RECONSTRUCTING THE 3D EVOLUTION OF THE ARCHAEOLOGICAL EXCAVATIONS OF THE TRINCHERA DEL FERROCARRIL SITES, SIERRA DE ATAPUERCA, BURGOS

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INTRODUCTION

In the last decade, the tridimensional documentation technologies have become excellent tools for the digital conservation of archaeological record. The in-situ traditional approach in places of cultural interest has been modified by the possibility of obtaining 3D replicas of archaeological contexts with millimetric resolutions.

The Paleolithic sites of the Trinchera del Ferrocarril in the Sierra de Atapuerca are an example of the importance that documentation of cultural heritage can achieve. Throughout each excavation campaign, the surface of the sites is irreversibly changed in the search of new remains, losing all the archaeological and geological information that has not previously been registered.

In this study, we present the 3D reconstruction models carried out each year in the Trinchera del Ferrocarril sites, Sima del Elefante, Galería and Gran Dolina (TD10 and TD4), through terrestrial laser scanner technology. Our aim is to show the importance of a sequential 3D record for the conservation of cultural heritage in archaeo-paleontological excavations.

The methodology started in 2011 consisted in a monitoring of the surface of the sites before the beginning of each excavation campaign, obtaining point clouds of each site (Fig. 1.). All the information related to high spatial resolution surface point clouds, and derived products, such as orthoimages of excavation plants and stratigraphic walls, digital elevation models, or descriptions of the excavation evolution are stored in a database, which is updated each year.

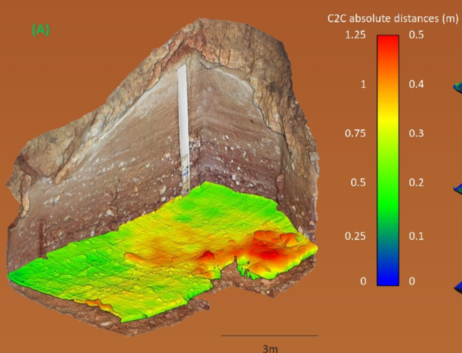
Fig. 1. Perspective view of the 2015 Galería site point cloud.

MATERIALS & METHODS

Since 2011, topographic surveys have been carried out using a terrestrial laser scanner in each of the Trinchera del Ferrocarril sites. A total of 4 zones, corresponding to Sima del Elefante, Galería, Gran Dolina TD10 and Gran Dolina TD4, have been rebuilt annually.

Laser scanners based on flight time (from 2011 to 2014) and phase shift variation (from 2015 to present) have been used, taking millions of measurements for the geometries recording and tens of photographs for the registration of colors in each of the performed scans.

The processing of the point clouds of each scan until the derived products, has been subdivided by zones and stages. (1) A first step of point clouds registration (Fig. 4. A), which consisted of filtering, aligning, georeferencing and applying color to all the point clouds generated in each zone. From this phase, a single point cloud is extracted and georeferenced in the reference system established for each site with the help of targets. (2) A second stage of cleaning the recorded point clouds (Fig. 4. B), in order to eliminate any element that does not belong to the natural surface of excavations such as scaffoldings, excavation tools, people, etc. (3) A third stage of meshing surfaces. (4) And a final stage of derivated products generation such as: cartographic products like orthoimages (Fig. 3.); comparisons of 3D models with methods like Cloud to Cloud (C2C) distances computation, which calculates the absolute distance between the closest points of two point clouds (Fig. 2.); or excavation evolution descriptions.



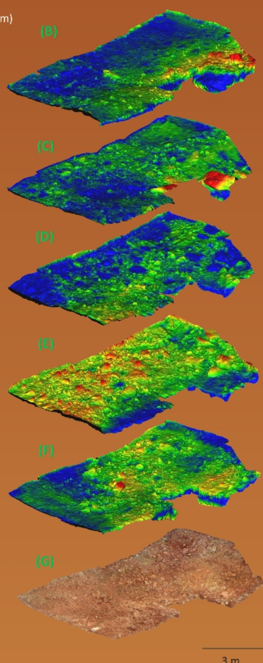
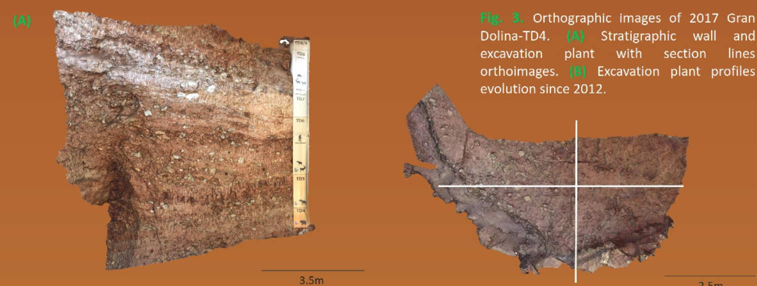


Fig. 2. Gran Dolina-TD10 point cloud excavation plants evolution from 2012 until 2017. Colors show the surfaces distances between different excavation campaigns. The values on the left of the color scale show the absolute distances of Figure A, while the values on the right show the absolute distances of Figures B, C, D, E and F. (A) Cloud to Cloud (C2C) excavation plants comparison between 2012 and 2017 pre-excavation campaign. It is estimated that more than 58 m³ of remains (earth and archaeological material) has been extracted in the last 6 years. (B) 2012-2013 pre-campaign comparison. (C) 2013-2014 pre-campaign comparison. (D) 2014-2015 pre-campaign comparison. (E) 2015-2016 pre-campaign comparison. (F) 2016-2017 pre-campaign comparison. (G) 2017 pre-excavation plant 3D model.

RESULTS

A total of six 3D models represent the geometric and radiometric characteristics of each one of the three archaeological excavation surfaces from the last 6 years. These models were stored in a database with all the archaeological and geological evolution of the deposits from a 3D and 2D vision. The 3D data includes three-dimensional models comparisons (Fig. 2.), meanwhile the 2D includes products such as orthoimages (Fig. 3. A), digital elevation models, or sections of excavation plants and stratigraphic walls (Fig. 3. B).



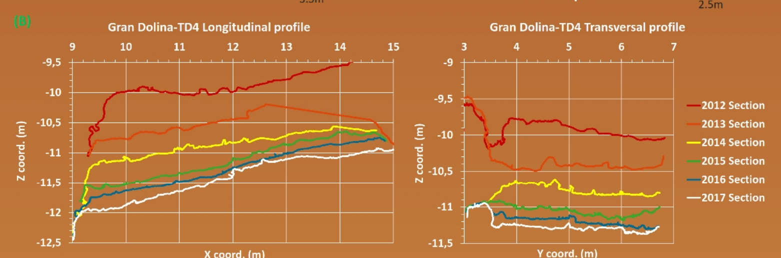


Fig. 3. Orthographic images of 2017 Gran Dolina-TD4. (A) Stratigraphic wall and excavation plant with section lines orthoimages. (B) Excavation plant profiles evolution since 2012.

DISCUSSION & CONCLUSIONS

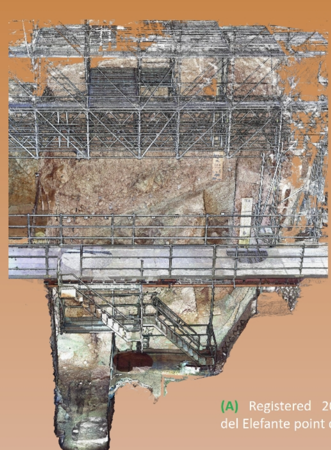
The use of 3D laser scanner is common for documentation of cultural heritage, as it allows capturing complex geometries in real estate. However, in the case of Paleolithic archaeological sites, the use of the laser scanner has been limited, due to the high costs and limited mobility compared to other equipment.

In this work the capabilities of the 3D laser scanner in archeological environments are shown; as well as the importance that the sequential tracking deposits and excavation process, through the creation of databases with radiometric and high-resolution geometric information.

Through 3D models, it is possible to: (1) Perform three-dimensional measurements (distances and angles) with millimeter accuracy at any point of the sites. (2) Generate sections (plants and profiles) at any position, or orientation through the point clouds or meshes. (3) Create orthophotos and digital elevation models that serve as the cartography of excavation plants and stratigraphic walls. (4) Generate realistic 3D visualizations or capture partially or totally surface images. (5) Create virtual scenarios of archaeological environments.

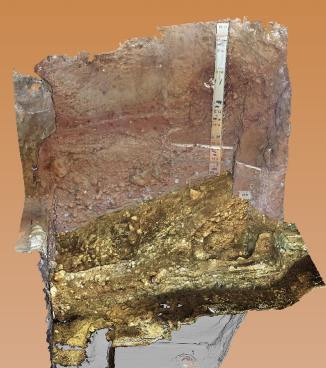
The set of 3D and 2D information gathered about the sites over the years, allows the digital perpetuity of this unrecoverable heritage. Information that is properly stored and classified can be used to a better understanding of the sites, supporting scientific research (spatial analysis, geological studies, etc.), improving the conservation and development of excavations, or even providing an educational and historical perspective in the archaeological excavations documentation.

Fig. 4. Point cloud evolution treatment in Sima del Elefante site (hidden opposite wall of the trench).



(A) Registered 2017 Sima del Elefante point clouds.

(B) Cleaned 2017 Sima del Elefante point cloud.



(C) 2012 Sima del Elefante excavation plant super-imposed on 2017 cleaned point cloud.

FURTHER READING

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