Archeologia e Calcolatori
9, 1998, 47-80

BEYOND GIS: THE ARCHAEOLOGY OF SOCIAL SPACES

1. GIS applications in Archaeology

In archaeology the 90s could be properly called the GIS decade. Geographical Information Systems have appeared as a new revolutionary tool-box to address many archaeological problems, handle and interpret spatially referenced data sets. Nevertheless, the growing use and increasing sophistication of GIS methods to manage archaeological data is not related to an increase in diversity. After two decades on a trial basis it is time to evaluate the current ability of GIS to meet the expectations placed upon them, especially concerning their role on archaeological method and theory.

The purpose of this paper is threefold. First, we want to summarize the main trends in Spanish GIS-based applications over the last years using a sample of the most recent bibliography. Next, to critically examine and evaluate the inherent shortcomings of some existing GIS applications. Finally, to review different underlying conceptions of space in GIS projects and to propose how such a software can be integrated into a proper theory of social space.

The large amount of GIS applications in Spanish archaeology which have been published during the last years makes difficult to summarize and quantify the main guidelines on this topic. We have only reviewed Spanish projects that have appeared in the most recent international bibliography (e.g. Johnson 1994; Hugget, Ryan 1995; Lock, Stančič 1995; Valdés *et al.* 1995; Wilcock, Lockyear 1995; Kamermans, Fennema 1996; Baena *et al.* 1997), as well as in the survey carried out on behalf of the Caere Project by Paola Moscati, in order to extract the most recurrent features of archaeological uses of GIS. In the next table we try to review the variability of GIS applications, their main objectives as well as the kind of data and techniques used to make archaeological explanations. Since this is not a comprehensive descriptive table but a synthetic scheme, there is obviously considerable overlap between the different research themes suggested here in terms of theoretical frameworks and kind of applications. That is the reason why the different sections we propose are not mutually exclusive since one single project may be engaged in more than one research area as well as sometimes some specific techniques not reported in this summary may have been used.

Among Spanish projects there seems to be some tendency to establish a dichotomy between cultural heritage management and historical research projects mainly due to political and economical reasons. However, practical applications show that both cases respond to the very same formulation:

GOALS	SCALE	DATA	TECHNIQUES
CENTURIATION	Intersite	Site coordinates; Remote Sensing; Satellite Imagery.	Gridding, hypotheses testing
EROSION MODELLING	Intersite Intrasite	Sites (surveyed field data); topographic data; geological data.	Mapping: Digital Elevation Models
HERITAGE MANAGEMENT	Intersite Intrasite	Sites (surveyed field data); historical record; archaeological data; ancient buildings	Mapping and database query; quantification and descriptive statistics; Risk Maps
HYDROLOGICAL MODELLING	Intersite	Sites (surveyed field data); historical record; topographic, geographic and hydrologic data; aerial photography	Mapping: Digital Elevation Model; Image Processing
LANDSCAPE ANALYSIS - Diachronic-	Intersite	Sites (surveyed field data); historical information; artefacts; environmental data; aerial photography	Mapping: thematic distribution maps; Nonlinear modelling, statistics
LANDSCAPE ANALYSIS - Synchronic-	Intersite	Sites (surveyed field data); artefacts; environmental data	Mapping: Digital Elevation Models, cost-surfaces, friction surfaces, statistics
LOCATION	Intersite Intrasite	Field survey data: sites, rock-art, burials, pottery, lithics, metal items, grinding equipment, etc.	Mapping: thematic distribution maps
PREDICTIVE LOCATION MODEL	Intersite	Site coordinates; burials; land use data; topographic data; geological data	Logit/Probit; ring analysis; stepwise linear regression
ROADS AND COMMUNICATION NETWORKS	Intersite	Historical information data (written, oral, archaeological)	Mathematical calculation of the “difficulty” of different alternative roads
URBAN/RURAL RELATIONSHIPS	Intersite	Site types; pottery types; metal detector finds; aerial photography	Mapping: thematic distribution maps, multivariate statistical analysis; Cost surfaces, DEM
VISIBILITY	Intersite	Environmental data (elevation topography); land use (historical record); archaeological sites (field survey data); ritual monuments, rock art, burials.	Mapping: Digital Elevation Model. QuickTimeVR, External statistics
EXCAVATION DOCUMENTATION	Intrasite	Artefacts; features, sediments, microstratigraphy	Mapping: Themathic distribution maps
IDENTIFICATION OF ACTIVITY AREAS	Intrasite	Pottery, bones, archaeological features, buildings, etc.	Mapping: Thematic distribution maps
SITE FORMATION PROCESSES AND SPATIO-TEMPORAL RELATIONSHIPS	Intrasite	Pottery, bones, features, degree of fragmentation, geomorphological and microstratigraphical data, vertical and horizontal stratigraphy	Mapping: Thematic distribution maps, three-dimensional maps

– *Heritage Management*: Its most common use is restricted to the location in space of archaeological sites and features using both archaeological information (e.g. count all monuments from the 12th century, count archaeological sites with stone houses, rectangular floor and three rooms, etc.) and "actual" information (e.g. list the total number of sites located near the A-17 highway, list sites which could be damaged by the construction of the Rialp dam, etc.). The main objective is to create local, regional or national databases with all recorded sites in order to prevent them from further deterioration and have a potential source of information for future survey and excavation projects. Therefore, in this specific area GIS software is basically used to create and maintain large databases, perform cartographically oriented database queries and mapping of archaeological elements. Although such an approach is descriptive, it is not theory-empty. The underlying assumption is that there should be a relationship between the archaeological features and modern constructions (communication networks, boundaries, buildings etc.). This relationship is called "spatial" because it deals with specific landscape features.

– *Archaeological Research*: In this field efforts have been basically directed towards the location of sites and features, but this time the structure of the spatial relationships becomes more complex. For example, we may count the number of sites located in a slope land that have a low erosion risk and a high agricultural productivity, and are less than 5 km far from a water source. Unfortunately, in these applications the relational structure continues to be based on the relationship between the archaeological features and modern natural or human constructions, since the geographical and ecological information which is used tends to be actual data. This choice leads to some problems which will be developed in-depth in the next section.

After a reading of the previous table it is possible to infer that besides the locational and cartographic works, which are not very different from those developed more than 50 years ago, the majority of projects carried out focus on the relationship between landscape and ecological, geographical, geological and archaeological factors, both in a synchronic and a diachronic temporal scale of analysis. It is assumed that the archaeological record has a spatial component which is not observable at a glance, and the role of computers and software is to enable the discovering of this complex network of spatial relationships. Consequently, it is easy to see that today's available computer software allows much more than the mere "cartography" of archaeological remains to be done.

Maybe the most interesting and promising field is the Predictive Location Methods in the context of planning, for the protection of the cultural heritage or as an initial preparatory stage in the organization of sampling survey schemes and some other research projects (García, Rodríguez 1996). These methods try to estimate the likelihood or the probability of archaeological site/feature presence, using patterns of known archaeological site locations in a region, by looking for correlations of the observed variable with other spatial variables (Kohler, Parker 1986; Carmichael 1990; Hasenstab, Resnick 1990; Kvamme 1990, 1992; Warren 1990; Della Bona 1993; Wheatley 1996). These variables usually tend to be environmental factors such as relief, elevation, slope, soil type, distance-to-water or geological substratum, whereas in the heritage field, variables tend to be related with modern uses of space: routes, dams, urbanization, etc.

The underlying theoretical frameworks may differ from these environmental approaches to more cognitive-symbolic studies which are specially focused on the perception of monuments in the landscape and how these elements communicate visual information. Among these approaches there are some applications of viewshed analysis such as the intervisibility between monuments (Gonzalez-Oubiña, in press), and some studies about the symbolic meaning of prehistoric rock art and ritual monuments (Bello *et al.* 1987), in which it is assumed that landscape is given significance by human perception. However these approaches are not essentially different from previous environmental landscape works, because they are still based on the measurable properties of the environment.

Another possible distinction that could be established among Spanish GIS-based applications is:

– *National-International Large Scale Projects*: These are related to the cartographic management of large databases in which "large" means lots of thousands of records, but a very reduced quantity of descriptive variables for each record. These big projects are more related to the cartographic aspects of GIS and the creation and maintenance of databases than a spatial analysis in the strict sense. The most typical large national project is the Cultural Heritage Management project.
– *Research Small Scale Projects*: These are mainly focused on landscape analysis and modelling as well as the correlation between society and landscape features. These projects are always restricted to relative small and well delimited areas, which involve the use of small databases, in which "small" means few records, but a lot of descriptive variables for each record. These uses of GIS software tend to go beyond the simple examination or location of places in a map, trying to model the spatial component of the archaeological record. Some typical examples of this type of projects are the site catchment and site territory exploitation analyses of one single site or the landscape modelling of a concrete area.

Usually GIS-based applications are related to macro-spatial scale projects (inter-site or regional), because they are focused on environmental and geographical issues. However, intrasite projects are less common. This fact is not due to the lack of suitability of GIS software to deal with intrasite spatial problems, but to the usual characteristics of inter-site archaeological information; large databases, large surfaces and environmental variables which are directly available in a GIS framework. Archaeological excavations usually cover small areas, where the amount of collected data tends to be smaller and at the same time environmental data have not the same significance to explain internal spatial organization.

A related problem is that intrasite spatial analysis is linked to the American quantitative tradition and some applications might require specialized algorithms that may not exist in commercial GIS packages. However, these technical problems are not inherent to intrasite spatial analysis and as we have recently pointed out (Barceló, Pallarés 1996) nowadays there are different possibilities to integrate formal statistical analysis in GIS framework. Therefore, neither technical problems nor the size of data sets are consistent objections to fail to take advantage of GIS potential to manage, process and analyze intrasite archaeological data. Some recent publications are beginning to apply GIS at the intrasite level, manage the documentation in archaeological excavations, reconstruct site formation processes and try to identify activity areas (e.g. Biswell *et al.* 1995; Meffert 1995; Theunissen 1996). However these intrasite applications have not yet exploited the full potential of GIS and do not tend to go beyond the scope of the descriptive distribution mapping.

The choice of the available GIS software to perform data management and analysis responds as well to this double typology. On the one hand, some big powerful programmes such as ArcInfo are used because they are suitable to manage and mapping large databases, on the other, programmes such as IDRISI or GRASS in which the analytical capabilities (tools for spatial analysis) are more important than the ability to manipulate large amounts of data.

In relation to the analytical techniques which have been more commonly applied in GIS-based analysis, a quick look through the table shows that analysis is normally restricted to mapping, in its different forms – distribution maps, thematic maps and three dimensional maps – together with some restricted analytical procedures such as polygon overlay, buffering, interpolation, zoning, digital elevation models and cost surfaces. In some cases some univariate and multivariate statistical techniques are applied outside the GIS framework and their results are projected onto a GIS layer.

Apart from the practical applications which have been taken into account in the previous discussion, in the latest years there has been an increasing debate concerning the analytical capabilities and the underlying theoretical basis of many archaeological GIS based analyses (e.g. Wheatley 1993;

Gaffney, Van Leusen 1995; Gaffney, Stančič, Watson 1995; Harris, Lock 1995; Verhagen *et al.* 1995; Barceló, Pallarés 1996; Gillings 1996; Voorrips 1996). However, very little attention on these topics has been paid by Spanish archaeologists. These contributions reflect that GIS has reached a stage of maturity and that before continuing with some mechanical applications it is time to pause and evaluate the work carried out in order to face GIS future successfully.

2. A critical view of GIS technology

As we have previously seen, GIS software is used to "discover" a relational structure (proximity in the physical space) which cannot be observed without a "scientific" instrument. Recovering and describing the spatiality of archaeological phenomena is a very ancient goal, which can be already found in Kossinna, before the Second World War. The only difference is that at that time maps were drawn by hand and today maps are drawn by a powerful computer. It is important to realize that the map is the instrument, and not the computer.

During the 50-60s, archaeologists continued believing that maps constituted the basic interpretative tool in archaeology, because at that time the social dynamics were considered a mere product of the movement and replacement of populations. Any observable change in the archaeological record was attributed to a population movement. So, the creation of cartographies with the different idiosyncratic types of archaeological materials enabled the modelling of migrations and, therefore, the reconstruction of historical dynamics.

Since the 70s this theoretical framework was replaced by an approach which explained archaeological changes by means of their correlation with ecological changes. Mapping enabled to mark out "site-catchment areas" within which economic resources could be evaluated and quantified. The prevalence of paleoecological underlying orientation in actual GIS projects demonstrates that this paradigm is not yet overcome. Although these projects should be oriented to the study of the relationship between Society and Space, this objective has been replaced by the relationship between Society and Landscape. The concept "Landscape" is considered as the humanization of the physical space, that is, the necessary resources that human societies "use" from the surface of the earth for their survival and reproduction.

From our point of view, there are some evident inherent constraints and conceptual errors in GIS-based applications which try to study the correlation between Society and Landscape throughout time. First, there has been some confusion and misunderstanding using the concepts of "territory", "landscape" and "social space". Space has been artificially restricted to the notion of Landscape which is likewise erroneously defined. Although evidences of past human action are relatively clear (the archaeological record), evidences of past landscapes are not so easily observable due to the many different processes that have acted upon them. As well as human society, the landscape has been continually modified and changed by successive cycles of transformation throughout time. It can be buried, eroded or modified by geological-geomorphological processes as well as anthropic activities such as the very sequences of successive human occupations. Despite these circumstances the ancient landscape is usually estimated by means of the elements we know from the actual landscape, incoherently assuming that men and women acted in the past upon the same landscape in which we actually live and act.

This correlation between ancient society and landscape is more significant in the Cultural Heritage Management (rural and urban planning), because in this case the study is focused on the risk that actual social actions damage or destroy evidences of past societies. CHM has been frequently underestimated because of the inherent political and economical interests related to its exploitation as well as its data-acquisition orientation, in contrast to research projects, more focused on data-analysis. However and paradoxically its underlying assumptions are more accurate because they pretend to conserve and prevent actual cultural landscape from actual social actions, and thus they are adequately using actual geographical-ecological data. These uses of GIS are closer to the original geographic conception of GIS technologies. Nevertheless, in historical research we are dealing with a different object of study, the spatial component of past social actions, and thus the correlation between ancient society and actual landscape has less significance.

Within the archaeological GIS-based projects summarized in the table it is usual to define territory as the set of natural resources located within a site-catchment area or a site exploitation territory. The objective of this sort of analyses is to evaluate and quantify the potential resources of the territory in which a settlement or production area is located, assuming that distance to resources determines site location. These approaches to land-use strategies, borrowed from geographic economical theory, assume that subsistence and productive activities are reduced to a rational economic behaviour which is a consequence of the human capacity of ecological adaptation to the environment. Proximity relationships are defined in different ways, both using an arbitrary radius (5 m/10 km) around sites and calculating the distance covered by an adult 1 or 2-hour walk. GIS software includes some sophisticated methods to automatically define these areas by calculating buffer zones, cost-surfaces, slope maps and degrees of accessibility. All these operations are performed by means of actualistic parameters such as: actual fertility of soil, topography, erosion risk, actual exploitable resources, actual water sources, actual distribution of vegetable species, actual rainfall and sunshine, etc. (e.g. GAFFNEY, STANČIČ 1991; KVAMME 1992; BAENA *et al.* 1997). These analyses disregard the fact that the articulation of sites and archaeological features is not necessarily testable with this kind of data.

Moreover, these uses of GIS which produce models that focus on relationships between regional site distribution and mappable attributes of the environment reflect an environmentally deterministic approach to archaeological explanation (WHEATLEY 1993; GAFFNEY, VAN LEUSEN 1995; HARRIS, LOCK 1995; BARCELÓ, PALLARÉS 1996). The easy of use and the visual graphic spectacular quality of GIS software has led archaeologists to choose the simplest way: working with environmental ecological variables that are relatively simple to map and which easily fit the prevalent GIS data model and correlate them with archaeological information we will get cheap and spectacular results. Unfortunately, these applications do not pay enough consideration to whether these data sets are adequate to explain real prehistoric socio-spatial organization. Used in such a way, powerful computer programmes are counter-productive.

The error is not in the toolbox or the techniques but in the way people use them. Archaeologists are using these simple and reductionist approaches not because they fit the prevalent models of social dynamics but because they are the more suitable for a simple way to work with the actual GIS software. However, GIS does not impose a conceptual model neither a specific kind of interpretation. The results of its application depend only on the questions formulated by the researcher (previous hypothesis) and on the reliability of available data.

If we had some reliable information about the landscape characteristics in past times, even for that periods without a written record about weathering and the productivity of human endeavour in the landscape, this paradox could be solved. In some cases there are some attempts to evaluate the paleoenvironmental side of the relationship between society and landscape by means of really ancient paleo-ecological data (e.g. LÓPEZ *et al.* 1991; VAN DER LEEUW 1995), and this is probably the most profitable research area. However, we must take into account that there is something else than the relationship between archaeological and paleo-ecological data and this "something else" is what seems still to be out of the scope of GIS software, as they have been commonly applied.

So, actual attempts to establish a correlation between society and landscape are heading for disaster, not just because of the common inadequate use of actualistic data, but because of the inaccurate conceptualization of the same correlation. Until recently, classical GIS spatial analysis has mainly focused on assuming that spatial patterns are a product of ecological adaptation, but are independent from its social context. This argument is a consequence of the widespread assumption that the development of preindustrial societies is inextricably linked to the land and then cannot be wholly understood outside the context of relationships between societies and natural resources. However, a site-catchment area is not comparable to social space. It is only that piece of exploitable natural space within the reach of a human group. Even though almost all social scientists consider that the spatiality of social action is something else than the mere accessibility to exploitable natural resources, archaeological GIS applications seem to be far from this assumption, to the point that most of GIS models that have been summarized in the table involve such an artificial reductionist and erroneous conception of the spatiality of social actions.

Recently, some authors seem to think that given the inferential linkages between past landscape use and social relationships, archaeology can benefit from an approach that more explicitly delineates relationships between systems of land use and land tenure, the social means through which people define and assert land use rights (Adler 1996). Conceived in this way the "territory" is not only the amount of natural resources, but a socialized natural space, that is, a space transformed by social actions carried out by a human group. Territories are spatial units that encompass the broadest range of a society's land-use behaviours as well as the history of human interactions with the natural landscape (Gili 1995; Castro *et al.* 1996; Adler 1996; Zedeño 1997). They are spatial units that result from the cumulative use of land and resources through time. All realms of societal life involve human-land interactions, a large number of which modify the landscape permanently. They can be studied using GIS software because they are aggregates of three kinds of objects: land, natural resources and objects of human manufacture.

Although this conception of territory and social space entails an improvement with regard to classical site catchment analyses, they do not mirror the multidimensionality of social space. In the next pages we will try to prove that landscape is interesting only when viewed as something constituted, reproduced or changed by social relations, and in turn constraining the unfolding of such relationships (Couclelis 1991). Therefore whichever analysis of a social reality might distinguish, following the proposal by Lefebvre (1974), between:

– spatial practices (our perceptions);
– representations of space (our conceptions);
– spaces of representation (lived space).

The basic idea we defend is that space forms an integrated part of social practices and/or social processes, and that such practices and processes are all situated in space (and time) and all inherently involve a spatial dimension (SIMONSEN 1996). Conceived in this way, relationships between Society and Landscape are much more complex than actual GIS-based applications pretend. The possibilities and inherent constraints on how to isolate, measure and record digitally the variables relevant to social theory in a GIS framework will be developed in next sections.

3. TOWARDS A THEORY OF SOCIAL SPACE

As we have previously seen, the structure and form in which GIS packages are used condition the sort of spatial relationships which archaeologists are able to discover. In these pages our objective is to try to provide the basic constituents for a theory of social space which may give meaning to logical operations performed by GIS software. In face of the actual differentiation between materialist theories – whose objective is the study of the social uses of the natural space (productive activities) –, and idealist theories – focused on the symbolic conceptualization of the perceived space –, we have decided to adopt a more global approach which integrates in a homogeneous theoretical framework the most significant elements of the different theories.

According to the materialist theory (CASTRO *et al.* 1996), the geographic space contains a series of natural elements which shape it and at the same time are indicators of its environmental conditions. In other words, the geographical space is the set of natural elements (including social agents) and the spatial relationships between them. As a consequence of the human action upon the geographical-natural space, space acquires a social meaning because of the appropriation of natural matter by men and women. In other words, production, distribution and consumption take place in a physical space, and as a consequence this physical space becomes transformed, socialized.

Therefore, to a strict materialist approach social space is an abstraction from the relations between its constituents (resources, agents, means of production) (SAYER 1985; SCHATZKI 1991). The analysis is focused on the interaction between social agents and how this interaction is conditioned by the relational structure between the same social agents (social distance based on the access to the means of production). However, very little attention is paid to spatial relationships (topological, metrical, qualitative) which link or detach non-productive activities performed by the different members of a community. From such a conception, features of space are thus little more than epiphenomena of non-spatial social processes, the mere territorial projection of the social relations, and particularly the relations of production (GOTTDINER 1991, 1994).

The point of departure of idealist theories is exactly the opposite, considering space as a mental cognitive design (e.g. Thomas 1991, 1996; Bender 1992, 1993; Werlen 1993; Pearson, Richards 1994; Tilley 1994; Wheatley 1995). Space is conceived as a cultural manifestation of mental processes and structures, but unlike structuralism, these structures are not universal but particular, contextual and historical. Attention is paid to the individual rather than to social relationships. Thus, the same space can become different settings, that is, it can be used differently and mean different things, at different times, which is tantamount to the organization of time. The different ways in which a space is organized can be understood as a physical expression of cognitive schemata, which are culture specific and become fundamental to understand the spatial organization (Rapoport 1982; 1994).

Idealist theories focus on the study of the spatial causality of any individual action. These actions are always performed according to a particular intentionality (individual intention) and thus, with a directionality (Werlen 1993). Approaching to the directionality of social action leads directly to the study of places of attraction, centres of activity, human significance and emotional attachment. In this sense the concept of space appears as a more abstract construct which only provides the situational context for places but derives its meaning from particular places and actions which took and are taking place within it (Relph 1976; Tilley 1994).

Whereas to the materialist theory the prime causal factor is the whole of productive actions and their attached social relations of production (acres to resources, land appropriation, etc.), to the idealist theory the whole of social actions, both productive and unproductive, are taken into account because all of them take place in a geographical space. In this case what determines the structure and nature of social space is the movement through space, the directionality, the individual motivation and the place in which different actions are performed as well as the place in which the performance of some specific actions is forbidden. The consideration of the individual "motivation" as one of the fundamental constitutive factors of social space leads to its individualisation and its multiplication. So, the social space is just a social agent's personal conceptualization of the spatial location of the physical (natural and artificial) and social (other agents) elements which surround them.

In this way, to postprocessual theories, the landscape is analogous to a multidimensional text which is continually altered, read, written and interpreted (Duncan, Duncan 1988; Thomas 1991; Tilley 1994, etc.). Monuments and architectonical features are considered as the equivalents of written discourse, as elements which are inscribed in a specific landscape as parts of a chain of signification. The physical and geographical space is transformed into social, as a result of its symbolic appropriation by social agents. This symbolisation depends on the accumulation of individual and collective experiences (not necessarily productive) of every place in which some meaningful actions have been performed. So, there is not one single natural landscape, but multiple subjective landscapes, which are significantly built in relation to human action and activity. The meaning of a particular space depends on who is experiencing it and how, and thus it is a result of social practice (Tilley 1994). Therefore, the experience of space is not innocent and neutral, but invested with power relating to age, gender, social position and relationships with other individuals within the community (Foucault 1975, 1977; Thomas 1991; Tilley 1994).

Even though we cannot underestimate the role of symbolic factors in the construction of a theory of social space, accepting individual motivation as the only explanatory factor is too limited to provide a full sense of social action. These subjective images of space are just one of the constitutive elements of social space. As Gosden (1994) has pointed out, the symbolic aspect of the landscape is derived from the actions carried out in it. Unlike this approach, we think that space is produced, experienced and shared by a series of individuals which exist in society, and thus are affected by social relationships. Space may be defined in the minds of social actors, but always as an answer to specific social actions, which are performed according to the social relations of production (Gottdiener 1991). Reducing space merely to a coded message and reducing science to a representation of that code, avoids the actual knowing of space, that is to say, the generative process through which this coding was constructed and produced (Swyngedouw 1992).

The different theoretical paradigms which have been previously approached deal with the following dimensions of space:

1) A *natural space* which is given shape by the existing exploitable resources, that are geographically arranged according to distance and proximity relationships. Natural space is thus independent of social action but it has its own internal dynamics.

2) A *social space* which is given shape by social agents, who are spatially arranged according to social distance relationships between them. This social space has two different manifestations:

2.1. The *territory*: It corresponds to the socialization of the natural space and consists on the management (planned or not planned) of the materiality (natural resources) which social practices demand (Adler 1996; Castro *et al.* 1996; Zedeño 1997). Thus, it is a socialized physical space where the set of human relationships are performed. Modern references to land tenure systems (Adler 1996) might be included in this section. Land tenure systems are complex risk-buffering strategies that are conditioned by the labour invested in food production, the size of groups holding direct access to productive lands and resources, and the temporal duration of land access rights (ADLER 1996). Conceived in this way land tenure systems comprise sets of social strategies that human groups develop to alleviate environmental uncertainty by socially circumscribing human use of productive resources. Therefore, land tenure can be generally defined as the systems of rights and privileges that human groups use to protect their resources and resource areas from outsiders.

2.2. The social landscape, which from a materialist approach corresponds to the symbolic universe by means of which a society perceives the social space (CASTRO *et al.*, 1996), and from an idealist approach is the multiple differential individual experiences of the social space (e.g. THOMAS 1991; BENDER 1993; TILLEY 1994).

Theoretical discussion on the conception of social space has been largely fuelled by a dichotomous polarity both in archaeology and other social sciences between these materialist and idealist approaches. Although the inherent subjectivity of idealist theories have been largely criticized by the processual archaeological community, materialist approaches are not significantly better, because of their empiricist conception of space, as a "natural" observable entity, and as a mere implicit background for human action.

From our point of view social action should not be seen as secondary and dependent on the environment and the original distribution of resources in space, because it embraces the whole set of imaginable formes of interaction between social agents. Likewise social space might not be restricted to the mere socialization of a natural space, but it is the very social action which creates its own social space. So, we defend a theory of social action which highlights the topological network of social actions as the principal dimension of social space. From this theoretical point of view, social space is conceived as «any network of spatial relationships linking any set of social units» (BARCELÓ, PALLARÉS 1996). Social units are both social agents and social activities, in such a way that there will be many different and simultaneous social spaces: the social space of productive activities, the social space of reproductive activities, the social space created by war, the social space created by exchange, etc. Conceived in this way social space is not absolute but relational. It depends on the underlying network of social actions, that is the interrelations among objects, objects and individuals, individuals and individuals, individuals and activities, as well as on the dynamics (ecological, geological) of natural space. All these relationships are creating/defining space and time, as well as the spacing (and timing) of phenomena also enables and constrains the relationships themselves (MASSEY 1992).

The first social action is, obviously, the appropriation of natural resources to allow the social agent survival. This action takes place on the surface of the earth (container of both the natural resources and the social agents), but it creates a specific form of social space. There are also unproductive actions (killing a neighbour, participating in a ceremony, etc.) related to the social reproduction of social agents and their community. These actions are produced not only on the surface of the earth, but on a social space produced by a previous social action (in this case, the preliminary appropriation of subsistence goods) as well. When the same social agent repeats the one "productive" action, it will be performed not in the preliminary social space, but in a social space transformed by whatever previous action. All these statements mean that the web of social actions and relationships take always place in a natural space which has been transformed into a social space by previous social actions. The temporal sequence of productive and reproductive actions create a complex topological network of social actions and social agents in different temporal and spatial locations. Therefore, from this theoretical point of view, space is both social and natural, but more social than natural, because social relations are the main causal factors of social action. Social interaction is then the main key to understand how social agents act in a social group, and these causes are not only subsistence based, but reproductive in their broadest sense (social and not biological).

Therefore, unlike the static conception of space maintained by the extreme materialist approaches, we defend that there is neither any social structure nor spatial ordering of social actions which can be defined as a fixed entity. Relational structure of social activities is not constant neither static, but it is dynamic because it is produced not only in space but throughout time too. From such an approach space and time cannot be seen as abstract qualities providing the medium of social action, but rather as dimensions created through the concrete operation of social actions (Gosden 1994). So, the continuum of social actions in time and space constantly have an affect on previous spatial arrangements, conditioning next social actions and constituting the dynamic nature of any social relationship. The assumption that the social and the spatial are inseparable and that the spatial form of the social has some effect in subsequent social actions is now accepted increasingly widely, especially in geography and sociology (e.g. Lefebvre 1974; Soja 1980, 1985, 1989, 1996; Gregory, Urry 1985; Gottdiener 1991, 1994; Massey 1992; Simonsen 1996).

According to this theoretical approach, space is not just a property ("location", "distance", etc.) of a social activity, but it has to be conceptualized as a dimension of social action and thus as the social possibility for engaging in action. The spatial distribution of natural resources are not the causal factor of social action, but social actions are the cause for other social actions. Social space is the omnipresent precondition for the developing configurations of activities that partly constitute the relational dimension of social spatiality (SCHATZKI 1991). Thus, social actions exist insofar as they are inscribed in space and in this way they produce space. But this space, as a material product of a social process acts back on social processes limiting, constraining, and providing use values for the next moment so that both action in space and the action of space produce a society's unique environment (LEFEBVRE 1974; SOJA 1989; GOTTDIENER 1991, 1994). Space is therefore simultaneously material object or product, the medium of social relations, and the reproducer of material object and social relations.

4. AN ARCHAEOLOGY OF SOCIAL SPACES

As we have previously discussed, social space cannot be only reduced to the empirical reality of the world in which we live or to the social uses of natural resources we need to live. Social space denotes any set of entities (in our case, social agents) to which may be attached associated attributes or properties defined on that set. To become "spatial", a relationship should be based on any quantitative or qualitative property of data varying spatially, that is, whose value varies from one entity to another with some appearance of continuity, and which contribute to explain the dependency relationships between those entities (MATHÉRON 1965; CRESSIE 1991; VOIRON CANICIO 1993; BARCELÓ, PALLARÉS 1996).

Different essays have been undertaken in order to characterize the basic spatial properties, from which the remaining spatial relationships derive. One of the possible strategies developed is to make the same kind of distinction that has been used for the temporal sequence, by means of the two axes of a Cartesian coordinate system. Object boundaries are then projected onto the two axes and a pair [x-Relation, y-Relation] is used to give the relative position of objects (HERNANDEZ 1994). Location is, therefore, the key concept because all other relationships (distance, orientation, etc.) can be obtained from it. As well as location in time is relative, location in space is also relative, because the Cartesian coordinate system does not exist in real space, but it is only an analytical convention. However, there are some fixed reference points both in the temporal sequence and in spatial ordering. Once a fact has been produced in a moment, it can be used to measure the temporal distance (according to an artificial scale of time) from other facts. The same is possible with spatial locations. We call geo-referencing to the construction of this fixed objective reference points, usually on the basis of the physical features of the landscape (natural space) whose existence is independent of social actions.

Spatial representation (a map of locations) is then a model of reality. Spatial relationships between archaeological entities do not exist in real world as empirical laws of nature, but they become a means for describing the ordering of units and the way in which some properties of units vary from one location to another.

We define an *array* as any collection of entities (varying spatially or not), a pattern as any ordered array, and a *structure* as any set of relationships (spatial or not) between entities in a pattern (Loeb 1976). But the main spatial unit of analysis is the *arrangement*, that is the order in which spatial locations (represented as points in a surface) appear on a view when scanning it from, say, left to right from an embedded point of view (Hernandez 1994). So, whereas "structure" can be referred to any relationship of ordering, spatial or not, an arrangement is only a spatial ordering of locations.

We call spatial analysis the analysis of the pattern of spatial regularities among locations in an arrangement. In our case, we are studying the spatial variability of social actions. Making things, using things, exchanging things or people, killing people or animals, breeding animals, herding, cutting timber, celebrating ceremonies... all these are examples of social actions, and they are performed in the landscape and they spatially configurate a social space. In other words, our objective is to analyze how a social action "varies from one location to another", and if there is some kind of regularity in this spatial variation. We are enlarging the usual materialist definition of social space, considering the location of all imaginable social actions, and not only productive actions. As we have stressed along this paper, "space" is not only the location of resources and "social space" is not only the social uses of these resources, but it contains the spatial properties among all social actions, and how this spatial structure conditions and determines the realization of other social actions. We are studying social interaction, that is, how people contact other people, the causes of these contacts, and their consequences (social inequality, power relationships, etc.). We are conscious that social interaction is mostly a product of social division of labour, but this division is not expressed only through the use of natural resources but as a pattern of differences and dependencies among social agents, and a flow of things (labour instruments, raw products, manufactured products) and information among social agents linked by a network of spatial dependencies. Consequently, an analysis of the differences and dependencies among the location points of social actions should give us a better representation to understand how social interaction is built and reproduced, as well as the consequences of the specific means of interaction adopted.

The shape and intensity of the spatial variability of a social action and the spatial correlation between different social actions can be described geometrically, calculating the ordering of points (location of social actions) by means of different distance metrics: euclidean (Minkowski, City-block, Mahalanobis, etc.) and non-euclidean. But it is also possible to "verbally" describe and classify the same pattern of regularities among locations, using the same spatial prepositions than in natural language (e.g. near, at, in, on, between), or even in a more complex way (left of, attached to, overlapping, inside, etc.; cf. WASSERMAN, LEIBOWITZ 1983; LUX, RIT 1988; EGENHOFER, FRANZOSA 1991; HERNANDEZ 1994). In other words, we can describe and measure:

– topological relations (how the boundaries of two or more social entities relate) between social agents, social actions and/or social agents and social actions;
– metric relations in terms of distances and directions between social agents, social actions and/or social agents and social actions;
– qualitative relations concerning the partial and total order of spatial objects between social agents, social actions and/or social agents and social actions.

Archaeologically we only have an ambiguous and uncertain evidence of an action and the location where it was once performed. An arrangement of bones is not a direct evidence of a hunting or butchering primary activity area, because different agents including biogenic, geogenic and anthropogenic processes can have acted upon the original arrangement altering or transforming its original structure. In spatial analysis it has been very often assumed that artifact concentrations can directly "map" activity areas. From these kind of approaches material concentrations have been used as a good surrogate for the location of spatial actions.

Nevertheless, it is important to consider that any pure inductive approach cannot directly reconstruct the social action on the basis of its material correlates. First, spatial distribution of artifact location does not necessarily reflect activity organization, since more than one single process can have contributed to the formation of archaeological spatial distributions. There is a big variety of transformational process with different dimensions and temporal rhythms that can have acted upon the archaeological record, disturbing or erasing any traces of the original relationship between social actions and their material correlates. Second, the archaeological record is not the result of one single action which can be easily isolated, but of a combination of social actions. The manufacture of a pottery vessel, for instance, is the result of a complex network of interrelated actions which leave some evidences on the final artifact spatial arrangement. Consequently, if we use "activity areas" as surrogates for the location of social actions, we should take into account the fact that:

– activity areas are not simple partitionings of physical space (the surface where the action is supposed to have been performed), but dispersed arrangements of points, with more or less structure, in which different ob-

jects and features are distributed into spatially distinct units or loci, each corresponding to a single social action or group of related actions and activities;
- activity areas are not necessarily restricted to specialized spatial units but the most of times they are agglomerated or multifunctional spatial units, characterized by the overlapping of different social actions.

Consequently, a single map of artifacts cannot be used as a surrogate for a map of social actions. Instead, we propose a deductive approach whose objective is not to perform a partition of "natural" space in activity areas, but to create a spatial distribution map with the probability for an action.

As in any deductive approach we start by obtaining some knowledge about the specific relationship between artifacts and social actions (by middle-range research: ethnoarchaeologically or experimentally), for instance, the spatial distribution of animal bones is related with the social action of hunting in a way *x*. The same distribution of bones is related to the social action of butchering in a way *y*, etc. Or in the macro-level scale, the spatial distribution of sites of type *T* is related to the social action of "access to a territory" in a way *z*, or the spatial distribution of pottery of type *P* among sites of type *T* is related to the social action of exchange in a way *w*. Consequently, we will not obtain a map showing the hunting, butchering or exchange areas (regions where these actions were performed), but a map with the probability that in location *L* an action like hunting, butchering, or exchange has been performed. Instead of a a single map with different activity areas, we should build a map for every social action.

Once we have hypothesized the relation between the formation processes of the archaeological record (social actions which originated a specific artifact type), we can transform the artifact location points in a map with the probability of that action. What we are proposing is nothing more than the translation of the uncertainty of social action location into a probability; the presence of many sites with uncertainties leads to cumulative probabilities, so that one then finishes up with a map of fuzzy sets, that can be adequately represented by isopleth (contour) maps, or as perspective diagrams.

This is not a totally new perspective, because it partially agrees with some postulates defended by WIEMER (1995) and with the underlying philosophy of Predictive Location Models, which also try to estimate the likelihood or the probability of archaeological site/feature presence, using patterns of known archaeological site locations in a region, by looking for correlations of the observed variable with other spatial variables (e.g. KOHLER, PARKER 1986; CARMICHAEL 1990; HASENSTAB, RESNICK 1990; KVAMME 1990, 1992; WARREN 1990; DELLA BONA 1993; GARCÍA, RODRÍGUEZ 1996; WHEATLEY 1996).

Our approach relies on a prior hypothesis of spatial smoothness, which considers that two neighbouring observations are supposed to have been more likely originated from the same group than two observations lying far apart. In other words, the probability that a social action occurs at a specific location is related to the occurrence of its material effects (archaeological record) at nearby locations, and the probability of measuring the same value decreases with increasing distance from the sample location. Admittedly artifact distributions are discrete, but post-depositional mixing processes may make it reasonable to treat artifact densities as more-or-less continuous.

All these assumptions are sound from a geo-statistical point of view. In geographic units data are tied together, like bunches of grapes or balls in an urn. According to Tobler's First Law of Geography (Tobler 1979; Anselin, Getis 1992): "everything is related to everything else, but near things are more related than distant things". This statement simply implies that we should expect stronger probabilities where artifacts have been found closer and in more dense accumulation.

Nevertheless, although these assumptions are correct from a geographical perspective, they are wrong to an archaeological approach, because spatial properties of social actions are not necessarily similar at nearby sites in space. In other words, the archaeological record is not distributed continuously along the physical space, because the social actions which produced it were performed "discretely" over the same physical space. In Geography and Geo-Statistics, it is assumed that data point locations are only a piece of the original information, consequently contour maps are developed to infer values at particular places between the sampling points. Geographical information (land use, mineral resources, etc.) have a continuous nature and therefore inductive methods that generalize from partial information are adequate. However, archaeological information is intrinsically discrete. Social action is not performed at different degrees over a surface but in specific locations in which its material consequences appear. However, most of the remaining surface has not any evidence of the social action, because it was not performed there. Geostatistical methods would perfectly fit archaeological purposes if social space was continuous (all infinite points in the surface had a "degree" of the social action), but this is not the case.

However, geostatistical tools can be of great utility in archaeology if we do not use them in order to cluster artifacts and get a map with the location of social actions, but as a method to translate some uncertainties in terms of probabilities, because this measure is a continuous function. In order to undertake such an approach we need:

– to hypothesize the relationship between the action and their material correlates, defining all actions which produced this particular archaeological record;

- to analyze the precise location of all social actions related to the archaeological record;
- to correlate the location of different social actions in order to define hypothetical locations for activity areas;
- to consider the time/temporal variable and its effects on the extension and nature of the activity area.

An "activity area" is not the place with the highest artifact quantity or diversity, but the place where a series of related social actions have been performed. The fundamental step of the analysis is to determine the proper relationship between the action and its material correlates in the archaeological record. If we cannot obtain such an information (of hypothetical nature) our analysis will never overcome a descriptive level. Geo-statistics should not be a substitute of the adequate theoretical analysis, but can be useful as a tool to express and test hypothesis about the archaeological record.

Our insistence on "probabilities" is a consequence of this deductive framework. A probability map is nothing more than the mathematical representation of a hypothesis. We use this procedure to test the hypothesis against other data or other hypothesis, for instance, the probability map of other social action that should be related to the first one.

Standard spatial analyses (with or without GIS software) tend to finish when the analyst obtains by means of Thiessen-polygons, contour maps or some partitive quantitative algorithms a partition of the physical space, which is used as a surrogate for the activity area. However, from our point of view the analysis does not finish with the construction of a probability map, because these maps explain only the uncertainties of social action location, and they might be used as fuzzy entities (surrogates for precise locations) in subsequent analyses (the spatial correlation of social actions).

5. GIS software and the archaeological study of social spaces

The analysis of social spaces might be approached from three steps:

- mapping the location of social actions;
- describing the topological properties of any (spatial) arrangement of social actions;
- calculating the spatial correlation (correlation of location points) between different social actions.

In the previous section we have discussed that we cannot accurately locate past social actions, because of the indirect relationship between the location of a specific action and its material correlates. In this chapter we want to demonstrate that GIS software can be very useful to work with maps of probabilities of such actions as surrogates for the location of these actions.

We have also stressed that probability maps should not be equated to activity areas, because an activity area is a very complex spatial entity where more than a single social action was performed during a period of time. Probability maps are synchronic representations of a single action in a fixed moment. Activity areas may be defined by an adequate processing of preliminary probability maps. Once we have made deductive assumptions about the relationship between social actions and their archaeological material correlates, and we have calculated the probability maps of all social actions involved, spatial analysis follows by analyzing the ordering and topological relationships existing in every single map. The goal is to detect any evidence of spatial dependence among the different locations where the action was "probably" performed. If a high or low probability of a social action *A* (for instance exchange) in a location *L* is related with a high or low probability of the same social action in another (maybe neighbour) location *LL*, we will conclude the existence of spatial dependence.

Why is so important the detection of spatial dependence? Because it allows to measure the degree of spatial continuity (uniformity/evenness) in the performance of a social action. Some social actions may have been produced in a centralized way in a single location, whereas some other actions may have been performed simultaneously in different locations, in a distributed way. These differences are important to evaluate the causal effects of social actions and how they contribute to define social spaces. Topology is the study of continuity. A topological space is thus one in which the only relevant spatial relationship is contiguity. Some important definitions for this conceptualization are the following ones:

- a regionalized variable is a function of space whose value varies from one location to another with some appearance of continuity, but this continuity cannot be approached by any linear law (Mathéron 1965; Voiron Canicio 1993);
- a field is a region which from the point of view of the phenomenon studied has some kind of homogeneity. In this region we accept the hypothesis of stationarity, that is, in the field spatial variation laws are the same everywhere (Cressie 1991).

GIS software allows the description of these spatial entities using:

- geometric variables such as distance, length, perimeter, area, point-location intersection and union;
- topological operators such as neighbourhood, next link in a polyline network, left and right polygons of a polyline, start and end nodes of polylines;

– spatial comparison operators such as intersects, inside, larger than, outside, neighbour of, etc.

Consequently, we are trying to discover the existence of continuous areas linking all locations with the same value on the probability function (Wall 1972; Sims 1976; Husain 1977). If physical space can be partitioned in this way, we will infer the existence of a spatial dependence structure in the arrangement of locations for those social actions. It is important to realize that the goal of spatial analysis is not to produce a list of geometric properties of the arrangement of locations. The shape (borders, continuity, neighbourhood relationships) of the arrangement should explain us something about how the social action was performed in space.

Spatial properties of a single action are important in themselves, but specially because the social space, that is the arrangement of the social action locations, conditions and determines the performance of other social actions. Therefore, the main objective of spatial analysis is the spatial correlation of different social actions: how the spatial distribution of an action has an influence over the spatial distribution of other(s) action(s). We want to discover if high or low probabilities of action A are related with high or low probabilities of action B in the same location or in neighbouring locations. The result is also a measure of spatial dependence, but now at a multidimensional level: dependence among locations is not the product of a single action, but a multidimensional set of social actions.

GIS software is specially good for this task. Its main feature is its capacity to overlay different arrangements of geo-referenced points, and this is exactly what we need. Spatial correlation should be calculated by overlapping probability maps of different social actions, once these maps have been geo-referenced to the same coordinate system.

Specially relevant for us are the possibilities to compute mathematical and boolean operations with points and clusters of points (arrangements, regionalized variables and fields, see *supra*). This paradigm is based on the MapAlgebra formalized language for expressing GIS functions developed by C. Dana Tomlin (Kirby, Pazner 1990; Tomlin 1991, 1994; Mills 1994). Raster-based Layers in Map Algebra are sets of georeferenced numbers that represent geographical features (rivers, elevation, soil types, etc.). In our case, a probability map can be defined as a layer too, because its georeferenced numbers represent the location of a single action. Here representation is raster-based because data (social actions) cannot be expressed in spatial objects such as points, lines, polygons, or networks, but through spatial "qualities" such as distance, direction, narrowness, density, rate of change, etc. (Tomlin 1994).

The core of MapAlgebra language consists on a set of operators to mathematically combine different layers. Here, interpretive capabilities are organized much like data: in elementary yet complementary units. Each of the data-processing units is a map algebraic operation which, like any conventional algebraic operation, accepts one or more variables as an input and generates a single variable as an output. In this case, however, variables involved are not merely numbers but layers (probabilities used as fuzzy numbers). According to Tomlin there are only four fundamental types of spatial operators:

- *local operations* compute a new value for every location as a function of the existing value(s) that is associated with the location on one or more specified layers. This function may count the number of dissimilar values associated with each location, compute arithmetic sums, differences, products, ratios, report statistical means, medians, maxima, minima, modes. For instance, using command Add Exchange Pottery Map to Exchange Lithic Map to Exchange Metal Map we will obtain a probability map of the locations for any form of exchange. Or we can calculate the ratio between the actions Lithic decortication, lithic knapping, and lithic retouching and we will get a probability map of the location of a lithic manufacture activity area;
- *zonal operations* compute a new value for each location as a function of the existing values from one layer that are associated with that location's zone on another specified layer. For example, count the dissimilar values associated with each zone; compute the relative magnitude of each location's value as compared with others in its zone. A simple archaeological example would be "adding the individual residence units on one layer, controlled by the site-catchments boundaries on another";
- *focal operations* compute a new value for every location as a function of the existing values, distances, and/or directions of neighbouring locations on a specified layer. Neighbourhoods may be defined in terms of physical separation, travel cost, intervisibility, or even by means of "spreading" and "radiating" non-Euclidean functions, which extend the concept of neighbourhood to include neighbourhoods defined by time and other factors (including those operating within other layers). For example, we can define a cluster of points with regard to a ring-shaped neighbourhood, with a diameter larger than 1 km, but smaller than 5 km.
- incremental operations compute a new value for every location as a function of its linea, area, or surface form on a specified layer. These operations may indicate each location's length or shape as part of a lineal network; its surface area, frontage or shape as part of an areal pattern; or its slope, aspect, drainage direction(s) or volume as part of a surface form.

Another way to calculate multidimensional spatial correlation is by using image processing techniques that compare the location of pixels in different pictures. Here a probability map is used as a bit-map picture. Standard operations with pixels may be also applied to point-locations, in order to evaluate multidimensional dependence structure. For instance, by calculating the gradient of a probability map you obtain a map that stands out areas (not necessary continuous fields) where probability values are statistically higher than neighbouring locations. Image processing software – also included in some GIS packages – allows segmentation techniques, geometric transformations, topological operators, shape representation and description. These techniques can be used in the same way that in the MapAlgebra approach to compute correlations among georeferenced probability maps.

6. Conclusions: spatial analysis, social theory and geographical techniques

In this paper we have proposed some techniques which can be useful to discover the existence of spatially related/unrelated social actions through time as well as to measure the existence/absence of some spatial correlation between them. How important is this correlation? It depends on the social theory which archaeologists try to develop and to test. We consider that science is a way of reasoning and not a database of "true" knowledge, consequently, we have to design tools that help us to discover relationships.

In this essay we have stressed the relevance of these "spatial" relationships. We consider that spatial coincidences among social actions are fundamental to understand social dynamics, although social dynamics cannot be reduced only to a comparison of locations. The real problem is that social dynamics is produced through time (both at short and long term) and space, and then these dynamics are far beyond the capabilities of observation of a single individual. For this reason, in order to infer social dynamics we use archaeological data (a long term record of social actions) which allow us to explain why and how we are acting in the present. Space and Time are the fundamental dimensions of change and dynamics. They have to be described, measured and understood. In this paper we have discussed some analytical approaches to the study of social spaces, and we have presented our own theoretical-methodological proposal (in essence an enlarged materialist approach) to discover the spatial dimension of social dynamics. We think that GIS is an ideal tool to undertake the study of social spaces if we use it beyond the simple representation and description of spatially referenced data. Spatial analysis involves operations whose results depend on data locations and thus cannot be reduced to the production of maps from a simple manipulation of the attribute database.

Of course, both theory and techniques proposed here are already un-der construction, but we hope that this contribution adds some new keys to continue working on the development of new methods to undertake the study of social space.

Juan Anton Barceló
Maria Pallarés

Universitat Autònoma de Barcelona
Divisió de Prehistòria
Facultat de Lletres

BIBLIOGRAPHY

Adler M.A. 1996, *Land tenure, archaeology and the ancestral Pueblo social landscape*, «Journal of Anthropological Archaeology», 15 (4).

Agorsah E.K. 1988, *Evaluating spatial behaviour of prehistoric societies*, «Journal of Anthropological Archaeology», 7 (3), 231-247.

Allen K.M.S., Green S.W., Zubrow E.B.W. (eds.) 1990, *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis.

Anselin L., Getis A. 1992, *Spatial statistical analysis and Geographic Information Systems*, «Annals of Regional Science», 26, 19-33.

Baena J., Blasco C., Recuero V. 1995, *The spatial analysis of Bell Beaker sites in the Madrid region of Spain*, in G. Lock, Z. Stančič (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 101-116.

Baena J., Blasco C., Quesada F. (eds.) 1997, *Los S.I.G. y el análisis espacial en Arqueología. Cantoblanco*, Madrid, Ediciones de la Universidad Autónoma de Madrid.

Barceló J.A. 1995, *¿Podemos determinar arqueológicamente la interacción social?* in *II Jornadas de Arqueología a la Carta*, Carratraca, Diputación de Málaga, in press.

Barceló J.A., Pallarés M. 1996, *From visual seduction to spatial analysis. A critique of GIS in archaeology*, in P. Moscati (ed.), *III Convegno Internazionale di Archeologia e Informatica (Roma, 22-25 novembre 1995)*, «Archeologia e Calcolatori», 7, 327-335.

Bello J.M., Criado F., Vazquez Varela J.M. 1987, *La Cultura megalítica de la Provincia de La Coruña y sus relaciones con el marco natural: implicaciones socio-económicas*, La Coruña, Diputación Provincial.

Bender B. 1992, *Theorising landscapes, and the prehistoric landscapes of Stonehenge*, «Man», 27, 735-755.

Bender B. (ed.) 1993, *Landscape: Politics and Perspective*, London, Berg.

Biskowski M. 1994, *GIS & the study of grinding tools in the Teotihuacan Valley, Mexico*, in I. Johnson (ed.), *Methods in the Mountains*, *Proceedings UISPP Commision IV Meeting (Victoria, Australia, August 1993)*, Sydney University Archaeological Method Series, n. 2., Sydney, 115-134.

Biswell S.L, Cropper J.E., Gaffney V., Leach P. 1995, *Gis and excavation: A cautionary tale from Shepton Mallet, Somerset, England*, in G. Lock, Z. Stančič (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 269-286.

Blasco C., Recuero V., Dàvila A.F., Baena J. 1995, *Sistemas de información geográfica en la gestión del patrimonio: definición de las zonas de protección arqueológica*, in *Aplicaciones informáticas en Arqueología: Teorías y sistemas, II Coloquio Internacional de Arqueología e Informática (Bilbao, 1993)*, Bilbao, 155-172.

Carmichael D.L. 1990, *GIS. Predictive modelling of prehistoric site distributions in Central Montana*, in K.M.S. Allen, S.W. Green, E.B.W. Zubrow (eds.) *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis, 216-225.

Castro P.V. *et al.* 1996, *Teoría de las prácticas sociales*, «Complutum Extra», 6 (2), 35-48.

Claval P. 1977, *Le marxisme et l'espace*, «L'espace géographique», 3, 145-164.

Cosgrove D. 1984, *Social Formation and Symbolic Landscape*, London, Croom Helm.

Couclelis H. 1991, *Requirements for planning-related GIS in spatial perspective*, «Papers in Regional Science», 70 (1), 9-19.

Cressie N. 1991, *Statistics for Spatial Data*, New York, John Wiley.

Della Bona L. 1993, *A preliminary predictive model of prehistoric activity location for the western Lake Nipigon watershed*, «Archaeological Computing Newsletter», 37, 11-19.

Duncan J., Duncan N. 1988, *(Re)reading the landscape*, «Society and Space», 6, 117-126.

Egenhofer M.J., Franzosa R. 1991, *Point-set topological spatial relations*, «International Journal of Geographical Information Systems», 5 (2), 161-174.

Fotheringham A.S., Rogerson P.A. 1993, *GIS and spatial analytical problems*, «International Journal of Geographical Information Systems», 7 (1), 3-19.

Foucault M. 1975, *The Birth of the Clinic: An Archaeology of Medical Perception*, New York, Vintage Books.

Foucault M. 1977, *Discipline and Punish: The Birth of the Prison*, New York, Vintage Books.

Gaffney V., Stančič Z. 1991, *Gis Approaches to Regional Analysis: A Case Study of the Island of Hvar*, Ljubljana, Znanstveni Institut Filozofske Fakultete.

Gaffney V., Stančič Z., Watson H. 1995, *The impact of GIS in Archaeology: A personal perspective*, in G. Lock, Z. Stančič (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 211-230.

Gaffney V., van Leusen M. 1995, *Postscript-GIS, environmental determinism and archaeology: A parallel text*, in G. Lock, D. Stančič (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 367-382.

García L., Rodríguez J. 1996, *Predicting the ritual? A suggested solution in archaeological forecasting through qualitative response models*, in H. Kamermans, K. Fennema (eds.), *Interfacing the Past. Computer Applications and Quantitative Methods in Archaeology 1995,* Analecta Praehistorica Leidensia, n. 28, Leiden, 203-216.

Gatrell A.C. 1983, *Distance and Space: A Geographical Perspective*, Oxford, Oxford University Press.

Gatrell A.C. 1991, *Concepts of space and geographical data*, in D.J. Maguire, M.F. Goodchild, D.W Rhind (eds.), *Geographical Information Systems: Principles and Applications*, London, Longman, vol. 1, 119-34.

Gili S. 1995, *Territorialidades de la Prehistoria Reciente Mallorquina*, Tesi doctoral, Universitat Autònoma de Barcelona.

Gillings M. 1996, *Not drowning but waving? Re-humanising GIS, the Tisza flood plain revisited*, in *Proceedings of XIII International Congress of Prehistoric and Protohistoric Sciences (Forlì, Italia, 8-14 September 1996)*, Forlì, A.B.A.C.O. Edizioni, 69-84.

Gosden C. 1994, *Social Being and Time*, Cambridge, Blackwell.

Gottdiener M. 1991, *Space, social theory, and the urban metaphor*, Current Perspectives in Social Theory, vol. 11, 295-311.

Gottdiener M. 1994, *Social Production of Urban Space*, Texas.

Gregory D., Urry J. (eds.) 1985, *Social Relations and Spatial Structures*, London, Mcmillan.

GREIDER T., GARKOVITCH L. 1994, *Landscapes: The social construction of nature and the environment*, «Rural Sociology», 59 (1), 1-24.

HARRIS T., LOCK G. 1995, *Toward an evaluation of GIS in European archaeology: The past, present and future of theory and applications*, in G. LOCK, Z. STANČIČ (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 349-366.

HASENSTAB R.J., RESNICK B. 1990, *GIS in historical predictive modelling: The Fort Drum Project*, in K.M.S. ALLEN, S.W. GREEN, E.B.W. ZUBROW (eds.), *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis, 284-306.

HERNANDEZ Z.D. 1994, *Qualitative Representation of Spatial Knowledge*, Lecture Notes in Artificial Intelligence, n. 804, Berlin, Springer-Verlag.

HODDER I. 1994, *Architecture and meaning: The example of Neolithic houses and tombs*, in M.P. PEARSON, C. RICHARDS (eds.), *Architecture and Order*, New York, Routledge, 73-86.

J. HUGGET, N. RYAN (eds.) 1995, *Computer Applications and Quantitative Methods 1994*, BAR International Series, n. 600, Oxford.

HUSAIN T. 1977, *Topology and Maps*, New York, Plenum Press.

INGOLD T. 1993, *The temporality of the landscape*, «World Archaeology», 25 (2), 152-173.

JOHNSON I. (ed.) 1994, *Methods in the Mountains*, *Proceedings UISPP Commision IV Meeting (Victoria, Australia, August 1993)*, Sydney University Archaeological Method Series, n. 2, Sydney.

KAMERMANS H., FENNEMA K. (eds.) 1996, *Interfacing the Past. Computer Applications and Quantitative Methods in Archaeology 1995,* Analecta Praehistorica Leidensia, n. 28, Leiden.

KIRBY K.C., PAZNER M. 1990, *Graphic Map Algebra, Proceedings of the 4th International Symposium on Spatial Data Handling (Zurich, July, 23-27).*

KOHLER T.A., PARKER S.C. 1986, *Predictive models for archaeological resource location*, in M.B. SCHIFFER (ed.), *Advances in Archaeological Method and Theory*, New York, Academic Press, vol. 9, 397-452.

KVAMME K.L. 1989, *Geographic Information Systems in regional research and data management*, in M.B. SCHIFFER (ed.), *Archaeological Method and Theory*, Tucson, University of Arizona Press, vol. 1, 139-203.

KVAMME K.L. 1990, *GIS algorithms and their effects on regional archaeological analysis*, in in K.M.S. ALLEN, S.W. GREEN, E.B.W. ZUBROW (eds.), *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis, 112-126.

KVAMME K.L. 1990, *The fundamental principles and practice of predictive modelling*, in A. VOORRIPS (ed.), *Mathematics and Information Science in Archaeology*, Bonn, Holos-Verlag, vol. 3.

KVAMME K.L. 1992, *Terrain form analysis of archaeological location through Geographic Information Systems*, in G. LOCK, J. MOFFETT (eds.), *Computer Applications and Quantitative Methods in Archaeology 1991*, BAR International Series, n. 577, Oxford, Tempus Reparatum, 127-136.

KVAMME K.L. 1992, *A predictive site location model on the high plains: An example with an independent test*, «Plains Anthropologist», 56 (2), 19-40.

LEFEBVRE H. 1974, *La production de l'Espace*, Paris.

LOCK G., HARRIS T. 1990, *Integrating spatial information in computerised SMRs*, in K. LOCKYEAR, S. RAHTZ (eds.), *Computer Applications and Quantitative methods in Archaeology 1990*, Oxford, Tempus Reparatum, 165-174.

LOCK G., HARRIS T. 1992, *Visualizing spatial data: The importance of Geographic Information Systems*, in R. REILLY, S. RAHTZ, (eds.), *Archaeology and the Information Age: A Global Perspective*, London, Routldge, 81-96.

LOCK G., MOFFETT J. 1992 (eds.), *Computer Applications and Quantitative Methods in Archaeology 1991*, BAR International Series, n. 577, Oxford.

LOCK G., STANČIČ Z. (eds.) 1995, *Archaeology and Geographical Information Systems*, London, Taylor & Francis.

LOEB A.L. 1976, *Spatial Structures*, London, Addison-Wesley.

LOPEZ P. *et al.* (eds.) 1991, *El cambio cultural del IV al II milenio a.C. en la comarca Noroeste de Murcia*, Madrid, CSIC.

LUX A., RIT J.F. 1988, *Modèles de raisonnement pour un module temporal*, in D. PASTRE (ed.), *Intelligence Artificielle, Actes des Journées Nationales (PRC-GRECO)*, Toulouse, Teknea.

MASSEY D. 1992, *Politics and space/time*, «New Left Review», 196, 65-84.

MATHÉRON G. 1965, *The Theory of Regionalized Variables and its Applications*, Les Cahiers du centre de morphologie mathématique de Fontainebleau, Paris, Ecole Nationale Supérieure des Mines de Paris.

MEFFERT M. 1995, *Spatial relations in Roman Iron Age settlements in the Assendelver Polders, The Netherlands*, in G. LOCK, Z. STANČIČ (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 287-300.

MILLS B. 1994, *MapAlgebra: An emerging standard for analysis in GIS*, «GISEurope», 3 (9), 18-20.

PALLARÉS M. 1995, *Cuestiones teórico-metodológicas sobre el estudio de la organización espacial de los asentamientos de comunidades cazadoras-recolectoras. Sota Palou, un caso practico*, in *Aplicaciones informáticas en Arqueología: Teorías y sistemas, II Coloquio Internacional de Arqueología e Informática (Bilbao, 1993)*, Bilbao, 387-408.

PARCERO-OUBIÑA C. (in press), *Deconstructing the land: The archaeology of sacred geographies*, in *Computer Applications in Archaeology 1997*.

PEARSON M.P., RICHARDS C. 1994, *Architecture and order: Spatial representation and archaeology*, in M.P. PEARSON, C. RICHARDS (eds.), *Architecture and Order. Approaches to Social Space*, London, Routledge.

PEARSON M.P., RICHARDS C. 1994, *Ordering the world: Perceptions of architecture, space and time*, in M.P. PEARSON, C. RICHARDS (eds.), *Architecture and Order. Approaches to Social Space*, London, Routledge.

PEUQUET D.J. 1988, *Representations of geographic space: Toward a conceptual synthesis*, «Annals of the Association of American Geographers», 78, 375-394.

RAPOPORT A. 1982, *The Meaning of the Built Environment,* Beverly Hills, SAGE.

RAPOPORT A. 1990, *Systems of activities and systems of settings*, in S. Kent (ed.), *Domestic Architecture and the Use of Space*, Cambridge, Cambridge University Press, 9-20.

RELPH E. 1976, *Place and Placelessness*, London, Pion.

RUGGLES C.L.N., MEDYCKYJ-SCOTT D.J., GRUFFYDD A. 1993, *Multiple viewshed analysis using GIS and its archaeological application: A case study in northern Mull*, in J. ANDRESEN, T. MADSEN, I. SCOLLAR (eds.), *Computing the Past: Computer and Quantitative Methods in Archaeology 1992*, Aarhus, Aarhus University Press, 125-131.

SÁNCHEZ-PALENCIA J., FERNÁNDEZ-POSSE M., OREJAS A. 1996 (in press), *Le projet de la zone archéologique de Las Medulas, l'emploi du SIG*, in *The Use of GIS in the Study of Ancient Landscapes and Features Related to Ancient Land Use, COST*, Workshop (Ljubljana, 27 abril 1996).

SAYER A. 1985, *The difference that space makes*, in D. GREGORY, J. URRY (eds.), *Social Relations and Spatial Structures*, London, Mcmillan, 49-66.

SCHATZKI T.R. 1991, *Spatial ontology and explanation*, «Annals of the Association of American Geographers», 81, 650-670.

SIMONSEN K. 1996, *What kind of space in what kind of social theory?*, «Progress in Human Geography», 20 (4), 494-512.

SIMS B.T. 1976, *Fundamentals of Topology*, New York, McMillan.

SOJA E. 1980, *The socio-spatial dialectic*, «Annals of the Association of American Geographers», 70, 207-225.

SOJA E. 1985, *The spatiality of social life: Towards a transformative retheorisation*, in D. GREGORY, J. URRY (eds.), *Social Relations and Spatial Structures*, London, McMillan, 90-127.

SOJA E. 1989, *Postmodern Geographies*, London, Verso.

SOJA E. 1996, *Thirdspace. Journeys to Los Angeles and Other Real -and- Imagined Places*, Cambridge, Blackwell Publishers.

SWYNGEDOUW E. 1992, *Review: Henri Lefebvre's "The Production of Space"*, «Economic Geography», 68 (3), 317-319.

THEUNISSEN R. 1996, *The cave as a landscape: A GIS assisted spatial analysis of stone artefacts at Petzkes cave, Northern NSW, Australia*, in *Proceedings of XIII International Congress of Prehistoric and Protohistoric Sciences (Forlì, Italia, 8-14 September 1996)*, Forlì, A.B.A.C.O. Edizioni, 232.

THOMAS J. 1991, *Rethinking the Neolithic*, London, Cambridge University Press.

THOMAS J. 1996, *The politics of vision and the archaeologies of landscape*, in B. BENDER (ed.), *Landscape: Politics and Perspectives*, Oxford, Berg, 19-48.

TILLEY C. 1994, *Places, Paths and Monuments. A Phenomenology of Landscape*, Oxford, Berg.

TOBLER W. 1979, *Cellular geography*, in S. GALE, G. OLSSON (eds.), *Philosophy in Geography*, Dordrecht, Reidel, 379-386.

TOMLIN C.D. 1991, *Geographic Information Systems and Cartographic Modelling*, Englewood Cliffs, Prentice Hall.

TOMLIN C.D. 1994, *Map Algebra: One perspective*, «Landscape and Urban Planning», 30, 3-12.

TRICOT C. 1987, *Statistique Spatiale*, Brouillons Dupont n. 15, Avignon, Groupe Dupont.

TRICOT C., RAFFENSTIN C. 1979, *Concentration et connexité ou pour un approche du concept de territorialité*, *Actes du colloque Géopoint76, Théorie et géographie (Genève, Groupe Dupont)*, Avignon, Universités de Genève et de Lausanne, 49-62.

VALDÉS L., ARENAL I., PUJANA I. (eds.) 1995, *Aplicaciones informáticas en arqueología. Teorías y Sistemas*, Bilbao, Denboraren Argia, vol. 2.

VAN DER LEEUW S. (ed.) 1995, *L'homme et la dégradation de l'environment*, *XVè Rencontres Internationales d'Archéologie et d'Histoire d'Antibes*, Sophia-Antipolis, Ed. APDA.

VERHAEGEN P., MCGLADE J., GILI S., RISCH R. 1995, *Some criteria for modelling socio-economic activities in the Bronze-Age of South East Spain*, in G. LOCK, Z. STANČIČ (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 187-209.

VOIRON CANICIO C. 1993, *Espace, structures et dynamiques regionales. L'Arc mediterranéen*, «Revue d'Analyse Spatiale Quantitative et Appliquée», 33, 1-296.

VOORRIPS A. 1996, *Archaeological theory and GIS, any relations?*, in *Proceedings of XIII International Congress of Prehistoric and Protohistoric Sciences (Forlì, Italia, 8-14 September 1996)*, Forlì, A.B.A.C.O. Edizioni, 209-214.

WALL C.T.C. 1972, *A Geometric Introduction to Topology*, Reading (MA), Addison-Wesley.

WANDSNIDER L. 1996, *Describing and comparing archaeological spatial structures*, «Journal of Archaeological Method and Theory», 3 (4), 319-384.

WARREN R.E. 1990, *Predictive modelling of archaeological site location*, in K.M.S. ALLEN, S.W. GREEN, E.B.W. ZUBROW (eds.), *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis, 201-215.

WASSERMAN K., LEIBOWITZ M. 1983, *Representing complex physical objects*, «Cognition and Brain Theory», 6, 333-352.

WERLEN B. 1993, *Society, Action and Space. An Alternative Human Geography*, London, Routledge.

WHEATLEY D. 1993, *Going over old ground: GIS, archaeological theory and the act of perception*, in J. ANDRESEN, T. MADSEN, I. SCOLLAR (eds.), *Computing the Past: Computer and Quantitative Methods in Archaeology 1992*, Aarhus, Aarhus University Press, 133-138.

WHEATLEY D. 1995, *Cumulative views analysis. A GIS-based method for investigating intervisibility and its archaeological application*, in G. LOCK, Z. STANČIČ (eds.), *Archeological and Geographical Information Systems*, London, Taylor & Francis, 171-186.

WHEATLEY D. 1996, *Between the lines: The role of GIS-based predictive modelling in the interpretation of extensive survey data*, in H. KAMERMANS, K. FENNEMA K. (eds.), *Interfacing the Past. Computer Applications and Quantitative Methods in Archaeology 1995,* Analecta Praehistorica Leidensia, n. 28, Leiden, 275-292.

WIEMER R. 1995, *How to look good and influence people: Thoughts on the design and interpretation of an archaeological GIS*, in G. LOCK, Z. STANČIČ (eds.), *Archaeology and Geographical Information Systems*, London, Taylor & Francis, 301-313.

WILCOCK J., LOCKYEAR K. (eds.) 1995, *Computer Applications and Quantitative Methods in Archaeology 1993*, BAR International Series, n. 598, Oxford, Tempus Reparatum.

ZEDEÑO M.A. 1997, *Landscapes, land use and the history of territory formation: An example from Puebloan Southwest*, «Journal of Archaeological Method and Theory», 4 (1), 67-102

ZUBROW E.B.W. 1990, *The fantasies of GIS software*, in K.M.S. ALLEN, S.W. GREEN, E.B.W. ZUBROW (eds.), *Interpreting Space: GIS and Archaeology*, London, Taylor & Francis, 184-193.

ZUBROW E.B.W. 1994, *Knowledge representation and archaeology: A cognitive example using GIS*, in C. RENFREW, E.B.W. ZUBROW (eds.), *The Ancient Mind. Elements of Cognitive Archaeology*, New Directions in Archaeology, Cambridge, Cambridge University Press.

RESULTS OF THE QUESTIONNAIRE GIS AND ARCHAEOLOGY

Title of the project: Informatización del registro arqueológico referido al territorio.

Promoting institution: Dirección General de Bienes Culturales, Consejería de Cultura y Medio Ambiente de la Junta de Andalucía.

Year of beginning: 1994.

Foreseen term: 1997.

Geographic area: Andalusian region, but we like to develop a general record of excavation independent of geographic area.

Excavation area: Andalusian region.

Short description of the project: The design and development of an Archaeologic Information System (SIA) focused on the following purposes:

1) to establish the necessary methodological concepts that permit to obtain an exhaustive information in the excavations;

2) to design a system of archaeological record that standardizes the information derived from the Andalusian excavations, obtaining a complete homologation in the archaeological information;

3) to incorporate into the system a procedure that permits to locate geographically (at level of the Earth) each archaeologic element;

4) to develop a computer system that provides reliability, and a quick and flexible management of the archaeologic information obtained through the previous methodology.

The computer program accomplishes the integration of the information according to:

– Alphanumeric Information with exchange in ASCII and DBF formats;

– Graphic Information (CAD). These data are incorporated into system in DXF format and are included in the corresponding databases file;

– Images & photo Information. The incorporation of the information is accomplished in the most usual formats: TIF, PCX, EPS, GIF, etc.

The GIS that links this environment will be ArcInfo.

Hardware: Workstations (Sun & Silicon Graphics), PC compatibles, magnetic drives 100Mb and 1Gb capacity, magnetoptical drives 1.2 Gb, scanners, colour & B/W printers, CD ROM read only and pens plotter.

Software: The main program is developed in Paradox database management and programming. This software accepts many standard formats to database and graphics files (DBF, ASCII, DXF, TIF, PCX, BMP, etc.). The CAD software are AutoCAD and Microstation. The images software are Photoshop and Photostyler.

Application of descriptive standards: Materials: Materials inventory, Samplings inventory, Materials classification and Sifted and flotation samplings. Stratigraphical units: Stratigraphical unbuild unit, Stratigraphical build unit and Aedilicius sampling. Structural entities: Structures, Structural complexes, Funerary structural complexes, Human Remains and Materials quantification by structures. Drawings (graphics CAD): Simple plants, Phase plants, Area graphs and Sections. Photos.

Application of Spatial Analysis: The application of Spatial Analysis comprises statistical spatial analysis (geostatistical data, point pattern analysis, and so) with programs that we will develope, and the statistical inference tests using as input the output that provides the ArcInfo development (see the A. Montufo works in this project).

Other important information:

Address: J.A. Esquivel, Departamento de Prehistoria y Arqueología, Instituto Andaluz de Geofísica, Universidad de Granada, Campus de Cartuja, 18071 Granada, Spain.

E-mail: esquivel@ululaya.ugr.es

www address:

****

Title of the project: GIS and matrix Harris. An application to the study of the archaeological site and the landscape evolution.

Promoting institution: Centre for the management of the cultural and natural heritage (CEM).

Year of beginning: 1991.

Foreseen term: 1998.

Geographic area: Region of Baix Llobregat, Penedès and Garraf (south of Barcelona).

Excavation area: Church of Santa Margarida (V-XIX century); Church square of Martorell (XI-XVI century); Devil's bridge of Martorell (I-XIX century); Castle of Castellvell de Rosanes (I-XVIII century); Castle of Gelida (IX-XVIII century).

Short description of the project: This project develops a specific methodology for integrating the management of historical and archaeological information, with special attention to space significance and landscape evolution. The initial methodology of support is the work of E. Harris and A. Carandini, specially. The data recording system allows us to use information from excavation, prospecting, structural analysis, historical documentation, environment data, etc., and easily obtain thematic and chronological maps of landscape or plans of excavation. This system provides the application of spatial analysis with very complete information, increases the quality and facilitates the data management.

Hardware: PC 486 DX, 66 Mhz with 1500 Mb HD and 20 Mb RAM; Digitizer tablet; Scan colour; Print Epson Stylus 1500, colour.

Software: Windows 95; MapInfo 4.0 Professional; Visual dBASE; Harris Matrix (program developed by Irmela Herzog).

Application of descriptive standards: This system uses three basic concepts: Stratigraphic Unit (SU), Topographic Unit (TU) (record of events in space and time) and Actor (AC) (record of protagonists linked with events). This record makes possible to identify the stratigrafic sequence of an archaeological site and the evolution of a landscape; we also rebuild the biography of the protagonists. This system uses one recording sheet model for every concept with an identication number for every SU, TU or AC. The recording sheet includes chronological data, geographic position (UTM), descriptive attributes, origin information and relationship.

Application of Spatial Analysis: We draw every SU and TU in two layers of map and identify every one with their number. This number allows us to attach the graphic representation with the recording sheet, select spatial objects and apply technics of spatial analysis.

Other important information: The first step of this project was published in: A. MAURI, L'aplicació del mètode Harris a l'estudi del territori, in La vida medieval als dos vessants del Pirineu, Patrimoni Cultural d'Andorra, Andorra 1995, 8-24. Recently I have presented my thesis of master at the University of Barcelona on this theme: "Sistemes territorials i l'estudi de les traces aqueològiques medievals. Un exemple d'aplicació a l'antiga baronia de Castellvell de Rosanes (Baix Llobregat, Barcelona)". This work is pendent of publishing.

Address: A. Mauri i Martí, C. Tarongers 20, 08790, Gelida, Spain. Tel.: 34-3-7790571; CEM, Pl. De la Vila 41, 08760, Martorell, Spain. Tel./ Fax: 34-3-7755546.

E-mail: bnn@bcn.servicom.es

www address:

****

Title of the project: Millares Project: The beginning of metallurgy and the development of societies in S.E. Iberia during the Copper Age.

Promoting institution: Autonomous governement of Andalucia (Spain).

Year of beginnig: The Phase 1 of the Millares Project has been developped between 1985 and 1992. GIS work began in late 1995.

Foreseen term:

Geographic area: The Millares Project covers the Almeria basin, in the lowlands of Almeria, and the Chirivel plateau, in the province of Granada. Archaeological sampling has been performed in the Tabernas basin (Almeria), the Fiñana corridor (Almeria) and the Chirivel plateau.

Excavation area: Archaeological excavation has been done in two major fortified settelements: Los Millares, located in the lowlands of Almeria, and El Malagon (Chirivel plateau).

Short description of the project: The role of GIS is performing territorial and landscape analysis, providing tools for cartographic production, spatial analysis amd data management. At the first stage, GIS work has been centered in developing the cartographic databases and archaeolgical databases as well as integrating these resources. So far, these include digital maps at 1:10000 scale, including contour lines, rivers, roads, administrative divisions, and archaeological sites, these coverages cover the Tabernas basin (200 sq. km.). A digital map has been also produced from the original input. GIS-based research so far is focused on the analysis of the DEM to characterize archaeological site location in terms of elevation, slope and aspect. Chi-square analysis is used to analize DEM-derived data.

Hardware: GIS sotware runs on a Sun Sparc Server 1000 (400 Mb RAM, Solaris 2.3) while the client is a Sun IPX Sparcstation.

Software: GIS software: ArcInfo 7.0.2. Databases: Paradox and Dbase IV. Remote sensing: Erdas Imagine 8.2.

Application of descriptive standards: Archaeological database: includes site location (UTM coordinates), archaeological finds, chronology, type of site, legal status of the site, owners and other information related to cultural resource management. Cartographic databases: digital maps are produced by digitizing the 1:10000 maps, georeferencing to UTM coordinates.

Application of Spatial Analysis:

Other important information:

Address: Antonio M. Montufo, Department of Prehistory & Archaeology, University of Granada, Granada 18071, Spain. Tel. +34 58 244091. Fax: +34 58 244089.

E-mail: montufo@ululaya.ugr.es

www address:

****

Title of the project: GIS work is being conducted within “The Risk Map of Archaeological Heritage of the town of Granada”, included in the major research project “Urban Archaeology in Granada”.

Promoting institution: The “Urban Archaeology in Granada” is promoted by the

Autonomous governement of Granada.

Year of beginning: GIS work within the "Risk Map project" started in 1996.

Foreseen term:

Geographic area: The project covers the town of Granada.

Excavation area: The project covers the town of Granada.

Short description of the project: The Risk Map of archaeological heritage attempts to propose levels of protection for the archaeological heritage in the town of Granada to prevent losses and damages due to urban developments. The Risk Map includes archaeological and historical data from written sources about the development of the town to identify and characterize the archaeological potential. Futher data account for the extent to which the archaeological deposits have been destroyed (basements and such) and future developments that may affect archaeologically sensitive areas. Bearing in mind all these data, different levels of protection are proposed. GIS is used for integrating and analyze these data, for database management and map production.

Hardware and software: ArcInfo 7.02 running on a Sun Sparc Server 1000; Paradox and Dbase running on Pentium PCs connected on a local network.

Application of descriptive standards: Different coverages (point, line, polygon) holds records of known archaeological elements (buildings, bridges, coins, single finds...). The main analysis is based on the cadastral parcel. The database holds data for each parcel about the date of construction, archaeological potencial, level of destruction of archaeological deposits, basements, size of the parcel, legal status, etc. Thematic maps are produced based on this database.

Application of Spatial Analysis: The primary role of the GIS within the Risk Map project are the map production and database management. It is used as decision-making tool, simulating different results of protection levels according to the criteria adopted. Spatial analysis involves mainly map algebra and reclassification.

Address: Antonio M. Montufo, Department of Prehistory & Archaeology, University of Granada, Granada 18071, Spain. Tel. +34 58 244091. Fax: +34 58 244089.

E-mail: montufo@ululaya.ugr.es

www address:

ABSTRACT

The growing use and increasing sophistication of GIS methods to manage archaeological data is not related to an increase in use diversity. After two decades on a trial basis, we evaluate in this paper the current ability of Spanish Archaeological GIS applications to meet the expectations placed upon them, especially concerning their role on archaeological method and theory.

The purpose of this paper is threefold. First, we summarize the main trends in Spanish GIS-based applications over the last years using a sample of the most recent bibliography. Next, we critically examine and evaluate the inherent shortcomings of some existing GIS applications, and finally we review different underlying conceptions of space in GIS projects and propose how such a software can be integrated into a proper theory of social space.