeology*, 13, pp. 51-63.
- Myers, Oliver Humphrys [1950], *Some Applications of Statistics to Archaeology*, Le Caire: Service des Antiquités de l'Égypte, vi–37 p.
- Negev, Avraham and Shimon Gibson (eds.) [2001], *Archaeological Encyclopedia of the Holy Land*, 2nd ed., New York and London: Continuum, 559 pp.
- O'Brien, Michael J. and R. Lee Lyman [2002], "The Epistemological Nature of Archaeological Units," *Anthropological Theory*, 2, 1, pp. 37-56, DOI: [10.1177/1463499602002001287](https://doi.org/10.1177/1463499602002001287).
- Ogburn, William F. and Dorothy S. Thomas [1922], "Are Inventions Inevitable? A Note on Social Evolution," *Political Science Quarterly*, 37, 1, pp. 83-98, DOI: [10.2307/2142320](https://doi.org/10.2307/2142320).
- Ormazabal, Aitor [1996], "El depósito prehistórico de Arrillor (Murua, Zigoitia; Araba): aplicación de la Estratigrafía Analítica," *Krei. Círculo de Estratigrafía Analítica*, 1, pp. 21-36.
- Péquart, Marthe and Saint-Just Péquart [1928a], "Techniques de fouilles préhistoriques," *Revue des Musées et Collections archéologiques*, 14, 3, pp. 2-19.
- Péquart, Marthe and Saint-Just Péquart [1928b], "Techniques de fouilles préhistoriques (suite)," *Revue des Musées et Collections archéologiques*, 16, 4.
- Péquart, Marthe and Saint-Just Péquart [1941], "Nouvelles fouilles au Mas d'Azil," *Préhistoire*, 8, pp. 7-42.
- Petrie, William Matthew Flinders [1891], *Tell El Hesi (Lachish)*, London: Palestine Exploration Fund, 62 pp.
- Petrie, William Matthew Flinders [2013], *Inductive Metrology. Or, the Recovery of Ancient Measures from the Monuments*, 2nd ed., Cambridge Library Collection – Egyptology,

- Cambridge: Cambridge University Press, DOI: [10.1017/CB09781107325265](https://doi.org/10.1017/CB09781107325265); trans. 1877.
- Plutniak, Sébastien [2017a], “L’innovation méthodologique, entre bifurcation personnelle et formation des disciplines : les entrées en archéologie de Georges Laplace et de Jean-Claude Gardin,” *Revue d’histoire des sciences humaines*, 31: *Faire science*, ed. by Camila Orozco Espinel and Yann Renisio, pp. 113-139, DOI: [10.4000/rhsh.435](https://doi.org/10.4000/rhsh.435), HDL: [10670/1.rw3o20](https://hdl.handle.net/10670/1.rw3o20).
- Plutniak, Sébastien [2017b], *L’opération archéologique. Sociologie historique d’une discipline aux prises avec l’automatique et les mathématiques. France, Espagne, Italie, 2<sup>e</sup> moitié du XX<sup>e</sup> siècle*, PhD thesis, École des hautes études en sciences sociales, x-864 p. HDL: [10670/1.xpgg09](https://hdl.handle.net/10670/1.xpgg09).
- Plutniak, Sébastien [2017c], “The Professionalisation of Science – Claim and Refusal: Discipline Building and Ideals of Scientific Autonomy in the Growth of Prehistoric Archaeology. The Case of Georges Laplace’s Group of *Typologie Analytique*, 1950s–1990s,” *Organon*, 49: *Approche historique des structures de l’archéologie préhistorique et protohistorique aux XIX<sup>e</sup>–XX<sup>e</sup> siècles*, ed. by Arnaud Hurel, pp. 105-154, HDL: [10670/1.y5rnm6](https://hdl.handle.net/10670/1.y5rnm6).
- Rudwick, Martin J. S. [2005], *Bursting the Limits of Time. The Reconstruction of Geohistory in the Age of Revolution*, Chicago (Ill.): University of Chicago Press, 708 pp.
- Sabatier, Philippe [1995], “Chronologie de la grotte du Gardon. Méthodologie de l’approche verticale,” in *Chronologies néolithiques. De 6000 à 2000 avant notre ère dans le bassin rhodanien*, Ambérieu-en-Bugey, Sept. 19-20, 1992, ed. by Jean-Louis Voruz, Documents du Département d’anthropologie et d’écologie de l’université de Genève, 20, Ambérieu-en-Bugey: Éditions de la Société préhistorique rhodanienne, pp. 113-122.
- Sáenz de Buruaga, Andoni [1991], *El paleolítico superior de la Cueva de Gatzarria (Zuberoa, País Vasco)*, Anejos de Veleia, Series maior, 6, Leioa: Instituto de Ciencias de la Antigüedad, Servicio Editorial, Universidad del País Vasco, 426 pp.
- Sáenz de Buruaga, Andoni [2006], “Estratigrafía Analítica: una profundización de la sistemática laplaciana en el movimiento estratigráfico,” in *Dialektikê. Cahiers de typologie analytique 2006. Hommage à Georges Laplace*, ed. by Francesc Gusi i Jener, Castelló de la Plana: Diputació de Castelló, Servei d’Investigacions Arqueològiques i Prehistòriques, pp. 126-139.
- Schweizer, Claudia [2008], “Stratigraphy in the Early Nineteenth Century: A Transdisciplinary Approach, with Special Reference to Central Europe,” *Annals of Science*, 65, 2, pp. 257-274, DOI: [10.1080/00033790701723477](https://doi.org/10.1080/00033790701723477).
- Vialet, Amélie [2019], “Interruption dans le processus de transmission du savoir : exemple des grottes préhistoriques de Montmaurin (Haute-Garonne) fouillées par Louis Méroc (1904–1970),” in *Pratiques de la médiation des savoirs*, ed. by Michel Sot, Actes des congrès nationaux des sociétés historiques et scientifiques, Paris: Éditions du Comité des travaux historiques et scientifiques, DOI: [10.4000/books.cths.5352](https://doi.org/10.4000/books.cths.5352).
- Wheeler, Mortimer [1954], *Archaeology from the Earth*, Oxford: Clarendon Press, 221 pp.