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Information Technologies, 3D Archaeological Models and GIS: The State of the Question — An Example of 3D GIS Stratigraphy: La LLuera I cave

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Abstract: The Prehistory shows us, that from 2 million years ago, the technology is something necessary for all the human species. Just like the Prehistory has proven that certain tools or modifications can invent or reinvent themselves in different historical periods depending on the need; today it is necessary to accept that the technology is, to us what the race and the claws to the lions, a biological and evolutionary adaptation. From the years 70, Information Technologies are not just a tool, but that lead all the fields of economics and research. In recent years, there is no site or caves with Paleolithic art, that you do not want to take a 3D virtual visit. For this reason, any site or cave with rock art must begin by creating your own 3D archaeological model. Within the 3D archaeological models, if someone is looking for not only magic, but the realism of the data's veracity, GIS are the best tool. Based on the example about the solutrean stratigraphy of La Lluera I cave (San Juan de Priorio, Oviedo, Asturias, Spain), we do an overview of how it has advanced in the study of the stratigraphies in 3D and its archaeological record. It is not just a matter of software, but on many occasions, it does not get adequate nor the quality nor does it solve many of the problems facing the Archaeology. In response to this, are the individual initiatives about elaborations of 3D stratigraphies using GIS which are giving real solutions to the archaeological record. In recent years, improvements in such software, specifically with regard to the voxelization lead us finally to be able to close a discussion: how does 2.5 GIS or 3D GIS? Today, 3D GIS more than ever. All this leads us to conclude, that GIS are the most appropriate tool for the study of any stratigraphy, and secondly, that the purpose of 3D archaeological models should not only be the reconstruction of the archaeological record, but help us to understand the same.

Key words: Information Technologies (IT), 3D archaeological models, Geographic Information Systems (GIS), stratigraphy, Cantabrian region

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“Por primera vez en la historia, la mente humana
es una fuerza productiva directa, no sólo un elemento
decisivo del sistema de producción.
Por lo tanto, las computadoras, los sistemas de comunicación,
y la decodificación y programación genética son todo
amplificadores y extensiones de la mente humana. Lo que
pensamos y como lo pensamos es expresado en bienes de
servicio, output material e intelectual, ya sea comida,
refugio, sistema de transporte y de comunicación,
computadoras, misiles, salud, educación o imágenes”.

Manuel Castells:
La revolución tecnológica de la información. ¿Qué revolución? 1999:3-4.
En la Era de la Información, Economía, Sociedad y Cultura, I.
SXXI. Editores. Buenos Aires.

“I don’t want realism; I want magic.
She goes on to say, by way of defining “magic”.
Yes, yes, magic. I try to give that to people.
I do misrepresent things. I don’t tell truths.
I tell what ought to be truth”.

Richard C. Beacham:
“Concerning the Paradox of Paradato. Or,
I don’t want realism; I want magic!”. 2009:27.
Actas I Congreso Internacional de Arqueología e Informática Gráfica,
Patrimonio e Innovación, I. Sevilla

1. Introduction

The chimpanzees and orangutans used stems for supplies of termites in a tree, and in this way obtained proteins (Sabater Pi, 1985). It is scientifically accepted, that the Australopithecus, like the Ardipithecus ramidus occasionally used quartzite, flint, or sandstone edges to stretch their wings over meat occasionally. But, it is from 2 million years ago when hominids produce what the researchers called lithic technology, first for the scavenging, and subsequently the hunting. In this step, toward new spaces — the savannah, do not deny for nothing nor the beginning of other activities such as harvesting, but the remains that we are in the majority of the cases are lithic industries. It is the first test of a technology, the lithic. The technology is to us what the race and the claws to the lions, a biological and evolutionary adaptation from 2 million years ago (Carbonell & Sala, 2000). The human mind has different areas. Steve Mithen (1996), in *The Prehistory of the mind: A search for the origins of art, religion and science,* tries to with archaeological evidence and based on theories of modern psychology track the mind’s evolution over the last 2 million years ago. Without going into spouting platitudes by all known, as for example that you protein requirement of the meat meant a revolution, thread-like driver uses the existence of several areas of intelligence along these 2 million years ago: general intelligence area, social intelligence area, linguistic intelligence area, technical intelligence area and natural intelligence area. Logically, in the present article the intelligence area that we are interested in is the technical intelligence area, but the draw areas in the mind is not new. In 1909, Brodmann, from a point of view medical, drew up a map of the 47 the mind’s area (Broca’s area, Wenicke, etc…). Throughout the SXX, to these 47 areas have been gradually adding the brain’s functionality, which roughly are summarized in the following: Broca area, hearing, Wenicke, cognition, emotion, vision front area, somato-sensory area, motor area, vision, vision-parietal, temporal vision and olfaction area. In the early 90, the dissemination by magnetic resonance allowed forcast the brain damage in cases of stroke. It was, then, when the tractography brought with it a whole new methodology for “mapping” the brain’s connectivity (Garfield, 2012). In which of them lies the technical intelligence?

Bordes (1950) asserts that along the Prehistory certain tools or modifications can invent or reinvent themselves in different historical periods depending on the need. Take an example. In the Cantabrian Region, during the Epipaleolithic (9,000-7,000 BP) developed a culture called Asturiense. Its director fossil is called Asturian pick (González Morales, 2008). Mysteriously after thousands of years of industry on sheets, and the entire range of retouching by all known that occur during the Upper Palaeolithic period, they become forms of carvings from the Ancien Palaeolithic, goes to work on a singing with its distal extremity in point and the unifacial retouching. The reason is very simple, there is a need to remove the rocks molluscs and barnacles, that is the shellfish as important source of protein in the diet. Functional studies of the points called Asturian pick shows that the wear of the distal extremities are produced by the hard matter, that is rock. Therefore, the point was used to remove from the rocks of the limpets.

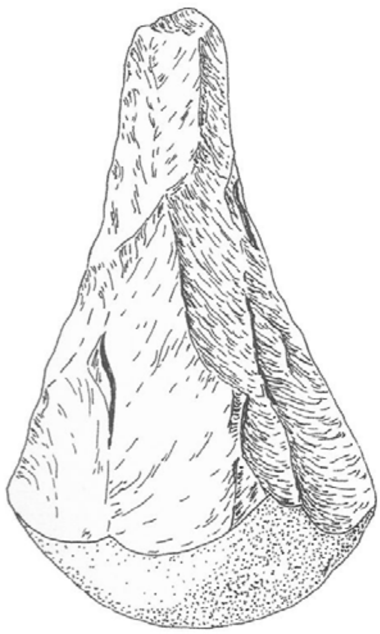

Figure 1 Asturian pick-Tremañes, Gijón (Rodríguez Asensio & Noval Fonseca, 1998)

The reason for this is very simple, functional needs made them return to solutions of the past and reinvent itself. The maxim of Bordes is certain, so it should be taken as a historical constant.

Today, we must assume that the technology is something indispensable for us. But then what is the reason why certain currents of thought in the Humanities are in some ways like pejorative the technology? In the first place, and especially in education are taking refuge in an “alleged” division Arts and Sciences. We have all heard the phrase technology is a thing of the Sciences, and some part of the world Humanities feels very comfortable with this assertion. Secondly, in the ignorance of the following historic variable, which has risen exponentially since the Second World War: (1) The technology always comes a point of technological development that is “cheaper”. (2) Technology multiplies the employment by 2, 3 or 4 in most cases. It should not be taken our affirmations as historic constant or as an equation. Simply, as a variable that is given, and is clearly seen in what we know today as Information Technologies. We are fully aware that always there are also failures and steps backwards, but it is a variable that in Information Technologies is not only reflects, but in each new tool that we put in our life it is noted that question. We could fill the article of numerous examples: the PC, mobile phone, smartphone, etc... The technology has been guilty of historically of great disaster, but it is essential. Let us take a simple example, the technology has been key in the worst of the world wars. But, in spite of the component during the destructive strife advances and their impact on later times are undeniable. It has always put the example of the progress that occurred in Medicine, but let's talk about Meteorology. To bombard towns was necessary, in order to predict the time in the short term. Born the Meteorology in the second World War. Obviously, all this has a destructive component… However, since the 50s are the substantial benefits that has given us the Meteorology. Imagine the energy savings it has taken us, the savings in planning jobs. Every day we are saving millions dollars or euros… Around to predict the weather, have been created in these past 50 years, thousands and thousands jobs.

Since the 1970s, the term, Information Technologies penetrates with force in our lives. There are many since the definitions and discussions that have led to these words. Apart from definitions that could class a world in constant expansion, agree with Cabero (1998) that "…las nuevas Tecnologías de la Información y Comunicación son las que giran en torno a tres medios básicos: la informática, la microelectrónica y las telecomunicaciones; pero giran, no sólo de forma aislada, sino lo que es más significativo de manera interactiva e interconexionadas, lo que permite conseguir nuevas realidades comunicativas…".

Therefore, as argues Castells (1999), for the first time that we think and as we think it is more crucial than ever, is a productive force directly. It was an equation that historically he intuited from the hominids, but today is the decisive element. Do not deny to nothing the destructive component of the technology, but it is essential. It is more on the destructive component of the technology there is to assume that you are in the Sapiens: prey on and gather or depredate? The Sapiens arrives with a depredation's component in the environment, that in spite of the fact that it is sensed in other species, such as for example the Neanderthal, is the Sapiens that whoever gives a different economic sense to environment's exploitation that surrounds them, is the one who initiates the depredate medium instead of prey on and gather... Beyond periods and areas of co-existence between Homo Sapiens and Neanderthal, when a Sapiens arrives to a valley, the exploits of a different economic way. Its technology is the scientific evidence. In an ordinary, everything takes a step beyond: the aesthetic transforms in art, eating the transforms in gastronomy, the sex in eroticism… So the technology does not have a destructive component, but that in certain historical periods give to a greater or lesser extent, but it is essential.

2. 3D Archaeological Models: The State of the Question

In recent years, the 3D archaeological models have become an indispensable tool for both scientific research and dissemination. While it is true that at the beginning of the 21st century we assisted, within the virtual archaeology, an invasion of all a visual language; currently we are witnessing the cyber's consolidation. Thanks to the internet, there is not site or cave with rupestrian art in the world that do not want to have a 3D virtual visit. It is a logical evolution, the increase memory computers, tablets, iphones, Google Glass or Gear VR Samsung glasses, etc., and better navigation of network. It is also a consequence of the most basic element that internet was born: interconnectivity. Therefore, it is a step more in the interconnectivity. In this context of cyber worlds, Mauricio Forte (2009) argues that it is more appropriate to speak of simulation than reconstruction's past. Maybe, you may not have to evoke the past, but a potential past. Therefore, the 3D information is considered as the knowledge's core, because it leads to feedback between the user, the scientist and the ecosystem (Forte, 2009). Thus arises the cyber-archaeology, a concept, where the past is generated and encoded by “simulation’s process” (Forte, 2009).

D. Plentickx (2009) defends the virtual archaeology as a method to learn and preserve the past. It is not only a simulation, simply must accept it there is always a interpretation's degree in approaching the study of the past. In response, should have a good methodology, and meet a few solid principles when making a 3D archaeological model. These principles are included in the London Charter: implementation, aims and methods, research and sources, documentation, sustainability and access (London Charter 2.1, 2009).

Robert Vergnieux (2009) argues that it should be promoted more each day the scientific use 3D archaeological models. However, are not simple virtual recreations, but which must always conform to scientific criteria. For the creation of a 3D archaeological model, it is always necessary to go through three processes: a restitution’s process of the archaeological reality, a validating data's process and a simulation’s process. Based on this, we approach to the world of 3D archaeological models from the perspective Geographic Information Systems (GIS) (Rodríguez Asensio, Barrera Logares & Aguilar Huergo, 2014b; Rodríguez Asensio & Aguilar Huergo, 2016).

It is, at this point, where should assume that these are the foundations for creating a good 3D archaeological model. As you said quote from the start: “... the people do not want realism, want magic. Don’t tell me what is true, tell me what seems to be the truth...”. And it is at that point where we are. The general public is approaching new 3D archaeological models amazed by the new technical advantages; but, as well, they say Barceló and Oriol (2009), we should not simply settle for feeling only heirs of a superior language; but you must help us to better understand the past. In this context, if someone searches for “realism” in 3D archaeological models, GIS are perhaps the best tool.

3. GIS: The State of the Question

Geographic Information Systems (GIS) are the proper tool to visualize and solve many of the problems facing the Geology and Archeology (Hodder & Orton, 1976; Baena, Blasco & Quesada, 1999; Conelly & Lake, 2009).

The first creation and definition GIS, the makes Tomlinson in 1967, on a computerized cartography where trying to take advantage the immense natural resources of Canada. According to Tomlinson GIS is a “computer application whose aim is to develop a set of tasks with digitized geographic information” (Tomlinson & Mounsey, 1988). In 1990, the National Center for Geographic Information and Analysis — USA (NCGIA) defines GIS as “hardware system, software and procedures developed to facilitate the acquisition, management, manipulation, analysis, modeling, rendering, and output of spatially referenced data, to solve complex planning and management problems” (Star & Estes, 1990).

This whole world GIS revolves around what is known as the tetrahedron GIS. Francisco R. Feito Higueruela and Rafael J. Segura Sanchez (2009) suggest as the basis for the tetrahedron GIS: hardware, software, and geo-data, then be within IT’s environment and, on the cusp, the geo-knowledge (both of the fields named as the world GIS). It is important to realize, that in these last two vertices of the tetrahedron appointed; passes, especially, by the human staff.

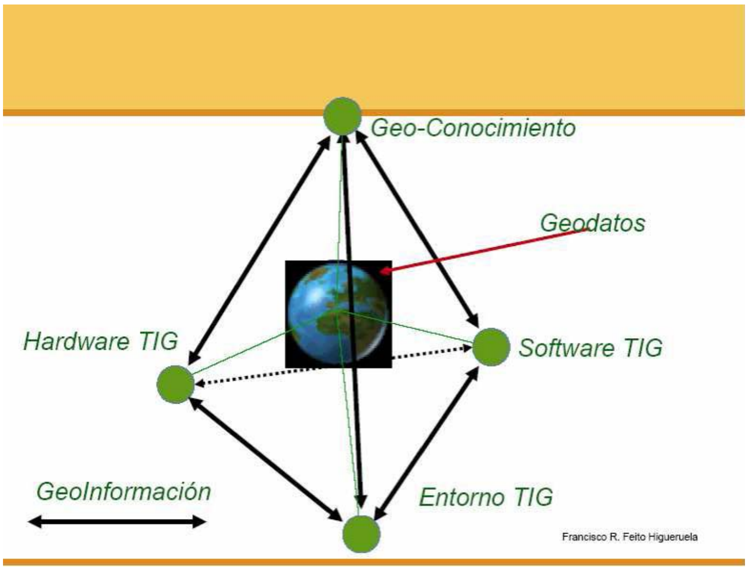

Figure 2 Tetrahedron GIS According Francisco R. Feito Higueruela & Rafael J. Segura Sánchez (2009)

But, what can I do with GIS?

Some of the applications GIS can be summarized in the following:

- Scientific: environmental sciences and related to the space, development of empirical models, cartographic modeling, dynamic models and remote sensing.
- Management: automated mapping, public information, cadastral surveys, physical planning, land management, urban planning, environmental impact studies, resource assessment and follow-up of performances.
- Business: marketing, distribution strategies, transport planning and optimal location. At this point, it is appropriate to include two new points. With the arrival of augmented reality, 3D GIS, must be placed at the service of the user in real time. Imagine all the range of possibilities opens up. Secondly, the whole range of computer applications developed to improve our daily lives that sometime need geolocation.
- Design: planning and infrastructure design, fiber-optic design (telecommunications networks), game design (real or fictitious mapping), architecture design with mapping.

All the GIS allow always in real time (2D and 3D):

- Organize data
- Data Visualization
- Production of maps
- Spatial Queries
- Spatial Analysis
- Perform all types of foresight studies
- Design

What are the most common GIS software?

ArcGIS. In 1981 the American company ESRI launched a new commercial product ArcInfo. During the years 80 complement ArcInfo with new programming languages as language AML. In the years 90, emerges as novelty ArcView, gave so much game to develop all sorts of applications for GIS. In fact, the need’s fruit on all kinds of space studies and thanks to the development of multiple applications for such investigations, becomes the program most used by archaeologists. At the end of the 90, ESRI launched a review of all its products and launches ArcGIS. The ArcGIS software can be used, depending on the degree of applications that you want to incorporate to the GIS software, since its version: ArcEditor, ArcView and ArcInfo. Also trying to improve the ESRI products, both trying to improve the functionality's extension as the analysis and 3D data's processing, is subdivided into 4 modules: ArcMap, ArcCatalog, ArcScene and ArcGlobe.

ArcMap is the basic module of ArcGIS. The capabilities that provide the extension are: methods, analysis and creation of 3D surfaces, vision's profiles and display surfaces as well as digitizing and 3D Symbology's incorporation (Feito Higueruela & Segura Sanchez, 2009).

ArcCatalog is the main module for data management. The fundamental functionality added is 3D data's preview as well as the generation of new layers and display properties related to 3D data (Feito Higueruela & Segura Sanchez, 2009).

ArcScene allows show multiple layers of data in 3D, creation of surfaces (TIN or raster) and the analysis of such surfaces. Includes the ability to manage a large geoprocessing digital terrain models, including those from LIDAR data, where it is possible, for example, to manage the variable intensity that provide these sensors (Feito Higueruela & Segura Sánchez, 2009).

ArcGlobe is a module that lets you display multiple forms of GIS data and layers. You can integrate GIS data, create and analyze multiple surfaces in 3D. You can also integrate vector and raster data, and combine them with digital terrain models (either in raster format, TIN or DEM). In addition, it is possible to use both techniques for multiresolution meshes as levels of detail in the raster formats (Feito Higueruela & Segura Sánchez, 2009).

GeoMedia Professional and GeoMedia Grid. Also, in the 80 in North America stems from the Intergraph company. Throughout these years, it has developed two star products both for all kinds of GIS solutions — 2D (GeoMedia Professional) as 3D (GeoMedia Grid).

Grass. It is a free GIS software developed in principle by the CRL (U.S. Army Construction Engineering Research Laboratory). Subsequently, before the close of the same, various universities, and research centers the continued. To be an open software, backed by the Open Source Geospatial Foundation, multiple research projects are being addressed with the same. Allows you to work in a manner very comfortable with the data (2D and 3D). Perform modeling, working with raster data from sensors, etc. All of this, makes certain institutions, especially the European Union this using many of its projects this software.

LocalGIS. It is a free spanish GIS software. Was formed in 2008, evolving initiative GeoPista system, and has been done on the initiative of the Ministry Industry, Tourism and Trade. It is a territorial information's system for Local Authorities (County Councils, town councils) that makes it easy for you to do the municipal management form georeferenced and offer services on-line information to citizens by using the mapping of the Municipality. Allows you to work and solve all kinds of problems in both 2D and 3D. In recent years, LocalGIS are now focusing on developing all kinds of applications to get improve your platform in 3D.

GvSIG. At the beginning of the 21st century arises this free spanish GIS software on the iniciative of Generalitat Valenciana. In principle, it was looking for autonomously meet their administrative needs, but little by little multiple Autonomous Communities and Municipalities, also chose to work with GvSIG. Allows you to work and solve all kinds of problems in both 2D and 3D. In turn, also lets you in one of its extensions added working with LIDAR data.

4. 3D GIS Stratigraphies: How Does 2.5 GIS or 3D GIS? A Necessary Debate, But Today "Sterile": An Example of 3D GIS Stratigraphy: La Lluera I Cave

Barandiaran (1981) argues that despite the undeniable progress that has produced the New Archaeology or Functional Archaeology three pillars are basic in Archaeology: typology, chronology and stratigraphy. Without calling into question, nor so if you want to by a single moment, the stratigraphy's validity as archaeology's first pillar, the study's importance of the archaeological record is undeniable. Both complement each other. But, what is meant by the archaeological record?: "…El registro arqueológico no se compone de símbolos, palabras o conceptos, sino de materiales y distribuciones de materia. El único modo de poder entender su sentido, la manera en que podemos exponer el registro arqueológico es averiguar cómo llegaron a existir esos materiales, cómo se han modificado y cómo adquirieron las características que vemos hoy…" (Binford, 1987). The problem is not new, so it is not surprising that in recent years, new Information Technologies have joined the debate. In recent years, there are several examples of 3D GIS stratigraphies which are attempts to trace methodologies, allowing us to provide solutions to the problems of the archaeological record. From these early attempts to 3D GIS stratigraphies arises the Z's problem. Graphic entities that represent the GIS are the point, line and polygon. The reason is very simple to be probably software closest to the accurate representation of reality, that is they are mathematical pure. Based on this, how represent the third dimension? Daly and Lock (1999) argue that from the 2D series structured along a third axis you can to represent the third dimension. Baena and Ríos (2006) qualify this "false" 3D GIS. The problem lies in how to deal the third dimension, taking into account the possible constraints that offer GIS.

Baena and Ríos (2006) define as a new and different models of 3D GIS. In this field arise as a great novelty the voxelization, where a series of programs such as Voxel Analyst, Earthviewer and Rockware, claim to be specialists in the realization of 3D GIS stratigraphies.

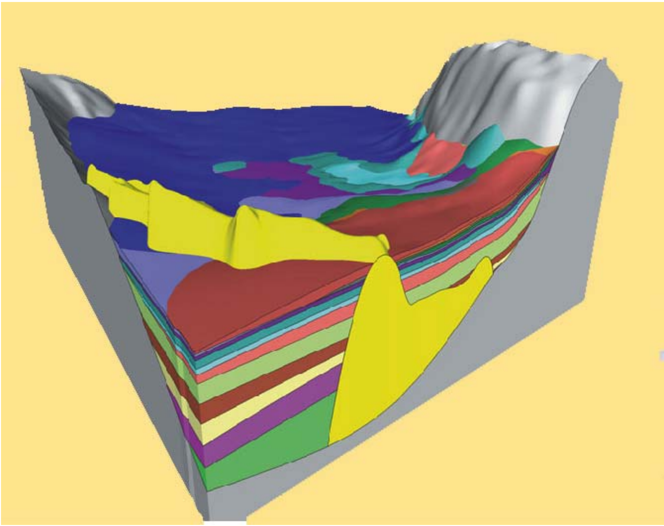

Figure 3 An example of 3D GIS stratigraphy: Earthviewer Software According Baena y Ríos (2006)

Lin and Mark (1991) they are the parents of the concept voxelization. The term voxelization arises from the word voxel. Voxel is a combination of the words volume and pixel. It is using GIS to create raster cells using volumetric pixels to incorporate the data. Through the voxelization, therefore, it is a matter of creating volumetric pixels in which is defined a third dimension, the cell's heigth (Baena & Rivers, 2006). In this way, either directly with these softwares (for example ArcGIS, Voxel) or through the development of applications for any GIS software, you can create volumes in 3D.

Wheatley and Gillings (2002) qualify, the Harris and Lock's stratigraphy (1996), as a very good 3D. Only found a problem, and it is very easy to find two points with the same X and y different Z. If we take into account the progress of GIS in the geo-coding of coordinates and the tools provided different GIS to solve this problem, should qualify the Harris and Lock's example (1996), not only as a stratigraphy in valid 3D GIS, but also of bright.

Besides Daly and Lock (1999), different examples of efforts charting methodologies when making a stratigraphy 3D through a sedimentary sequence, are those of Harris and Lock (1996) and the Undine Lieberwirth (2008). In Spain, it is also the case 3D stratigraphy showing Barceló, Maximiano and Oriol (2006). Not only dealt with the 3D stratigraphy's realization from the Rockware software, but that they plotted a new methodology by study of the archaeological record. They coined a new concept: the archaeological space. Is meant by archaeological space "…a la estructura relacional que emerge de la localización en el tejido espacio temporal de las consecuencias materiales de la acción social…" (Barceló, Maximiano & Oriol, 2006).

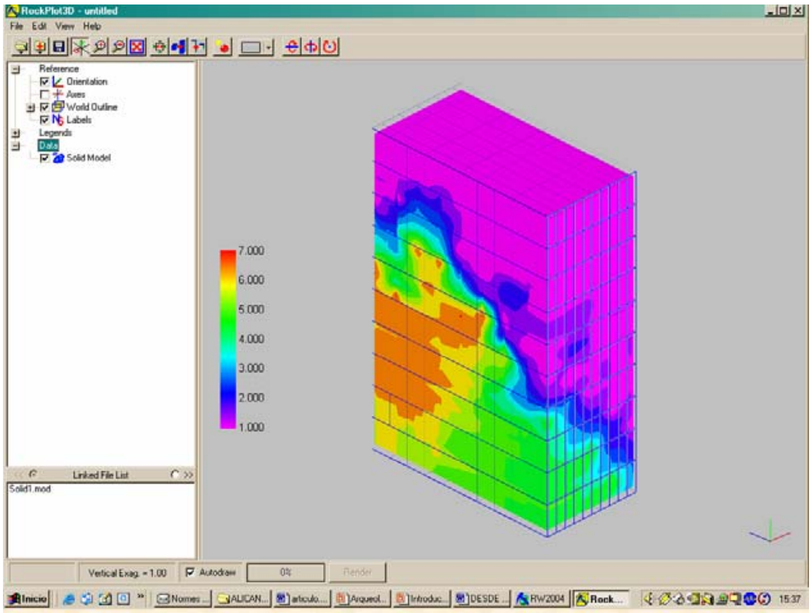

Figure 4 3D GIS Stratigraphy: Barceló, Maximiano & Oriol (2006) by Rockware Software

In the Lieberwirth's case (2008), not only draws a 3D stratigraphy in the Akroterion of the Kastri site in Kythera (Greece), but that is openly advocating the implementation of the same in the sites describing them as "authentic 3D geographical and interactive maps". It is based on the GRASS software, and is openly advocating the voxelization's possibilities that offers the same.

Every day, there are archaeological sites anywhere in the world. Many of the problems with which the archaeologist are collected in leaves of photos, stratigraphies drawings, pdas, etc. It is an attempt to document, as more faithfully as possible, the archaeological record. Today, day, is this question: what is can do computer with all of this? With the elaboration by a GIS of the solutrean stratigraphy — La Lluera I cave, we try to respond to this question, and at the same time, show the archaeologist, that many of the problems are facing on a daily basis, they need to be addressed with the appropriate tool: GIS (Rodríguez Asensio, Barrera Logares & Aguilar Huergo, 2014b).

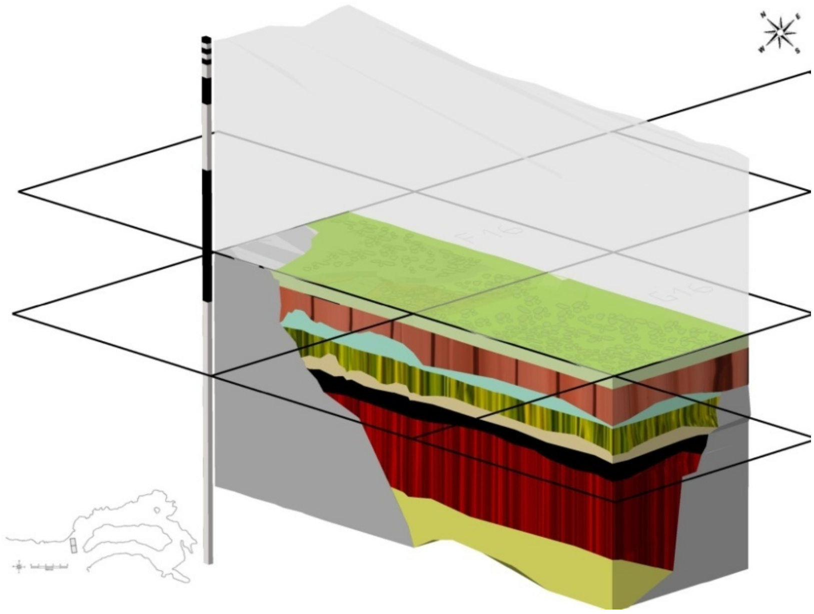

Figure 5 Solutrean Stratigraphy - La Lluera I cave (Grey- Azilian and Maddalenian Levels). Scale: 2 m

Rather than enter into discussions, is not just a matter of using the software. On many occasions, is not achieved or the adequate quality or resolved many of the problems facing archaeology. Faced with this, individual initiatives in the development of 3D GIS stratigraphies, as the examples presented here are: Lin and Mark (1991), Daly and Lock (1999), Harris and Lock (1996), Barcelo, Maximiano and Oriol (2006), Undine Lieberwirth (2008) and Rodriguez Asensio, Barrera Logares and Aguilar Huergo (2014b); that better results are giving in providing solutions to the multiple problems facing the archaeologist. However, we agree fully with authors Baena and Ríos (2006) that if we accept the temporary variable of each stratum (own sedimentology), will have to accept that the application of these studies to the stratigraphies, collides with the limite of temporal reference. Trying to correct this, we have superimposed drawings of geological and archaeological soils, for in this way get as faithfully as possible to the occupation's levels and the archaeological record's formation. We were lucky, in Velez-Blanco (Almería) during the Solutrean International Congress (2012), exchange views on where can be the solution to this problem... And we reaffirm that the solutions in our field, will come the computer programming (probably javascript or visualbasic) which will be added to simple solutions, in principle, as our... But it is an inherited problem own archaeology, the archaeological record, sedimentology, and of how the different levels of an occupation are interpreted. The final solution will be to develop new Software. All of these solutions seen here, it would be mark patterns of programming the different strata based on classifications sedimentological drawn by M. Aguirre, J. C Lopez Quintanta, A. Ormazabal and A. Sáenz de Buruaga (1999). For us, without a doubt, the best methodology of sedimentology drawn today in archaeology... But it would ultimately develop software under these patterns. The future will tell, but exactly, do we mean? From the sedimentology's field has been mapped around a practical body of support to be able to decipher a stratigraphy. M. Aguirre, J. C Lopez Quintanta, A. Ormazabal and A. Sáenz de Buruaga (1999) declare themselves heirs to the sedimentary definitions of the Anglo-Saxon system *"Wentworth scale"*, and adapted it to charting a new methodology for the Cantabrian Region caves. Different grain categories of sedimentary materials, according to dimension components, allow us to trace the sedimentary fractions. They set out to do this, the following Table 1.

Table 1 Categories of Granulometric Sedimentary Materials, Dimensions and Sedimentary Fractions According to M. Aguirre, J. C Lopez Quintanta Ormazabal, A. and A. Saenz de Buruaga (1999)

FRACCIÓN	DIMENSIÓN MÁXIMA	DENOMINACIÓN GRANULOMÉTRICA
GRUESA	> 10 cm	Bloque
GRUESA	10 – 2 cm	Clasto
MEDIA	2 cm – 2mm	Grava
MEDIA	2 – 0,002 mm	Arena
FINA	0,02- 0,002 mm	Limo
FINA	> 0,002 mm	Arcillla

But, it is necessary to bear in mind that in site (cave) they predominate over the depositions and the transformations of climatic causality: "…Los yacimientos en cueva y abrigos paleolíticos y epipaleolíticos están formados esencialmente por materiales sedimentarios no consolidados y por aportes antrópicos, que son afectados por alteraciones-modificaciones diagéneticas y de estructura estratigráfica- provocadas simultánea o posteriormente por el clima y los seres vivos…" (Aguirre, López Quintanta, Ormazabal & Sáenz de Buruaga, 1999). Not only that, but: "…El relleno detrítico de estos yacimientos cuaternarios se genera, además de por la circunstancialidad ambiental- determinada por las variables temperatura y humedad- a partir de aportes mecánicos sobre el mismo lugar de la deposición, eventualmente modificados por acciones erosivas y diversas transformaciones de origen químico (suelos estalagmíticos, carbonatos, concrecciones cálcareas, etc.) y de pedogénesis…" (Aguirre, López Quintanta, Ormazabal & Sáenz de Buruaga, 1999). All this, despite all this methodology to the Cantabrian caves, leads them to conclude that there are limitations where it comes to plotting a stratigraphy "…La Estratigrafía no es una ciencia exacta y nuestro alcance perceptual es limitado…" (Aguirre, López Quintanta, Ormazabal & Sáenz de Buruaga, 1999).

La Lluera I, subjected to a strong system of floods and emptying in the cavity, which in turn next to the humans contributions have shaped their stratigraphy, is a good proof of this (Hoyos, 1995; Rodríguez Asensio, Barrera Logares & Aguilar Huergo, 2014a). In Figure 7, tables H10 and H11, it exists an upwelling that goes to modeling the level V (green).

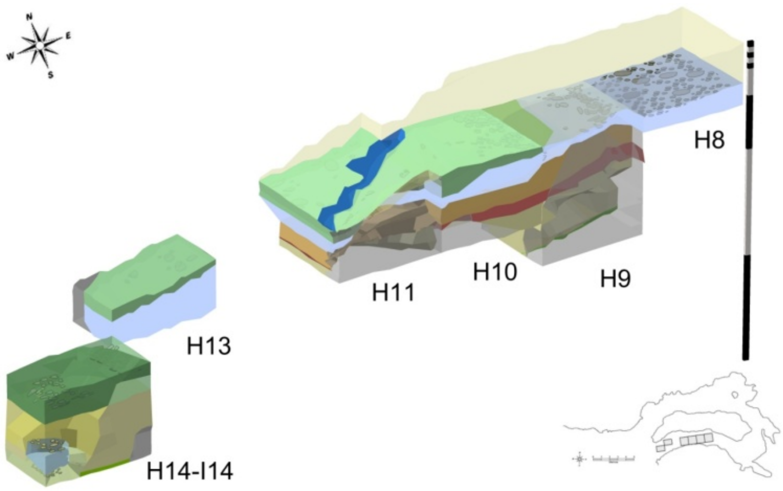

Figure 7 Solutrean Stratigraphy - La Lluera I cave (grey- Azilian and Maddalenian Levels). Scale: 3 m

Being fully aware that there are more examples 3D GIS stratigraphies, in this article we briefly mentioned those who have given better technical solutions from the point of view GIS as the archaeological record. Although, today continues to boom the debate 2.5 GIS or 3D GIS, the voxelization's arrival and the realization of the abovementioned stratigraphies are evidence not only of progress produced, but that is about to close the discussion definitely: 3D GIS. On the other hand, we are still, in the first place, in which the GIS are the most suitable tool for the study of any stratigraphy, and secondly, that the purpose of 3D archaeological models should not only be the archaeological record's reconstruction, but help us to understand the same.

References

Aguirre M., López Quintanta J. C., Ormazabal A. and Sáenz de Buruaga A. (1999). "Determinación práctica del sedimento en el campo y jerarquización de componentes sedimentológicos en Estratigrafía Analítica", *Krei*, Vol. 4, pp. 3–27.

Barandiarán I. (1985). *Las Culturas del Tardiglaciar en Vizcaya*, Ed. Universidad del País Vasco (Prólogo de la tesis de J. Fernández Eraso). Vitoria.

Baena Preysler J. and Ríos Mendoza P. (2006). "Realidad y abstracción: límites de la integración de datos en los SIG", in: Ignacio Grau Mira (Eds.), *La aplicación de los SIG en la Arqueología del paisaje*, Alicante: Publicaciones Universidad de Alicante, pp. 15–28.

Baena Preysler J., Blasco Bosqued C. and Quesada Sanz F. (1999). *Los S.I.G. y el análisis espacial en Arqueología*, Ediciones UAM. Madrid.

Barceló J. A. and Oriol V. (2009). "Qué hacer con un modelo arqueológico virtual. Aplicaciones de la inteligencia artificial en visualización científica", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. II, pp. 93–97.

Barceló J. A., Maximiano A. and Oriol V. (2006). "La multidimensionalidad del espacio arqueológico: Teoría, Matemáticas y Visualización", in: Ignacio Grau Mira (Eds.), *La aplicación de los SIG en la Arqueología del paisaje*, Alicante: Publicaciones Universidad de Alicante, pp. 29–40.

Binford L. (1987). *En busca del pasado*, Editorial Crítica. Barcelona.

Bordes F. (1950). "L´evolution buissonante des industries en Europe Occidentale. Considerations theoriques sur le Paleolithique ancien et moyen", *L´Anthropologie*, Vol. 54, pp. 393–420.

Cabero J. (1998). "Impacto de las nuevas tecnologías de la información y la comunicación en las organizaciones educativas", in: Lorenzo M. & Otros C. (Eds.), *Enfoques en la organización y Dirección de instituciones educativas formales y no formales*, Granada: Grupo Editorial Universitario, pp. 197–206.

Castells M. (1999). "La revolución tecnológica de la información. ¿Qué revolución?", in: SXXI (Eds.), *La Era de la Información, Economía, Sociedad y Cultura*, Buenos Aires:SXXI, pp. 3–4.

Carbonell E. and Sala R. (2000). *Planeta Humano*, Ediciones Península. Barcelona.

Conelly J. and Lake M. (2009). *Sistemas de Información Geográfica aplicados a la Arqueología*, Ediciones Bellaterra S. L. Barcelona.

Daly P. and Lock G. (1999). "Timing is everithing comentary on managing temporal variables in Geographic Information Systems", in: Barceló J., Britz I. & Vila A. (Eds.), *New Techniques for Old Times*, Oxford: BAR Int. Series 757, pp. 287–294.

Feito Higueruela F. R. and Segura Sánchez R. J. (2009). "Herramientas SIG 3D", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. IV, pp. 251–256.

Forte M. (2009). "Cyber-Arqueology: Notes of simulation of the past", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. I, pp. 21–32.

Frischer B. (2009). "Art and Science in the age of digital reproduction: From mimesis to virtual reality", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. I, pp. 33–48.

Garfield S. (2012). *On the Map: Why the World Looks the Way It Does*, Ed. Santillana: London.

González Morales M. R. (2008). *La Prehistoria en Asturias. Un legado artístico único en el mundo,* Ed. Prensa Asturiana. Oviedo.

Harris T. and Lock G. (1996). "Multi-dimensional GIS: exploraty approaches to spatial and temporal relations-hips within archaeologycal stratigraphy", in: Kamer-Mans H. & Fennema K. (Eds.), *Interfacing the Past: Computer Aplications and Quantitive Methods in Archeology- CAA95*, Vol. 2, pp. 307–316.

Hodder I. and Orton C. (1976). *Spatial Analysis in Archaeology*, Cambridge University Press: Cambridge.

Hoyos M. (1995). "Paleoclimatología del Tardiglaciar en la Cornisa Cantábrica basada en los resultados sedimentológicos de los yacimientos arqueológicos kársticos", in: A. Moure Romanillo & C. González Sainz (Eds), *El final del Paleolítico cantábrico. Transformaciones ambientales y culturales durante el Tardiglacial y comienzos del Holoceno en la Región Cantábrica*, Santander: Universidad de Cantabria, pp. 77–117.

Lieberwirth U. (2008). "Voxel-based 3D GIS: Modeling and analisys of Archaeological stratigraphy", in: Bernard Frischer & Anastasia Dakouri-Hilo (Eds.), *Beyond Ilustration: 2D and 3D Digital Technologies as Tool for Discovery in Archeology*, Virginia: British Archaeological Reports International Series, pp. 78–86.

Lin H. and Mark D. (1991). *Spatio-temporal Intersection and Volumetric Modelling: Procedings of the GIS/LIS*, Taylor & Francis LTD: London.

London Charter 2.1 (2009). *The London Charter for the Computer-based: Visualitation of Cultural Heritage*, Hugh Denard: London.

Mithen S. (1996). *The Prehistory of the Mind: A Search for the Origins of Art, Religion and Science*, Ed Crítica. London.

Pletinck D. (2009). "Virtual Arqueology as an integred preservation method", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. I, pp. 49–56.

Rodríguez Asensio J. A. and Noval Fonseca M. A. (1998). G*ijón antes de Gijón. Breve aproximación a los primeros predadores en la Prehistoria asturiana*, Gran Enciclopedia Asturiana GEA/2000. Gijón.

Rodríguez Asensio J. A., Barrera Logares J. M. and Aguilar Huergo E. (2014a). "Cueva de la Lluera I (San Juan de Priorio, Oviedo, Asturias, España): Estratigrafía solutrense", *Espacio, Tiempo y Forma, Serie I Nueva época, Prehistoria y Arqueología*, Vol. 5, pp. 235–249.

Rodríguez Asensio J. A., Barrera Logares J. M. and Aguilar Huergo E. (2014b). "Las Cuevas de la Lluera (San Juan de Priorio, Oviedo, Asturias, España): Elaboración mediante un SIG de una estratigrafía solutrense", *Espacio, Tiempo y Forma, Serie I Nueva época, Prehistoria y Arqueología*, Vol. 5, pp. 249–259.

Rodríguez Asensio J. A. and Aguilar Huergo E. (2016). "La Lluera I cave (San Juan de Priorio, Oviedo, Asturias, Spain): Art and GIS of the more figurative areas or 'niche areas' of a sanctuary", in: Roberto Ontañón (Ed.), *Nuevas soluciones para viejos problemas: el uso de nuevas tecnologías para la documentación y conservación del arte prehistórico*, Oxford:Archaeopress Oxford, In editorial.

Sabater Pi J. (1985). *Etología de la vivienda humana: De los nidos de gorilas y chimpancés a la vivienda humana*, Labor. Barcelona.

Star J. and Estes J. (1990). *Geographic Information System: An Introduction*, Prentice Hall. New Jersey.

Tomlinson R. and Mounsey H. (1988). *Building Databases for Global Science*, Taylor & Francis LTD: London.

Vergnieux R. (2009). "Archeological research and 3D models (Restitution, validation and simulation). L'usage scientifique des modèles 3D en Archéologie. De la validation à la simulation", *Actas I Congreso Internacional de Arqueología e Informática Gráfica, Patrimonio e Innovación*, Vol. I, pp. 59–62.

Wheatley D. and Gillings M. (2002). *Spatial Technologie and Archaeology: The Archaeologycal Applications of GIS*, Taylor & Francis: London.