



HAL
open science

The spatio-temporal dynamics of settlement patterns from 800 BC to 800 AD, in Central and Southern Gaul

Frédérique Bertoncello, Élise Fovet, Cristina Gandini, Frédéric Trément,
Laure Nuninger

► To cite this version:

Frédérique Bertoncello, Élise Fovet, Cristina Gandini, Frédéric Trément, Laure Nuninger. The spatio-temporal dynamics of settlement patterns from 800 BC to 800 AD, in Central and Southern Gaul: models for an interregional comparison over the long term. 7 millennia of territorial dynamics: settlement pattern, production and trades from Neolithic to Middle Ages: closing colloquium of The ArchaeDyn program (“Spatial dynamics of settlement patterns and natural resources: towards an integrated analysis over a long term, from Prehistory to the Middle Ages”), Jun 2008, Dijon, France. hal-00404926

HAL Id: hal-00404926

<https://hal.science/hal-00404926>

Submitted on 24 Aug 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.

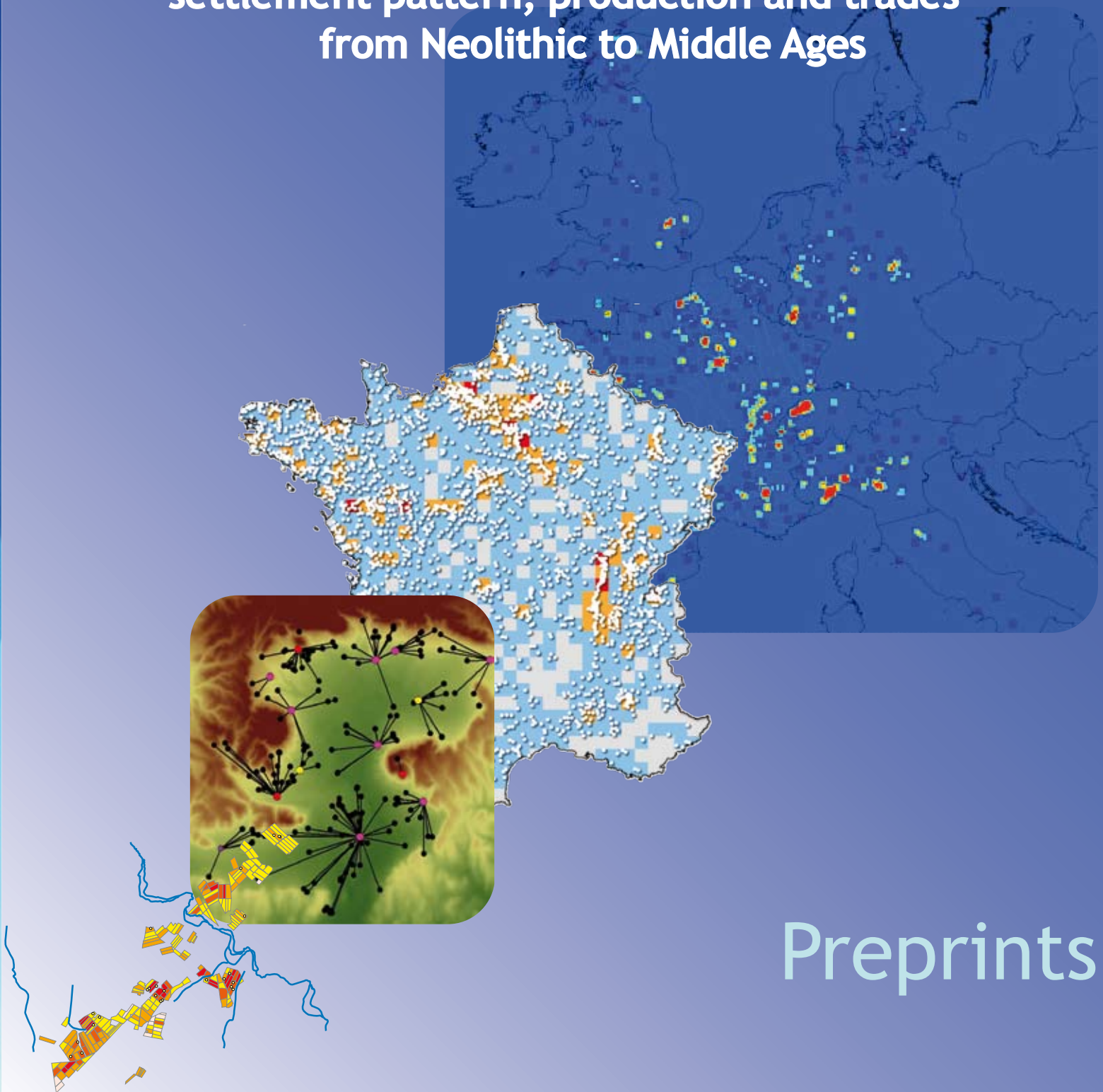
L’archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ACI "Spaces and territories" 2005-2007
Final conference - Dijon, 23-25 june 2008

ARCHAEDYN

7 millennia of territorial dynamics

**settlement pattern, production and trades
from Neolithic to Middle Ages**



Preprints

Pre-proceedings directed by

Cristina GANDINI (*UMR 8546 AOROC, ENS Ulm Paris*)

François FAVORY*

Laure NUNINGER*

Organisation committee

Cristina GANDINI,

Laure SALIGNY***

Laëtitia BASSEREAU**

Jean-Marc BOURGEON***

Brigitte COLAS**

Marion LANDRÉ****

Isabelle MOURET****

Sophie BUI****

Sylvie COSTILLE-VAREY*

Nathalie PUILLET*

Scientific committee co-chairs

François FAVORY*

Claude MORDANT**

Laure NUNINGER*

* *UMR 6249 ChronoEnvironnement*

** *UMR 5594 ARTeHIS*

*** *MSH Dijon UMS 2739*

**** *MSH C. N. Ledoux, Besançon USR 3124*

ACI « Spaces and territories » 2005-2007

Contract ET 28

**Spatial dynamics of settlement and natural resources :
toward an integrated analysis over the long term
from Prehistory to Middle Ages**

Final Conference – University of Burgundy, Dijon, 23-25 june 2008

ARCHÆDYN

7 millennia of territorial dynamics

*settlement pattern, production and trades
from Neolithic to Middle Ages*

Preprints

THE SPATIO-TEMPORAL DYNAMICS OF SETTLEMENT PATTERNS FROM 800 BC TO 800 AD IN CENTRAL AND SOUTHERN GAUL: MODELS FOR AN INTERREGIONAL COMPARISON OVER THE LONG TERM

Frédérique BERTONCELLO

CEPAM, UMR6130, Valbonne

Elise FOVET

Laboratoire de Chrono-Environnement UMR6249, Besançon

Cristina GANDINI

AOROC, UMR8546, ENS-Paris

Frédéric TRÉMENT

CHEC, EA1001, Clermont-Ferrand

Laure NUNINGER

Laboratoire de Chrono-Environnement UMR6249, Besançon

with the collaboration of the members of Workgroup 2'

1. The team includes 19 researchers from 8 universities and the CNRS: Auvergne-Limagne: B. Dousteysier, M. Segard, F. Trément (University of Clermont-Ferrand 2, EA 1001); Berry – Champagne berrichonne: C. Gandini (ENS, Paris, UMR 8546); Berry –Sancergues: N. Poirier (University of Tours, UMR 6173); Bourgogne – Vallée de l'Yonne: P. Nouvel (University of Franche-Comté, UMR 6249); Languedoc – Vauvage/Combas: F. Favory, E. Fovet, L. Nuninger (University of Franche-Comté, UMR 6249), C. Raynaud (Lattes, UMR 5140); Provence – Argens-Maure: F. Bertonceo, M. Gazenbeek (Valbonne, UMR 6130); Provence – Préalpes de Grasse: L. Lautier (Valbonne, UMR 6130); Provence – Verdon: D. Garcia, F. Mocci (Aix-en-Provence, UMR 6573); Touraine – Neuvy-le-Roi: V. Hirn (University of Tours, UMR 6173); Touraine – Tavant, Îles Bouchar et Crousilles: A. Moreau (University of Tours, UMR 6173); Slovénie – Doljenska: K. Ostir, S. Tecco-Hvala (ZRC, SAZU, Ljubljana).

ABSTRACT:

The aim of Workgroup 2, "Settlement patterns and territories", is to apprehend the intensity, stability and the modalities of the occupation of rural space over the long term (from 800 BC to 800 AD) using indices related to settlements. Eleven study areas in the south and centre of France and in Slovenia are involved in this study. In order to allow interregional comparisons, a common protocol was defined to homogenise the data and assess their reliability. Two types of indices are used: quantitative and chronological indices which show the settlement intensity and dynamics; and qualitative indices which express the hierarchical typology of the settlement. The combination and spatialisation of these indices allow us to apprehend the structure of settlement patterns and to locate the areas which were more or less intensely occupied, in a more or less durable and stable manner during the 16 centuries under consideration.

KEY WORDS : Settlement patterns, intensity and stability of settlement, spatial analysis, modelling, Central and Southern France, Iron Age and Antiquity.

RÉSUMÉ :

L'atelier 2 « Peuplement et territoires » a pour objectif d'appréhender, à partir d'indicateurs relatifs au peuplement, l'intensité, la stabilité et les modalités d'occupation de l'espace rural dans la longue durée (de 800 av. n. è. à 800 de n. è.). Onze zones-atelier sont concernées par l'étude, dans le Sud et le Centre de la France, et en Slovénie. Afin d'autoriser les comparaisons interrégionales, un travail d'homogénéisation et d'évaluation de la fiabilité des données a été réalisé. Deux types d'indicateurs sont mobilisés : des indicateurs quantitatifs et chronologiques, qui mettent en évidence l'intensité et la dynamique du peuplement ; et des indicateurs qualitatifs qui rendent compte de la typologie hiérarchique de l'habitat. La combinaison de ces indicateurs et leur spatialisation permettent d'appréhender la structure du peuplement et de repérer les espaces occupés plus ou moins intensément, plus ou moins durablement et de manière plus ou moins stable au cours des 16 siècles considérés.

KEY WORDS : Système de peuplement, intensité et stabilité du peuplement, analyse spatiale, Modélisation, France centrale et méridionale, Age du fer et Antiquité.

Introduction

In the framework of the ACI Archaeodyn, Workgroup 2, "Settlement patterns and territories", aims at apprehending the intensity, stability and the modalities of the occupation of rural areas over the long term, using indices related to settlements. The study is diachronic – from 800 BC to 800 AD - and interregional since 11 study areas, located in Southern and Central France and in Slovenia (Dolenjska) are concerned (fig. 1). Based on the data collected by field walking surveys in the framework of different research programmes or academic work, we aimed at pinpointing the following in the 11 micro-regions and for the 16 centuries under consideration:

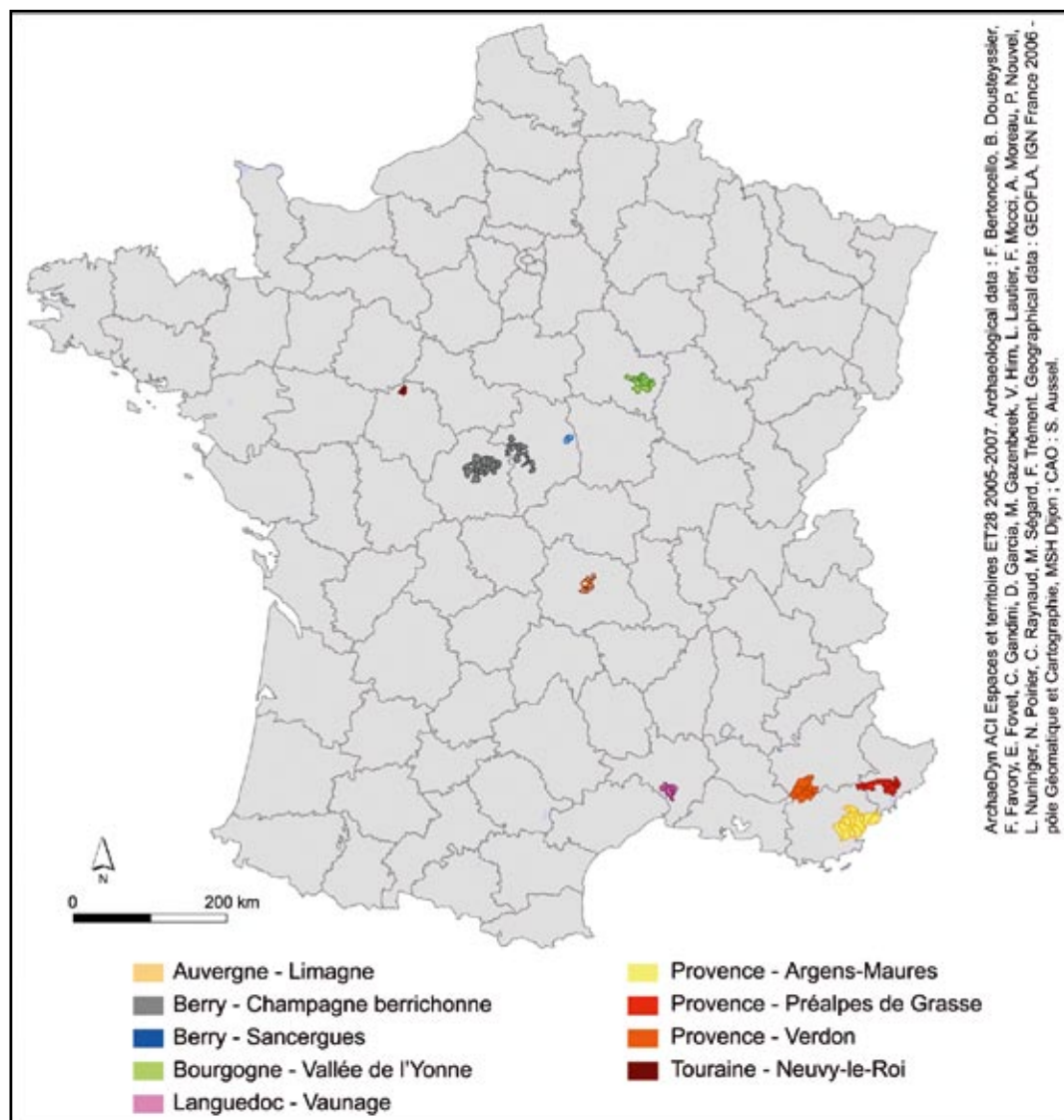
- What are the settlement dynamics and patterns?
- Which are the occupied and the abandoned areas?

- What are the relations between the hierarchy of the settlements, the intensity and the stability of the occupied areas?

This consisted of creating synthetic indices of settlement based on existing data, thereby making it possible to confront interregional situations with common methodological and conceptual bases. From the basis of the methodological achievements of the European Archaeomedes programme² (Favory *et al.*, 1999; Van der Leeuw *et al.*, 2003), we further developed the spatial approach of settlement dynamics. The principal innovation consists of changing the object of study: we went from analysing the settlements and the system of the settlement (hierarchized, structured) to studying the space occupied by the settlements, which represents a particularly appropriate perspective to our comparative, diachronic and interregional approach. This also opens a field of cooperation with other approaches

2. Programmes of the DGXII of the Commission of the European Communities Archaeomedes I "Understanding the natural and anthropogenic causes of soil degradation and desertification in the Mediterranean basin", Archaeomedes II "Policy-relevant models of the natural and anthropogenic dynamics of degradation and desertification and their spatio-temporal manifestations".

Figure 1 Location of the areas studied in France (CAM: S. Aussel)



to land use (such as those developed by Workgroup 1 of the Archæodyn programme on the areas of manured land). Finally, it must be pointed out that the geographical extent of the study was considerably enlarged in relation to the Archaeomedes programme which was centred on Southern France. On the basis of a shared analytical protocol, this expansion enables an unprecedented comparison of the settlement patterns and dynamics between the Southeast and the Centre of France. This comparison is extended to a micro-region of Slovenia solely for the Iron Age. However, due to the type of data, the comparison could only be made possible with a single French micro-region, and we will not develop this case here (Lautier, Tecco-Hvala in Bertoncello, Trément dir., 2007).

I. Ways for a comparative approach

1. Redefining the datasets

The variety of the areas taken into account in the study leads to an unavoidable heterogeneity of the data which is mainly due to three factors:

- the geographical diversity of the regions studied;
- the important variability of the spatial scales concerned: if some study areas correspond to a few communes (50 km²), most of them are situated on a micro-regional scale (between 100 and 500 km²), while one case concerns a regional scale (about 18000 km²);
- the diversity of the procedures used to collect data, not only between the areas surveyed in a systematic or partial manner, but also in function of the differences in the systematic surveying and collection methods.

In order to reduce this heterogeneity and to be able to compare the information, the areas which offer optimal resolution and data quality were chosen, thus sometimes reducing the size of the study areas initially planned.

In order to guarantee a certain homogeneity of the chronological resolution and the formal characteristics of the settlements (particularly for the building materials), the study was refocused on the period between 800 BC and 800 AD: this is the minimal chronological interval documented in all of the study areas, thus enabling the elaboration of a common typology of the settlement.

From a qualitative point of view, only the settlement remains were taken into account. Burial sites were not directly included in the analysis because they follow a different logic of occupying space and a particular temporal resolution (generally longer). In addition, the problem of the availability of this type of information in all of the regions under consideration and its spatial continuity arose.

Settlement is considered here in a broad sense, such as it is defined in geography by R. Brunet: "The settlement ("l'habitat") is the grouping and the layout of dwellings in a given space; it can include annexes for animals and reserves, as well as workshops and other constructions for professional use. [...] The rural settlement ("l'habitat rural") [corresponds] to anything built in the country" (Brunet *et al.*, 1992: 229). However, a precise distinction was made between the notions of "site" and "settlement":

- The site corresponds to a localized and delimited concentration of archaeological remains sufficiently characterized to be dated. The site is then understood as a geographical and archaeological reference, in other words, a basic entity which can be located by survey in addition to the indices of sites or manuring (off-site remains).
- The term settlement refers more precisely to human occupation. A settlement is a place where man settles (without a structural or functional connotation) at a given moment, in a more or less durable manner and without breaks. A settlement can then correspond to a site or part of a site: several human occupations (= several settlements) could have followed in the same point of space (= on the same site).

Since the workgroup "Settlement patterns and territories" aims at studying the intensity and the stability of the occupation of spaces over the long term, the settlements and not the sites have thus been retained in the analyses: quantitative curves of settlement patterns, hierarchical organization and spatial distribution of the settlement.

Finally, the dataset which was originally envisaged was reduced by half, from 4213 to 2127 settlements. It must be noted that the contribution of the different study areas to the dataset is unequal, from 25% to less than 1% of the dataset according to the areas.

2. Evaluating the reliability of the data

A common protocol for evaluating the representativeness of the data was defined collectively in order to interpret the results of the spatial analysis. It consists of defining the levels of reliability in function of the degree of investigation and the survey conditions in each study area (table 1).

The definition of the study area, which varies according to the criteria adopted by each team, was homogenized for the analysis. It was delimited in each zone by cumulating the buffers calculated around each settlement. Several radii were tested for the buffers: a radius of 3000 m was chosen which makes it possible to best define the distribution of the settlements while minimising the residual interstices within the cumulated buffers.

However, superimposing the map of reliability and the study area would show the possible inclusion of extensive non-reliable areas (level 3) within the study area, or more exceptionally, the exclusion of very reliable areas which lack data. In order to minimize this problem, buffers were also calculated around sectors of reliability 1 and 2 (reliable and fairly reliable) exclusively. The intersection of this space and the study area then constitutes the so-called area of reference used for the spatial analysis.

Finally, as for each thematic workgroup, the "confidence map" represents the result of this process of data evaluation, which is crucial for assessing the validity of the interpretations proposed at the end of the spatial analysis. The confidence map not only locates the areas presenting a concentration or, on the contrary, a lack of settlements, but also allows us to evaluate the extent to which these over- or under-representations can be linked to the investigative conditions (Ostir *et al.*, forthcoming; Saligny *et al.*, this volume).

II. The indices of settlement intensity, stability and patterns

Two types of indices were used to apprehend the settlement intensity, stability and organization over the long term:

- quantitative indices which show the settlement intensity and dynamics (number of settlements and total surface occupied per century, number of created, abandoned and reoccupied settlements);
- qualitative indices (hierarchical typology of the settlements) which inform the organization of settlement patterns.

The combination of these indices and their spatialization makes it possible to locate the areas which were more or less intensely occupied, in a more or less durable and stable manner during the 16 centuries under consideration. Taking the hierarchical level of the settlements into account also allows us to apprehend the modalities of the settlement patterns in each area.

1. The quantitative indices

The distribution of the number of settlements occupied per century gives a first indication of settlement intensity and its evolution on the long term (fig. 2). Three important phases can be identified: 1) the first one, which took place between the 8th c and the 3rd c BC, is globally characterized by a low proportion of occupations (less than 5% of the occupations studied between the 8th c BC and the 8th c AD); 2) the number of occupied settlements increases strongly (except in Touraine - Tr) between the 2nd c BC and the 2nd c AD, and generally reaches a peak in the 1st c AD. Although this is an absolute maximum in almost all of the cases, the rhythm of this phenomenon is variable; 3) an important decrease in the number of occupations takes place between the 2nd-4th c and the 8th c AD, except in Touraine (Tr), according to different rhythms and modalities from one region to another.

Table 1

Level 1 (reliable)	Level 2 (fairly reliable)	Level 3 (not reliable)
1) areas where systematic field walking with spacing of 10 m maximum has been completed, and 2) where there are optimal visibility conditions (ploughing or vineyard or lavender).	1) areas where systematic field walking with spacing of more than 10 m has been completed, or 2) where systematic field walking has been carried out but there is only partial visibility of the ground (wildland, fallow, meadow, woods)	1) areas where only partial or no field walking has been performed and/or 2) there is very poor visibility due to land use and/or 3) areas where significant taphonomic problems are assumed (sedimentary covering or erosion).

The curves of the cumulated surface of the settlements³ globally contribute to restore the balance between the different periods, particularly to the benefit of the second Iron Age, late Antiquity and the Early Middle Ages. A more or less regular increase of occupied area is observed from the 6th c BC in Languedoc (Lg), Verdon (Vd) and Argens (Ar), and from the 3rd c in Limagne (Lm) and the Pre-Alps (Pg). The occupied area in most of the other regions tends to increase in the 2nd c BC and particularly in the 1st c BC, to peak in the 1st c AD. The peak observed almost everywhere in the 1st c BC has a very variable duration according to the regions: limited to the 1st c AD in Languedoc and the Pre-Alps; it continues in the 2nd c in Argens, Verdon, Berry (Br), and up to the 3rd c in Burgundy (Bg) and Limagne.

The analysis of the frequency of creations, abandonments and reoccupations per century shows the underlying process of this settlement dynamic. The period included between the 2nd c BC and the 1st c AD is characterized by a strong activity of creation. The asynchrony of this phenomenon must be pointed out. It begins in the 2nd c BC in most of the regions (Burgundy, Berry, Argens, Languedoc, the Pre-Alps, Verdon), and even in the 3rd c in Limagne. While it increases in the 1st c BC in Burgundy, Berry, Argens and Languedoc, it is temporarily interrupted in Limagne, the Pre-Alps and Verdon. In several regions (Limagne, Languedoc, Argens, Verdon), the 1st c AD corresponds to the most abundant phase of creations and reoccupations. It is interesting to note that this period of growth is marked in some regions by high settlement instability, which is expressed by simultaneous creations and abandonments: this is true of Limagne in the 2nd c BC and particularly of Languedoc in the 1st c BC.

The following period (2nd-8th c AD) shows a relatively low rate of creations (with the exception of Touraine). On the contrary, the abandonments of settlements are relatively numerous from the 2nd c and until the end of the period. The very strong asynchrony of this phenomenon of abandonment, which is long-lasting and appears complex, must be pointed out. These regional discrepancies contradict the hypothesis of a "general crisis" in the countryside during the Late Empire. Now and then, signs of renewal are even observed in places, in the form of late creations (in Languedoc in the 4th c and in Argens in the 5th c) or reoccupations (in Languedoc, the Pre-Alps in the 4th c; in Limagne, Argens and Verdon in the 5th c; in Touraine in the 6th c and in Berry in the 6th-7th c). The low chronological correlation

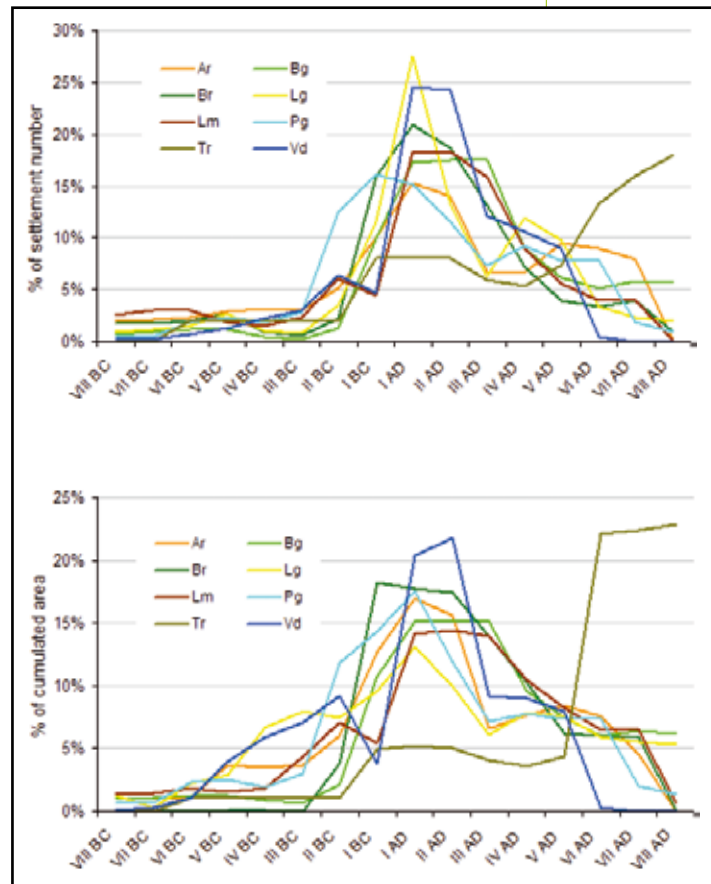


Figure 2
Quantitative evolution of the settlement in 8 French study areas. Two areas (Berry-Sancerques and Touraine-Tavant, the Île Bouchard, Crouzilles) were not taken into account in the quantitative analysis by century because they were not statistically representative.

between these phenomena of creations/reoccupations and abandonments suggests a certain settlement stability in a system which is most likely undergoing change.

The modalities of development vary over time depending on the regions and express particular regional dynamics which do not necessarily refer to a simple opposition between the Transalpine Gaul and the Three Gauls. Nevertheless, it is possible to propose two "models" of development for the Roman period (fig. 3):

- a model represented by Languedoc and Argens and, to a lesser extent Verdon and the Pre-Alps (mode A), characterized by a relatively short period of optimal development in the Early Empire (1 to 2 centuries), followed by an early but rather limited decline in the 3rd c AD, and a pronounced but unsynchronised renewal in the 4th and 5th c;
- a model represented by Burgundy, Berry and Limagne (mode B), characterized by a more durable but unsynchronised period of development (3 centuries), followed by a pronounced and durable decline from the 3rd-4th c AD.

These two models are only provisional working hypotheses which will be more deeply explored.

3. The surface of all the occupied settlements is cumulated for each century. This index expresses more accurately the intensity of human pressure over each region.

2. The hierarchical indices

In order to compare the settlement organization in the different regions and over the 16 centuries considered, a common hierarchical typology of the settlement was realized. The descriptive grid used includes five variables: the surface of the settlements, building materials, duration of the settlement's occupation, former occupation of the site, and settlement's function. These variables have proved to be the most relevant for characterising rural settlement over the twenty years' experience acquired in Southern France, particularly in the context of the Archaeomedes programme (Fiches *et al.*, 1987; Favory *et al.*, 1987-1988; Favory *et al.*, 1994; Durand-Dastès *et al.*, 1998; Bertonecello, 1999; Bertonecello, 2002; Nuninger, 2002; Van der Leeuw *et al.*, 2003; Bertonecello and

Gandini, 2005). The descriptive grid has also been adapted to the specificities of the regional databases and the set of problems addressed by Workgroup 2 (Gandini and Bertonecello, forthcoming).

The hierarchical typology was realized on 1278 settlements from 10 study areas in France, occupied between the 8th c BC and the 8th c AD. Seven classes of settlements were defined using an automatic classification based on Factor Analysis (AFC) and Agglomerative Hierarchical Clustering (CAH – Ward's method) (Saligny *et al.*, this volume; Gandini and Bertonecello, forthcoming) (fig. 4). By hierarchy, we mean the sorting of the settlements according to a degree of importance based on the level and the range of their forms and functions (Durand-Dastès *et al.*, 1998). There is no intention to estimate the social and legal status of a settlement. The aim of this classification is to provide a scale of reference for approaching the spatial organization of the settlement pattern.

The analysis of the classes reveals a clear hierarchy of the settlements which are sorted from the smallest and short-lived (class 1) to the biggest ones, with more comfortable and sustainable occupations (class 6). The interpretation of class 7 is more difficult because it regroups atypical settlements whose profiles do not fit the logic of the classification. It includes, for example, large but short lived settlements, or settlements

Figure 3 The two models of settlement development

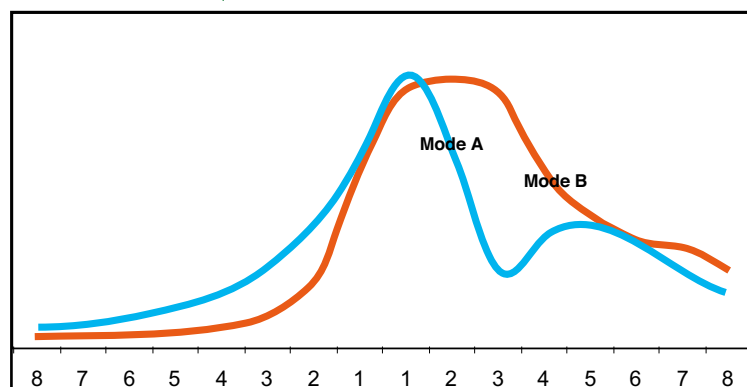


Figure 4 The hierarchical typology of the settlements

Classes	Frequency	Surface	Duration of occupation	Building materials	Former occupation	Function	Interpretation
1	15%	< 0.1 ha	< 1 century	stones and tiles	none	agricultural or without a known function	agricultural buildings, small farms or small hamlets
2	22%	< 0.1 ha or 0.1 to 0.3 ha	< 1 century or 2 centuries maximum	tiles and/or stones or perishable materials or absence of materials	none	agricultural or without a known function	
3	24%	0.1 to 0.5 ha	1 to 3 centuries	tiles	none	agricultural or without a known function	farms or hamlets
4	12%	0.5 to 1 ha or even 1 to 2 ha	3 to 4 centuries or 2 to 3 centuries	stones and tiles + for some hypocaust bricks, tubuli, painted coatings	none	agricultural or without a known function	large farms or villages
5	14%	1 to 2 ha or even 0.5 to 1 ha	5 to 10 centuries	ordinary (stones and/or tiles) or more elaborate (mosaic, marble, sculpted elements and/or hypocaust bricks, tubuli, painted coatings)	none or ancient former occupation (earlier than 2 centuries before)	agricultural or without a known function	villae or villages/ oppida
6	3%	2 to 5 ha or even > 5 ha	> 5 centuries, or even > 15 centuries	mosaic, marble, sculpted elements	none or ancient former occupation (earlier than 2 centuries before)	political and/or religious and/or symbolic function	agglomerations, large oppida
7	8%	2 to 5 ha	< 1 century or 2 centuries maximum	varied (from perishable materials to mosaic, marble, sculpted elements)	none	varied: mainly agricultural function or without a known function, but 31% with a political and/or religious and/or symbolic function + most of the settlements with specialized craft activity are in this class	atypical settlements

with elaborate architecture but of small size and short duration. Although they are atypical according to the logic of the classification⁴, these settlements correspond to a reality in the settlement typology and can easily be reintegrated in the interpretation on a micro-regional scale.

It must be noted that the same class can group various types of settlements, as for example dispersed and grouped ones, according to the regional features of the settlement pattern. This classification is thus able to give a hierarchical system of reference of the settlement common to the 10 study areas, independently of regional specificities, while respecting the hierarchical progression of each micro-regional corpus.

3. The indices of settlement intensity and stability

3.1. Modelling the spatio-temporal dynamics: mean center analysis

The spatial dynamics of the settlement can be modelled over the long term by using two indices of spatial statistics: the mean center and the standard deviation ellipse (Pumain and Saint-Julien, 1997, p. 53-56; Zaninetti, 2005, p. 43-61; Gandini, 2008; Saligny *et al.*, this volume). The displacements of the mean center give the first synthetic index of the settlement spreading in a given area, which take into account the hierarchical status of

each settlement. The standard deviation ellipse makes it possible to apprehend the phases of expansion or withdrawal of the occupation.

The example presented here concerns the study areas of Eastern Languedoc and Limagne (Auvergne). The mean center and the standard deviation ellipse were calculated in each study area for the settlements occupied between the 5th c BC and the 7th c AD⁵ and weighted by their hierarchical level (fig. 5).

The variations in localization of the mean center within the two study areas show quite different evolutions. Generally, for the entire period, the mean center of Limagne records more important changes of localization from one period to another compared to Vaunage (more than 1000 metres against 800 metres on the average). The rate of variation of the mean center per period (fig. 5) corresponds to the value of variation (distance in metres) recorded for each transition (from one period to another) related to the total sum of the variations (i.e. the cumulated distances in metres). On the long term, the comparisons are made on the profile of each region rather than the value of the localization variations. Limagne appears much more instable than Languedoc from this point of view. Effectively, if the Languedoc study area has an important phase of mobility between the 5th and 1st c BC (the rates vary from 24 to 8%), the evolution of the settlement tends to stabilize later. The values of the histogram

4. That is why the settlements of class 7 were not taken into account in the spatial analyses based on assigning hierarchical weight to each class (cf. infra). They are, however, represented cartographically in order to be able to analyse their spatial and/or chronological relations with the rest of the regional dataset.

5. The 8th, 7th and 6th c BC and the 8th c AD were not taken into account in this calculation due to a statistically insufficient sample of settlements.

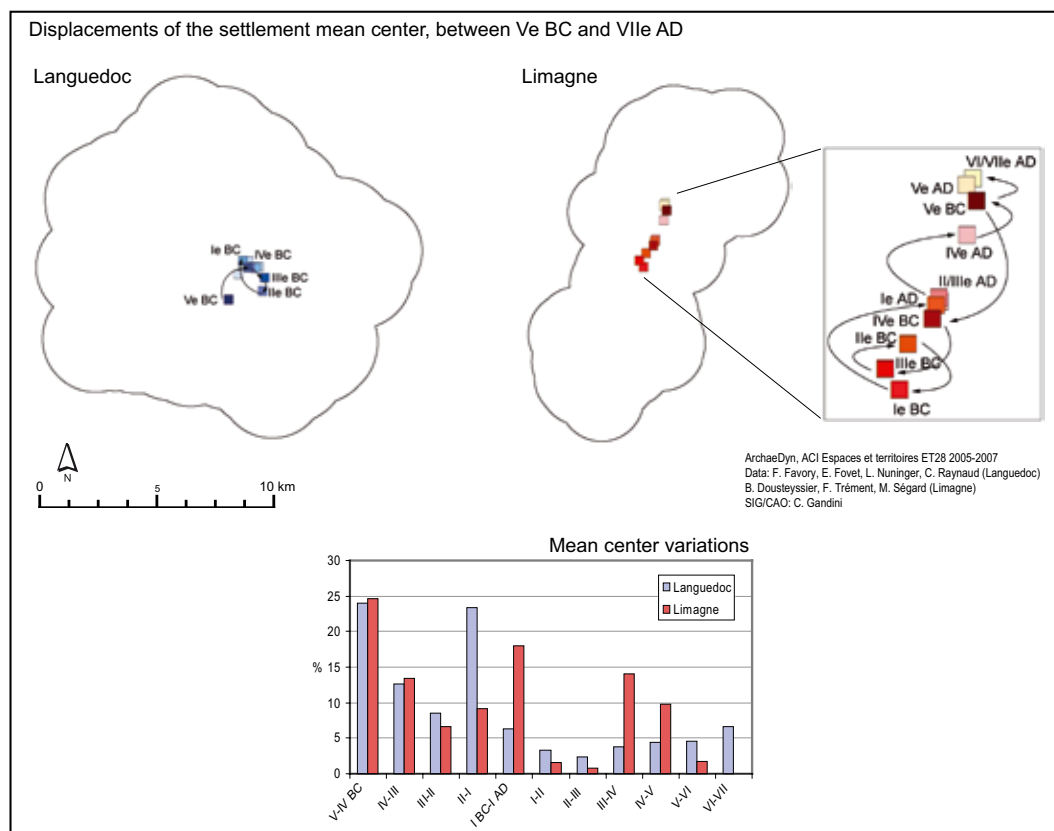


Figure 5 Comparison of the evolution of the localization of the mean center in the Languedoc and Limagne study areas between the 5th c BC and the 8th c AD

for Limagne show phases of great mobility and periods of stabilization; the highest variations take place between the 5th c BC and the 1st c AD (the displacements of the mean center vary between 25 and 6.5%), while the settlement stabilizes between the 1st and the 3rd c AD (rates of variation inferior to 2%). A new phase of instability takes place between the 3rd and the 5th c AD.

The variations in the size of the standard deviation ellipse clarify these first observations (fig. 6). From the 5th to the 3rd c BC in Limagne, the ellipse is very narrow and stretched. It becomes wider in the 2nd c BC, expressing a phase of settlement extension and the possible expansion of land use, which must be linked to the increasing number of settlements' creations in the 2nd c BC. This level is maintained until the end of the period under consideration (consolidation), even if the ellipse tends to contract slightly at the end of Antiquity, in relation to a drop in the number of occupied settlements (*cf.* fig. 2). From the 5th c BC to the 1st c BC in Languedoc, the deviation ellipse alternates between important phases of contraction and expansion. After a phase of withdrawal between the 3rd and the 2nd c BC, the settlement shows a strong extension between the 2nd and the 1st c BC (the ellipse increases by 26%). This extension then tends to stabilize: the size and the direction of the

deviation ellipse show little changes and the mean center only moves slightly.

This analysis shows that, over the 12 centuries considered, the Languedoc study area is characterized by a relatively stable and homogeneous settlement pattern compared to Limagne whose global evolution seems less linear.

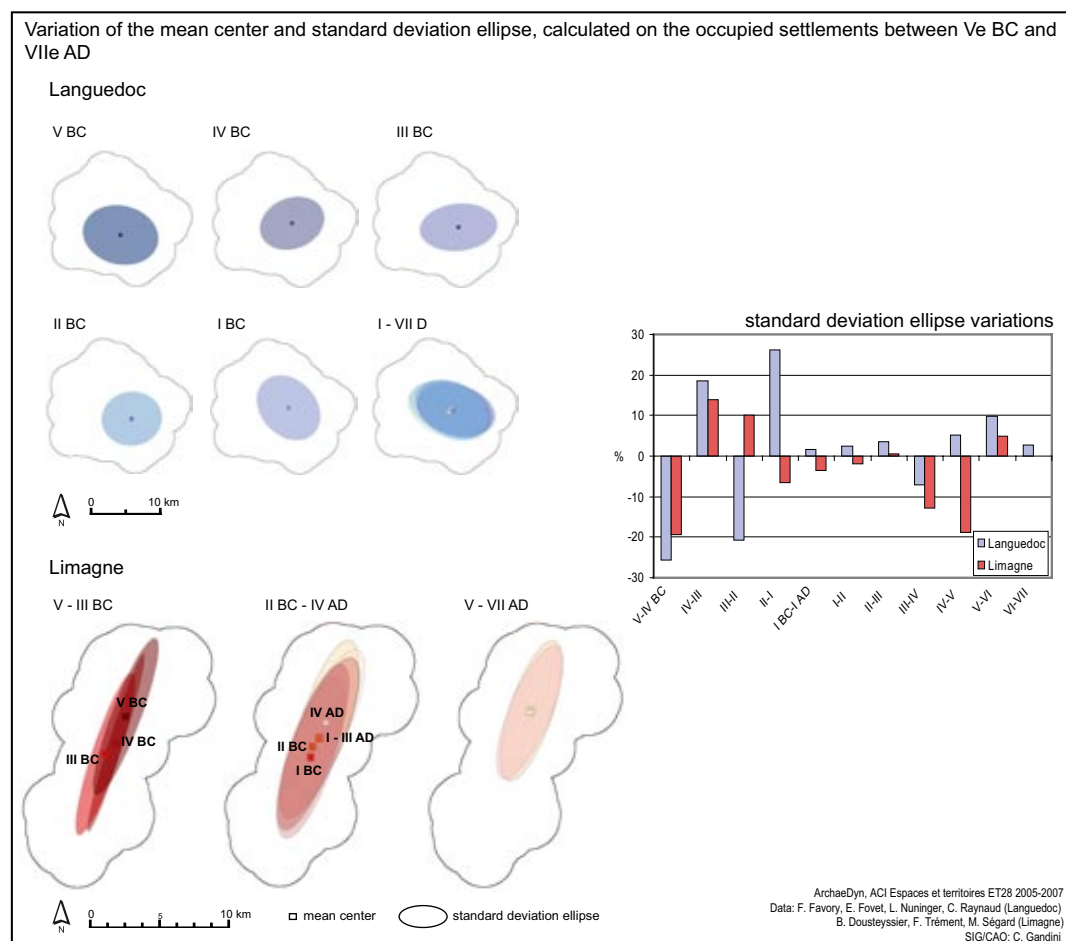
The results remain to be interpreted by combining them with the results of the other analyses presented, but this example already shows the utility of these two basic indices of spatial statistics for apprehending the spatio-temporal dynamics of settlement patterns and for making synthetic regional comparisons.

3.2. The indices of stability: the maps of density change

Maps of the settlement density cumulated over the 16 centuries under consideration (from 800 BC to 800 AD) and by periods of 4 centuries have been made for each study area using the kernel method (Saligny *et al.*, this volume). They reveal the most intensely occupied areas at different periods, the most attractive areas during phases of settlements creation or those most affected by abandonments.

These periodical maps were used to calculate maps of "density change" which express the change that took place between two states,

Figure 6 Evolution of the standard deviation ellipse in the Languedoc and Limagne study areas between the 5th c BC and the 7th c AD

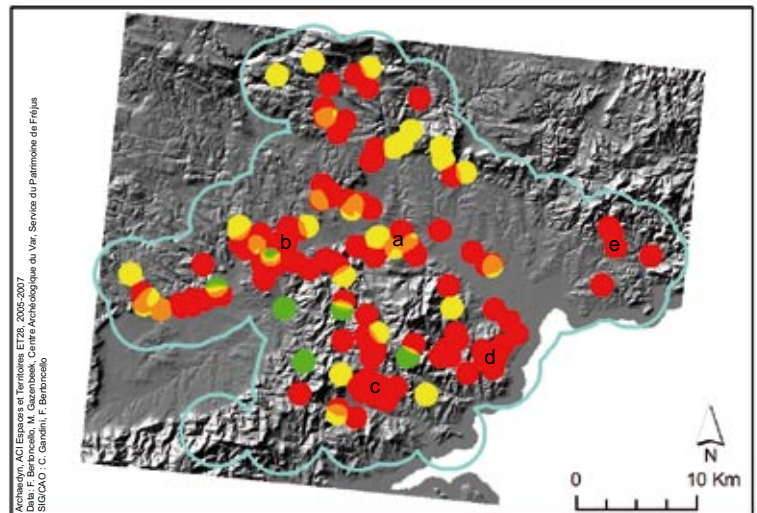


thereby making it possible to visualize the dynamics between two sequences rather than the periodical sequences themselves. The method of the “normalized ratio” was used to calculate the difference between two maps (Béguin and Pumain, 2003; Saligny *et al.*, this volume).

The study area of Argens (Provence) serves as an illustration. Figure 7 presents the difference between the density map of the settlements occupied between the 8th and the 5th BC (period 1) and the density maps of the settlements occupied between the 4th and the 1st c BC (period 2).

The preponderance of the sectors shown in red expresses the extent of the phenomenon of settlement creations which occurs at the end of period 2 from the 2nd to the 1st c BC (*cf.* II.1. above). These creations increase the settlement density of some areas already occupied during the first Iron Age, as, for example, on the Rocher of Roquebrune-sur-Argens (fig. 8, zone a). The relative stability of some areas must be nuanced by taking into account the chronological imprecision of some settlements which can not be precisely dated within the Iron Age and are thus counted in both period 1 and period 2. This densification of already occupied areas remains, however, relatively weak compared to the creations of the 2nd and 1st c BC which mainly settle in unoccupied spaces during the first Iron Age: mainly in the plains and basins (fig. 7, zones b and c), but also in the reliefs of the Petits Maures or the Estérel (fig. 7, zones d and e). Finally, a few green spots appear which correspond to the *oppida* whose occupation does not exceed the 6th or the 5th c BC. The second Iron Age and the 2nd and the 1st c BC in particular, thus appear as a particularly dynamic period, characterized by an intensification of the settlement and the conquest of new areas.

This process continues in the 1st c AD (fig. 8) with the creations of settlements which now clearly reinforce the stable areas of occupation from the 2nd – 1st c BC (in yellow). The only newly invested areas are found to the east of the region, around the Roman colony of *Forum Iulii* (Fréjus). However, we must be wary of over-interpreting this phenomenon because of the uncertainties associated with the dating of numerous settlements in this sector: occupied during the Roman era, they were counted in period 3 (1st – 4th c AD) and 4 (5th – 8th c AD), but we cannot insure that they were not created earlier nor that they were continuously occupied until the end of Antiquity. While the occupation extends in the plains, the settlement nuclei organized around the *oppida* during the Iron Age are abandoned in the early Empire (in green), as



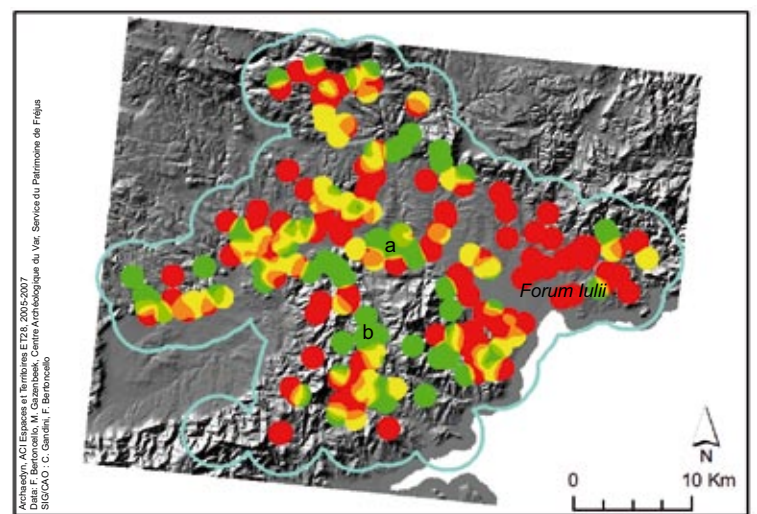
Density change



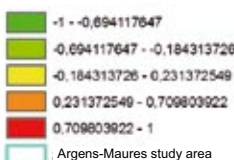
Geographical informations:
 a: Rocher of Roquebrune-sur-Argens
 b: Permian depression
 c: Plan-de-la-Tour basin
 d: Petits Maures Massif
 e: Estérel Massif

Figure 7 Map of the change in occupation density between period 1 (8th - 5th c BC) and period 2 (4th - 1st c BC) in the Argens study area. The yellow areas show stability of occupation, the red an increase in the settlement density and the green a decrease

The measure of the surface covered by each ellipse and the observation of the variations in its size from one phase to another can be interpreted as an index of the extension or of the contraction of the occupied areas. The more the ellipse is big and distended, the more the spatial and quantitative variability of the settlement pattern is important; on the contrary, a small ellipse contracted around the mean center evidences the settlements concentration



Density change



Geographical informations:
 a: Rocher of Roquebrune-sur-Argens
 b: Maures Massif

Figure 8 Map of the change in occupation density between period 2 (4th - 1st c BC) and period 3 (1st - 4th c AD) in the Argens study area. The yellow areas show stability of occupation, the red an increase in the settlement density and the green a decrease

in the Massif des Maures or on the Rocher of Roquebrune-sur-Argens (fig. 8, zones a and b). The two or three centuries around the change of the era (2nd-1st c BC – 1st c AD) then really correspond to a period of mutation in the settlement patterns, characterized by a maximal land occupation, particularly in the plains, while the protohistoric settlement system more centred on the massifs declines.

Figure 9 Map of the change in occupation density between period 3 (1st - 4th c AD) and period 4 (5th-8th c AD) in the Argens study area. The yellow areas show stability of occupation, the red an increase in the settlement density and the green a decrease.

Figure 10 Different combinations of the indices of hierarchical variety and range which show different levels of hierarchical organization of the settlement patterns

The occupation thus reaches its maximal intensity during the early Empire, not only in terms of density, but also of spatial extension of the settlement. Moreover, it must be noted that the increase in the number of creations observed between the 2nd c BC and the 1st c AD (cf. II.1. above) expresses very different modes of spatial organization: the settlements of the 2nd and the 1st c BC tend to be pioneers which settle in areas to be developed, while those of the 1st c AD are essentially “opportunist” settlements densifying the occupation of already exploited areas that they will continue to develop.

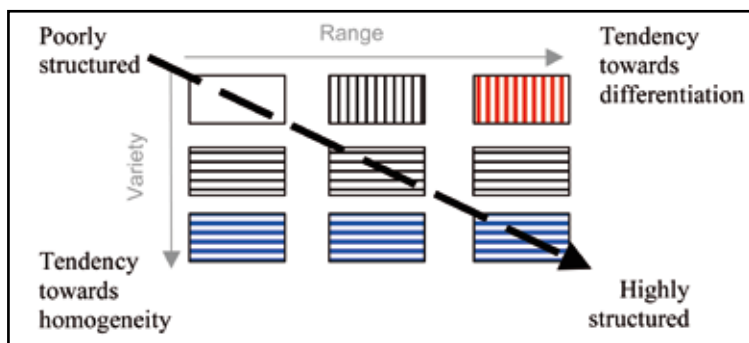
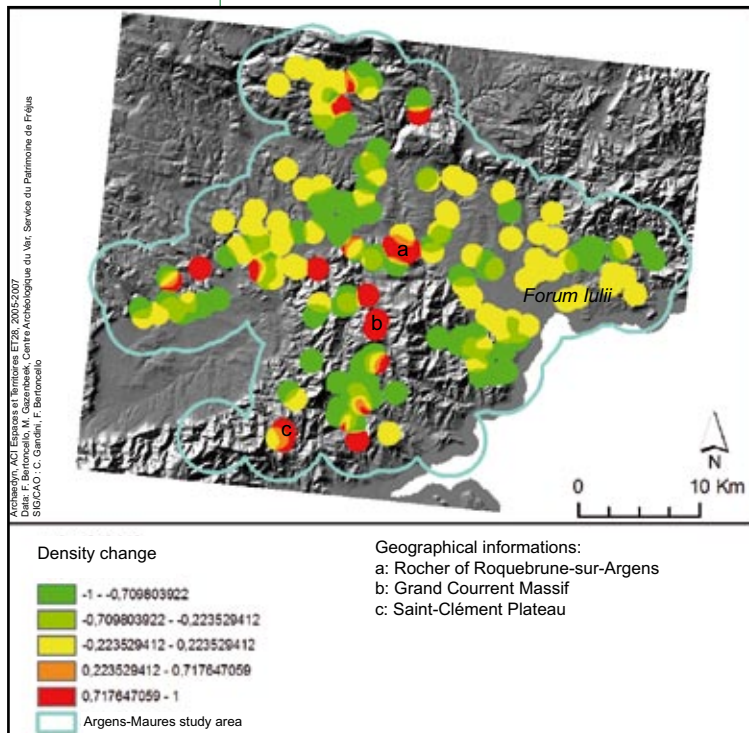
At first glance, the map of density change between period 3 (1st - 4th c AD) and 4 (5th-8th c AD) shows an important stability in the settlement pattern (fig. 9). If this stability is a reality which reflects the continuous occupation of a certain number of settlements throughout Antiquity, its extent must be nuanced by taking into account the chronological uncertainties already mentioned for this region concerning the settlements dated to the Roman period without more precision (Bertoncello, 1999;

Bertoncello and Nuninger, forthcoming). The map mainly shows the extent of the areas abandoned between the two periods, following the massive phenomenon of settlements abandoning which occurred in the region in the 2nd c AD (cf. fig. 2). This results in a more scattered settlement pattern, contracted around durable settlements mostly of high hierarchical level (class 5, cf. II.2. above). The few red spots which appear on the map show the emerging, particularly from the 5th c, of a more dynamic process of (re)investment of certain areas unoccupied in the early Empire. Whether it concerns fortified grouped settlements (of class 6 or 7, cf. II.2. above) or dispersed settlements interpreted as farms (classes 2 or 3), these settlements have in common the reinvestment of relief areas abandoned since the end of the Iron Age (fig. 9, zones a, b, c). One should maybe see here the beginnings of a second important mutation in the settlement pattern which, after other transformations, will lead to the mediaeval settlement system.

4. The indices of the level of hierarchical organization

The density maps were weighted with the hierarchical level of the settlements as it was defined from the results of the CAH (cf. II.2. above). These maps of “hierarchical density” nuance the intensity of the occupation according to the hierarchical level of the settlements (with the exception of class 7, cf. II.2. above): thus the density of spaces occupied by settlements with a high hierarchical level (for example, classes 5 and 6) is increased in relation to spaces occupied by settlements with a low hierarchical level (for example, classes 1 and 2).

In addition to the maps of “hierarchical density”, another type of analysis also using the results of the typology, shows the degree of structuring of the settlement patterns. It consists in identifying the level of “hierarchical organization” of the settlement pattern within each aggregate of settlements defined according to the basic density map. The observation scale is that of the aggregates and it is based on the very distribution of the settlements in the study areas. The level of “hierarchical organization” is estimated by combining two indices: 1) the hierarchical variety (or degree of diversification depending on the number of different classes represented) and 2) its range (or level of differentiation which expresses the homogeneity of the documented classes). A low range - i.e. a high homogeneity - thus indicates the association of settlements



belonging to classes hierarchically close (ex. classes 1 and 2, or classes 5 and 6). On the contrary, the association of settlements belonging to very distant classes (ex. classes 1 and 6) will show a high range or, in other words, a strong differentiation. The index of range is obtained by calculating the standard deviation between the classes under consideration (coded from 1 to 6). This synthetic analysis, carried out on periods of 4 centuries, makes it possible to differentiate areas according to the general tendencies of the settlement organization (fig. 10): low level of organization (little diversified and differentiated), average and high level of organization (diversified and showing a large spectrum of types of settlements).

This method was tested on the study area of Eastern Languedoc. Between the 8th and the 5th c BC, the settlement density is low with scattered settlements. The analysis shows that the settlement pattern globally presents a low level of hierarchical organization and is very homogeneous (poorly diversified settlements and of similar hierarchical level). The comparison with the “hierarchical density” map of this period (fig. 11) shows that the lowest level of organization corresponds largely to the sectors occupied by small ephemeral settlements (sporadic occupations). Two settlements of similar type and high hierarchical level are occupied in this period: one is isolated (along the river Vidourle), while the other (in Vaunage) is associated with several small ephemeral settlements, thus presenting a slightly higher level of organization with a clear tendency towards differentiation.

The occupation gets more dense and the structure of the settlement pattern becomes more complex between the 4th and the 1st c BC, with a larger variety of hierarchical classes (fig. 12). Two areas are more strongly structured. Along the Vidourle River, the expansion of the settlement from the pole identified in the preceding period leads to a strong structuring of the settlement system (very high level of organization). Land use also expands in Vaunage with higher structuring than in the previous period, although it is relatively lower than in the valley of Vidourle. This is due to the numerous settlements with a low hierarchical level which tend to make the settlement’s structure quite homogeneous. On the contrary, although the settlement pattern of the northern and southern areas (at the foot of the Bois des Lens massif), is more dense than in the preceding period, it remains little structured: poorly diversified (few classes) and very homogeneous (classes with a similar hierarchical level).

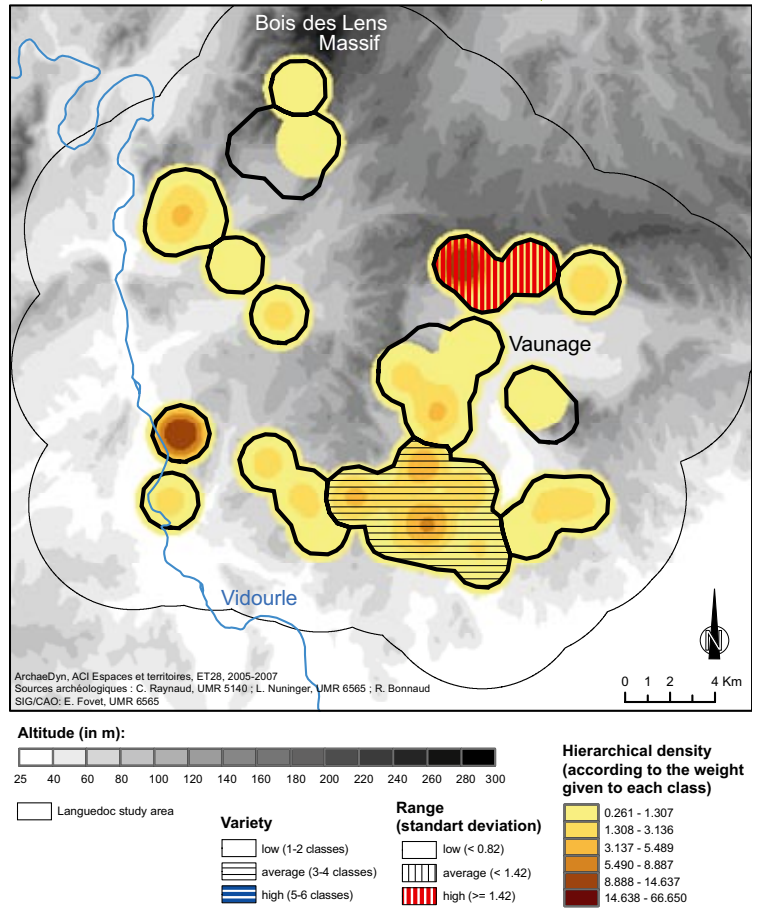


Figure 11 Comparison of the hierarchical level of organization and density in the Languedoc study area between the 8th and th 5th c. BC

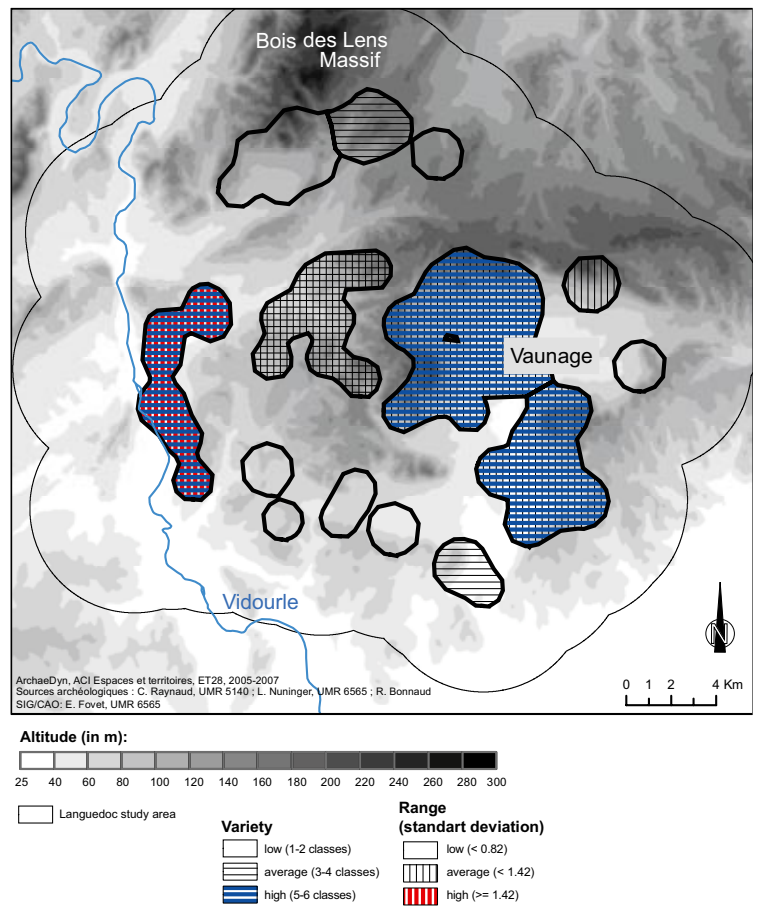


Figure 12 Analysis of the level of hierarchical organization in the Languedoc study area between the 4th and th 1st c. BC

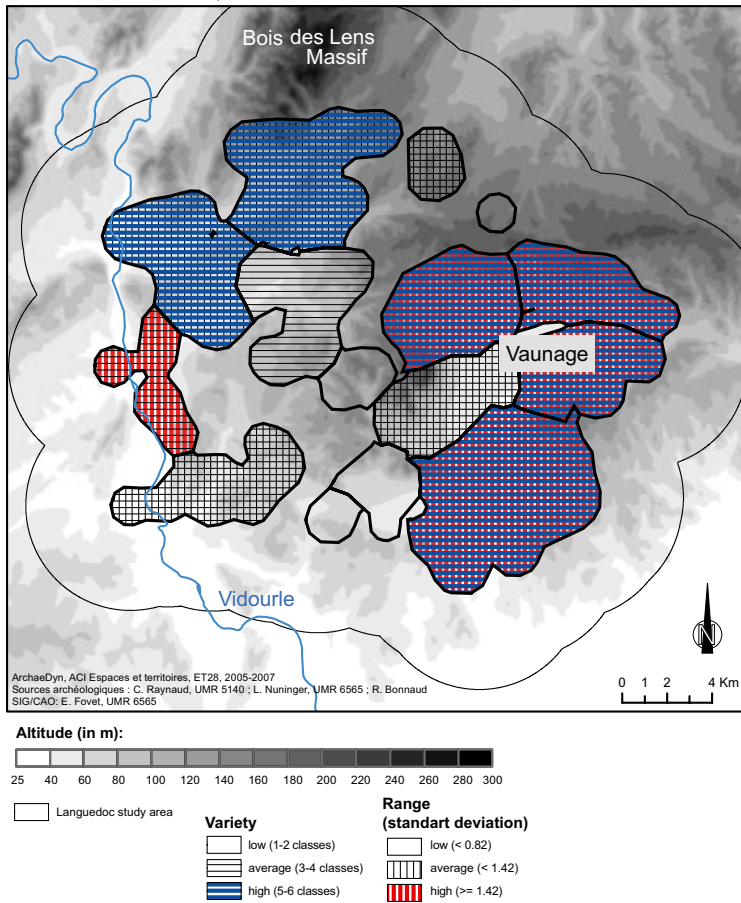


Figure 13 Analysis of the level of hierarchical organization in the Languedoc study area between the 1st and th 4th c. AD

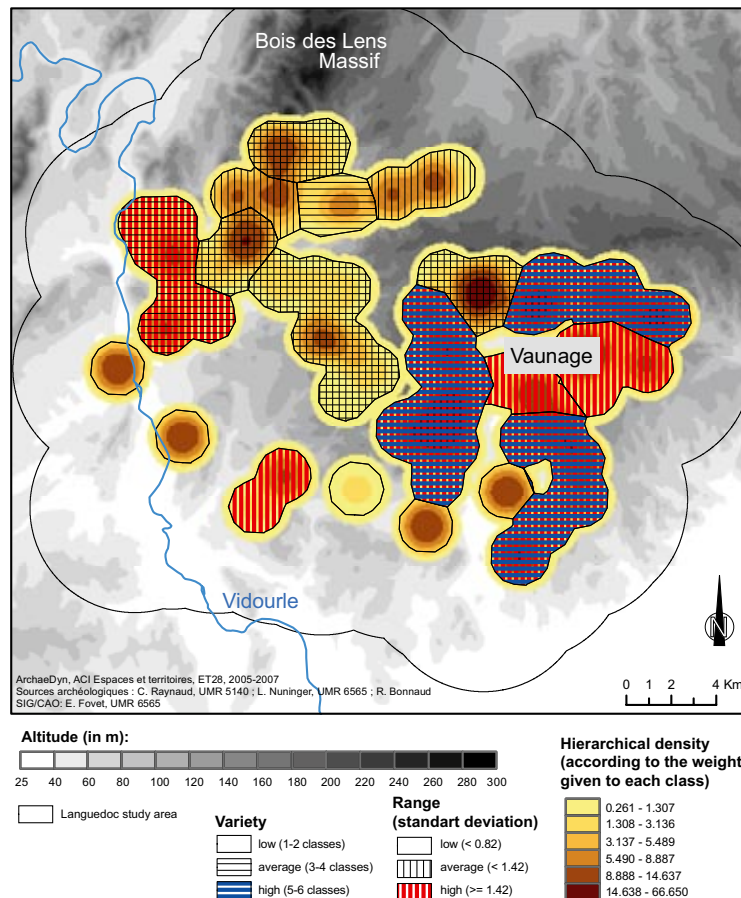


Figure 14 Comparison of the hierarchical level of organization and density in the Languedoc study area between the 5th and th 8th c. AD

The occupation in the following period (1st – 4th c AD) becomes even more dense and the structuring of the settlement system tends to become more complex (fig. 13). The areas at the foot of the Bois des Lens massif expand and become structured to reach the same level of organization as that of Vaunage during the preceding period. The area of Vaunage follows its development equally from the point of view of land use as in terms of hierarchical structuring. The southwestern sectors remain poorly structured, while the central part of the area, along the valley of the Vidourle and between Vaunage and the foot of the Bois des Lens, shows a lower level of organization compared to the preceding period.

The drop in the density of occupation between the 5th and the 8th c AD is expressed by a larger amount of small aggregates of settlements and a clear tendency towards differentiation: fewer classes of settlements are found within the aggregates but their hierarchical level is quite distinct (fig. 14). This simplification of the hierarchy is very clear within the loose conglomeration of settlements which spreads out from the Bois des Lens massif as far as the river Vidourle. While the settlements of Vaunage (particularly those on the foothills) are still organized in a complex mode, the central sector shows a slight increase in the level of hierarchical organization compared to the preceding period.

It is interesting to note that, over the long term - i.e. during the four periods considered - the different geographical areas (foot of the Bois de Lens, valley of Vidourle, Vaunage) do not show the same evolution and develop according to different rhythms. The level of hierarchical organization nuances the simple density of settlement and makes it possible to apprehend the capacity of an area to develop or, on the contrary, to progressively lose its importance. Thus, for example, the settlement in the valley of Vidourle was structured relatively quickly with a high level of organization in the second Iron Age. However, it progressively loses this capacity during the roman period, which prefigures its break-up and the progressive abandoning of this area during late antiquity. On the contrary, the pole identified to the north of Vaunage during the first period progressively structures its sector at the end of the Iron Age and during antiquity. Therefore, even if the power of this pole of protohistoric origin diminished during late antiquity, it contributed to the creation of the neighbouring sectors which became strong during the roman period. Thus, in spite of having been broken up into

three highly structured sectors, the region of Vaunage continued to develop.

This case study shows that some areas have a mode of organization quite specific within the general evolution of settlement patterns, which merit further interpretation. This analytical method is still exploratory, but the first results are very promising for going beyond the simple quantitative estimation of settlement dynamics. It gives a synthetic view of the modalities of settlement pattern and enables interregional comparisons as the analysis concerns the relative hierarchical associations and differences between neighbouring settlements rather than the sole value of the hierarchical classes, some classes being only poorly represented in some regions.

Conclusion and perspectives

The collective work accomplished by the workgroup "Settlement patterns and territories" allowed to develop indices capable of expressing the intensity, stability and organization of the rural settlement. The analyses that were carried out contributed mainly to the apprehension of the settlement spatial dynamics, both in their quantitative dimension (evolution of the occupation density and its underlying processes) and

qualitative dimension (settlements' hierarchy and organization). From an archaeological point of view, emphasize must also be given to the constant concern of the workgroup for synthesis in order to compare study areas which are geographically and culturally very different, by using the same system of reference. This represents an innovation in relation to earlier research programmes. The spatial analyses, tested on certain micro-regions, must now be generalized to all of the study areas. The synthetic indices developed (density values, mean center, standard deviation ellipse, indices of hierarchical variety and range) are the tools which will allow interregional confrontations and the modelling of settlement systems over the long term from a structural and spatial point of view. Such a model will reveal the settlement tendencies common to the 11 study areas, and will allow to identify the "anomalies": regional and/or historical specificities which will have to be explained. Other spatialized, particularly geographic and environmental, datasets will be used in this analytical and interpretative phase. The work done on evaluating the data reliability will be particularly useful at this stage by allowing us to pinpoint the eventual effects of the conditions of data collection on the definition of the regional profiles.

Bibliography

- Béguin and Pumain 2003 : Béguin (M.), Pumain (D.) - La représentation des données géographiques, statistique et cartographie. Paris, A. Colin (coll. cursus), 2003, 192 p.
- Bertoncello 1999 : Bertoncello (F.) - Le peuplement de la basse vallée de l'Argens et de ses marges (Var) de la fin de l'Âge du Fer à la fin de l'Antiquité. Thèse de Doctorat, Université de Provence Aix-Marseille I, 1999, 3 vol.
- Bertoncello 2002 : Bertoncello (F.) - *Villa/vicus* : de la forme de l'habitat aux réseaux de peuplement. In : Garmy (P.), Leveau (Ph.) éd. - Dossier *Villa et vicus* en Gaule Narbonnaise. Revue Archéologique de Narbonnaise, 35, 2002, p.39-58.
- Bertoncello and Gandini 2005 : Bertoncello (F.), Gandini (C.) - Valeur et pertinence des indicateurs hiérarchiques de l'habitat rural : quelques réflexions à partir des établissements berrichons. In : Berger (J.-F.), Bertoncello (F.), Braemer (F.), Davtian (G.), Gazenbeek (M.) - *Temps et Espaces de l'Homme en Société : Analyses et modèles spatiaux en archéologie*. Actes des XXV^e Rencontres Internationales d'Archéologie et d'Histoire d'Antibes, 21 - 23 octobre 2004. Valbonne, Éditions APDCA, p. 237-248.
- Bertoncello and Nuninger forthcoming: Bertoncello (F.), Nuninger (L.), - From Archaeological Sherds to Qualitative Information for Settlement Pattern Studies. In : Nicolucci (F.) (éd.) - *Beyond the artifact : digital interpretation of the past CAA2004, Computer Applications and Quantitative Methods in Archaeology*, 13-17 April 2004, Prato (Italy). Budapest, Archaeolingua, forthcoming.
http://hal.archives-ouvertes.fr/view_by_stamp.php?label=UNIV-FCOMTE&action_todo=view&langue=fr&id=halshs-00077361&version=1
- Bertoncello, Trément dir. 2007 : Bertoncello (F.), Fovet (E.), Gandini (C.), Lautier (L.), Nuninger (L.), Tecco-Hvala (S.), Trément (F.) - *Atelier 2 Peuplement et Territoires*. ACI Espaces et Territoires, Contrat ET28, 2005-2007. Rapport final, inédit.
- Brunet *et al.* 1992 : Brunet (R.), Ferras (R.), Théry (H.) - Les mots de la géographie: dictionnaire critique. Paris, GIP RECLUS / La Documentation Française, 1992, 470 p.
- Durand-Dastès *et al.* 1998 : Durand-Dastès (F.), Favory (F.), Fiches (J.-L.), Mathian (H.), Pumain (D.), Raynaud (C.), Sanders (L.), Van der Leeuw (S.) - *Des oppida aux métropoles : Archéologues et géographes en vallée du Rhône*. Paris, Anthropos, 1998, 280 p.
- Favory *et al.* 1987-1988 : Favory (F.), Fiches (J.-L.), Girardot (J.-J.) - L'analyse des données appliquée à la typologie des sites gallo-romains dans le Beaucairois (Gard): matériel de prospection et environnement paysager. Essai méthodologique. *Gallia* 45, 1987-1988, p. 67-85.
- Favory *et al.* 1994 : Favory (F.), Girardot (J.-J.), Raynaud (C.), Roger (K.) - L'habitat gallo-romain autour de l'Étang de l'Or (Hérault) : hiérarchie, dynamique et réseaux du II^e s. av. au V^e s. ap. J.-C. In : Mactoux (M.-M.), Geny (E.), éd. - *Religion, anthropologie et société*. Paris, Annales Littéraires de l'Université de Besançon, 1994, p. 123-215.
- Favory *et al.* 1999 : Favory (F.), Girardot (J.-J.), Nuninger (L.), Tourneux (F.-P.) - Archaeomedes II : une étude de la dynamique de l'habitat rural en France méridionale dans la longue durée (800 av. J.-C. - 1600 ap. J.-C.). *Bulletin de liaison de l'association AGER*, 9, 1999, p. 15-35.
- Fiches *et al.* 1987 : Fiches (J.-L.), Gasco (Y.), Michelozzi (A.) - L'occupation des sols et l'exploitation de l'espace rural. In : Bessac (J.-C.), Christol (M.), Fiches (J.-L.), Gasco (Y.), Janon (M.), Michelozzi (A.), Raynaud (C.), Congès (A.), Terrer (D.), éd. - *Ugernum : Beaucaire et le Beaucairois à l'époque romaine*, I. Caveirac, ARALO, 1987, p. 85-112.
- Gandini 2008 : Gandini (C.) - *Villes et campagnes : une interaction réciproque. L'exemple de la cité des Bituriges Cubi (II^e s. av. J.-C. - VII^e s. ap. J.-C.)*, RTP Modys, Rencontre de doctorants, Avignon, 19-20 déc. 2007.
<http://isa.univ-tours.fr/modys/rencontre.php?year=2007>
- Gandini and Bertoncello forthcoming: Gandini (C.), Bertoncello (F.) - *Hierarchical typology and settlement patterns modeling at inter-regional scale*, CAA 2007, publication en ligne et sur CD (avec la collaboration de Estelle Gauthier, Laure Nuninger, Frédéric Trément).
- Nuninger 2002 : Nuninger (L.) - *Peuplement et territoires protohistoriques du VIII^e au I^{er} s. av. J.-C. en Languedoc oriental (Gard-Hérault)*. Thèse de Doctorat, Université de Franche-Comté, Besançon, 2002. (http://tel.ccsd.cnrs.fr/documents/archives/00/00/29/81/index_fr.html).
- Oštir *et al.* forthcoming: Oštir (K.), Kokalj (Z.), Saligny (L.), Tolle (F.), Nuninger (L.) - *Confidence maps : a tool to evaluate archaeological data's relevance in spatial analysis*. CAA 2007, publication imprimée, en ligne et sur CD (avec la collaboration de Françoise Pennors et Klemen Zaksek).
- Pumain et Saint-Julien 1997 : Pumain (D.), Saint-Julien (T.) - *L'analyse spatiale ; 1. Localisations dans l'espace*. Paris, Armand Colin - Cursus, 1997, 167 p.
- Saligny *et al.* this volume : Saligny (L.), Nuninger (L.), Oštir (K.), Bertoncello (F.), Fovet (E.), Gandini (C.), Gauthier (E.), Kokalj (Z.), Poirier (N.) - *Models for territorial dynamic studies*. Actes du colloque « 7 millennia of territorial dynamics: settlement pattern, production and trades from Neolithic to Middle Ages », Université de Bourgogne, Dijon, 22-25 juin 2008.
- Van der Leeuw *et al.* 2003 : Van der Leeuw (S.), Favory (F.), Fiches (J.-L.) - Archéologie et systèmes socio-environnementaux : études multiscalaires sur la vallée du Rhône dans le programme Archaeomedes. CNRS éd., Paris, 2003, 403 p. (CRA monographies , 1147-5358 ; 27).
- Zaninetti 2005 : Zaninetti (J.-M.) - *Statistique spatiale, méthodes et applications géomatiques*. Paris, Hermès science, 2005, 320 p.