APSAT 1. TEORIA E METODI DELLA RICERCA SUI PAESAGGI D'ALTURA

a cura di
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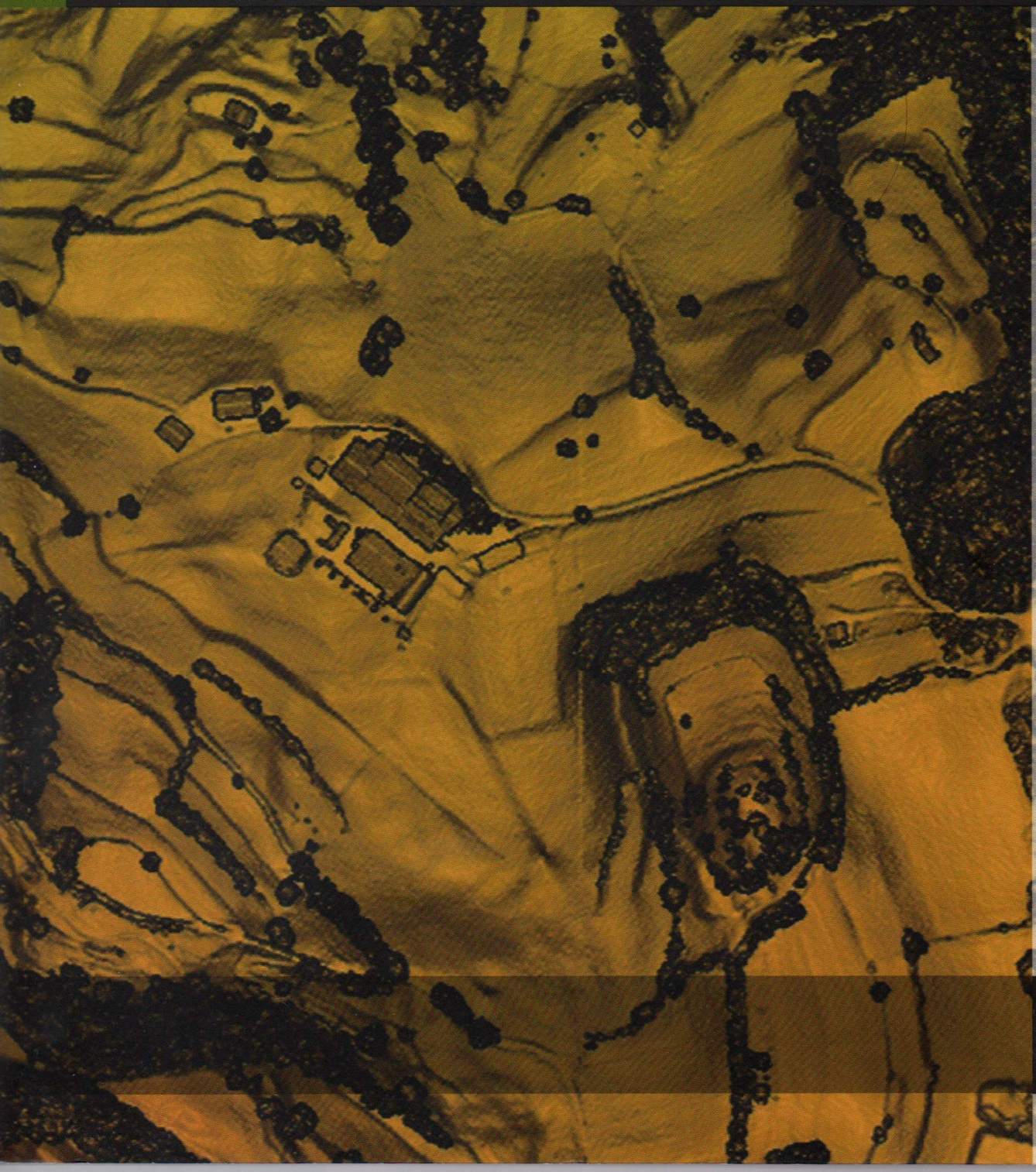

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HYDRAULIC ARCHAEOLOGY IN SOUTH-EAST SPAIN MOUNTAINOUS LANDSCAPES[1]

Jose Mª Martin Civantos*

Abstract

The study of mountainous landscapes shows an image that detaches from the statism pervading a part of the Andalusi history. Knowledge on productive areas is a source of key information to know more about settlements, territorial organization and their historical evolution. All of them were conditioned by the use of water, the main natural resource since the intensive irrigated agriculture was spread. The importance of agrarian transformations that occurred on the Iberian Peninsula during the creation of al-Andalus is well known. The study area is located in Sierra Nevada, in Southeast Spain, where a research project is being developed analyzing the historical landscape beginning from the most important element: the use of water and the irrigation systems.

Keywords: mountainous landscapes, irrigation systems, agriculture, data base, Sierra Nevada, al-Andalus, alquería.

The study of landscape from a cultural or patrimonial perspective has received special attention in recent years. Interest has increased in part due to a higher level of environmental awareness, but also due to the need to understand and preserve European cultural landscapes, many of wich are being damage, and many of them are disappearing at a very rapid pace.

Cultural landscape is in itself a complex reality, comprising both natural and culturally tangible and intangible elements, which combine to shape its identity. In accordance with the UNESCO World Heritage Convention, different types of cultural landscapes may be defined. As a result, an official classification of cultural landscapes has been developed[2].

The present study focuses on rural landscapes which have been granted special attention within the UNESCO classification. By far, they account for the majority of the world territory, and are the most affected by development in other areas, such as urban and industrial, including infrastructure.

Agriculture as a system of production turns natural landscape into rural landscape. In this sense, agricultural activity may be defined as the "process by which nature is artificialized", in so far as it simplifies the biocenotic structure of a given "ecosystem in order to arrange its constituent parts on the basis of human needs and/or whims" (Gastó, Vieli, Vera 2006, p. 31. Translation from the Spanish version).

As a result, agriculture, and to some extent livestock, shape a cultural landscape derived from human actions, with or without a clear intention. In some cases, the resulting landscape is designed or residual. "In that regard, agricultural activity is not only about producing goods and services in rural areas, but also about generating a landscape which is both environmentally sustainable

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[2] Plan Nacional de Paisajes Culturales *(National Plan on Cultural Landscapes)*. http://www.mcu.es/patrimonio/MC/IPHE/PlanesNac/PlanPaisajesCulturales/PaisajesCult.html.

and socially acceptable..." (Gastó, Vieli, Vera 2006, p. 31. Translation from the Spanish version).

As F. Gonzalez Bernaldez points out, it is in fact in areas with an "old agriculture and cattle farming tradition" where landscape is more deeply humanized. "The history of agriculture and human diet is one of the most valuable clues when interpreting changes in landscapes with a prolonged anthropic influence" (González Bernáldez 1981, pp. 145-147. Translation from the Spanish version).

Five stages have been identified within the different types of landscape, which are based on the degree of development or transformation:

- Harmonious landscape: society, culture and natural conditions are consistently related to each other.
- Stressed out landscape: land use intensity exceeds land receptive capacity. A permanent state of pressure deteriorates landscape.
- Dying landscape: advanced and ongoing degree of deterioration, landscape lacks an endogenous capacity to recover.
- Feral landscape: originally artificialized, it was abandoned and tends to recover its natural conditions.
- Relict landscape: conserving the original ecosystem, landscape is integrated within the cultural landscape environment.

These types of cultural landscape are often the result of a given action with no determined intention in connection with the landscape itself. In addition, they may be the result of policies developed to create a given landscape on the basis of the needs of players in society and the restrictions in terms of culture and nature (Gastó, Vieli, Vera 2006, p. 31).

Existing definitions and classifications of landscape are very precise and highly conceptualized. Nevertheless, we find that all of them, and specially the definition of cultural landscape, overlook a significant element that is worth making explicit despite being present implicitly. In our opinion, it is essential to acknowledge that the current mosaic created by landscapes is undeniably a product of History. Landscapes should be understood as four-dimensional elements. In other words, they do not just take up a place in space, but in order to comprehend them we must be aware of the diachrony of landscapes, of evolutionary and constructive processes taking place over time. Thus, landscapes must be interpreted as a construct shaped by successive generations of human experimentation and modification, and of interaction with material elements and natural processes.

Bearing in mind such a high degree of conceptual accuracy, we fully agree with R. Buxó regarding the construction of landscapes that could now be called historical landscapes: "Landscapes are essentially multidimensional constructions derived from the interaction between historically determined structures and contingent processes. Agricultural landscapes and human landscapes as a whole are the framework of human life and the setting where social life takes place. As such, they are historical constructions derived from the interaction between biotic and abiotic factors in the environment. Every historical interpretation must be based on the understanding of these dynamics. Therefore, landscapes need to be considered a consequence of long-term socio-natural coevolution" (Buxó 2006. Translation from the Spanish version).

The dynamic condition of landscapes is one of the theoretical foundations within the discipline that, from the wider field of Geography, is in charge of studying them. This is highly motivating, both from a theoretical point of view and from a practical one, since it enables sequential analysis and actions aimed at preserving the historical values of landscapes.

"Proper knowledge on geosystems may be a source of valuable information to understand the structure and current dynamics of these systems, since past conditions are the origin of their current configuration. [...] In addition, un-

derstanding the state of affairs of the system as a particular moment in the evolutionary time sequence is necessary to comprehend the dynamics of present landscapes and interpret them as systematic progression, regression or stability with regard to a set situation. Systems are so entrenched that one may talk about evolutionary processes leading to the preservation of the system's structures, their transformation into more complex, rich and varied ones, or conversely the previous system becoming unstructured. In other words, the current state of affairs of landscape cannot be 100% assessed without knowing what it looked like before" (Jiménez Olivencia, Porcel Rodríguez 2008, pp. 152-153. Translation from the Spanish version).

However, following the European Landscape Convention, landscape historicity and temporality, and therefore the need for proper study and understanding from this perspective, is not considered frequently enough or "is not really shown explicitly" (Jiménez Olivencia, Porcel Rodríguez 2008, p. 155)

It is worth mentioning that interesting contributions are being developed from the field of Archaeology, although it is not a new topic in this field. The relationship between human beings and nature has always been a key subject in the field of Archaeology. It has resulted in various specializations, such as Environmental Archaeology, but more importantly in the theories and methods emanating from New Archaeology. They, in particular recent variants like Landscape Archaeology and Land Archaeology, belong to the so-called Spatial Archaeology.

Under no circumstances can archaeological research overlook the study of the environment where human beings have inhabited. A relationship with nature is implicit in the production and reproduction processes. From this relationship raw materials and energy are obtained. There is no doubt that the way societies evolve is conditioned by the environment. However, societies are also able to alter their surroundings, to transform them, even radically, by creating highly humanized landscapes and new ecosystems reliant on the external energy supply provided by humans. K. Butzer (Butzer 1989) introduced the concept of ecosystem in Archaeology, referring to the set of living beings that are in contact with the physical environment in a determined area. When applied to 'human ecosystem', this concept underlines the interdependence between environmental and cultural variables.

Landscape Archaeology has traditionally been understood as the archaeology of settlements and their organization in space. Theoretical and technical concerns were mainly related to visibility, intensity and the organization of the survey, setting-up of chronologies and dispersion areas and, over all, to the identification of existing relationships between settlements in the same area (Field Archaeology and Spatial Archaeology). This trend has only been modified by some studies carried out in the UK, where Landscape Archaeology and studies of fossilized cultivation fields have a longer and more deeply-rooted tradition (Bradford 1957; Ashbee 1972; Clarke 1977; Hoskins 1955; Jones 1962; Myres 1951; Ward-Perkins 1964; Fowler 1972). Even so, the relationship between residential and work spaces within territory and within the environment as a whole, has rarely been studied in a comprehensive way or from a truly archaeological perspective. This is the case in Italy, for example, where, despite the definitions provided by G. Barker (Barker 1986), Italian archaeological tradition has mainly limited to the identification and study of settlements on the basis of surface survey and the development of analysis techniques. The handbook by N. Terrenato and F. Cambi may serve as an example, which has not yet been surpassed. The recent volume *Medioevo, paesaggi e metodi* is yet another case. In the conclusions, G. P. Brogiolo devotes particular attention to the need to overcome the aforementioned conception on the basis of a more complex and elaborate theory, which to a large extent is based on our proposal of strat-

ified landscape (Barker, Hodges 1981; Cambi, Terrenato 1994; Mancassola, Saggioro 2006. See also the French case: Bazzana, Guichard 1986).

Indeed, more elaborate theories and a more complex methodology have more recently been brought to the archaeological debate, in an attempt to set up a direct connection between settlement locations and work areas. F. Criado and the team working at CSIC (Spanish National Research Council) Landscape Laboratory in Santiago de Compostela (Criado Boado 1999; Criado Boado, Parcero Oubina 1997), Spain, have developed one of the most comprehensive theoretical proposals. Another very comprehensive proposal is that of A. Orejas (Orejas Saco Del Valle 1998 and 1991; Orejas Saco Del Valle, Ruiz Del Árbol Moro, López Jiménez 2002), which is based on prehistoric and ancient mining. Recent examples of this change may be seen in the aforementioned proposal by G.P. Brogiolo on "Archeologia delle relazioni" or "Archeologia della complessità" (Brogiolo 2006 and 2007).

This debate has penetrated the international sphere and is concerned with a conceptual and epistemological redefinition of our discipline following the new post-processual trends. The debate and interest raised by this question is not only noticeable in Europe, where UK researchers are producing a great deal of literature (see B. Bender, M. Edmonds, J. Thomas, C. Tilley, W. Ashmore, J. C. Barrett, R. Bradley, T. Darvill, T. Ingold, A. Sherratt, *etc.*), but also in the United States, as is evidenced in the annual meetings of the Society for American Archaeology. It can also be seen in recent syntheses, such as that by K. Anschuertz, R. H. Wilshusen and C. L. Scheick (Anschuetz, Wilshusen, Sheick 2001).

Curiously enough, Prehistoric Archaeology is playing a very active role in this theory-oriented debate. Such an active role is due to the need to define the materiality/immateriality of the archaeological record, and the existence or non-existence of prehistoric landscapes, which is directly linked to the notion of symbolic landscapes. Beyond these conceptions, other proposals are grounded on more solid material foundations, which are in turn based on an undeniable reality: our landscapes are, to a large extent, a medieval construction that is still quite recognizable and that has a high impact on the physical environment and settlement.

This trend is largely based on the concept of landscape as suggested by F. Gonzalez Bernaldez (González Bernáldez 1981), which was described by E. Tello as follows: "As a historical construction, landscape is similar to a palimpsest that records the successive direct marks on the territory –and, on a larger scale, the global "environmental mark" as well– of the various societies that have followed one another over time. The shapes and sizes of such marks depend on energy flows and extracted materials, on the impact and waste resulting from processing, and on selection between existing species or species inserted into the environment by human intervention, whether voluntary or not. The socio-ecological metabolism described above is culturally and technologically mediated. Every technological complex and every farming culture has left a different territorial mark, which is in turn combined with other natural factors, have a history on their own" (Tello 1999, p. 197. Translation from the Spanish version).

Essential in their creation is, among other factors, the interaction between human beings and nature, and also the way in which a given social formation is expressed in space (see related studies by Garcia De Cortazar 2004). Actually, landscape as a synthesis of social relations is nothing but a vast archaeological site. This means that landscape can be known and understood from a historical and spatial point of view (Martín Civantos 2006 and 2008).

First, the study of irrigated land requires the consideration of the archaeological documentation in an expansive and complex sense. In other words, the concept of the archaeological record extends to include all the elements that were produced by societies in the past, i.e. not only the settlements and the

materials found in excavations, but also other landscape components such as production spaces and communications.

Second , the concept of the archaeological site requires further revision. Understanding archaeological sites as remnants of human activity in any period or with any function (Binford 1964), both a castle or a rural settlement and a work space –be it a mine or a hydraulic system– could be included within this category. The same occurs in research when a site is defined as the basic research unit of surface archaeological remains. If this is the case, it is also possible to define production areas as archaeological sites. This serves as the basis of highly specific disciplines, such as Mining Archaeology (Francovich 1993) and Hydraulic Archaeology.

Hydraulic Archaeology has mainly focused on the al-Andalus area. The objective of this discipline is to carry out a time reconstruction of water use processes in irrigated agriculture, which led to the creation of systems for capturing and distributing water, although mainly for its use in intensive cultivation. These systems were responsible for landscapes turning into irrigated productive spaces known as *vega* (irrigated area)[3]. Their application, however, must go beyond the merely technical or technological aspects. Their discourse needs to penetrate the social and economic dynamics of the territory in which they arise.

[3] See related works by Miquel Barceló and his team, among others Barceló 1989 and 1995; Kirchner 1995; Kirchner, Navarro 1994.

[4] Amin 1974. See also the introductory essay in this edition carried out by M. Barceló; Haldon 1984; Wickham 1985. Specifically see the monographic issue on this discussion in Hispania: "Revista española de Historia", vol. 58, no. 200 (1998), with de Haldon, Acién Almansa and Manzano Moreno's contributions; and by the same author: *Conquistadores, emires y califas. Los Omeyas y la formación de al- Andalus*, Barcelona 2006. See the highly interesting synthesis by Garcia Sanjuan 2006.

Irrigated agriculture

Intensive irrigated agriculture has been shown to be one of the basic economic foundations of the social and political development of al-Andalus. Therefore, addressing the significance of irrigation for society in the Andalusi world implies discussing tributary mode of production and Islamic social formations, which is usually overlooked in our time[4]. Due to its nature, this activity necessarily determined the relationship between labor and means of production, the social relations surrounding production and the relationships between peasant communities and the Islamic State, i.e. the methods used to obtain productive surplus.

For this reason, dealing with the social significance of intensive irrigated agriculture in al-Andalus involves addressing number of issues, such as those arising from the connection between irrigation and land ownership, those derived from the relationship between water control and distribution and social structure, organization of peasant communities, and land organization, those resulting from intensive irrigation agriculture and taxing, and those existing between intensive irrigation agriculture and trade.

Obviously, these matters cannot be fully dealt with in this paper. We merely enunciate certain elements we consider of interest for further research.

The first problem that needs to be addressed is quantification. What is the actual importance, i.e. in hectares, of irrigated agriculture in al-Andalus? Unfortunately, we do not have an answer yet. Despite M. Barcelo's proposal to create a "hydraulic map" following archaeological method, there is still a long way to go before attempting to do so. In a recent study, 161 hydraulic systems in the old territory of al-Andalus have been catalogued. However, despite this huge effort, the amount accounts for only a small sample; they are specially referred to the area of the Balearic Islands (see Sitges i Vilaró 2006). For instance, in the current province of Granada, only the systems in three areas have been studied in depth: the small system of Los Guajares (Barceló 1988), the Zenete (Martín Civantos 2007) systems (located on the Northern side of the Sierra Nevada mountain range) and the systems in the Loja (Jiménez Puertas 2007) area (located on the Western part of the *huerta* in Granada). Work on these systems has barely begun.

On the other hand, within these systems, there are key differences in size.

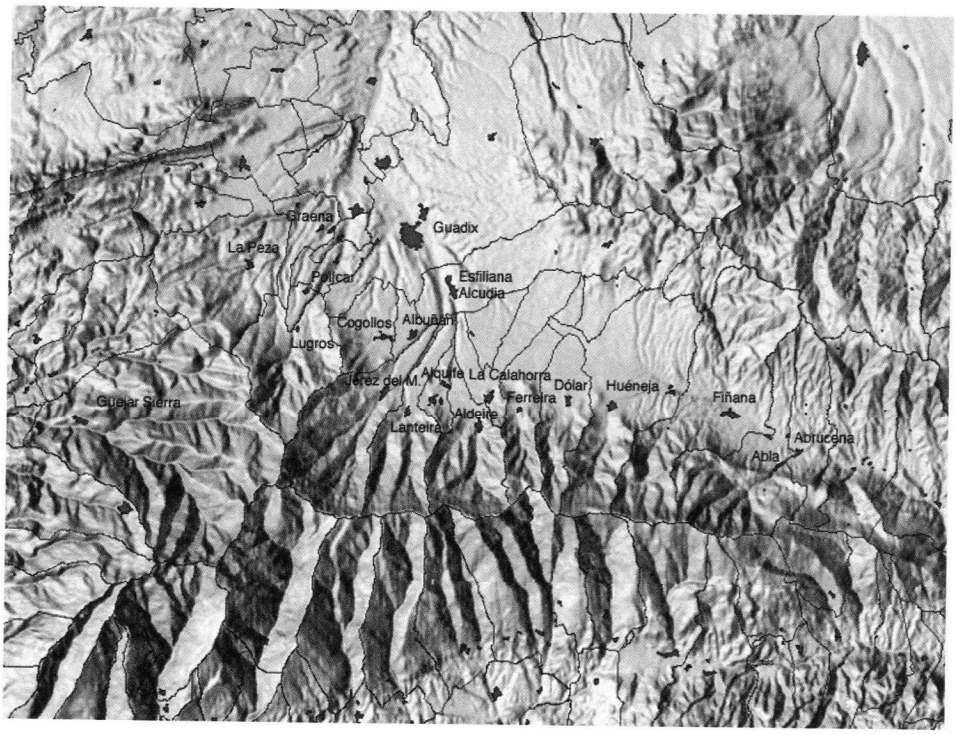

Fig. 1. Location map from the North side of the Sierra Nevada Mountains and the Guadix territory, including the mentioned main towns.

Although this does not indicate their degree of complexity, these differences are significant from the point of view of productivity. An attempt was made to classify these productive spaces with respect to their size as follows (Butzer, Matew, Butzer, Kraus 1988-1989): macrosystems (bigger than 50-100 km), mesosystems (smaller than 100 ha) and microsystems (smaller than 1 ha). E. Sitges' recent proposal is very different from the aforementioned attempt. It is based on a large sample of case studies, of which only fourteen have irrigated lands of over 2 ha of size, the biggest one being only 15 ha and the average size equaling 1.2 ha (Sitges i Vilaró 2006, p. 284). These data clearly differ from those referring to other peasant spaces, such as the ones in the Zenete mentioned before. There, all eight of the villages included in the study were over 200 ha of size each. The same is evident if they are compared to the size of the *huertas* in urban areas like Granada, Lorca, Murcia or Valencia.

The second question is of qualitative nature. What is the productivity level achieved with this type of agriculture? What is the achieved productivity compared to non irrigated lands? Even if irrigation accounted for a theoretically smaller productive space in quantitative terms, its productivity is much higher and, therefore, the resulting net production is also expected to be higher. However, the maximum levels of productivity in these areas are not exactly known. They depend both on water supply and on other factors, such as intensification techniques, cultivation management and type of soil. As a general rule, at least three objective variables could be considered: the amount of water available, the extension of land to be irrigated, and its quality, including aspects such as structure, depth, and capacity to retain humidity, among others. Other factors could be considered, such as inclination, humidity and temperature, exposure to sunshine, etc. Other aspects are to be considered, however they are more difficult to quantify. Among them, competition, knowledge of techniques and cultivation, type of plants and adaptation to the environment, organization capacity and cohesion of peasant communities, nature and degree of external coercion, and the role of agriculture within the community productive activities, are but some of the aspects to be considered.

The scenario of lands that are temporarily irrigated makes a good example. These lands are irrigated sporadically, when a surplus of water is available. They have been found on the Northern side of Sierra Nevada (Granada) (Martín Civantos 2007); however, more examples may probably be found elsewhere. There might be no records or material evidence, or they might just have transformed into *vega* areas as a result of a change in agricultural use, i.e. reducing yield per area in exchange for an enlargement of the cultivation area in the summer. This action may be implemented by changing the type of cultivation or dropping one of the annual crops. In the cases studied, lands are community lands, which are only irrigated in the spring, since water –in this case meltwater from the mountains– is more abundant. It is then when cereals may be irrigated in order to guarantee harvest, which in poor soils like these is always scarce. However, the presence of snow or mountain areas might have not been required for this type of land to exist. A surplus of water is almost guaranteed in the spring, even though it depends on rainfall and temperature. By using the same amount of water, a wider surface area could be irrigated until the beginning of the summer, when irrigated lands are limited to the most fertile areas, which are normally the most wooded ones and, as a general rule, belong to private owners. It is worth mentioning that fruit trees or vegetables do not require the same amount of water as cereals, olive trees or vineyards. In fact, in the case of vineyards they may be irrigated several times over the year, although irrigation is normally scarce, just enough to guarantee production. However, they cannot be irrigated in excess. Sugar production must be guaranteed during the ripening process, since it helps protect the plant from diseases caused by excessive humidity. That is why they are not normally located in *vega* or riverside areas, which are excessively wet. They are commonly located in small sunny rural lands, probably because lands with less developed soils and even some scree are easily found in those areas.

Undoubtebly that the case load shapes a complex reality, which is often dependant on numerous factors. These matters are considered in other disciplines, such as Geography, Environmental Sciences and Agronomy: "Regarding the model of human intervention in the territory, it is worth mentioning that two aspects are to be considered. Both of them are equally significant when interrelations between natural and cultural elements are settled, as well as in the formal landscape setting. On the one hand, by exploiting resources the elements in the system are modified or new ones are introduced, thus different agrosystems and anthroposystems are promoted. On the other hand, the final mosaic of soil coverage derived from the cultivation model is consistent with the fact that each particular point in the area in question is assigned a set of functions in the framework of the model. This way, the board or territory is reorganized, in such a way that its final composition must be interpreted in functional terms" (Jiménez Olivencia, Porcel Rodríguez 2008, pp. 156-157. Translation from the Spanish version).

Regarding hydraulic systems for irrigated agriculture, the general principles formulated by M. Barceló and the corpus created by him and the research group he belonged to must serve as the basis (see references in footnote 3). Nevertheless, after studying irrigation systems in the Northern side of Sierra Nevada and the Guadix (Granada) area, some methodological questions deserve our attention. They could enrich certain aspects related to documentation on these productive spaces.

Obviously, the first problem was related to their extension. In the study of these lands, extension was not only a theoretical problem, but also a technical and methodological one.

In the first instance, we focused on water harvesting, storage and supply. However, the study area was already becoming complex at that stage. Most

systems harvest water from diversion dams placed on gullies in the rivers born in Sierra Nevada. However, there are also centrings and even underground galleries that could be considered *qanat*, like the ones in Aldeire-La Calahorra, as well as fountains and water mines. At some of them only one mother irrigation ditch was recorded, at others several were found. Water was found to be often shared by two or more villages; however, at times, one village had a right to use water from several rivers or fountains. A pool was available in most villages, and several at some of them. In all cases, waterwheels and other hydraulic infrastructures such as rainwater tanks were present within systems. Some lands have a right to be irrigated throughout the year, and are considered *vega* lands, while others are only irrigated when a surplus of water is available.

After analyzing these systems a further problem arose. A need for a method of handling a vast amount of data and enabling approaches at different scales, such that a plot may be studied as the basic study unit within agricultural spaces while inserting it into a more complex set, which in turn derives not only from juxtaposing plots of lands or adding one after another, but also from a prolonged process of historical evolution, thus in a logical and reasonable way. It must also allow us to consider these work spaces in connection with residential places and the rest of the landscape of which they are an essential part. In addition, it must enable to consider them in connection with the notion of territory, in so far as it is appropriate and a socially organized space.

These efforts involve difficulties at all levels. Integrating data that are heterogeneous both in terms of nature and quality is a complex task, which in turn involves handling and organizing data both spatially and chronologically. In short, it involves looking at information from a four-dimensional perspective that is necessary to understand how agricultural space develops in a given territory throughout a diachrony.

This requires applying space analysis techniques and being able to record and handle a large amount of data. The latter require decoding and systematizing, being sorted on the basis of their common or distinguishing elements. This demanding task can become easier thanks to New Information Technologies.

However, the effectiveness of new technologies depends on the analytical skills of their creators and developers, and they only succeed if the archaeologist is able to decode, synthesize and sort elements in order to formulate relevant questions regarding to both the data and the software available.

The first we focused on the creation of a database for storing and handling a vast amount of heterogeneous data. These, in turn, must form the basis to draw historical knowledge on landscape and the way it works. They are structured hierarchically. All the elements deserve similar treatment, at least in theoretical terms. This structure places settlements, work spaces and communications at the same level. The rest of the elements are subsequently developed as has been explained before, i.e. by organizing data according to different levels (represented in tables) that are treated as different entities. However, despite being based on data breakdown, this structure is useful in so far as the different information levels may be articulated and combined with each other.

When creating a database, the first step involves designing the structure and relationships between data, i.e. thinking on the amount and nature of the data in question and their hierarchy, thus decoding and systematizing the type of data we have or foresee. For this purpose a relational database is chosen. Data in relational databases are organized in tables, with identifiers that serve as links between them. Different types of relationships range from 1:1, 1:N to N:N. For this reason, creating auxiliary tables and relations tables is necessary. They make the database lighter and speed up data handling and search, however they may make its structure more complex.

The database requires a temporal and spatial dimension, but achieving this is not easy, nor is it easy to organize the data in a coherent, standardized and easily scalable manner. To this end, it is highly advisable to bear in mind the use of fields or auxiliary tables for the localization (including georeferencing) and chronology of the items we insert in an adequate number of levels, although avoiding redundancies.

In differently treated information levels, it would be necessary, for instance, to distinguish between technological and administrative units. From these perspectives, a hydraulic system and an irrigated area (*vega* or *huerta*) are different, as well as the district of the municipalities and the communities which manage them. It has an influence not only on the spatial organizational level, but also on the social and work space ones. This must be taken into account during the creation of a data category. Besides, this is important from the historical point of view, because it can show changes in management and an evolution from the chronological perspective.

The best complement to manage it is the creation of Geographic Information Systems (GIS), which enables the incorporation of databases into cartographic representation. It should be the graphic expression of the spatial and temporal dimensions and it should allow more efficient data analysis. It is necessary to distinguish between the various work scales, in order to reach the highest possible level of detail.

The hydraulic infrastructures' database is generally composed by 103 fields in total, divided into ten tables connected among them and among the rest of the database in general. In the databases, there are corresponding auxiliary tables including the georeferencing, chronology, bibliography, writer, project, municipality, etc.

Generally, as mentioned before, the elements under study are divided into the hydraulic system and the *vega/ huerta*. The hydraulic system corresponds to the technological unit, while the *vega/ huerta* is an administrative entity, which does not necessarily correspond to a complete or a single system.

The hydraulic system is esentially characterized by an infrastructure composed by a single main irrigation channel with its catchments and its irrigated land. Obviously, it is composed by its own catchments, the main irrigation channel, the armlets or secondary irrigation channels, which branch from the main one, or more armlets which can also start from other armlets. Besides, it could have reservoirs to regulate the irrigation, which can belong to the community or being privately owned with a single entrance and, generally, a single exit.

The *vega* or *huerta*, as administrative entity, was the irrigated space or district related to a single irrigation community or a municipality. The *vega* could be formed by one or several irrigation systems and it can even share a system or just the water with another close *vegas*, determining the irrigation distribution and its organization.

Vegas/huertas are divided into districts known as *pagos* or *alfoces* (terrains), which take turns to use water following a set order. These terrains may use water from both the main irrigation channel and secondary ones. Therefore, the terrain was an administrative subdivision to organize the irrigation turns. This division is also linked to the different qualities of the land and to their location in relation to the catchments. Therefore it is possible to find peripheral terrains or some used to specific plants which could have special needs or be more adapted such as vineyards, chestnut trees and walnut trees, etc. Consequently, it is a part of *vega/ huerta* with a homogeneous land quality which is irrigated by water turns and, generally, by the same armlet.

Finally, when several *vegas* share one hydraulic system, the turn-taking scheme may be based on the number of *vegas* sharing the system.

Fig. 2. Ferreira and its *vega*. Air photograph of the American flight (1956). The vegetation gradation is clearly shown in the intensive irrigated lands (*vega*), the casual irrigated lands (fields) and the unirrigated lands.

Broadly speaking, the conceptual model outlined above allows us to organize information encompassing: irrigation system; irrigation channel; water source; harvesting system; construction materials; pond; *vega*; *terrain*; field (casual irrigation area); lot.

Each *vega* must be assigned different elements of the system in question. These elements account for a set of elements belonging to the broader system where the *vega* is located. In other words, the set of hydraulic elements in each

system is obtained by "bringing together" hydraulic elements from the different administrative units in the system. Elements in the system are identified by allocating in each *vega*-field-*terrain* a set of hydraulic elements.

The smallest reference unit is the plot. The reference to the plot is governed by the land registry, which enables us to directly have access to information about the surface and uses, but also to the official georeferenced cartography. The numbering in accordance with official land values should allow us to use the information we generate for the irrigation communities, municipalities and other entities and organisms that have any competence in water, agriculture or spatial planning.

Theoretically, if we know the terrain is related to each plot, we will also know which irrigation channel is irrigating it and which *vega/ huerta* and system is integrated on it. Therefore, a hierarchical and logical information management system is created, allowing us to work, at the same time, with technological units and administrative entities and, also, to relate them with the rest of the elements constituting the landscape and the territory through the rest of the remaining database tables, mainly with those corresponding to an archaeological site or other work spaces.

Irrigated areas from the Northern side of Sierra Nevada mountains and territorial evolution

Wide differences exist between the cases studied; however the conceptualization efforts made so far in the development of the information system have proven useful to set up a series of interpretative patterns that might be highly valuable in clarifying the organization of the spaces we are focusing on, both presently and diachronically.

Firstly, we deem it appropriate to distinguish between "simple" and "complex" irrigation spaces (fig. 3). The former are those where the *vega* and the system itself coincide, i.e. where a single hydraulic system with a single harvesting system and a main irrigation channel supply water to the *vega*. This does not mean, however, that they are simple or small areas. They can reach an important extension depending on the volume of flow and slope, which do not only depend upon the natural conditions, but on the historical relations established with their neighbors, that can share water usage rights with different catchments (that means, with different systems), or if their territories have conditioned the extension of the irrigation area despite the presence of areas with favorable slopes. Simple irrigated spaces account for a minority. They occur, for instance, in the *vegas* from Dolar or Ferreira in the province of Granada.

Complex irrigated spaces are those comprising an irrigation system and a *vega/huerta* that do not correspond to each other, be it because it is shared by several administrative divisions or irrigator communities, be it for opposing reasons, i.e., because the *vega* within a village comprises several systems working as a unit from the administrative point of view, i.e., within a single irrigators community. Complex spaces are the most common ones (fig. 3). This type takes place in Hueneja, Aldeire-La Calahorra, Lanteira-Alquife, Jerez del Marquesado, Cogollos, Albunan, Alcudia, Esfiliana or the river Alhama in Guadix, in the province of Granada.

Therefore, the range of cases can be summarized as follows:

- A hydraulic system corresponding to a single *vega*. (1:1)
- A *vega* constituted by several hydraulic systems. (N:1)
- A hydraulic system supplying water to several *vegas* simultaneously. (1:N).

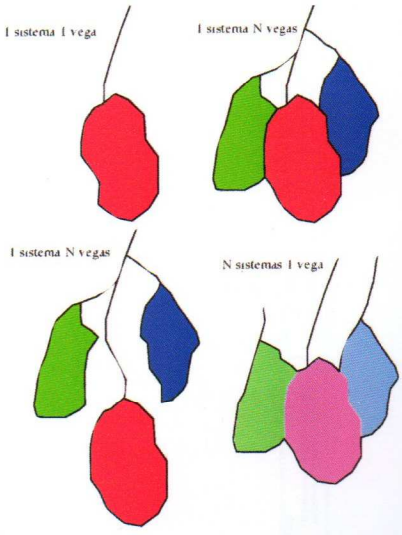

Fig. 3. "Simple" and "complex" irrigation spaces sketch, depending on the relationship between the technological units (hydraulic system) and the administrative units (*vega/huerta*). The former are those where the *vega* and the system itself coincide (1:1). In the complex ones we could find one system shared by more than one *vega* or one *vega* composed by more than one system (1:N / N:1).

In addition, differences have been found among the latter type, mainly based on the spatial distribution of *vegas* irrigated by one system. Therefore, a further difference may be stressed: juxtaposed *vegas* between which a physical division cannot be made, and *vegas* divided in space while sharing the supply of a single main irrigation channel and harvesting system.

Complex *vegas* are open to a richer interpretation regarding their evolution. Very often, they are connected to segregation or concentration processes that may be easily identifiable and clearly related to the evolution of population and territorial organization. Furthermore, many of these processes took place over the Andalusi period and modifications were not recorded as a result of the arrival of Castilian peoples.

The segregation processes in Aldeire-La Calahorra and Lanteira-Alquife (fig. 5, 6) are some of the examples found so far. The study of irrigation structures may provide important information, always in conjunction with other data available for the terrain in question. The creation of two *alquerias* has been identified in this area, called La Calahorra and Alquife. They derive from two ancient villages, Aldeire and Lanteira, respectively. This segregation process is related to the construction of two castles, and very likely to actions implemented by the State. La Calahorra possibly corresponds to the Caliphal period and Alquife to the Ziri period. In both cases it becomes obvious that the *vegas* in Aldeire-La Calahorra and Lanteira-Alquife belong to the same irrigated area. Actually, rivers are found in both Aldeire and Lanteira: they have full ownership over one of them, while the other is shared with a village located in a lower area nearby . In this way, even though the most "logical" division would have been based on each of the four villages owning one of the water courses – and thus making the districts boundaries coincide with the river basins, a different choice was made. It was based on the aim of guaranteeing the oldest *alquerias* had control over resources. Aldeire and Lanteira maintained their control over the lands in the mountains, where the water comes from and is taken from, while La Calahorra and Alquife do not own mountain lands. In addition, districts were divided, in such a way that each *alqueria* could have both *vega* lands and fields. This division is still visible in the districts, which have remained untouched since the new villages were created. Accordingly, lands are divided by others owned by different neighbors in some parts of the municipalities.

Concentration processes are slightly more numerous. There is no doubt that the main one took place in Jerez del Marquesado (fig. 4); however, many others are worth mentioning, such as the ones in Alcudia, Esfiliana and the city of Guadix.

The *alqueria* Jerez is the biggest one in the Zenete region. Three rivers flow close to the village, which is advantageous for the irrigation of its large *vega* area: Alcazar, Alhori and Bernal. However, five different juxtaposed systems exist under an apparent homogeneity of the irrigated lands in a sole *vega*. They corresponded with five old *alquerias* which gradually disappeared from the Lower Middle Ages. Their territories and water were absorbed by Jerez when its castle was built in the 12th century. These five *alquerias* were: Jerez/Tuyina, Alcazar, Nush, Mecina and Batillana.

From the Alcazar River, in the West, two irrigation channels start some meters up from its confluence with the Alhori River. The Alcazar irrigation channel is derived from the right side and the Guadix channel from the left. The Alcazar River supplies water to the homonymous terrain, comprising the area between the river of Jerez and the one belonging to Pueblo de Lanteira, to the East. Guadix irrigation channel starts on the left of the Alcazar River. Immediately, it crosses the Alhori River and ascends. It runs under an aqueduct through which

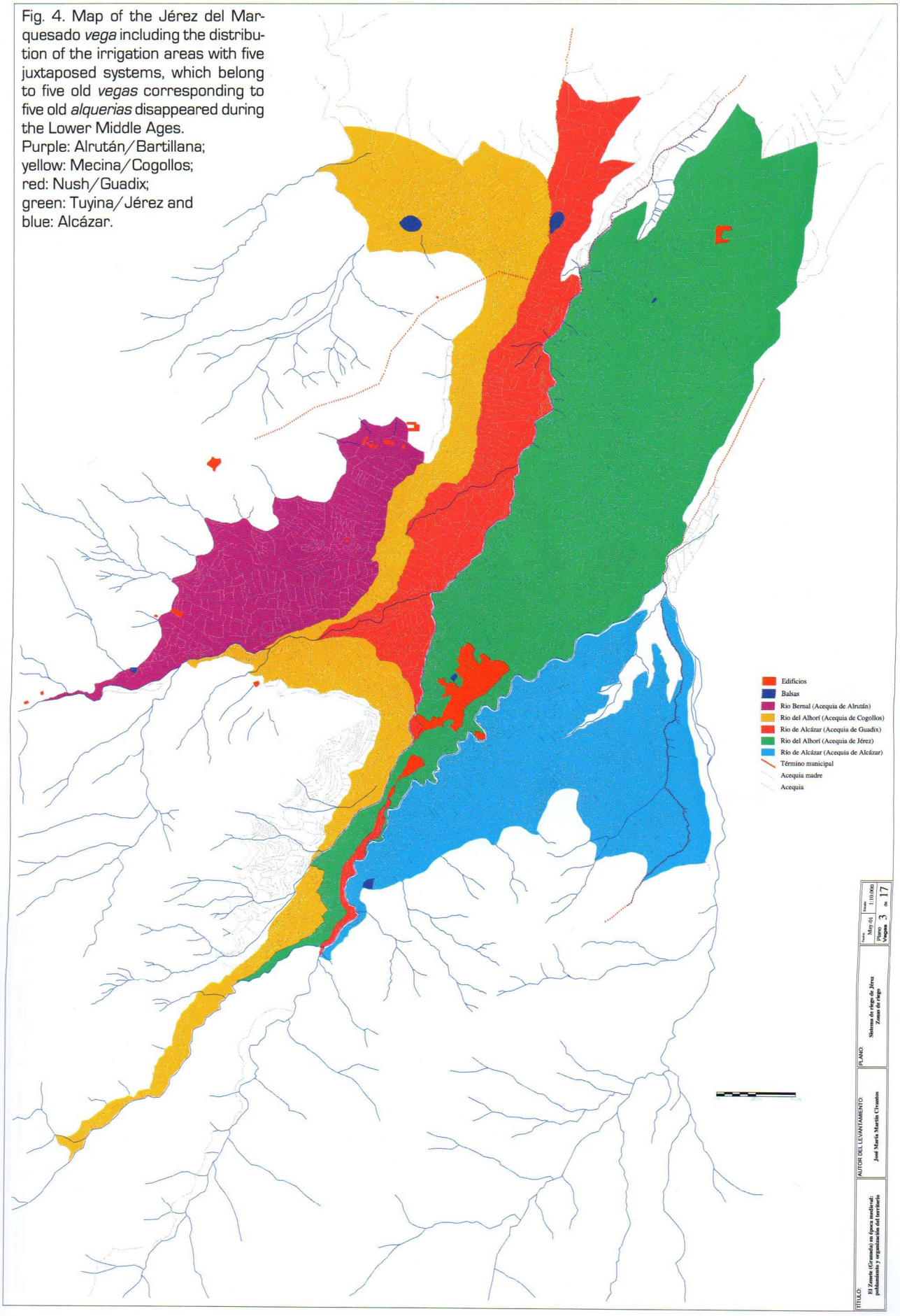

Fig. 4. Map of the Jérez del Marquesado *vega* including the distribution of the irrigation areas with five juxtaposed systems, which belong to five old *vegas* corresponding to five old *alquerías* disappeared during the Lower Middle Ages.
Purple: Alrután/Bartillana;
yellow: Mecina/Cogollos;
red: Nush/Guadix;
green: Tuyina/Jérez and
blue: Alcázar.

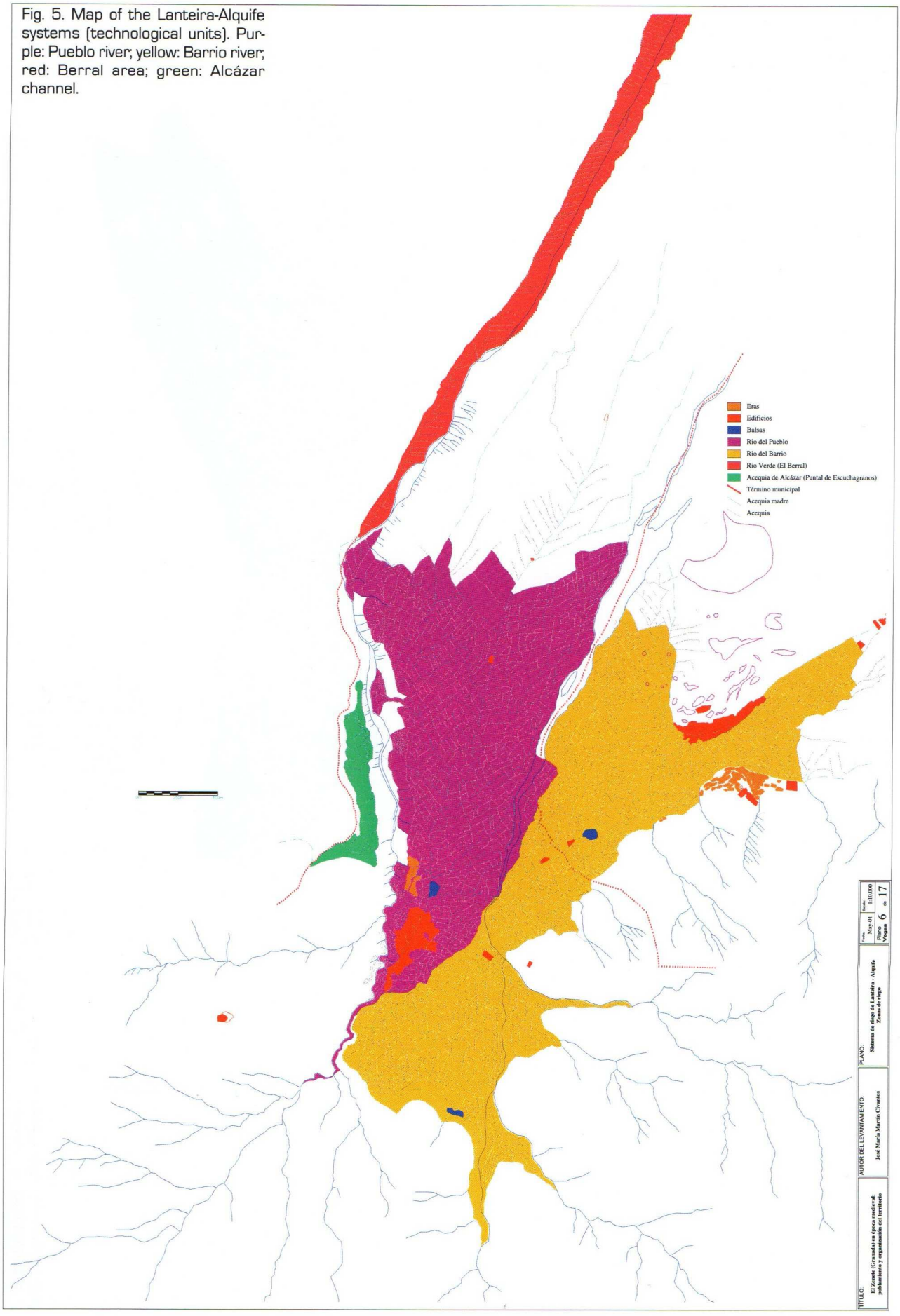

Fig. 5. Map of the Lanteira-Alquife systems (technological units). Purple: Pueblo river; yellow: Barrio river; red: Berral area; green: Alcázar channel.

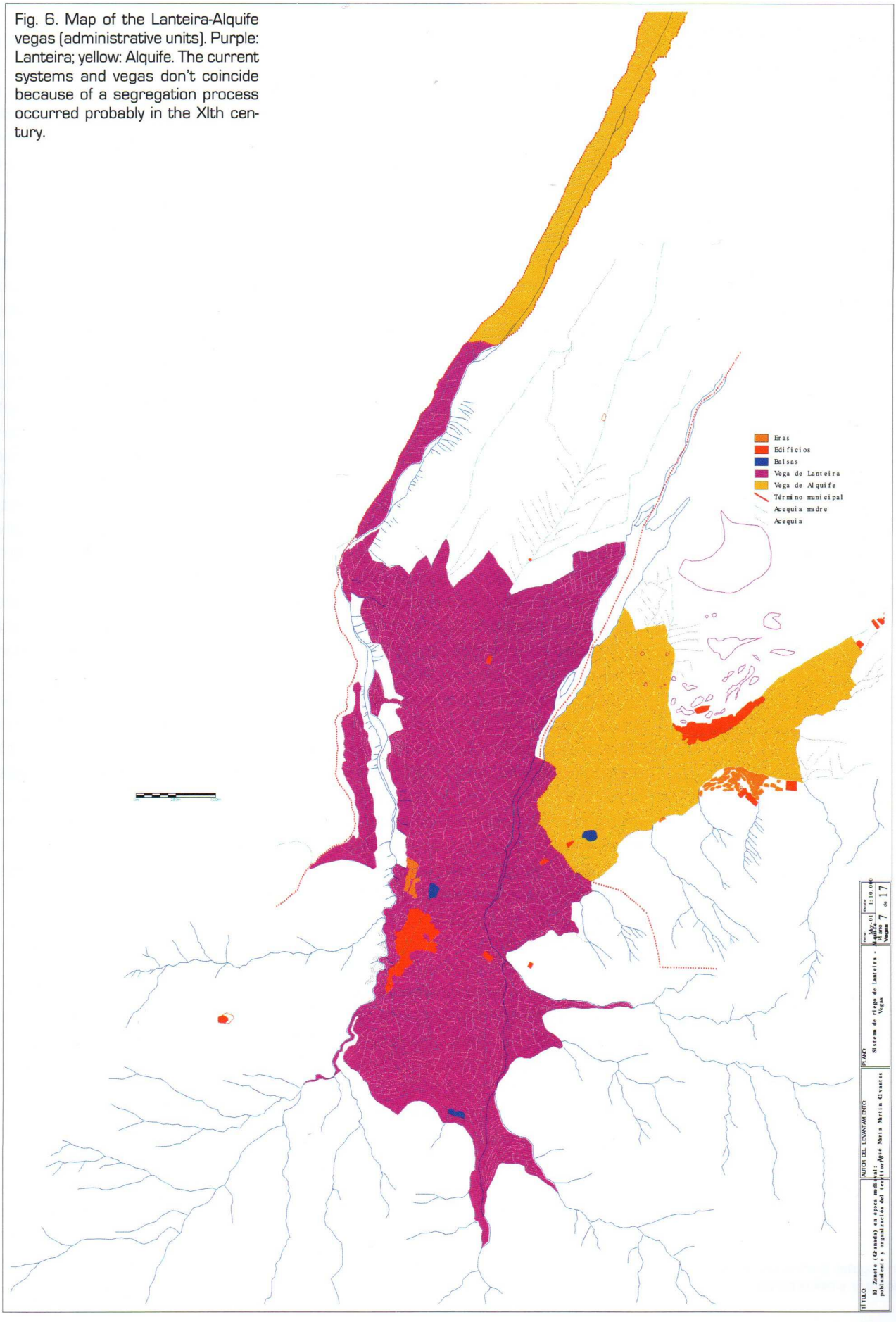

Fig. 6. Map of the Lanteira-Alquife vegas (administrative units). Purple: Lanteira; yellow: Alquife. The current systems and vegas don't coincide because of a segregation process occurred probably in the XIth century.

the Jerez irrigation channel flows and irrigates the Jerez vega area. Then, it penetrates the Albunan area, supplying water to two mills (Piedras and Sordillo), and soon after flows into the pond of the village.

A single main irrigation channel is derived from the Alhori River, the Jerez or Cogollos Alta. A supply channel goes upwards and takes advantage of the steep slope to move water for up to ten mills. However, at the middle of this mill complex, the irrigation channel is divided into two further channels: it goes straight heading North, moving one towards Jerez one, while the Cogollos channel flows on the left. the Jerez irrigation channel runs through the road in the marquisate area, via an aqueduct placed above the irrigation channel. It penetrates a village through the Barrio Alto, heading to the pond to which the only mother ditch available is connected, which in turn subdivides into secondary ditches heading towards the *vega* and the fields. The Alta de Cogollos irrigation channel heads down steep slope up to el Bernalillo or Rambla Seca; it runs through it and starts heading upwards again, irrigating the area on the right. When it reaches the Raja mill, the supply channel is further divided into two channels: the Rutanillo de la Jubaya is found to the left, a higher armlet supplying water to the Raja. The armlet goes along the hill of Ermita de la Virgen de la Cabeza (a shrine of Mecina), penetrates Cogollos, supplies a mill called Molino de las Penas, and irrigates a number of lots located above the village pond. The main irrigation channel continues straight on, in parallel to the previous one. It irrigates the Fabrica and Tierras de la Iglesia terrains, penetrates the Cogollos district along the hill side; sets the Balsa mill in motion and supplies water to the pond in Cogollos, which is used to irrigate the *vega* in this village[5].

Two irrigation channels are derived from Bernal River, supplying water to the Western area of the Jerez *vega*. The main irrigation channel is the Alrutan supply channel, which soon after reaches the regulation pond. The second irrigation channel is born in the Bernal River, where it joins the Piletas gully.

As we said before, the waters of Alcazar River are shared by Albunan and the *alquerias* located below that level through the Guadix irrigation channel: Aute, Zalabi and Zigueni, up to Guadix. Water from the Alhori River is also shared with Cogollos through the homonymous irrigation channel. From here a basin transfer occurs and the irrigation channels from Jerez (coming from the Alhori River) and from Guadix (from the Alcazar River) are crossed. These three rivers do not get mixed with each other. Each river irrigates the corresponding area in such a way that it looks as if several *vegas* were juxtaposed. This becomes especially clear in the terrains in Alcazar and Alrutan.

Each of the irrigation channels in Alcazar, Jerez and Alrutan has a pond on its own. Neither the irrigation channel in Cogollos nor the one in Guadix have a pond until the head of the Albunan and Cogollos districts.

In the documents on the Zenete area, of Arab origin and published by A. Gonzalez Palencia, the first and oldest one mentiones, an "agreement between the villages Bartiliana and Lubros regarding the division of water in their boundaries" (González Palencia 1940, pp. 321-328). It dates from the end of Ramadan 685 (19th November 1286), but it is a copy of an older one, dated back to the epoch of the second tenth of the Rabi I 583 (20th - 30th May 1187).

Fountains, transpiration areas and springs quoted in this case are those created by *chortales* or *chorreras* (waterfalls) by diverting meltwater during the winter and the spring. This water use and control system confirms the location of Bartillana in the basin of the Bernal River. Water is thought to have been diverted from the head of the neighboring Alhama River to the Bernal River. As we have already proved, Bartillana was located in the Alrutan terrains, which is, as mentioned before, independent from the rest of lands of the Jerez *vega*.

[5] In Cogollos there is also a modern *pantaneta* or small reservoir.

Bartillana disappeared before the Castilian conquest. At that time, the only memory of it existence was the Bertillana terrain, which is mentioned in the registration archive of 1549 (Spanish National Historical Archive, Osuna section, bundle of papers 1867-10 and 1868-1). In Arab documents about the Zenete area it is still recorded as an *alqueria* in the sale of royal properties in 1330 (González Palencia 1940, p. 332); however, it may refer to a previous village. Despite being on the Western side, the lands sold were adscribed to Jerez castle and *alqueria*, around the mines in Santa Constanza. Indeed, the demarcation and appraisal was carried out by its neighbors. Thus, Jerez would likely have absorbed the Bartillana *alqueria* and its territory, even though it was still remembered or a borough named after it existed.

During the Castilian period, a lawsuit began between the monastery of Parral from Segovia, administrator of Cogollos, and the Jerez Council in connection with the distribution of water from the Alhori River, which was taken through the irrigation channel known as Acequia Alta of Cogollos or Mecina (Spanish National Historical Archive, Osuna section, bundle of papers 4.230-1. Espinar Moreno, Quesada Gómez 1993-1994, pp. 81-95). Rights wielded by Cogollos were written in the Legal Manifiesto. They are use rights established by at least the 12th century. In this case, conflicts dating back to the Andalusi period during the years 1197, 1227 and 1472 and, subsequently, to the attempt of water appropriation by Jerez in 1549 are recurrently put forward.

People from Jerez, acting in self-defense, state that Alhori and the irrigation channel are born within Jerez territory, in particular in Camarate and Cabraleche or Chorreras Negras. Meanwhile, Cogollos wields an Arab document from the year 624 H (1227), written by the Muslim judge from Guadix. The three villages at stake in the document are Jerez, Cogollos and Mecina. As proved in the first lawsuit dating back to 1197, the Cogollos and Mecina *alquerias* built the irrigation channel and, therefore, were the only ones having a right to them. Actually, maybe Jerez did not exist at that period and it exclusively obtained its rights because it replaced Mecina when the latter disappeared, thus taking over its territory and water. The Cogollos chapel was known as the Mecina chapel, which used to be a *rabita* (mosque) and would be used as a border between Zenete and Guadix.

But, what was to become of Jerez? In accordance with the lawsuit, the Jerez *alqueria* already existed in 1197 and had taken over the Mecina lands and water. This chronology coincides with the one derived from in ceramics and construction techniques used in the village castle, dating back to the 12th century. It might have brought together the population in the neighboring villages, mainly after the predatory action carried out by Alfonso The Warrior in 1125-1126 (*Al- Hulal al-Mawshiyya*, pp. 109 ff.; Ibn Al-Jatîb 1976, pp. 109-110. See also *Crónica de los Estados peninsulares* 1955, pp. 127-128). The Jerez irrigation channel and its irrigation system may date back to a previous time. Otherwise, it would not have rights over water, especially over such an abundant amount of water. We do not know what *alqueria* or *alquerias* it belonged to. The mysterious °ilyāna may have existed already. It is located twelve miles from Guadix and mentioned by Ibn Sa'îd, Al-Maqqarî and Ibn Al-Jatîb (Ibn Sa'Îd 1995, pp. 91-186; Al-Maqqarî 1949, I, p. 143; Ibn Al-Jatîb 1998). The registration from 1549 shows some neighbors named Giliani (Spanish National Historical Archive, Osuna section, bundle of papers 1867-10), probably coming from Yilyâna, and thus reinforcing the idea that it was located close to the town. However, the Tuyina/Tuyana terrain is mentioned later in that document. It was sold as royal goods in 1459 and it is probably also a Latin place name, such as Bartillana and Mecina/Masâna (Pabón J. M. 1953, pp. 75-90). Despite

Fig. 7. Dam for the Alhama river system in the same place where the XIIth century's document mentioned the *Maqsam* to distribute the water into the two main channels.

lacking traces suggesting that it was a nucleus herd, its location coincides with the Farusa settlement, dated from the Late Middle Ages.

Waters from the Jerez territory were also used by the following towns: Cogollos, Mecina, Nûsh, Albunan, Fahs al-Hawzâ, Aute, Zalabi, Zigueni and by a part of the Guadix lands. All of them used the Guadix irrigation channel to irrigate at least part of their *vegas*. All of them were placed downhill from Jerez, but this does not mean that they were founded later. Actually, it is highly probable that they were older, like Cogollos and Mecina, and had a right to use water coming from the Sierra Nevada Mountains through the Alcazar River.

The first we can find nowadays is Albunan, which was first mentioned in 1330 in a bill of sale of some royal goods. It is considered an *alqueria* belonging to Guadix, together with the Nûsh and Fahs al-Hawzâ ones (González Palencia 1940, pp. 304 and 341).

In accordance with this document, the river waters were divided into two to be taken by the Nûsh irrigation channel, one of the *alquerias* mentioned before. This Nûsh irrigation channel is, without any doubt, the current channel called the Guadix irrigation channel, which actually irrigates one of the aforementioned *alquerias*, al-Bunyân (Albuñán). Given that the irrigation channel is named after the first town which uses it to irrigate and the order in which the three of them are mentioned is correct, we can deduce the Nûsh *alqueria* was uphill from Albunan. In other words, its *vega* was formed by lands placed between the Guadix irrigation channel and the Bernal River, under the Mecina irrigation channel, where the limit of the Jerez municipality currently is. In the registration of 1549, there are some neighbors called Ratalnos (Spanish National Historical Archive, Osuna, legs. 1867-10), which may be referred to harât al- Nûsh, that is, this *alqueria* could have become a neighborhood of Jerez before it disappeared. The Fahs al Hawzâ *alqueria* could be placed downhill from Albunan and it may correspond to any of the archaeological sites found in the plain over the Alamo irrigation channel.

In addition to these segregation and concentration processes, another interesting phenomenon is worth mentioning here: We have called it the fossilization process. It would mainly occur, at least partially, in those cases where different *alquerias* shared the same system, i.e. the same catchments and

Fig. 8. Water distributor in the main irrigation channel in the Lugros *vega*.

main irrigation channel, but whose irrigation spaces were divided. In such cases, it is more problematic to assert that the concentration processes mentioned above took place, even in different systems such as the Jerez one.

Westwards another basin is located, related to the Alhama de Guadix River. An important document describing this river and how water was distributed, dating from the 12th century (year 1138-1139), is still preserved (Molina López 1991; Espinar Moreno 1987). Both original Arab documents are preserved in the Archives of the Cathedral of Guadix, the first draft dating back to the 12th century and the last one to the 15th century. The Romance version from 1536 is still available. It was written as a result of a lawsuit held in the Chancellery of Granada.

The river course is utilised by up to seven *alquerias* through two different irrigation channels and in perfectly regulated turns. Water flowing down from the Sierra Nevada Mountains was dammed at a place called *al-Maqsam* (water castle or distributor channel) at the source of the Alhama River. Distribution was equitably made to the two irrigation channels, which are four miles long from that point. One of them is used by neighbors in Lugros, Abraynit and Guebro, and the other one by those from Bizar, Graena, Fazalares and Qabsun. The second one was further divided into two: One for the Fazalares and Bizar *alquerias*, the former having a right to full use of water available every Saturday and the latter using water the rest of days; and another one for Qabsun neighbors, who were allowed to use the full amount of water available for seven alternate days per month. For remaining days, water belongs to the Graena *alqueria*. Water is "a land right of the aforementioned *alquerias*" and "of the owners of those estates". Therefore, water is ascribed to land. The distribution type, equal between both irrigation channels, shows they were built at the same time and as a part of the same design for an irrigated space. The valley was organized in accordance with this design and work spaces and residential places were mostly built simultaneously. Furthermore, customs and old rights are also mentioned, i.e. a significantly solid organization dating back from long before the lawsuit was held. In a later lawsuit involving Lubros (Lugros) and Bartillana *alquerias* in 1187 regarding waters coming from the Sierra Nevada Mountains (González Palencia 1940, pp. 321-328), the aforementioned old rights were referred to. Indeed, they were considered the final argument supporting the people from the Lugros *alqueria*.

Interpretation Proposals

The study of these landscapes depicts shows an image that departs from the statism pervading a part of the Andalusi history. Knowledge on productive areas is a source of key information in learning more about settlements, territorial organization and their historical evolution.

Water conditions the settlement and the territorial organization in the ancient *alquerias* in the entire Northern side of Sierra Nevada Mountains. It determines organization not only in towns located in the mountains and serving as the source of basins coming from the summits, but also in towns located downhill. It is downhill where the shape of the territories becomes less elongate, because they do not control the source of the river basins and their stablished *vegas* boundaries delimiting the territory controlled by each of these towns.

In addition, water division among different *alquerias* highlights a meaningful problem related not only to the settlements chronology, but also to the social organization of both space and labor processes.

In a previous study we proposed some ideas for the interpretation of spatial distribution, and in particular for the distribution of groups in charge of building up irrigation spaces when they are set up (Martín Civantos 2007). We consider that spatial distribution determines the later evolution to a large extent, depending on whether the hydraulic system or only the water are shared, and also on whether irrigation spaces are separate or not. In this regard, three hypotesis were suggested by us:

a.- Clans or groups share the river or the aquifer, however they do not share the irrigation structures, i.e. the irrigation channels or the receptacle pool, or the space.

b.- Groups share the system, but each of them has its own irrigation channel and space completely differentiated from the rest, even in spatial terms. This is the case, for instance, of the Alhama de Guadix River, which is shared by seven *alquerias* through two irrigation channels. That means that each group owns a *vega*, even though their *vegas* may be close together and seem to be only one. The clan's heritage is consistent and is irrigated jointly.

c.- They share the system within the same space, that is, the same *vega*, where it is difficult to distinguish each of the groups in the space. This last scenario would only be possible if the kinship structures were dissolved allowing the neighbouring ones to participate in the distribution.

In any case, the system of hydraulic organization would have originally been one that was defined as either "a" or "b", the only ones where kinship social structures are recognizable, resulting in a third type as they became neighbours. In the first two cases, communal relations can be developed on the basis of a deeply-rooted link with the land and neighbourhood. Thus, the systems are maintained once the tribe has disappeared. However, under the second case, where different clans share the system but not the same spaces, more important or easier changes take place, especially in the location of residential areas when spaces are concentrated. Due to dispersion conditions, the first scenario makes possible the fossilization of settlement structures.

Diverse factors influence these possibilities, among which the spatial factor plays an important role. Spatial differentiation of the cultivation areas should not be understimated: it influences the organization of labor and determines its location, since the proximity to the residential area is a key criterion. In the first type of system, *vegas* are usually very distinguishable, as well as the processes involved: catchments, water transportation and distribution (although

there may have been specific agreements concerning distribution and in turn common vigilance). This becomes especially obvious in cases where each *alqueria* irrigates using its own fountain or reservoir and irrigation channel. However, the same thing happens in the second type of system, where the same catchments of water and irrigation supply water to the *alquerias* located alongside a valley or a river. In this case, the group in charge of maintaining the infrastructure changes depending on the existing settlement agreements for each group, but the community labor has to be set by force majeure. As we mentioned above, this would be the state of affairs in the neighboring river Alhama de Guadix, as proven by a document dating back to the 12th century.

The relationship becomes even more complicated when different clans or groups live together. They might share the same system, but each of them has its own juxtaposed *vega*. Although they are together and give an impression of unity, the clan patrimony remains consistent and irrigation is undertaken jointly. Therefore, each *vega* is easily distinguishable from the one another. However, it can also occur that different systems are juxtaposed and independent at the same time, as it happens in Jerez or Alcudia. This model would allow the greatest changes in settlement once the kinship social structures become neighbouring ones. This is likely to be the case in the concentration processes we have identified.

In the case of the Cogollos irrigation channel and especially in the Guadix one, a new perspective is opened to us, which is as much interesting as difficult to resolve without a more detailed study. The final result indicates that a settlement concentration was taking place in Jerez since the 12th century. It became more and more important and its territory grew bigger due to the incorporation of Mecina, in the first place, and later on Bartillana, Nûsh and Alcazar. The only surviving nucleus was the last one, which became a mere neighborhood of Jerez in the 15th century. In the Castilian documents from the 16th century it is described this way, and it seems to have survived unchanged until it virtually disappeared after the expulsion of the Moriscos.

In other cases, common trends such as the concentration of a part of the settlements from the 12th century are identified. We know that some of the *alquerias* in the valley of the Alhama River mentioned in documentary sources related to water distribution from the 12th century disappeared, although we cannot specify the chronology of these desertions. Therefore, Bizar, which is nowadays known as Policar, absorbed Fazares and its territory; Graena also took up Qabsun; while the Abraynit and Guebro *alquerias* were incorporated into an area of the city of Guadix. All of them became country houses and survive to present day. In the current municipality of the Valle del Zalabi, close to the Verde River, archaeological findings prove that the Aute and Picena *alquerias*, which were included in the Alcudia territory, were abandoned after the 12th century.

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