AN EXAMPLE OF USING A RELATIONAL DATA BASE FOR DELIMITING TECHNOLOGICAL DOMAIN SYSTEMS IN THE PREHISTORY OF THE IBERIAN PENINSULA: PROJECT AU

Oscar García Vuelta
Dpto. de Prehistoria. Centro de Estudios Históricos –CSIC.
C/ Serrano nº 13. 18001. Madrid. Spain.
E-Mail: ovuelta@ceh.csic.es

Alicia Perea
Dpto. de Prehistoria. Centro de Estudios Históricos –CSIC.
C/ Serrano nº 13. 18001. Madrid. Spain.
E-Mail: perea@ceh.csic.es

Summary
The aim of this paper is to draw attention to the efficiency and profitability of data processing tools, based on relational database systems, for carrying out complex, technological and social studies in Archaeology.

Project AU is a long-term, research strategy, designed to create the theoretical, methodological and analytical foundations, that will make it possible to identify and establish the origins, and delimit the interactions, between the various, technological domain systems, in the Prehistory of the Iberian Peninsula. It is based on a study of the processes used for transforming precious metals, in order to determine the mechanisms governing technological change and transmission, which ultimately lead to social change. The metallurgy of gold has been chosen for a case study, due to its technological complexity and also its social and economic significance. An interdisciplinary, methodological approach has been adopted, which uses the latest analytical techniques, integrating various, methodological and theoretical lines of work and means of dissemination.

The projects, currently under way, include, "A Microscopic and Microanalyticalal Database for studying Technological Domain Systems in Prehistory. Change and Transmission in Gold Metallurgy", which is being financed by the DGICYT (PB 94-0129) and has been undertaken, in collaboration with thè National Center for Metallurgical Research (C.E.N.I.M., CSIC), and also, "Visigoth Gold Technology. Guarrazar and Torredonjimeno, in the Framework of a Visigoth Presence in the Madrid Region", which is being financed by the Regional Government of Madrid (Ref. N§ 06/0022/1997). These studies form part of the Anthropology of Technology: Archeometallurgy research line, organized by the Prehistory Department of the Center for Historical Studies (C.E.H., CSIC), Madrid.

The first results came in, in 1997, when the AU relational database was designed and launched. It was presented at the 2nd National Congress of Archaeometry (Zaragoza, Spain, September, 1997). This application served as one of the foundations for the work that we are doing now, and was conceived to be a fundamental tool for organizing and developing a complex, archaeological study. It went beyond the concept of a database, as a simple tool for organizing lists, and was capable of analyzing, in depth, the results of a combination of studies, presented from various perspectives. The studies, undertaken to date, already represent a first step, towards the technological and social analysis of various sets of peninsular goldwork, which can, in turn, be used as a starting point for the social and spatial characterization of the technological systems and domains, within which they developed.

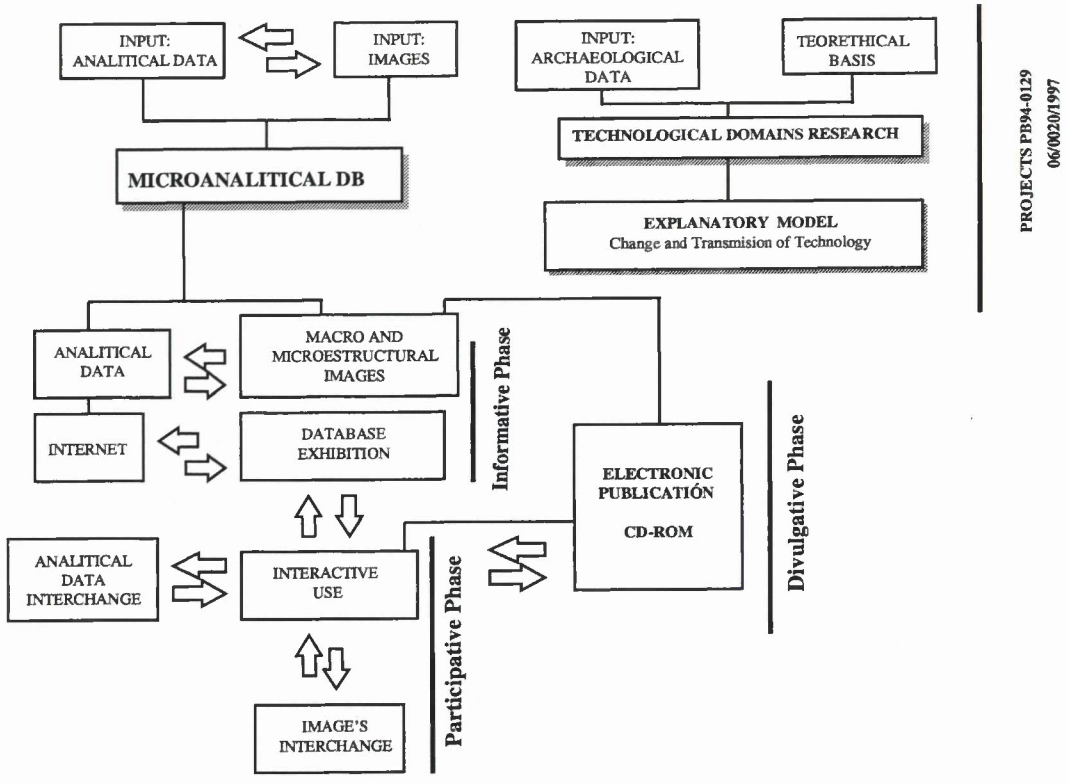
General methodology

The Au database reflects our work's methodological and conceptual approaches, expressed through a study system, which takes into account the individuality of artifacts, in their archaeological and social context (Perea, 1997a). This methodology is divided into two phases:

a) *Topographical Phase.* This is based on the observation, identification and documentation of working traces, left by tools, on the surface of the metal being shaped, or the superficial, macro- and microstructures, which appear as the result of heat processes or chemical changes in site conditions. This allows us, first of all, to discover the techniques used to produce an object, and second, to reconstruct the tools, which were used; third, it allows us to determine the processes of wear, through use and deterioration, throughout the course of archaeological time.

Topographical observation is carried out on two levels, depending on the characteristics and accessibility of the artifacts. First, it is carried out at a macro level, using optical instruments for enlargement, and then on a micro level, using electronic instruments (generally, a scanning electron microscope (SEM), one of the most versatile tools available to current research). The process of obtaining topographic data can be compared to that of an archaeological excavation: a piece is observed in increasingly greater depth, from its superficial levels, where the processes of wear can be documented, through to its finishing, polishing and

PROJECT'S FLOWCHART



deterioration (through use, etc.), and down to the deeper levels of raw material manipulation, assembly of its various structural parts, and the fixing of its parts.

b) *Microanalytical phase.* This consists of a chemical analysis of the alloys used, and the effects and changes, produced in them, caused by the passage of time and site conditions. Among the advantages of the SEM, used in the topographical phase, there is the possibility of carrying out an analysis, using the electron microprobe, which is provided with an energy dispersion spectrometer (EDS). The advantage of the microprobe is that it can carry out a chemical analysis of areas as small as 3 micras, which makes it possible to reach areas (such as the necks of the soldering, or any other microstructure), which might have been seen in the topographical examination.

After the morphological and microstructural analysis of a piece has been carried out, *a study of the context* is made, both from the archaeological point of view and from its relationship to a particular, technological environment. The associations, between artifacts and the general characteristics of the site and the sets, are analyzed and then, contrasted in the supraregional environment (Determination of Technological Domains). All of the levels of study are completed with integrated, graphic information, which is included in the *AU repertory of metallographic, macro- and micrographs*, stored in a digital format, so that they can be processed and recovered within the database.

The AU data base. Design and function

The complexity of this type of research, where work proceeds, simultaneously, on various fronts, and the singular character of sets is analyzed, means that the synthesis of the enormous quantity of information, generated in a conventional database, is a complex task; and, hence, its subsequent management is difficult. However, a project, with long-term objectives, such as the possibility for debate among researchers and the exchange of scientific information, in real time, should not be restricted, by being arranged in an unalterable way; this is important, since, in many cases, it is the very individuality of the artifact studied, that necessarily determines the guidelines for its structure, in an every-increasing volume of information.
Therefore, we proposed that a versatile structure should be designed, which ensures that the system is sound, but which, at the same time, is sensitive to possible structural changes and adaptable to the results of any new technical or archaeological advances, that may be made. This would avoid turning the system into a mere catalogue of museum pieces, or an impermeable data archive, only useful for the initial objective, for which it was originally conceived.

Using this idea as a starting point, the Au database has been made up from various, independent databases and archives, which have been inter-linked, to create a single system. It has been configured to be an extensive, relational environment, which makes it possible to study various levels of contextual, archaeological, technical and analytical information, while still respecting the singular character of an archaeological piece, in relation to images, which reflect the different aspects of the study (AU Repertory of

metallographic macro- and micrographs). This research process allows that a find can be subsequently related to a specific, technological environment.

The whole structure is presented as a graphic environment, which permits access to various levels of research and accelerates the possibilities for consultation and management. The potential set of possibilities, which its application offers, makes it a very useful tool, not just for specific, archaeometallurgical tasks, but also, for undertaking complex studies, having objectives, which go beyond traditional database usage.

The Au database is presented in a standard format (DBF), which uses commercial software, in order to take advantage of the great versatility, power and constant evolution of current products (always limited, unfortunately, by economic constraints), and which ensures the compatibility of its data, with work undertaken by other research teams.

Structure of the application

We conceived this database, to be a process of continuous information exchange, for pieces in a "from *macro* to *micro*" study framework, where the user selects the object to be studied, and conducts his research from the most "superficial" levels of the piece (Archaeological Base), to the "deepest" levels (Microstructural Base). Throughout this process, the complementary bases supply the information necessary, for enriching or contrasting the data, in the different aspects of the study (Previous Analyses, Image Bank, Bibliographic Repertories, etc.). The base's basic units, which form the foundation of its structure, are the find-piece and the find-set.

The Archaeological Base

This is the *contextual* section of our study methodology. This level of knowledge is organized into various sections of information, in relation to a general picture of the piece. The first of these relates to *identification* data: *find-site*, previous and present *location* of the piece, original seriation, and *museum* of origin. Then, the circumstances of the *find* are presented, noting variables of *type* (necropolis, settlement, hoard, etc.) and *form* (ancient excavation, scientific excavation, casual find, etc.). New blocks refer to the artifact's *morphological classification* and *chronology*, and *the materials used in its manufacture.*
All of this information is followed by a level of *contextual* information, which is organized on the basis of ranking the value and reliability of information; three *associative units* are defined, which classify the available data, on the basis of the artifact's association to other objects and on the circumstances of abandonment and discovery.

Finally, we include basic *bibliographic references*, to the find and the piece, held in the auxiliary bibliographic database.

The Technical Base

This corresponds to the *topographical phase* of our work, where a specific study is made on the different *structural elements* of the artifact, after analyzing its general, technical data in a first block of information.

This division permits a detailed approach to each of the phases of the piece's production process, in relation to the detail images, which illustrate it. Both, the object as a whole, and each, particular structural element, are studied from the technological, structural, and ornamental point of view; this section also looks at the *state of preservation and the signs of wear.*

Specific and comparative studies can also be carried out, in relation to the find as a whole (materials of direct association). Finally, information is offered on the various, *previous treatments*, to which the piece might have been submitted, after its recovery, evaluating to what extent those may have affected its present state of preservation.

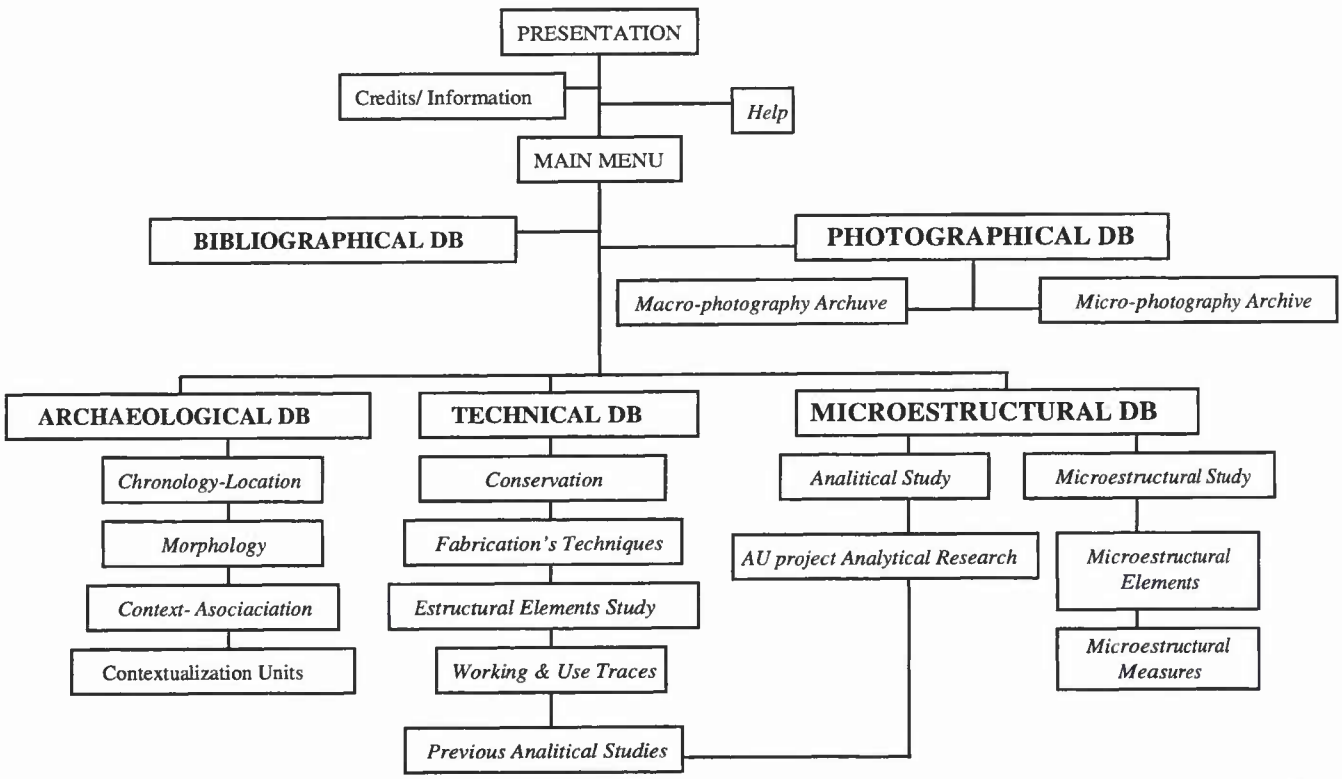
The Microstructural Base

This base, which closes the formal process of study, is used for the *microstructural phase* of our working methodology. In this section, the *identification* of the various *microstructures* is combined with their *microanalyticalal study* (EDS). As in the technical base, access is accomplished,by means of general information screens, which show the different *treatments*, to which the piece has been subjected, and which summarize the set of studies, carried out on the object, giving the total number of spectrographic readings, the definition of the microstructures examined, and the number of *micrographs* obtained. From this general level., we can go on to the specific *analytical data* for each microstructure, detailing its characteristics and carrying out an archaeometric study, which includes options for comparing different microstructures, belonging to the same object, as well as the possibility of analyzing them, in comparison to other sets. The data from the same base can also be contrasted with the analytical conclusions, obtained from the work of other research teams (previous analyses).

Complementary data bases and archives.

a) *AU Repertory of metallographic macro- and micrographs.* This was developed from the photographic archive, generated by Dr. Perea's earlier work; the micrographs were obtained in the microanalyticalal studies, carried out in collaboration with the National Center of Metallurgical Research (C.E.N.I.M., CSIC), and from the current photographic records of the pieces being studied. The process of digitizing this repertory means that we now have an ample bank of graphic information, which contains more than one thousand macrostructural images, and over five hundred micrographs, generated by scanning electron microscope (SEM).
b) *Photographic Base.* The digital, graphic information of the repertory is stored in an independent, relational database, which acts as a graphic server for the studies presented in the Au base. The photographic repertory is divided into two blocks: the first (topographic images) acts as a server for the archaeological and technical bases, and the second (micrographic images) stores and presents the graphic data of the microanalyticalal database.

AU DATABASE : ORGANIZATION'S CHART



c) *Bibliographic Base.* This base offers an abundant tool, for referencing and contrasting the information presented in the various bases. It is organized under a specific, graphic environment, with numerous consultative options. This environment permits the independent use of the entire database and, at the same time, provides direct access to basic, bibliographic references to the pieces being studied.

d) *Earlier Analyses.* As a complement and contrast to the microstructural study, carried out by Project AU, the analytical results, obtained by previous research teams, on pieces being studied, are presented, with information about their methodology.

Current lines of work and outlook for the future. Conclusions

Since it was presented last year, the Au Database System has undergone considerable structural changes, which have primarily affected the graphic management environment and the structure of the relationships, between the various databases, which make it up. The database is now very close to achieving its immediate objectives, although its size means a series of adjustments are still required, in the medium and long term, before it will be fully operational. However, its presentation and objectives achieved already permit its complete exposition for scientific discussion.

With regard to content, we have succeeded in managing a considerable volume of information; this includes almost five hundred pieces, and there are even more analytical studies, with some, three thousand analyses, from which more than six hundred scanning electron microscope micrographs have been obtained. The Au repertory of metallographic macro- and micrographs also contains a considerable volume of information.

The phase of linking it up with the future objectives of the project has been initiated, such as the publication of the system on the Internet, through a specific application, which includes different levels of access, permiting the exchange of information or scientific debate, in real time, between research teams. For the moment, basic information about our research is being published on the Net, information which will shortly be available on the web pages of the Center of Historical Studies (CEH) in Madrid (*http://www.ceh.prehistoria.csic.es*).

Finally, in the field of computer applications in archaeology, we believe that the Au Database is a good example of how a tool, which provides easy access and management, can actively contribute to the practical work involved in concluding a complex, research project, not just by managing, organizing and publishing information, but by structuring the actual work process and making the communication and amplification of its results possible.

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