Spatio-temporal dynamics of settlement patterns in Central and Southern Gaul from 800 BC to 800 AD : models for long-term interregional comparison

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

Settlement Patterns, Production and Trades from the Neolithic to the Middle Ages

ARCHAEDYN
Seven Millennia of Territorial Dynamics

Final Conference
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CONTENTS

CHAPTER 3
SPATIO-TEMPORAL DYNAMICS OF SETTLEMENT PATTERNS IN CENTRAL AND SOUTHERN GAUL FROM 800 BC TO 800 AD:
MODELS FOR LONG-TERM INTERREGIONAL COMPARISON

F. Bertoncello, E. Fovet, C. Gandini, F. Trément and L. Nuninger

With the collaboration of the members of Workgroup 2

Abstract: Workgroup 2 on 'settlement patterns and territories' seeks to apprehend the intensity, stability and the forms of long-term (800 BC – 800 AD) occupation of rural space using indices related to settlements. Eleven study areas in central and southern France and in Slovenia are examined. A common protocol was defined to homogenize the data and assess their reliability so interregional comparisons could be made. Quantitative and chronological indices show settlement intensity and dynamics while qualitative indices express the hierarchical typology of settlements. The combination and spatialization of these indices reveals the structure of settlement patterns and allows us to identify the areas that were more or less intensely occupied, in a more or less permanent and stable manner throughout the 16 centuries under consideration.
Key-words: Settlement patterns, settlement intensity and stability, spatial analysis, modelling, Central and Southern France, Iron Age and Antiquity.

As part of ACI Archaedyn project, Workgroup 2, on 'settlement patterns and territories',[1] investigates the intensity, stability and forms of occupation of rural areas over the long term, using settlement-related indices. The study is both diachronic, ranging from 800 BC to 800 AD, and interregional, since 11 study areas in southern and central France and in Slovenia[1] (Dolenjska) are covered (fig. 1).

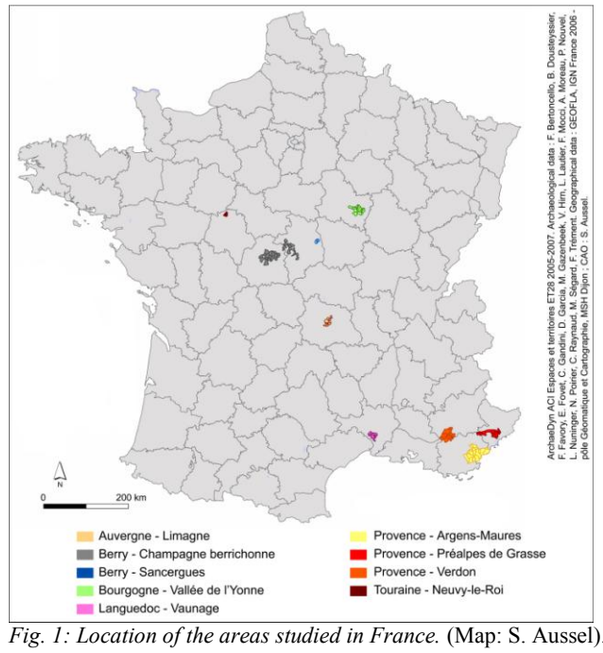

Fig. 1: Location of the areas studied in France. (Map: S. Aussel).

On the basis of data collected by field walking surveys as part of various research programmes or academic work, for the 11 micro-regions and 16 centuries under consideration, we ask:
- What are the settlement dynamics and patterns?
- Which areas are occupied and which abandoned?
- What are the relations between the hierarchy of the settlements, the intensity and the stability of the occupied areas?

This involves creating synthetic settlement indices based on existing data so that interregional situations can be compared on a common methodological and conceptual

[1] The team includes 19 researchers from 8 universities and the CNRS: Auvergne-Limagne: B. Dousteyssier, 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 – Vaunage/Combas: F. Favory, E. Fovet, L. Nuninger (University of Franche-Comté, UMR 6249), C. Raynaud (Lattes, UMR 5140); Provence – Argens-Maure: F. Bertoncello, M. Gazenbeek (Nice, UMR 6130); Provence – Préalpes de Grasse: L. Lautier (Nice, 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 Bouchard et Crousilles: A. Moreau (INRAP, Paris); Slovenia – Doljenska: K. Ostir, S. Tecco-Hvala (ZRC, SAZU, Ljubljana).

basis. Drawing on the methodological achievements of the European Archaeomedes programme[2] (Favory *et al.,* 1999; Van der Leeuw *et al.,* 2003), we further develop the spatial approach to settlement dynamics. The principal innovation consists in changing the subject of study: we move from analysing the settlements and the system of settlement (hierarchized, structured) to studying the space occupied by the settlements, which is a particularly appropriate perspective for our comparative, diachronic and interregional approach. This also opens up a field of cooperation with other approaches to land use (such as those developed by Workgroup 1 of the Archaedyn programme on the areas of manured land). Finally, it must be pointed out that the geographical extent of the study is considerably enlarged compared with 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 and Tecco-Hvala *in* Bertoncello and Trément (eds), 2007).

1. A comparative approach

1.1 Redefining the datasets

The diversity of the areas covered by the study leads to unavoidable heterogeneity of the data, which can be attributed to three main factors:

- the geographical diversity of the regions studied;
- the large variability of the spatial scales involved: while some study areas cover just a few *communes* (50 km²), most are situated on a micro-regional scale (100–500 km²), and one on a regional scale (about 18 000 km²);
- the diversity of data collection procedures, not only between the areas surveyed in a systematic or partial manner, but also as a function of differences in the systematic surveying and collection methods.

To reduce this heterogeneity and compare the information, the areas offering optimal data resolution and quality were selected, thus sometimes reducing the size of the study areas initially planned.
To ensure some homogeneity of the chronological resolution and the formal characteristics of the settlements (particularly for building materials), the study was refocused on the period between 800 BC and 800 AD: this is the minimum chronological interval documented in all of the study areas, thus enabling us to develop a common typology of settlement.
Qualitatively, only settlement remains were taken into account. Burial sites were not directly included in the analysis because they obey a different logic of spatial occupation and exhibit a specific temporal resolution (generally longer). In addition, the problem arose of the availability of this type of information in all of the regions under consideration and of its spatial continuity.
Settlement is considered here in a broad sense, such as it is defined in geography by R. Brunet: '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. […] Rural settlement (*l'habitat rural*) [corresponds] to anything built in the country' (Brunet *et al.,* 1992: 229). However, a sharp distinction was made between 'site' and 'settlement':
Site refers to a localized and delimited concentration of archaeological remains that are sufficiently characterized to be dated. Site is understood therefore as a geographical and archaeological reference; it is a basic entity that can be located by survey in addition to the indices of sites or manuring (off-site remains).
Settlement refers more specifically to human occupation. A settlement is a place where humans settle (with no structural or functional connotation) at a given moment, in a more or less permanent and uninterrupted manner. A settlement may correspond therefore to a site or part of a site: several human occupations (several settlements) may follow one another at the same point in space (on the same site).
Since the 'Settlement patterns and territories' workgroup aims at studying the intensity and the stability of the occupation of spaces over the long term, settlements and not sites are used in the analyses: quantitative curves of settlement patterns, hierarchical organization and spatial distribution of settlement.
Finally, the dataset originally envisaged was halved, from 4213 to 2127 settlements. The different study areas contribute unequally to the dataset, from 25% to less than 1% of the dataset depending on the area.

1.2 Evaluating data reliability

A common protocol for evaluating how representative the data is was defined collectively in order to interpret the results of the spatial analysis. It consists of defining levels of reliability as a function of the extent 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 aggregating the buffers calculated around each settlement. Several radii were tested for the buffers: a 3000 m radius was chosen, making it possible to best define settlement distribution while minimizing the residual interstices within the aggregated buffers.

[2] Programmes of 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'.

Level 1 (reliable)	Level 2 (moderately reliable)	Level 3 (unreliable)
(1) areas where fields were systematically walked with maximum 10 m spacing, and (2) where visibility conditions are optimal (ploughland or vineyard or lavender).	(1) areas where fields were systematically walked with more than 10 m spacing, or (2) where fields were systematically walked but the ground is only partially visible (wildland, fallow, meadowland, woodland)	(1) areas where fields were only partially walked if at all and/or (2) visibility is very poor due to land use and/or (3) areas where significant taphonomic problems are assumed (sedimentary cover or erosion).

Table 1: Levels of reliability as a function of the extent of investigation and the survey conditions.

However, superimposing the reliability map and the study area would reveal the possible inclusion of extensive unreliable 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 levels 1 and 2 (reliable and moderately reliable) exclusively. The combination of this space and the study area then constitutes the reference area 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 exhibiting 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.,* 2008; Nuninger *et al.,* chapter 1).

2. The indices of settlement intensity, stability and patterns

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

1. quantitative indices showing settlement intensity and dynamics (number of settlements and total area occupied per century, number of settlements created, abandoned and re-occupied);
2. qualitative indices (hierarchical typology of the settlements) reflecting 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 permanent and stable manner over 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.

2.1. The quantitative indices

The distribution of the number of settlements occupied per century gives a first indication of settlement intensity and its long-term evolution (fig. 2). Three major phases can be identified: (1) the first, between the 8th C and the 3rd C BC, is globally characterized by a low proportion of occupation (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 peaks in the 1st C AD. Although this is an absolute maximum in almost all cases, the rhythm of this phenomenon is variable; (3) a substantial decline in the number of occupations occurs between the 2nd–4th C and the 8th C AD, except in Touraine (Tr), with different rhythms and modalities from one region to another.

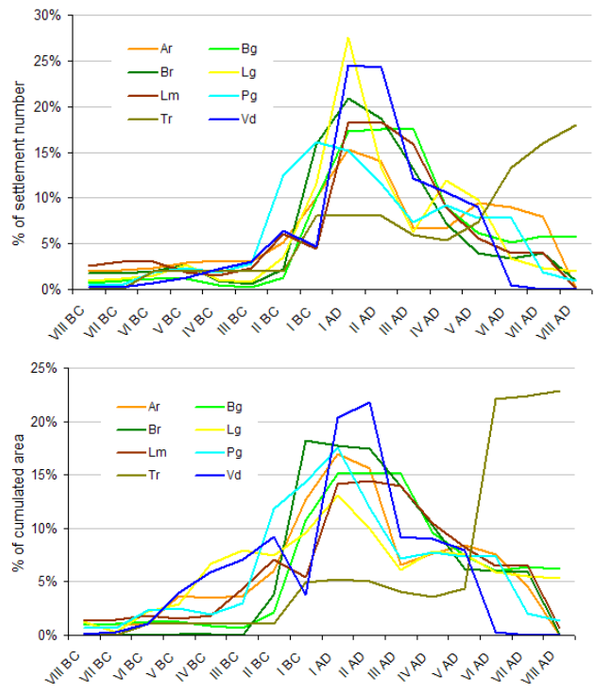

Fig. 2: Quantitative evolution of settlement in eight French study areas.

The curves of the sum of the settlements area[3] globally contribute to restoring 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 in the 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-

[3] The area of all the occupied settlements is added for each century. This index expresses the intensity of human pressure across each region more accurately.

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 from one region to another: while limited to the 1st C AD in Languedoc and the Pre-Alps, it continues into the 2nd C in Argens, Verdon, Berry (Br), and into the 3rd C in Burgundy (Bg) and Limagne.

Two areas (Berry-Sancergues and Touraine-Tavant, Île Bouchard, Crouzilles) were omitted from the quantitative analysis by century because they were not statistically representative.

Analysis of the frequency of creations, abandonments and re-occupations per century reveals the underlying settlement dynamic. The period between the 2nd C BC and the 1st C AD is characterized by intense creation. The asynchrony of this phenomenon must be pointed out. It begins in the 2nd C BC in most regions (Burgundy, Berry, Argens, Languedoc, the Pre-Alps, Verdon), and even in the 3rd C BC 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 is the most abundant phase of creations and re-occupations. 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) displays a relatively low rate of creations (with the exception of Touraine). On the contrary, abandonments of settlements are relatively numerous from the 2nd C until the end of the period. The very marked 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 rural areas 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 re-occupations (in Languedoc and 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 loose chronological correlation between these phenomena of creation/re-occupation and abandonment suggests a certain settlement stability in a system which is most likely undergoing change.

Although the modalities of development vary over time depending on the regions, some general trends stand out allowing us to propose two development 'models' 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 unsynchronized renewal in the 4th and 5th C;
- a model represented by Burgundy, Berry and Limagne (mode B), characterized by a more sustained but unsynchronized period of development (3 centuries), followed by a pronounced and sustained decline from the 3rd–4th C AD.

These two models express particular regional dynamics which need to be more deeply explored but do not necessarily refer to a simple contrast between Transalpine Gaul and the Three Gauls.

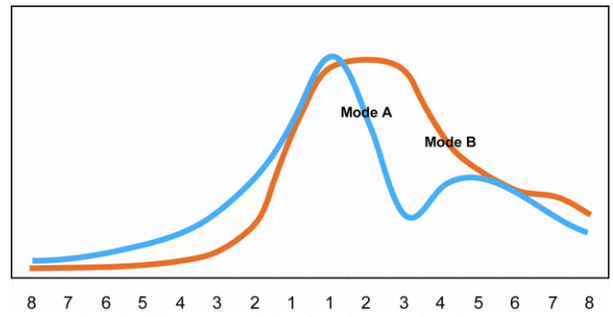

Fig. 3: The two models of settlement development.

2.2 The hierarchical indices

In order to compare settlement organization in the different regions and over the 16 centuries considered, a common hierarchical typology of settlement was drawn up. The descriptive grid used includes five variables: settlement surface area, building materials, duration of settlement occupation, former occupation of the site, and settlement function. These variables have proved to be the most relevant for characterizing 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; Bertoncello, 1999; Bertoncello, 2002; Nuninger, 2002; Van der Leeuw *et al.,* 2003; Bertoncello and Gandini, 2005). The descriptive grid has also been adapted to the specificities of the regional databases and the range of problems addressed by Workgroup 2 (Gandini and Bertoncello, 2008).

Classes	Frequency	Area	Duration of occupation	Building materials	Former occupation	Function	Interpretation
1	15%	< 0.1 ha	< 1 century	stones and tiles	none	agricultural or no known function	agricultural buildings, small farms or hamlets
2	22%	< 0.1 ha or 0.1–0.3 ha	< 1 century or 2 centuries maximum	tiles and/or stones or perishable materials or absence of materials	none	agricultural or no known function	
3	24%	0.1–0.5 ha	1–3 centuries	tiles	none	agricultural or no known function	farms or hamlets
4	12%	0.5–1 ha or even 1–2 ha	3–4 centuries or 2–3 centuries	stones and tiles + for some hypocaust bricks, tubuli, painted coatings	none	agricultural or no known function	large farms or villages
5	14%	1–2 ha or even 0.5–1 ha	5–10 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 (more than 2 centuries earlier)	agricultural or no known function	villae or villages/ oppida
6	3%	3% 2–5 ha or even > 5 ha	> 5 centuries, or even > 15 centuries	mosaic, marble, sculpted elements	none or ancient former occupation (more than 2 centuries earlier)	political and/or religious and/or symbolic function	agglomerations, large oppida
7	8%	2–5 ha	< 1 century or 2 centuries maximum	varied (from perishable materials to mosaic, marble, sculpted elements)	none	varied: mainly agricultural function or no 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

Table 2: The hierarchical typology of the settlements.

The hierarchical typology was established from 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) (Nuninger *et al.,* chapter 1; Gandini and Bertoncello, 2008) (Table 2). By hierarchy, we mean the sorting of the settlements by degree of importance based on the level and the range of their forms and functions (Durand-Dastès *et al.,* 1998). No attempt is made to estimate the social and legal status of settlements. 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 shortest-lived (class 1) to the largest, with more comfortable and sustainable occupations (class 6). Class 7 is more difficult to interpret because it includes atypical settlements whose profiles do not fit in with the logic of the classification. It includes, for example, large but short-lived settlements, or settlements with elaborate architecture but of small size and short duration. Although they are atypical by the logic of the classification,[4] these settlements correspond to a reality in the settlement typology and can easily be re-integrated in the interpretation on a micro-regional scale.

It must be noted that the same class may include various types of settlements, for example dispersed and grouped settlements, depending on the regional features of the settlement pattern. This classification is thus able to yield 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.

2.3 The settlement intensity and stability indices

Comparing several spatial distributions in different historical and geographical contexts is one of the difficulties faced by archaeological studies of settlement.

[4] That is why the settlements of class 7 were omitted from the spatial analyses based on assigning hierarchical weight to each class (*cf. infra*). They are, however, shown on the maps so their spatial and/or chronological relations with the rest of the regional dataset can be analysed.

Several methods of analysis and spatial statistics have been tested to develop indicators for summarizing and comparing spatial dynamics.

2.3.1 Modelling spatio-temporal dynamics: mean centre analysis

The long-term spatial dynamics of settlement can be modelled by using two spatial statistics indices: the mean centre and the standard deviation ellipse (Pumain and Saint-Julien, 1997, p. 53-56; Zaninetti, 2005, p. 43-61; Gandini, 2008; Nuninger *et al.,* chapter 1). The displacements of the mean centre give synthetic index of the settlement spreading in a given area, which takes into account the hierarchical status of each settlement. The standard deviation ellipse makes it possible to apprehend the phases when occupation expands or contracts. Measurement of the area covered by each ellipse and the observation of the variations in its size from phase to phase can be interpreted as an index of the extension or contraction of the occupied areas. The longer and wider the ellipse, the greater the spatial and quantitative variability of the settlement pattern; contrariwise, a small ellipse that is compact around the mean centre is indicative of a concentrated settlement pattern.

The example presented here concerns the study areas of Eastern Languedoc and Limagne (Auvergne). The mean centre and the standard deviation ellipse were calculated in each study area for the settlements occupied between the 5th C BC and the 7th C AD[5] and weighted by their hierarchical level (fig. 4).
The variations in localization of the mean centre within the two study areas exhibit quite different evolutions. Generally, for the entire period, the mean centre of Limagne shows greater changes in localization from one period to another compared with Vaunage (more than 1000 m versus 800 m on average). The rate of variation of the mean centre per period (fig. 4) 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 aggregate distances in metres). In 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 unstable than Languedoc from this point of view. Although the Languedoc study area exhibits a major 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 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 centre vary between 25 and 6.5%), while the settlement stabilizes between the 1st and the 3rd C AD (rates of variation less than 2%). A new phase of instability occurs between the 3rd and the 5th C AD.

The variations in the size of the standard deviation ellipse clarify these initial observations (fig. 5). From the 5th to the 3rd C BC in Limagne, the ellipse is very narrow and elongate. It broadens in the 2nd C BC, reflecting a phase of settlement extension and the possible expansion of land use, which must be linked to the increasing number of settlement 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 decline 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 major phases of contraction and expansion. After a contraction phase between the 3rd and 2nd C BC, the settlement exhibits intense expansion between the 2nd and the 1st C BC (the ellipse increases by 26%). This extension then tends to stabilize: the size and direction of the deviation ellipse change little and the mean centre shifts only slightly.

This analysis shows that, over the 12 centuries considered, the Languedoc study area has a relatively stable and homogeneous settlement pattern compared to Limagne whose global evolution appears 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.

[5] The 8th, 7th and 6th C BC and the 8th C AD were omitted from this calculation due to a statistically insufficient sample of settlements.

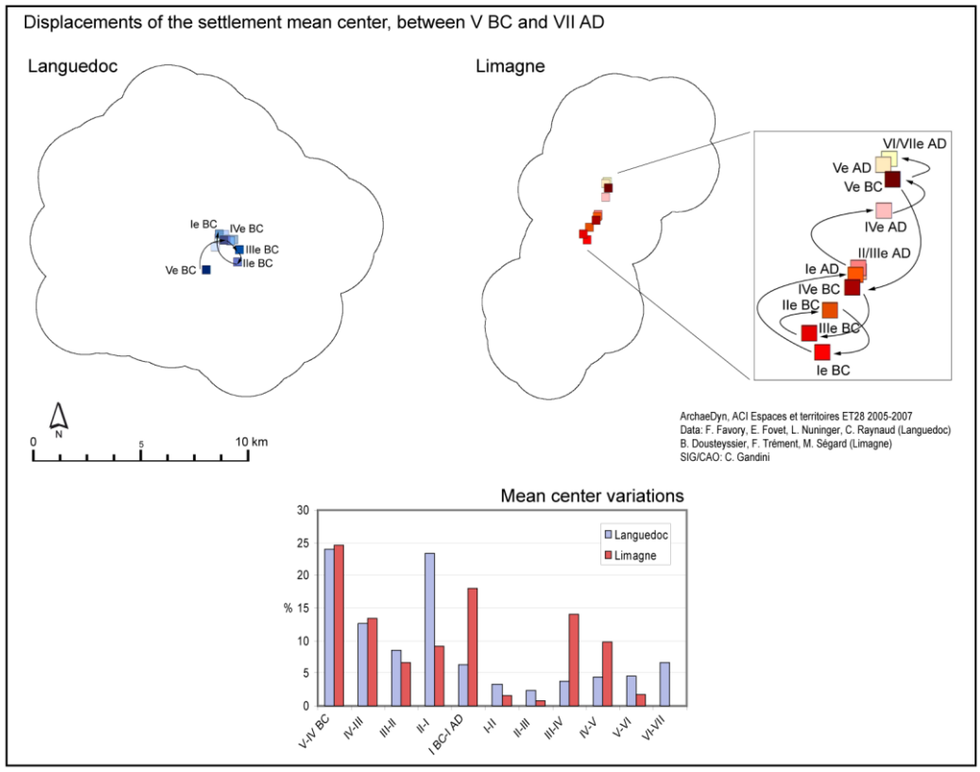

Fig. 4: Displacements of the settlement mean centre in the Languedoc and Limagne study areas between the 5th C BC and the 8th C AD. (Sources Nuninger *et al.* and Trément *et al.,* map: C. Gandini).

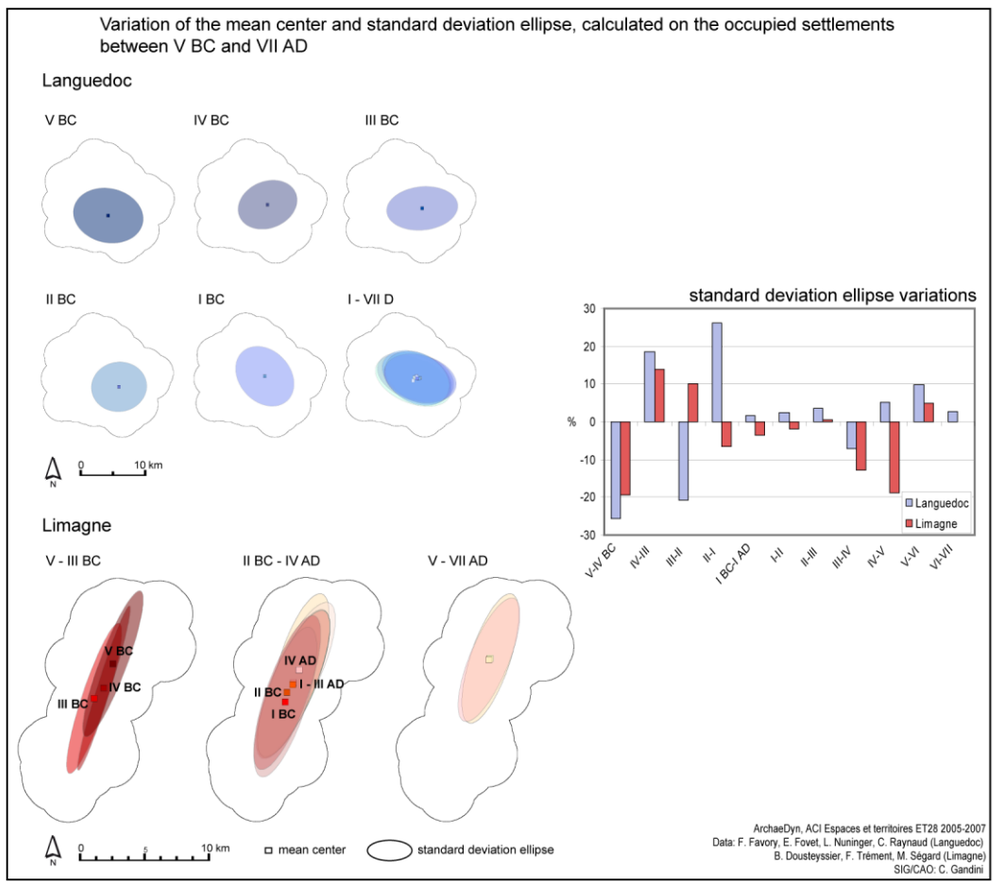

Fig. 5: Changes in the settlement spatial extent in the Languedoc and Limagne study areas between the 5th C BC and the 7th C AD. (Sources Nuninger *et al.* and Trément *et al.,* map: C. Gandini).

2.3.2 The stability indices: maps of density change

Maps of settlement density aggregated over the 16 centuries under consideration (800 BC – 800 AD) and by periods of 4 centuries have been made for each study area using the kernel method (Nuninger *et al.,* chapter 1). They reveal the most intensely occupied areas at different periods, the most attractive areas during phases of settlement creation, or the areas most affected by abandonment.

These periodical maps were used to calculate 'density change' maps, which express the change that occurred between two states, thereby making it possible to visualize the dynamics between two sequences rather than the periodical sequences themselves. The 'normalized ratio' method was used to calculate the difference between two maps (Béguin and Pumain, 2003; Nuninger *et al.,* chapter 1).

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

The preponderance of sectors in red expresses the extent of settlement creations at the end of period 2 from the 2nd to the 1st C BC (*cf.* 2.1 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. 6, zone a). The relative stability of some areas must be nuanced by taking into account the chronological imprecision of some settlements, which cannot be precisely dated within the Iron Age and are thus counted in periods 1 and 2. Such densification of already occupied areas remains, however, relatively slight compared with the creations of the 2nd and 1st C BC, which occur mostly in unoccupied spaces during the first Iron Age: mainly in the plains and basins (fig. 6, zones b and c), but also in the upland areas of the Petits Maures or the Estérel (fig. 6, zones d and e). Finally, a few green spots appear corresponding 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 a particularly dynamic period, characterized by an intensification of settlement and the conquest of new areas.

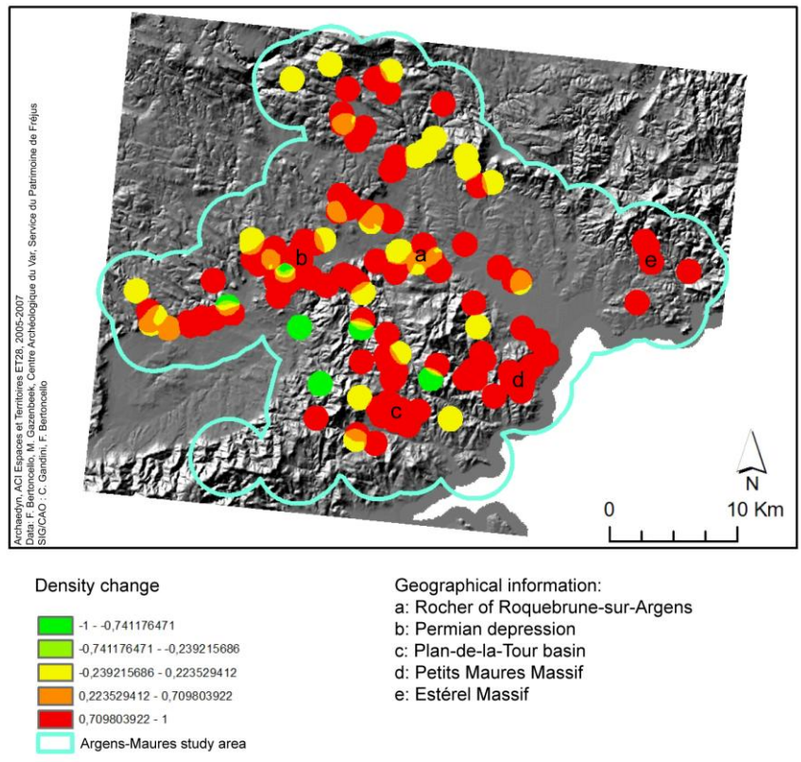

Fig.6: Map of the change in occupation density between periods 1 (8th–5th C BC) and 2 (4th–1st C BC) in the Argens study area. (Data: F. Bertoncello, M. Gazenbeek, map: C.Gandini, F. Bertoncello).
Yellow areas are for stable occupation, red for increased and green for decreased settlement density.

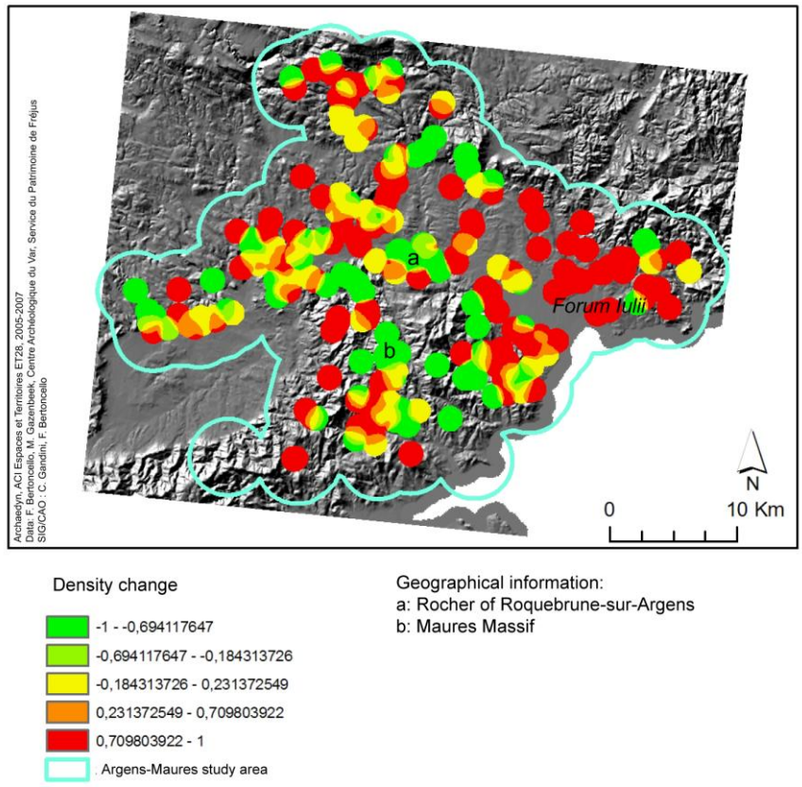

Fig. 7: Map of the change in occupation density between periods 2 (4th–1st C BC) and 3 (1st–4th C AD) in the Argens study area. (Data: F. Bertoncello, M. Gazenbeek, map: C.Gandini, F. Bertoncello). Yellow areas are for stable occupation, red for increased and green for decreased settlement density.

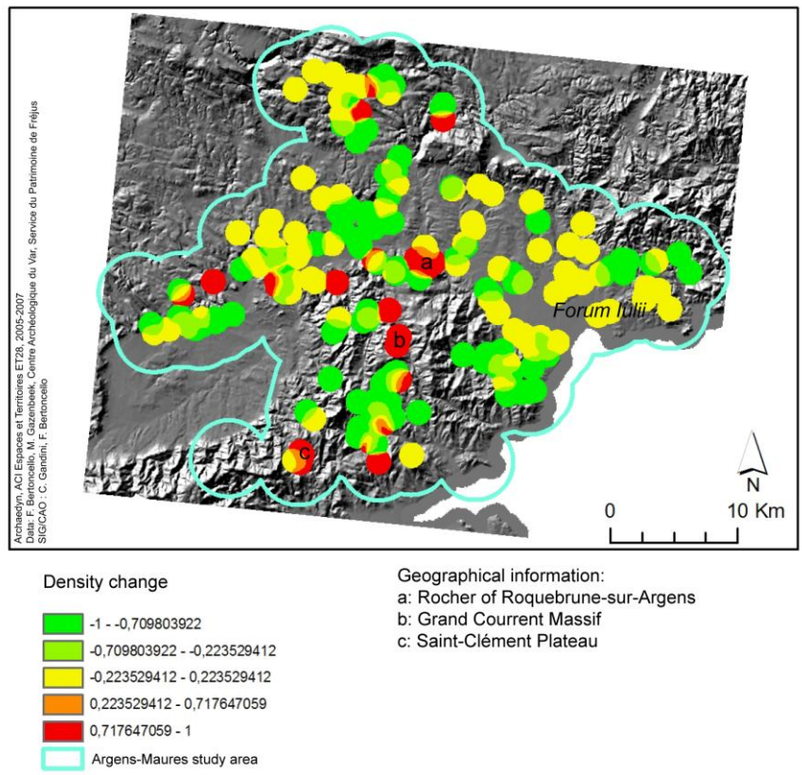

Fig. 8: Map of the change in occupation density between periods 3 (1st–4th C AD) and 4 (5th–8th c AD) in the Argens study area. (Data: F. Bertoncello, M. Gazenbeek, map: C.Gandini, F. Bertoncello). Yellow areas are for stable occupation, red for increased and green for decreased settlement density.

This process continues in the 1st C AD (fig. 7) with the creation of settlements now clearly reinforcing 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 be sure 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 in the Massif des Maures or on the Rocher of Roquebrune-sur-Argens (fig. 7, zones a and b). The two or three centuries around the turn of the era (2nd–1st C BC and 1st C AD) then really correspond to a period of change in the settlement patterns, characterized by maximum land occupation, particularly in the plains, while the protohistoric settlement system, centred more on the uplands, declines. The occupation thus reaches its maximum intensity during the early Empire, not only in terms of density, but also of the spatial extent of settlement. It must also be noted that the increase in the number of creations observed between the 2nd C BC and the 1st C AD (*cf.* 2.1. above) expresses very different modes of spatial organization: the settlements of the 2nd and the 1st C BC tend to be pioneering settlements in areas to be developed, while those of the 1st C AD are essentially 'opportunistic' settlements densifying the occupation of already exploited areas that they continue to develop.

At first glance, the map of density change between periods 3 (1st–4th C AD) and 4 (5th–8th C AD) displays considerable stability in the settlement pattern (fig. 8). While this stability does reflect the uninterrupted occupation of a certain number of settlements throughout Antiquity, its extent must be qualified by taking into account the chronological uncertainties already mentioned for this region with respect to settlements dated to the Roman period without further precision (Bertoncello, 1999; Bertoncello and Nuninger, 2010). The map mainly shows the extent of the areas abandoned between the two periods, following the massive phenomenon of settlement abandonment in the region in the 2nd C AD (*cf.* fig. 2). This results in a more scattered settlement pattern, contracted around sustained settlements mostly of high hierarchical level (class 5, *cf.* 2.2. above). The few red spots on the map show the emergence, particularly from the 5th C onwards, of a more dynamic process of (re-)occupation of certain areas unoccupied in the early Empire. Whether fortified grouped settlements (of class 6 or 7, *cf.* 2.2. above) or dispersed settlements interpreted as farms (classes 2 or 3), these settlements have in common the re-occupation of upland areas abandoned since the end of the Iron Age (fig. 8, zones a, b, c). One might see here the beginnings of a second significant shift in the settlement pattern which, after other transformations, was to lead to the mediaeval settlement system.

2.4 Indices of hierarchical organization

The diachronic and inter-regional comparison of settlement organization is set against the unequal distribution of different classes of the hierarchical classification of settlements by region. Due to the variety of forms of the settlements, the various classes are not represented in the same proportions in all of the study areas. Thus, in each region, the corpus of settlements is divided hierarchically along a gradient of its own. Accordingly we sought to compare the spatial organization of settlements based not on one-to-one class distribution but on the hierarchical spectrum covered in each region.

The analysis consists in identifying the level of 'hierarchical organization' of the settlement pattern within each cluster of settlements defined according to the basic density map.[6] The scale of observation is that of the clusters and it is based on the actual 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 hierarchically similar classes (e.g. classes 1 and 2, or classes 5 and 6). By contrast, the association of settlements belonging to very distant classes (e.g. classes 1 and 6) reflects a wide range or, in other words, a marked differentiation. The range index is obtained by calculating the standard deviation between the classes under consideration (coded from 1 to 6).[7] This synthetic analysis, carried out on periods of four centuries, makes it possible to differentiate areas by the general tendencies of settlement spatial and hierarchical organization (fig. 9): weakly organized (little diversified and differentiated), moderately and highly organized (diversified and showing a wide spectrum of settlement types).

This method was tested on the study area of eastern Languedoc. Between the 8th and 5th C BC, settlement density is low with scattered settlements. The analysis shows that the overall settlement pattern has a low level of hierarchical organization and is very homogeneous (poorly diversified settlements and of similar hierarchical level). Comparison with the 'hierarchical density' map[8] for the period (fig. 10) shows that the lowest level of organization corresponds largely to the sectors occupied by small ephemeral settlements (sporadic occupations). Two settlements of similar types and high hierarchical levels are occupied in this period: one is isolated (along the river

[6] It should be recalled here that this density calculation is based on the kernel method, with a radius of 1000 m and ignoring hierarchy (*cf.* 2.3. above, Nuninger *et al.,* chapter 1).

[7] The methodology is presented in detail in Nuninger *et al.,* chapter 1.

[8] The "hierarchical density" maps weight the settlement density according to the hierarchical level of the settlements as it was defined from the results of the CAH (with the exception of class 7, *cf. 2*.2. above). Thus the density of spaces occupied by settlements with a high hierarchical level (for example, classes 5 and 6) is increased compared to spaces occupied by settlements with a low hierarchical level (for example, classes 1 and 2).

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.

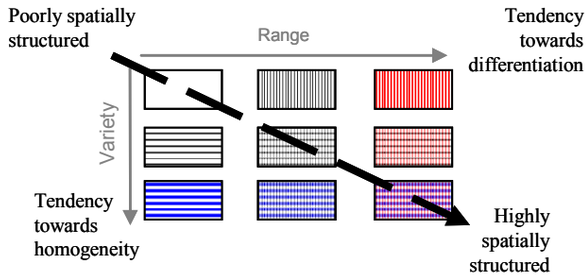

Fig. 9: Different combinations of the hierarchical variety and range indices showing different levels of hierarchical organization of settlement patterns. (E. Fovet).

structured: poorly diversified (few classes) and very homogeneous (classes with a similar hierarchical level).
Occupation in the following period (1st–4th C AD) becomes even denser and the hierarchical structuring of the settlement system tends to become more complex (fig. 12). The areas at the foot of the Bois des Lens massif expand and become hierarchically structured to reach the same level of organization as at Vaunage in the preceding period. The Vaunage area continues to develop in terms of land use and of hierarchical structuring. The southwestern sectors remain poorly structured, while the central sector along the valley of the Vidourle and between Vaunage and the foot of the Bois des Lens is less organized (less diversified) than in the preceding period.

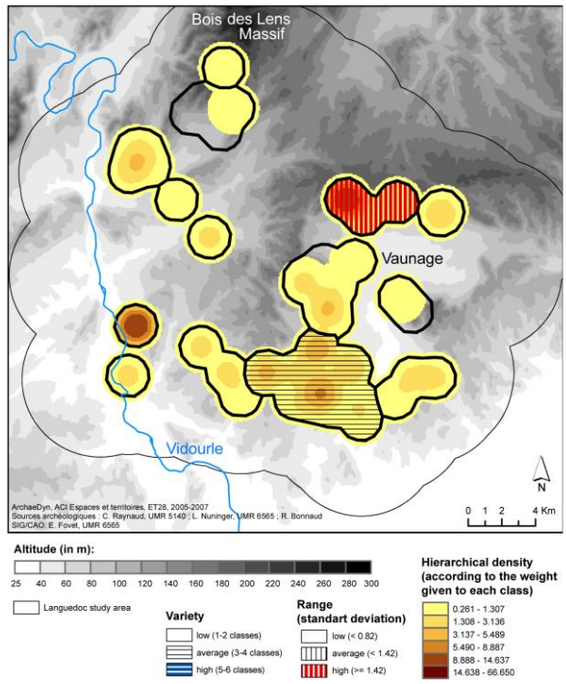

Fig. 10: Comparison of the hierarchical level of organization and density in the Languedoc study area 8th–5th C BC. (Map: E. Fovet).

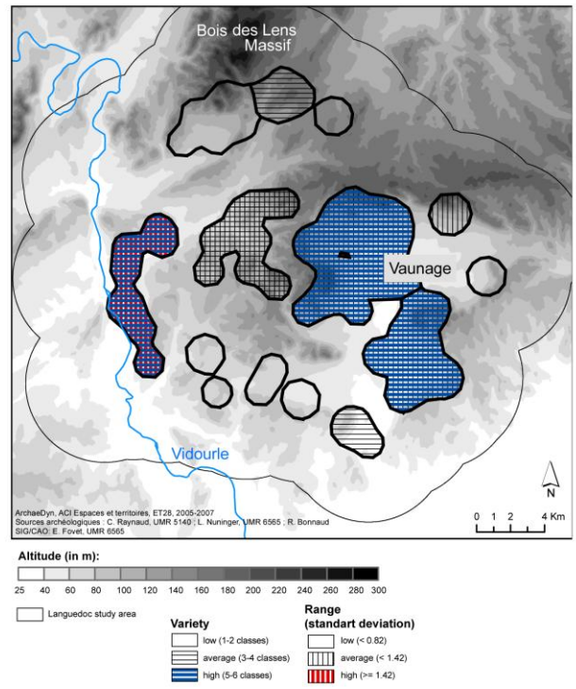

Fig. 11: Analysis of the level of hierarchical organization in the Languedoc study area 4th–1st C BC. (Map: E. Fovet).

The occupation becomes denser and the structure of the settlement pattern more complex between the 4th and the 1st C BC, with a wider variety of hierarchical classes (fig. 11). Two areas are more intensely structured. Along the Vidourle River, the expansion of the settlement from the pole identified in the preceding period leads to a strong hierarchical structuring of the settlement system (very high level of organization). Land use also expands in Vaunage with greater hierarchical structuring than in the previous period, although less than in the Vidourle valley. This is because the numerous settlements of low hierarchical level tend to make the settlement structure fairly homogeneous. By contrast, although the settlement pattern of the northern and southern areas (at the foot of the Bois des Lens massif) is denser than in the preceding period, it remains loosely

The decline in the density of occupation between the 5th and 8th C AD is reflected by more small clusters of settlements and a clear tendency towards differentiation: fewer classes of settlements are found within the clusters but their hierarchical level is quite separate (fig. 13). This simplification of the hierarchy is very clear within the loose conglomeration of settlements that spreads from the Bois des Lens massif as far as the river Vidourle. However the settlements of Vaunage are still organized in a complex way, and the central sector exhibits a slight increase in the level of hierarchical organization compared with the preceding period.
Interestingly, over the long term—i.e. during the four periods considered—the various geographical areas (foot of the Bois de Lens, Vidourle valley, Vaunage) do not

evolve in the same way but develop at different paces. The level of hierarchical organization nuances simple settlement density and makes it possible to apprehend the capacity of an area to develop or, on the contrary, to go into gradual decline. Thus, for example, the settlements in the Vidourle valley became structured relatively quickly with a high level of hierarchical organization in the second Iron Age. However, it progressively loses this capacity during the Roman period, foreshadowing its break-up and the gradual abandonment of the area during late Antiquity. In contradistinction, the pole identified to the north of Vaunage during the first period progressively structures its sector in the late Iron Age and during Antiquity. Therefore, even if the power of this pole of protohistoric origin waned during late Antiquity, it contributed to the creation of the neighbouring sectors, which thrived during the Roman period. Thus, despite being broken up into three highly structured sectors, the Vaunage region continued to develop.

This case study shows that some areas have a highly specific form of hierarchical and spatial organization within the general evolution of settlement patterns, deserving further investigation. This analytical method is still exploratory, but the initial results are very promising for going beyond simple quantitative estimates of settlement dynamics. It provides a synthetic view of settlement patterns 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.

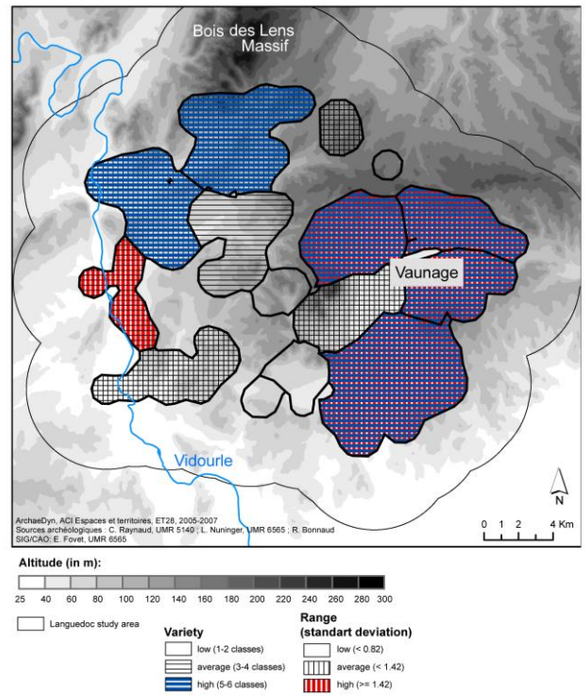

Fig. 12: Analysis of the level of hierarchical organization in the Languedoc study area 1st–4th C AD. (Map: E. Fovet).

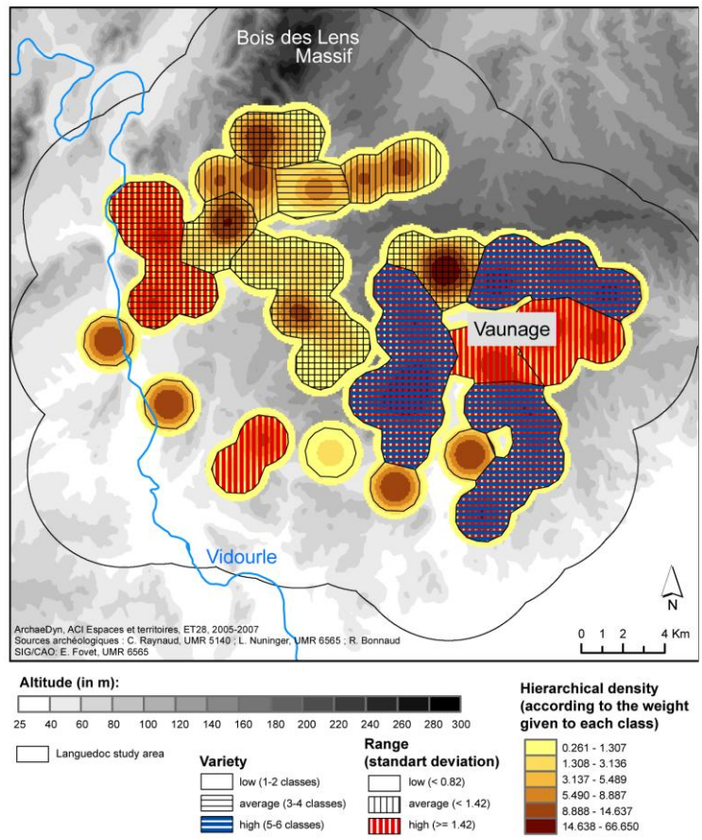

Fig. 13: Comparison of hierarchical level of organization and density in the Languedoc study area 5th–8th C AD. (Map: E. Fovet).

3. Conclusion and prospects

The collective work by the 'Settlement patterns and territories' workgroup has allowed us to develop indices for expressing the intensity, stability and organization of rural settlement. The analyses performed have furthered our understanding of settlement spatial dynamics, both quantitatively (evolution of occupation density and its underlying processes) and qualitatively (settlement hierarchy and organization). Archaeologically, emphasis must also be placed on the workgroup's constant concern for synthesis so as to compare study areas that are geographically and culturally very different using the same system of reference. This is an innovation on 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 centre, standard deviation ellipse, indices of hierarchical variety and range) are the tools which will allow interregional comparisons and 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 enable us to spot any '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 data reliability will be especially useful at this stage, allowing us to pinpoint the possible effects of data collection conditions on the definition of the regional profiles.

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