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## From Archaeomedes to ArchaeDyn

*Abstract:* This paper presents some aspects of the research developed within the framework of two projects: Archaeomedes (1992–1999) and ArchaeDyn (2005–2007). Both projects attempt to manage territorial dynamics over the long term. This involves varied approaches at several levels over space and over time. We focus on the issues of different scales we had to face and the way we attempted to solve them. Taking into account the advantages and limitations, we introduce the ArchaeDyn project issues and perspectives.

This paper presents some aspects of the research developed within the framework of two projects: Archaeomedes<sup>1</sup> (1992–1999) and ArchaeDyn<sup>2</sup> (2005–2007). Both projects deal with territorial dynamics over the long term. By territorial dynamics, we mean the complex relationship between spaces and human activities which is being continuously redefined. To be defined as a territory, an area must be delimited by the people who occupy it. Furthermore, the territory behaves as a dynamic system. The state of the system depends upon the economic and social development of the population, and upon the environmental potential. Consequently, delimitations and appropriations are continuously changing. The territories can be assumed to be a co-evolutionary system where interdependent communities and environments evolved, each adapting to changes in the other. The success or the poor development of a particular territory cannot be explained and described by a simple combination of several contemporary criteria no matter how complex they may be. According to this point of view, the territorial studies developed in both projects considered a longer term perspective as the main challenge in order to catch the rhythms, cycles and changes. In addition, not all territories are on the same socio-economic level nor

at a similar geographical scale. The following are the main points considered: How to define the territorial object from archaeological remains, geographical context, historical and anthropological knowledge? How to explore this object in several dimensions as spatial, temporal, social, economical or political? How to underline overall processes while also having a focus on contrasting peculiarities or anomalies?

Even if it were possible, we have not attempted to answer the questions in all detail. However based on such background problems, we will present the results and methodological development of the Archaeomedes/ArchaeDyn groups.

### *The Territorial Object*

Firstly, the difference between territory and life space<sup>3</sup> should be considered so as to avoid ambiguity. If the territory cannot be reduced to an administrative entity, it implies a juridical or political dimension (BRUNET / FERRAS / THÉRY 1993). For an archaeologist, juridical or political dimensions are the most problematic points since archaeological remains are mute witnesses, except in very rare cases. Nevertheless

<sup>1</sup> Archaeomedes I (1992–1994): “Understanding the Natural and Anthropogenic causes of soil degradation in the Mediterranean Basin” (Program Environment of the European Commission DGXII); Archaeomedes II (1996–1999): “Policy-relevant models of the natural and anthropogenic dynamics of degradation and desertification and their spatio-temporal manifestations” (Program Environment of the European Commission DGXII), coordination S. van der Leeuw (Arizona State University).

<sup>2</sup> ArchaeDyn I (2005–2007): “Spatial dynamic of settlement patterns and natural resources: toward a long-term integrated analysis from Prehistory to the Middle Ages” (Action Concertée Incitative – ACI Spaces and Territories of French Ministry of Research and New Technologies, contract ET28), coordination F. Favory and L. Nuninger.

<sup>3</sup> According to DI MEO 1998, the life space is the area of social practices. It represents the frequented space. The life space is composed by attractive places and nodes where the individual existences appear (inhabitat, working place, recreation area...). The life space is the expression of the concrete practice of the area.

shape, value, assemblage or pattern, and distribution of such remains give indirect clues. Analyzing these remains from different points of view, allow archaeologists to provide relatively strong assumptions that enable them to reconstruct the evolution of some territories. An estimation of the spatial and temporal trajectory of the territory entities is therefore the aim of the study, and the expected result. Since territory is multidimensional spatially as well as temporally, in our opinion the sum and/or combination of several life spaces is the best way to further understand its non-linear evolution. Even if it is impossible to get information regarding all life spaces, archaeologists have to admit that life spaces which we are able to study are somehow representative of a part of the past reality. Past life spaces are understood by archaeologists through the spatial distribution of archaeological evidence: objects (pottery, coins, metal or lithic tools) or assemblages (site or off-site units for example). Using models, one can design conceivable links between object/object, assemblage/assemblage, object/assemblage and the reverse. For example, one can design hierarchical and spatial links to generate networks of settlements using a gravity model. In such a way, models are not explicative where links are *a priori* explained, but usually they offer a reference framework where the trajectory of several case studies can be compared. Both projects Archaeomedes/ArchaeDyn come within the scope of such parameters which have a special interest in analyzing the position of particular or individual trajectory. In our opinion, there is no single appropriate level to study territorial dynamics, but a constant dialogue between the individual (in the statistical sense of the word, i.e. considering the observation itself) and the overall levels is needed to point out similarities and incoherences. This is most important to enrich our knowledge.

### *The Problem of Temporal and Spatial Scale*

Even if the territorial problem is conceived according to different levels, each life space should be analyzed at the most reliable scale depending on both the object and context studied. The Archaeomedes project focused on land degradation and desertification in Mediterranean Europe, ancient land use changes and environmental problems of the Rhone valley (Fig. 1).

Two approaches were used in developing the research project: a) settlement pattern; and b) land use

as an qualitative and quantitative indicator. The aim was to underline mutations in both approaches in order to fully understand the role of the geographical context for settlement durability and territorial development. Does an attractive context contribute to settlement durability? Does an unfavorable context dissuade those who choose to work or live there?

These issues could not be investigated through a simple micro-regional case study, since no generalization of the results is possible. The way to manage this problem was to analyze a set of micro-regions (Fig. 1) with the same protocol, in order to compare them and to highlight shared trends.

The archaeological data used for the project is a set of archaeological occupations: 934 gallo-roman occupations for Archaeomedes I, extended to 2155 occupations, from Iron Age to Middle Ages, in Archaeomedes II. An "archaeological occupation" is a location delivering archaeological artifacts, occupied (inhabited or used as technical building) without any chronological gap. This differs from "archaeological sites" which can include several occupations. For the analysis, each occupation was considered as the smallest statistical observation. Every observation "occupation" is therefore described by a set of variables according to a common grid for each studied area (FAVORY et al. 1999; VAN DER LEEUW / FAVORY / FICHES 2003). Variables are related to: a) archaeological observations; for example occupation area, quality and variety of building material, duration; b) interpreted connections as the "symbolic position" defined gradually by a lack of evidence of burial, religious or political evidences; c) geographical and relational context such as position within the road network, number of direct relationships among contemporaneous occupations, distance to water, slope or solar radiation).

As the goal was to understand the land-use pattern, an initial step was to evaluate the number of settlements and their condition over time. And the first question asked was: How to manage time? Which kind of periodicity is the most reliable according to the topic and data?

### **Timescale Issues**

Regarding time, three main problems should be considered: 1) dating of the archaeological occupations; 2) relevance of the studied periods; 3) comparison between data coming from different periods and timescales.

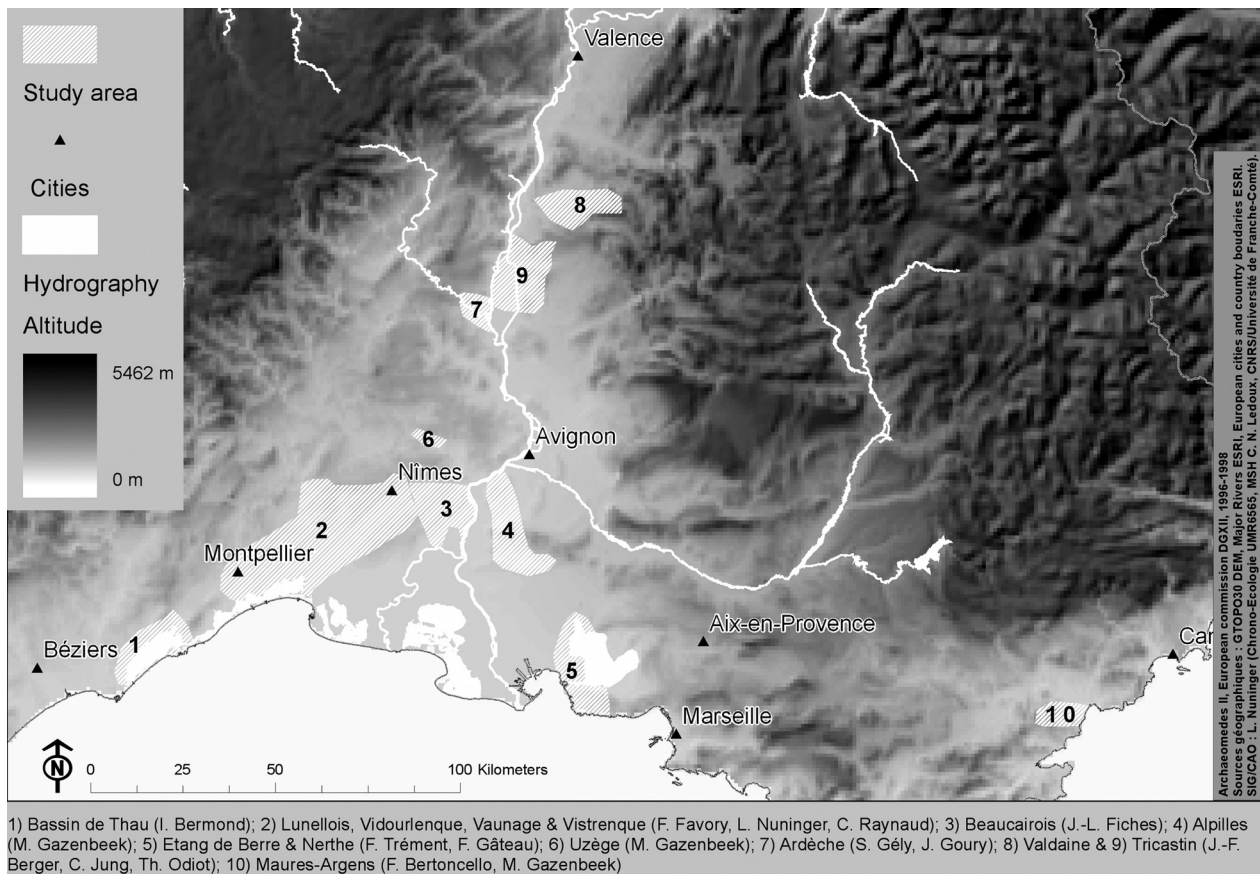


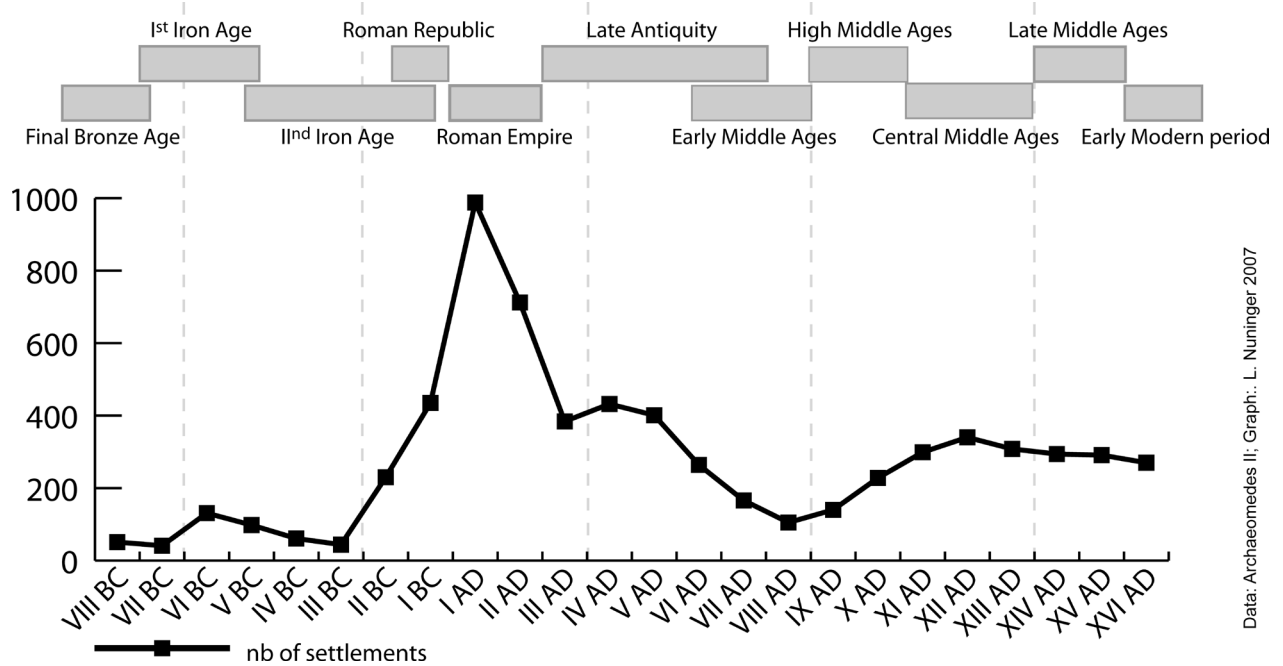
Fig. 1. Map of the study area within the Archaeomedes's ancient Rhone valley project.

Dating is a central problem when it comes to integrating all databases. Most of the archaeological data we used came from field walking investigations which used a similar protocol of recording. However resolution of dating differs from period to period or from area to area. Where gallo-roman occupations can be dated within a chronological resolution of half a century, one or even two centuries is the minimum resolution which can be accepted for Iron Age occupations. Regarding poorly dated sites without possible improvement (BERTONCELLO / NUNINGER in press), the related occupations were left out of the chronological analysis. The final quality of dating in each database allowed a chronological analysis with the minimal resolution of one century (Fig. 2). This was presumed to be the most reliable database and including more than 2000 well dated occupations, which allowed analysis to proceed.

According to the chronological analysis, the team was able to distinguish six main periods which do not exactly match with the classical ones. Every period is described as a cycle including increasing, peak, and decreasing phases. The intensity of each phase is variable. The most important effect can be seen dur-

ing the transition from late Iron Age to Roman Empire (Fig. 2). From an archaeological point of view, these periods can be viewed as more "natural" than the conformist historical periods. Therefore, they were chosen to experiment with spatial scale effects in the geographical context analysis (see below).

The final problem is linked precisely to the geographical context analysis. Since the palaeoenvironmental data could not be obtained for such a micro-regional scale, the team had to work with present environmental data (DEM, geological and soil maps). Timescale then becomes the fundamental question. Environmental contexts change over time and present data cannot be assumed to fit with past conditions. Moreover the topography, pedology and geology do not imply the same temporality. When considering land use issues, our perception of the landscape usually defines the relationship between archaeological settlement and geographical features. However complex it may be, no method can completely overcome such difficulties. Nevertheless, through debating choices, having a critical mind and well controlled experiments it is possible to develop new ways to examine these issues relating to the project.



Data: Archaeomedes II; Graph: L. Nuninger 2007

Fig. 2. Settlement dynamics over 24 centuries (number of settlements). Archaeomedes's ancient Rhone valley project.

Considering perceptions of soil within the Archaeomedes, one attempt takes into account the Roman concepts through the prescription of the Latin agronomy (BERGER et al. 1997). According to the agronomist prescription, a typology was defined in order to classify soils according to their degree of attractiveness and fertility. To validate this, an experiment was conducted on the Roman cadastre B of Orange (medium Rhone valley, France). Several fragments of marble coming from this cadastre have been preserved and could be georeferenced. This means renting prices of land per Roman century can be linked to the present type of soil. We can consequently assess the correlation between the price and the degree of attractiveness.

### Spatial Scale and Geographical Context

Regarding topography, it was presumed at a micro-regional scale that the general shape of the relief did not change in the last 3000 years. In addition, it was also presumed that the very well known and usually small<sup>4</sup> areas of erosion or sedimentary deposit cannot affect the overall picture. Under these condi-

tions, the present DEM was used to compute several variables in order to describe the topographic surrounding of each occupation. The goal was to design a framework of reference to compare micro-regions over time. The central question was how to define the catchment area of each occupation. Since micro-regions contain various topographical features from the mountainous, in Maures montains and around Argens valley (Var), to very flat plains in Lunellois (Languedoc) for example (Fig. 1), the use of the same radius to describe the occupation's catchment is not appropriate for comparison. While occupation's surrounding in flat areas are described with a single topographical variable, in mountainous contexts almost all variables are represented. To overcome this problem, an optimal radius was calculated for each area and each period (see above) taking into account the maximum of variance as well as a minimum radius to maintain statistical significance (FAVORY et al. 1999). With this radius, it was possible to assign the catchment area of each occupation to one out of a dozen classes which were defined by an ascendant hierarchical classification algorithm<sup>5</sup>. The ratio of each type of context occupied can therefore

<sup>4</sup> Comparing to the micro-regional scale.

<sup>5</sup> Agglomerative hierarchical clustering (CAH) and factor analysis (AFC) algorithms used within the project branched off the correspondence analysis developed by Benzecri at the end of the 1960s (BENZECRI 1992; <http://www.micheloud.com/FXM/COR/e/index.htm>).

be compared per block of half century in reference with the micro-regional potential (Fig. 3).

The curves on the left side represent the number of occupations, creations (new settlements that are created) and abandons per half century. These curves give the significance of the context profile occupied per period. The two columns represent the occupied profile per period according to the classes of topographical context (at bottom). The top profiles (first line) represent the average topographical context available in each study area.

In other words, one can stress the evolution of human choices according to the environmental context. It is important to point out the same tendencies despite different topographical conditions in each area. By the end of Middle Ages, the settlements occupied almost all regional potential (Fig. 3) without any particular preferences. The situation was different around 900/1000 AD where particular contexts were preferred as flat areas in Lunellois plain or in reverse, steep slopes in Vaunage. Finally, it is interesting to see that the massive abandonment observed by the end of the 1<sup>st</sup> century AD was not motivated by environmental constraints. Indeed the context profile remains the same as it was before, i.e. during the peak of productivity.

### *Local Relationships and Overall Dynamics*

If some changes, such as the considerable decrease of settlements, cannot be understood by environmental constraints at a micro-regional scale, one can seek an explanation exploring other spheres or scales. Going down to the individual occupations, different ranges can be observed from the smallest one (technical buildings) to the largest one (villages or towns). By a simple reduction of the scale of observation toward a small scale, the smallest settlement would be neglected although the surrounding of the larger one would be analyzed. From an agricultural point of view, it is the surrounding of the smallest settlement that is vital for the comprehension of environmental choices.

The local relationships among settlements should be understood in order to explain land use behaviors over time. Their relationship needs to be defined within a framework of reference valid for each area to enable a valid inter-regional comparison. Befitting this scope, the whole occupations are ranged according to a hierarchical typol-

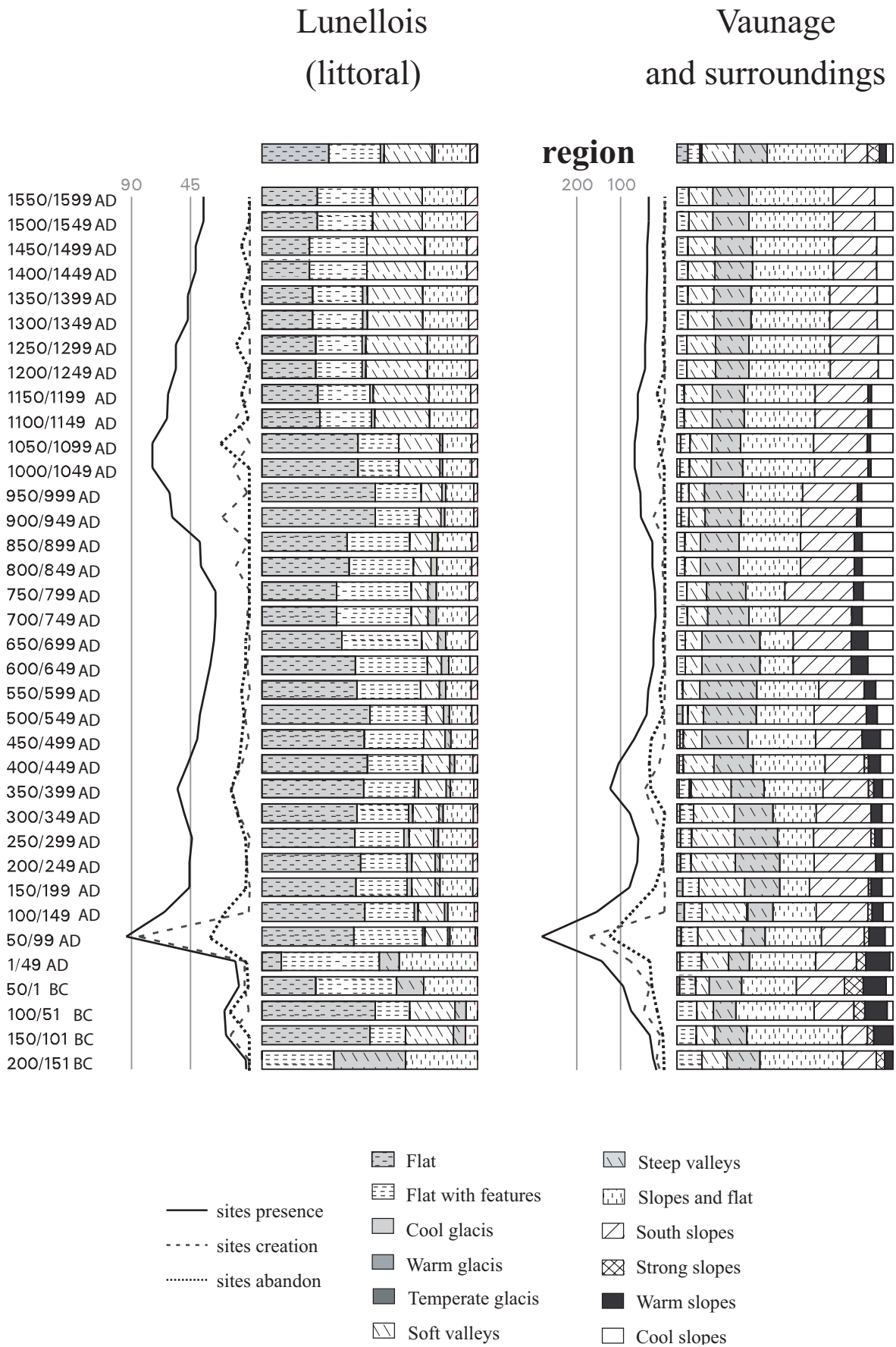
ogy using AFC/CAH algorithms (see note 4, VAN DER LEEUW / FAVORY / FICHES 2003; VAN DER LEEUW / FAVORY / GIRARDOT 2004; FAVORY et al. 1999; GANDINI et al. 2008). Next the relationship among settlements, according to their range and the distance which separates them, is specified using a gravity model (NUNINGER / SANDERS 2006). Such a model enables the design of networks of settlements and their evolution over time. The way links between settlements appear or disappear points out the relative mutations of the settlement pattern. Comparing micro-regions, a similar event as the 1<sup>st</sup> century AD peak of creations can provide different patterns and consequent interpretations. Within the ArchaeDyn project, the studied area in Auvergne, in comparison with the one from Languedoc, records small networks dominated by medium rank settlements. In the Languedoc area, a higher level of settlements controls all the living space. There is no opportunity for a smaller rank settlement to develop its own network.

Within the Languedoc study area, a similar result is observed by considering land use activities analyzed through manuring remains. Assuming that off-site material was provided from past manuring activities, models are designed to estimate the evolution of the agricultural areas exploited over time (NUNINGER 2004a; BERTONCELLO / NUNINGER in press; POIRIER / TOLLE 2008).

Comparing the land use activities model to the settlement network's one, it is interesting to consider the particular situation of some settlements during the first century BC which seem in competition to control space. Going back to their own history based on the raw archaeological data, the competition seems to appear several centuries before (NUNINGER 2004b). In spite of such local observations, the study of each settlement involved demonstrates that the complex relationships among such settlements cannot be understood if external factors, such as commercial influences for example, are not taken into account (NUNINGER 2002).

### *Towards ArchaeDyn*

If Archaeomedes was a great experiment that brought central methods and new perspectives for socio-environmental studies in archaeology (VAN DER LEEUW / FAVORY / FICHES 2003; VAN DER LEEUW / FAVORY / GIRARDOT 2004; FAVORY et al. 1999), its scope regarding territorial dynamics is too limited. Ar-



Data: Archaeomedes II; Graph: F.P. Tourneux, F. Tolle 2007

Fig. 3. Topographical contexts over 18 centuries. Archaeomedes's ancient Rhone valley project.

Archaeomedes is indeed too focused on agricultural communities, neglecting other resources and activities which create social relationships. From this point of view, the ArchaeDyn project in progress is more ambitious. It includes different kinds of data, not only site and off site-records, but also objects or raw materials, for example metal objects or salt resources (GAUTHIER 2008). Moreover, it involves a large range of scales: 1) from local to the European one 2) from the Neolithic to the medieval period.

The main issue of the ArchaeDyn project is related to territorial dynamics through the study of the behavior of several areas or spaces. In this context space is viewed as the object of the study. It means that several parts of space are clearly defined according to grids and each part, or *cell*, is defined by archaeological criteria. This approach aims to consider three principal questions: Which are the areas permanently occupied, conquered, and then abandoned? Which areas are used regularly but without long-term contributions?

From a practical point of view, it is a matter of producing homogenous synthetic indicators based on existing data to be compared and combined in models of spatial analysis. Three types of indicators are defined: 1) indices of occupation or abandonment of the area (settlement patterns, activities, influence-abandonment of the milieu etc.); 2) indices of concentration or dispersion (population, activities, exchanges etc.); 3) indices of stability or instability (settlement patterns, environmental contexts etc.).

Four thematic groups are used to define such indicators at various levels. On local and micro-regional scales, catchment area, local soil combinations (terroirs) and community lands are investigated in order to evaluate the influence on exploited spaces to ensure domestic supply (agriculture, forestry and craft activities) (POIRIER / TOLLE 2008; GEORGES-LEROY / TOLLE / NOUVEL 2008). A second approach aims to estimate the needs of a community and the environmental capacity to fulfil them (environmental potential: terroirs, and specific resources). In regional and micro-regional scales, settlement patterns, networks and territories are the main topics used to study the territorial structuring on several scales through comparisons and inter-regional analysis. This group focuses on the settlement pattern organization (hierarchy, concentration, dispersion, interaction) and its degree of stability (GANDINI et al. 2008). From regional to European scales, the diffusion of raw materials and manufactured objects is understood as a diachronic study of management in the area of the

consumption of various products (bronze, flint, jadeite, stoneware, salt, ceramics etc.). These products include objects of various uses (millstones, axes, weapons, tools etc.) found in different contexts (habitats, deposits, river finds etc.) (GAUTHIER 2008).

Based on the existing and very heterogeneous databases, the project copes with many problems of scale, many points of view and different work procedures of the archaeologists involved. Within a common workgroup "tools and methods" the main goal is to define the relevance of each archaeological kind of information according to the part of area or cell considered. The first step was to characterize the reliability level of the information and to compute maps with confidence to guide spatial analysis and therefore interpretation (OŠTIR et al. 2008).

As in Archaeomedes, the ArchaeDyn project attempts to develop not only methods, but a framework of reasoning. The aim is to provide relevant comparisons and translate results of various approaches into the form of synthetic indicators which can be integrated within a territorial analysis. As opposed to Archaeomedes' focus on the Rhone valley, ArchaeDyn is working on multiple cultural and geographical areas. It must be stressed that this is the first project involving areas from the north and south of France with such a degree of integration.

To conclude, it should be emphasized that within both the Archaeomedes and ArchaeDyn projects, the time and space issues are all pervasive. When comparing various contexts over time and space, researchers have to deal with many different perspectives. In our opinion, neither "processual" nor "postprocessual" approaches are fully satisfactory ways to understand the complexity of territorial dynamics. However, both theoretical frameworks and their methods can be useful to varying degrees according to the phenomenon to be considered. But a holistic approach that is based on interdisciplinary research which clarifies assumptions and their scale of relevance at every step of the analysis is preferable. Finally, the overall interpretation of this interaction should carefully take into account to avoid the large mistakes commonly made when moving from one scale to another.

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### References

BENZECRI 1992

J. P. BENZECRI, *Correspondence Analysis Handbook* (New York 1992).

BERGER et al. 1997

J. F. BERGER / F. FAVORY / T. ODIOT / M. P. ZANNIER, *Pédologie et agrolgie antique dans le Tricastin central (Drôme-Vaucluse), d'après les textes agronomiques et épigraphiques latins et les données géomorphologiques*. In: J. BURNOUF / J.-P. BRAVARD / G. CHOUQUER (eds.), *La dynamique des paysages protohistoriques, antiques, médiévaux et modernes. 17<sup>th</sup> international meeting of archaeology and history in Antibes, France (Sophia-Antipolis 1997)* 127–154.

BERTONCELLO / NUNINGER in press

F. BERTONCELLO / L. NUNINGER, *From Archaeological Sherds to Qualitative Information for Settlement Pattern Studies*. In: F. NICCOLUCCI (ed.), *Beyond the Artifact – Digital interpretation of the past. CAA 2004. Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 32nd CAA conference, Prato, Italy, April 13–17, 2004* (Prato 2004).

BRUNET / FERRAS / THERY 1993

R. BRUNET / R. FERRAS / H. THERY, *Les Mots de la géographie: Dictionnaire critique* (Montpellier 1993).

FAVORY et al. 1999

F. FAVORY / J. J. GIRARDOT / L. NUNINGER / F. P. TOURNEUX, *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.)*. *AGER* 9, 1999, 15–35. <http://mti.univ-fcomte.fr/ager/AGER9.pdf> [31 Dec 2007].

GANDINI et al. 2008

C. GANDINI / F. BERTONCELLO / E. GAUTHIER / L. NUNINGER / F. TRÉMENT, *Hierarchical Typology and Settlement Patterns Modelling at Interregional Scale*. In: Present volume, 278.

GAUTHIER 2008

E. GAUTHIER, *Consumption and Circulation of Prehistoric Products in Europe: Characterization of Spatial Evolutions Using Map Algebra*. In: Present volume, 375.

GEORGES-LEROY / TOLLE 2008

M. GEORGES-LEROY / F. TOLLE / P. NOUVEL, *Analysis of the Intensity of Agrarian Exploitation by Spatial Analy-*

*sis of Ancient Field Systems Preserved by the Forest Cover*. In: Present volume, 281.

VAN DER LEEUW / FAVORY / FICHES 2003

S. VAN DER LEEUW / F. FAVORY / J. L. FICHES, *Archéologie et systèmes socio-environnementaux. Etudes multiscalaires sur la vallée du Rhône dans le programme ARCHAEOMEDES*. *CRA Monographies* 27 (Paris 2003).

VAN DER LEEUW / FAVORY / GIRARDOT 2004

S. VAN DER LEEUW / F. FAVORY / J. J. GIRARDOT, *The archaeological study of environmental degradation. An example from Southern France*. In: C. L. REDMAN / S. R. JAMES / P. R. FISH / J. D. ROGERS (eds.), *The Archaeology of global change. The impact of humans on their environment* (Washington 2004) 112–129.

DI MEO 1998

G. DI MEO, *Géographie sociale et territoires* (Paris 1998).

NUNINGER 2002

L. NUNINGER, *Peuplement et territoires protohistoriques du VIII<sup>e</sup> au I<sup>er</sup> s. av. J.-C. en Languedoc oriental (Gard-Hérault)*. (Besançon 2002). [http://tel.ccsd.cnrs.fr/documents/archives0/00/00/29/81/index\\_fr.html](http://tel.ccsd.cnrs.fr/documents/archives0/00/00/29/81/index_fr.html) [31 Dec 2007].

NUNINGER 2004a

L. NUNINGER, *Contribution à la modélisation des finages protohistoriques: un cas d'étude micro-régional en Languedoc oriental (Gard)*. *AGER* 13, 2004, 6–23. <http://mti.univ-fcomte.fr/ager/AGER13.pdf> [31 Dec 2007].

NUNINGER 2004b

L. NUNINGER, *Understanding the protohistorical territorial heritage by means of Iron Age settlement system analysis in GIS: a case study in the eastern Languedoc (France)*. In: K. AUSSERER FISCHER / W. BÖRNER / M. GORIANY / L. KARLHUBER-VÖCKL (eds.), [Enter the Past]. *The E-way into the Four Dimensions of Cultural Heritage*. CAA 2003. *Computer Applications and Quantitative Methods in Archaeology. Proceedings of the 31st Conference, Vienna, Austria, April 2003*. *BAR International Series* 1227 (Oxford 2004) 286–290.

NUNINGER / SANDERS 2006

L. NUNINGER / L. SANDERS, *La modélisation des réseaux d'habitat en archéologie: trois expériences*. *Mappemonde* 83, 2006. <http://mappemonde.mgm.fr/num11/articles/art06302.html> [31 Dec 2007].

OŠTIR et al. 2008

K. OŠTIR / Z. KOKALJ / L. SALIGNY / F. TOLLE / L. NUNINGER, *Confidence Maps: a Tool to Evaluate Archaeological Data's Relevance in Spatial Analysis*. In: Present volume, 272–277.

POIRIER / TOLLE 2008

N. POIRIER / F. TOLLE, *Measurements of Diachronic Stability of Agrarian Exploitation*. In: Present volume, 281.



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