Archeologia e Calcolatori
15, 2004, 409-420

"SEGEDA PROJECT": THE I.T. MANAGEMENT OF THE TERRITORY OF A CELTIBERIAN CITY-STATE

1. Introduction

The "Segeda Project" originated in 1998 in order to study this Celtiberian city-state and its associated territory. The preservation and conservation of the results from the archaeological excavations, as well as the establishment of a Centre for the Interpretation of Segeda and the region of Celtiberia, aim to foster the social, cultural and economic development of the territory where Segeda is situated (Mara and Belmonte de Gracián, province of Zaragoza, Spain). Modern I.T. resources have played an essential role in the recording, investigation, virtual reconstruction and distribution of the archaeological information. The development of a web page (www.segeda.net) has been taken to be the most efficient and direct medium for the dissemination of the results (Burillo, Ostalé 1983-1984; Burillo Mozota 2001a, 2001b).

Segeda is mentioned by classical writers with regards to the events of 154-153 BCE as an important Celtiberian city of the Belos. The enlargement of the urban area of Segeda instigated a Roman declaration of war, causing Nobilior to mobilise some 30.000 soldiers. Segeda formed an alliance with Numantia, the neighbouring Celtiberian city of the Arevaci. According to Apianus (*Iber*. 45), the confrontation between the Roman and Celtiberian armies took place on the 23rd of August in 153 BCE. The Celtiberian victory caused Rome to establish this as a *nefas* day (Richardson 2000). The important role played by Segeda as suggested by the classical sources is confirmed by the fact that this was one of the first Celtiberian cities to mint coins in the Iberian System mountain range. These coins had the indigenous name of *Sekeida* and reaffirmed a hierarchy within a vast territory, which underscores the city's economic and political importance (Burillo Mozota 2001c; Gomis Justo 2001).

2. The archaeology of the city of Segeda

Unlike other Celtiberian cities (e.g. Numantia, Uxama or Tiermes) where the Roman settlement lies on top of an indigenous city, Segeda displays a first occupation on the hill of Mara (Zaragoza). Following its destruction and abandonment in 153 BCE, a new city was built in Durón de Belmonte de Gracián next to the ruins of the old settlement. This new city would subsequently be destroyed and abandoned indefinitely as a result of the Sertorian wars of the seventh decade BCE. From then onwards and throughout the

Roman imperial period, Bilbilis Italica (located by the River Jalón, 11 kilometres from Segeda) acted as the capital of the territory.

Archaeological excavations at Segeda I have confirmed the existence of the first phase of the city on the hill of Mara. The hillsides were terraced and two-storey houses were built. The walls were made of stone and coated with a layer of clay. Some of the rooms were painted white with a black fringe along the socle. The extension of the city where, according to the classical sources, the neighbouring populations were sheltered, has been discovered in a sedimentary terrain east of the hill. This extension displays a pre-designed reticular structure with simple single-storey houses that allowed for a fast occupation of that section of the city, doubling the settlement's size. The total dimensions thus reached have not yet been definitively established, although an area of approximately 20 hectares has been estimated. As a reference we should bear in mind that Numantia (another great Celtiberian city-state) had an area of approximately 8 hectares (JIMENO *et al*. 2002, 26).

A defensive system was set up south of the city, separated from the urban nucleus by an unoccupied area. Thus far, a stretch of wall 4,10 metres wide and at least three outposts displaying a quadrangular layout have been discovered, circumscribing an area that reached 40 hectares (including the occupied section of the city). The material culture that has been retrieved, including coins from the earliest monetary issues of Segeda I, confims the date of 153 BCE as the point at which the city was abandoned (BURILLO MOZOTA 2001-2002).

The city of Segeda II was built on a flat terrain next to the old settlement. It displays an area of 16 hectares, and its reticular layout can be appreciated along the limits of the fields. The settlement was surrounded by a thirty-metre-wide ditch and a wall that is still partly visible. Information from previous excavations demonstrates the existence of rooms with *opus signinum* paved surfaces and stuccoed walls belonging to the Pompeyan I type. The urban model of Segeda II is similar to that of other cities that emerge along the Valley of Ebro during this period and that are presently being excavated, as is the case with Caridad de Caminreal (VICENTE *et al.* 1993) or Burgo de Ebro (FERRERUELA, MÍNGUEZ 2000).

3. SEGEDA, CITY AND TERRITORY

The wording of the title for this chapter is intended to reflect a functional dialectic relation composed of two distinct elements: the city and the territory, which are intertwined to such a degree and cohered by such strong links that one cannot be understood without the other.

The diverse and intense nature of this relation gives rise to a complex territorial organisation, which demonstrates Segeda's sophisticated technical

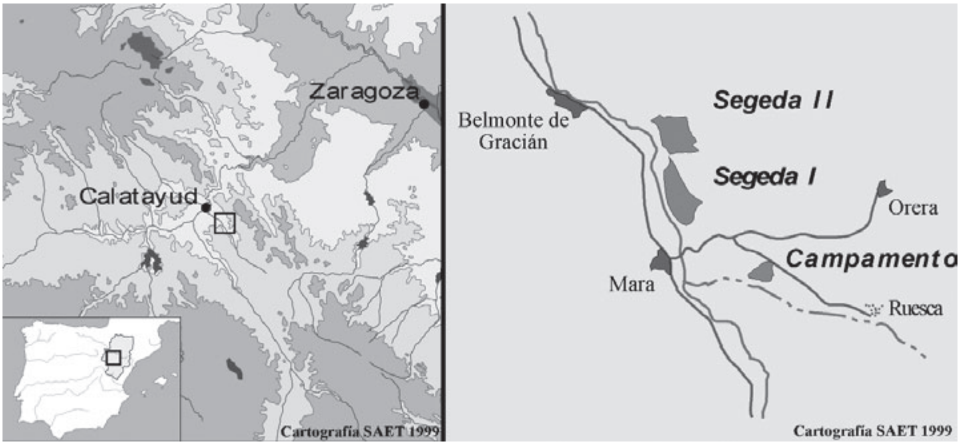

Fig. 1 – Location of Segeda.

Fig. 2 – Limits of Segeda I and Segeda II, aerial view.

Fig. 3 – Cities and ethnic groups that participated in the Celtiberian Wars of 154-150 BCE against the Romans.

and administrative capabilities. Indeed, this vast administrative area comprises a wide range of territories with starkly dissimilar geographical features. The successful exploitation of its resources is only possible through a profound knowledge of the relevant technological requirements. The landscape produced as a result of the interaction between the individual, society and nature is diverse and complex, as corroborated by the classical sources and the archaeological record.

Segeda displays a complex historical development, for the city's existence predates the Pacts of Graccus and hence the Roman conquest of the Valley of Ebro. During the period ranging from 179 BCE to 154 BCE, Segeda achieved a great political and economic development as evidenced by the coalition of cities for a common public administration (*sinecismo*) mentioned by the classical sources, and by the fact that it was the first city to mint coins in the Iberian System mountain range (where Numantia never minted coins). However, establishing the boundaries of Segeda's associated territory is a

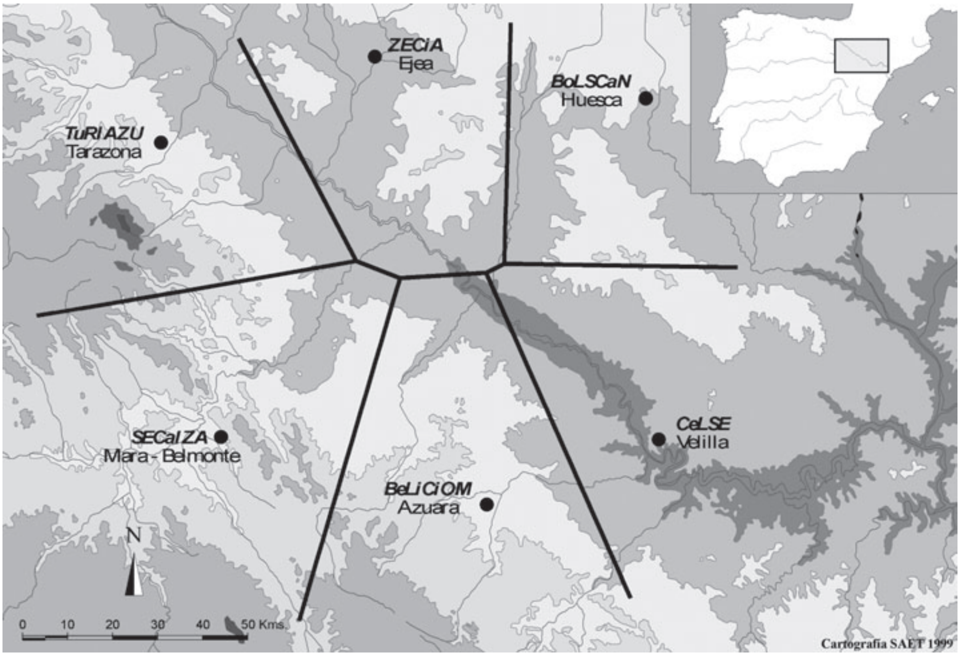

Fig. 4 – Cities that minted denarii in the middle Valley of Ebro and hierarchy of the territory towards the second century BCE.

difficult task. The only piece of information that we have in this respect is provided by Apianus, who points out that the army recruited by the Numantia-Segeda coalition consists of 20.000 infantry and 5000 horsemen, which implies an approximate population of 120.000 people. Nonetheless, the classical sources also mention the existence of other cities in the territory, such as Axinius, Ocilis and Nertobriga. Their exact location remains unknown.

The foundation of a new city, Segeda II, during the second half of the second century BCE, implies the continuation of the Segedan state, for the name *Sekeida* remains unchanged on the legend of the coins. The analysis of the monetary distributions in the Valley of Ebro during the end of the second century BCE will help us establish the possible boundaries of Segeda's territory during this period. Very few mints issue denarii, and their regular distribution corroborates the existence of a pre-designed strategy with regards to their location. We have interpreted this as evidence for their role as fiscal centres in the territory occupied by Rome. This implies a hierarchy with respect to the indigenous cities, which only minted bronze coins within this territory.

The territory whose boundaries we have established through the study of the cities that minted silver coins is limited to this very specific aspect and historical period. These criteria, however, offer a starting point for the analysis of the large rural population that existed in the area. The study of this population will consequently provide us with a better understanding of the historical process that saw the emergence and development of Segeda as a city-state.

4. Applying GIS to the study of Segeda's territory

The use of Geographic Information Systems (GIS) has become increasingly common in archaeological investigations since the publication of Allen, Green and Zubrow's book (1990) as a means of structuring, storing, modelling and examining information located in the geographic space (i.e. georeferenced) (Lock, Stančič 1995; Baena, Blasco, Quesada 1997; Gillings, Mattingly, Dalen 1999; González 2001; Wheatley, Gillings 2002). We have opted to make use of this technology for the organisation of the information in this project, since the spatial dimension is essential for the interpretation of the relation between the city and its territory.

4.1 *Archaeology, territory and GIS*

The elements of the triad "archaeology, territory and GIS" are not equivalent as epistemological categories or, of course, as concepts, although it is possible to affirm that the "territory" acts as a common ground that allows us to combine a scientific discipline (i.e. archaeology) with a set of methods and tools (i.e. GIS) that could form the nucleus of what could eventually become a new scientific discipline.

Indeed, the datum (or the elemental unit of information of archaeology's data model) represents objects – usually material remains – and incorporates not only attributes of their nature, function and meaning, but also a spatial location. It becomes evident that, parting from an object's location, we can reconstruct and interpret spatial, metric and topological relations, which are integrated as explicative variables as well as variables to be explained within the matrix of information provided by the material remains.

On the other hand, the term "Geographic Information System" refers to a subgroup of new technologies organised to obtain, store, manage, analyse, model and examine information located within the geographic space (i.e. georeferenced). This technique is usually applied as a means of solving problems in which the geographic information acquires an essential strategic character.

The development of any historic society can only take place within a particular territory. This otherwise self-evident assertion leads us to a variety of interpretive theories about the relation between social organisation and the territory, and suggests various methods for the study of this phenomenon. Each proposal is related to one of the philosophical currents by which we construct our understandings of space, constituting the frame of reference and the conceptual system within which we approach spatial phenomena. This theoretical antithesis can be re-expressed in the case of geography through the differences between the concepts of "space" and "territory".

The traditional system of analysis and presentation of results in archaeology has involved the production of analogical maps. The most common method has consisted of the creation of a thematic cartography of the distribution of objects or archaeological data on a map, displaying the topography, hydrographic network, soil exploitation, present or historic infrastructures or any other variable relating to the phenomenon that is to be explained. The interpretation remains an eminently intuitive process based on the visual recognition of spatial patterns. This methodological approach has been shared by all sciences using spatial information, including geography.

Halfway through the 1960s, New Archaeology introduced the notion of the "quantitative revolution" to the discipline, which implied above all the use of new techniques and analytical procedures to measure and typify spatial distributions (often imported directly from geography, landscape ecology and other disciplines), as well as the proclamation of the hypothetic-deductive method as a means of producing theories and explaining hypotheses in a scientific manner.

This approach presupposes the existence of an objective observer and a transparent, measurable object: space is conceived as a passive base that is often isotropic when reduced to its metric measurement. Social groups are understood as systems that evolve towards stability, affected by factors that can be internal or external (i.e. ecologic). Cultural differences are explained in terms of diverse forms of functional adaptation to the environmental variables. According to this approach, traces or remains are embedded in the space as if they were a palimpsest, and can be identified, classified, measured and organised in coherent models.

More recent critical currents have pointed out some of the conceptual and methodological weaknesses of this approach (e.g. the deterministic conception of the society-space relation or the immutable, constant nature of space and its role as a passive base within this relation). Modern scientific approaches to society and the environment stress the complex nature of this relation (Hillier, Hanson 1984; Morin 1999) and the important roles played by random factors as creative and generative elements in this society-environment relation.

Within these parameters, space becomes territory: a complex concept resulting from the interaction among the individual, society and nature that displays a cyclical – not linear – character. The territory contains organisational features of its society, and society is concomitantly linked to the characteristics of the configuration of the territory. This thus constitutes a unit that is full of signification, values and qualities that can play very relevant roles in the creation of social identities as well as other aspects of social organisation. Territory does not exist as a category that is independent of the activities of its social groups.

The archaeological use of GIS must take into account the theoretical and methodological developments derived from the critical approaches of the social sciences and the "paradigm of complexity". In practical terms, this involves the need to develop our own models from an archaeological stand and construct new elements of reference and procedures. Certainly, this objective does not preclude the use of elements borrowed from disciplines such as geography, psychology of space, landscape ecology or spatial economy. It is important, nonetheless, that these elements are critically reformulated and adapted to the needs and nature of the archaeological discipline.

4.2 *The system of geographic information (GIS) of the territorial data*

4.2.1 The data model

The most advanced data model for the management of geographic information is perhaps the so-called "geobase" (geodatabase), for it allows the integration of different types of objects and phenomena (along with their attributes, relations and behaviour) in a flexible and consistent manner (Zeiler 1999).

Considering the similarity in the contents and the data collection procedure, we have opted for the creation of three geobases for the management of the geographic data. Their contents and basic characteristics are displayed in Tab. 1.

4.2.2 Analysis and modelling

The ultimate objective of our application of GIS to Segeda involves the production of information that will allow a better understanding of the patterns and models of territorial use. Bearing this in mind, we have opted for the location and spatial relation of the artefacts, the technological state and the mode of social organisation as fundamental variables. These characteristics allow us to explain, *a priori*, the temporal rhythms of use and spatial layout of the territorial elements and subsystems, such as the arrangement of different crops, the location of the potters workshops or ovens for the processing of metals, the density and quality of the roads and paths etc.

The physical representation of the territory is carried out fundamentally through the analysis of the topography, making use of a Digital Elevation Model (DEM) and incorporating the hydrographic network to this.

Using the data of the altitudes found in the digital cartography at scale 1:25.000, we have developed two DEMs. One has a resolution of 20 metres and is applied to the area which would hypothetically encompass a territory dominated by the city-state of Segeda (i.e. approximately 10.000 kilometres

Types of elements	Classification	Mode of representation	Comments
Geobase: Physical environment			
-Elevations (DEM)	-Altitudes	-TIN -Raster	Information obtained from slopes, orientations, illumination, topographic forms...
-Water	-Subtypes and domains (flow, springs, wells...)	-*Dataset*: geometric network	
Geobases: Soil exploitation			
Agrarian uses	-Present and past uses; subtypes and domains (agrarian, pastoral and forestry uses)	-Polygons (topology) -Lines -Dots	
Settlements	Subtypes and domains (permanent; temporary)	-Lines -Dots	
Mining and Industry	-Subtypes and domains (sites, potters' workshops, ovens...)	-Polygons -Lines -Dots	
Images	-Raster		- 'Olivo' flight -Other large-scale images
Geobase: Communications network			
-Present network	-Subtypes and domains (types of road, width, tunnels, bridges...)	-*Dataset*: geometric network	
-Historic roads	-Subtypes and domains (Roman roads, paths, bridges...)	-Lines -Dots	

Tab. 1

square). The second one is applied to the territory that would encompass the immediate environs of the city and has a resolution of 10 metres (which is the maximum allowed by the allimetric data that we have used) (Tav. VIII, a).

Based on the DEMs, we have produced maps of the orientations, slopes, inter-visibility, topographic forms etc. which constitute the point of departure for more specific analyses in relation to the archaeological remains. For example (Fig. 5), the calculation of the distribution of slopes in an area that is circumscribed by a circle with a 1500-metre radius covering the sites allows us to establish clear differences with respect to the sites' topographic structure. The possibility of quantifying these variables facilitates the production of indexes and, hence, the classification of sites according to the physical characteristics of the immediate environs.

The location, in the simplest sense of the word (i.e. considering the specific situation and its relation with the characteristics of the physical environment), will allow us to develop models relating to the functions of the settlements in relation with the immediate environment. Moreover, the use of GIS and its capacity for the production of spatial analyses encourages the

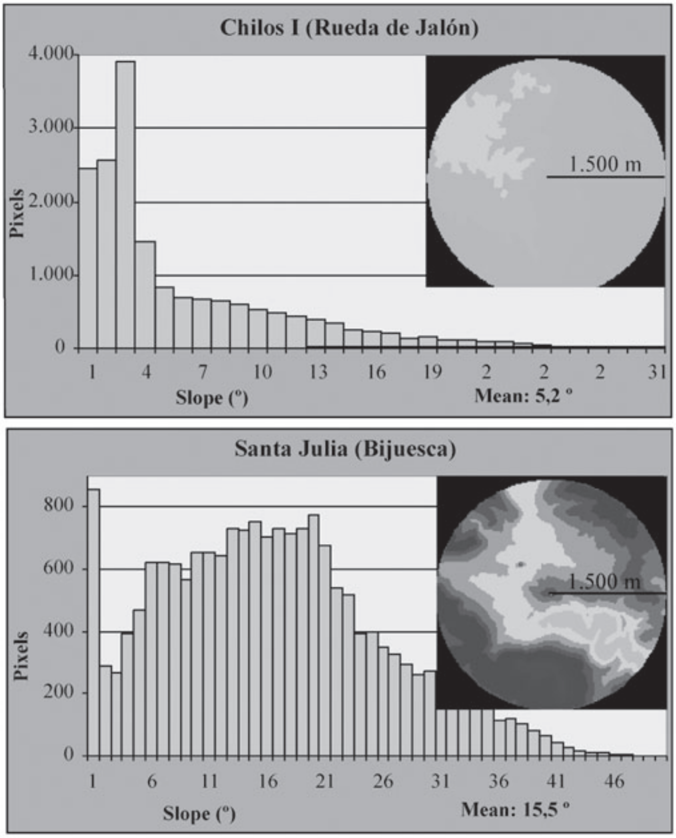

Fig. 5 – Distribution of slopes on the sites' surroundings.

formulation of questions or hypotheses about the location of the sites with regard to elements of reference that are essential for their development (i.e. other locations, sources of mineral, cultivation areas, water courses). The relations of proximity or distance thus become explicative variables of the territorial model (Tav. VIII, b). Establishing the limits of zones or areas of influence of the locations in the territory constitutes a first step towards its modelling. Tav. IX, a represents the allocation of specific zones between neighbouring sites according to the distances that have been established.

As well as the location of points of habitat, the interconnection between them becomes a key element for the establishment of models of territorial organisation. The calculation of the optimum routes of travel between sites and other points of interests demands a consideration of the friction surface imposed by the characteristics of the territory. However, in order to obtain valid explicative models, it is necessary to experiment with different values in certain parameters, particularly those affecting the movement of people, animals and carts. Tav. IX, b displays the optimum routes between the site of Segeda and other neighbouring locations.

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Acknowledgements

This work has been developed as part of the project I+D: BHA2001-2439, funded by the Ministry of Science and Technology and the FEDER funds.

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ABSTRACT

This article defends the use of Geographic Information Systems (GIS) for the management, analysis, examination and modelling of the archaeological data concerning the territory. Within this context, we outline some types of analyses that are being carried out with the use of GIS applied to the case of Segeda. Drawing on these and other experiments, we conclude that GIS technologies and their well-established capacity for the integration, analysis and examination of information from different sources constitute a particularly effective tool for the modelling of complex realities such as the one we are concerned with in our project.