PROMONTORIA MONOGRAFICA DIGITAL 1

ATAS

XI

ENCONTRO DE ARQUEOLOGIA DO SUDOESTE PENINSULAR

ENCUENTRO DE ARQUEOLOGIA DEL SUROESTE PENINSULAR

21-23 OUT
2021 LOULÉ

Maria João Valente
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LiDAR hypsometry in the Chalcolithic territory of La Zarcita (Santa Barbara de Casa, Huelva, Spain)

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Resumen

Para evaluar si los datos de LiDAR (Laser Imaging Detection and Ranging) disponibles para el territorio español permiten el reconocimiento de estructuras propias del Calcolítico como poblados, atalayas, sepulcros, caminos, minas o zonas cultivables se ha utilizado como zona de análisis el paraje de La Zarcita en Santa Bárbara de Casa (Huelva), cuyo entorno ha sido ampliamente prospectado por renombrados arqueólogos como Obermaier, los Leisner, Cerdán o Piñón Varela. Usando esta nueva fuente de información, junto con los métodos de la arqueología del paisaje y las técnicas de análisis espacial mediante SIG, se puede valorar hasta qué nivel los datos LiDAR permiten la identificación de estructuras construidas, la cartografía de sus emplazamientos y la reconstrucción virtual de un paisaje prehistórico a escala local. Asimismo, esta evaluación es extrapolable al análisis del poblamiento en otros periodos como la Edad del Bronce o del Hierro.

Palabras clave

Lidar, ALS, Calcolítico, Andévalo, La Zarcita.

Abstract

In order to evaluate if the LiDAR data available over the Spanish territory allow the reconnaissance of Chalcolithics features such as settlements, watchtowers, graves, roads, mines or fields; La Zarcita in Santa Bárbara de Casa (Huelva), a widely surveyed area by renowned archaeologists as Obermaier, the Leisner, Cerdán or Piñón Varela, has been used as a testing area. Applying this new data source, in combination with the methods of landscape archaeology and spatial analysis techniques through GIS, it is possible to evaluate if the LiDAR data allow the identification of built structures, in order to mapping their locations and the virtual reconstruction of a prehistoric landscape at a local scale. Likewise, this evaluation can be extrapolated to an initial survey of settlement in other periods such as the Bronze or Iron Age.

Keywords

LiDAR, ALS, Chalcolithic, Andévalo, Zarcita.

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1. Introduction

Airborne Laser Scanning (ALS) precision altimetry is becoming a new source of complementary information in archaeological prospection projects due to the possibility to measure slight changes in terrain elevation entering through vegetation, to reveal hidden structures, both positive and negative. This is a very recent technology which, in any case, is still under development and subject to an accurate assessment of its potential.

The archaeological application of LiDAR has proved to be useful in forested areas of Northern Europe or in the rainforests of Central America and South-East Asia, although it has not yet been widely used in Mediterranean environments. The first ALS projects for archaeological prospection are only two decades old and were carried out in well-documented areas in order to assess whether it was possible to detect already known archaeological structures. Since 2007, English Heritage has undertaken a systematic prospection program for the whole English territory (Historic England, 2018), based on the UK Environment Agency's testing in the Salisbury Plain in 2001 (Barnes, 2003). At the same time, other pioneering projects have been developed: in Austria for the identification of mounds, in Norway to study old coal pits, in Maryland regarding 18th century slave plantations or in Ireland in the archaeological site of the Boyne Valley (Opitz and Cowley, 2013).

However, the most spectacular results from intensive scanning campaigns have been found in tropical jungle areas, where filtration of vegetation has revealed extensive historical landscapes. The campaign deployed in Cambodia between 2012 and 2015, which drew detailed cartography of temples, villages, ponds and irrigation of the Khmer Empire, found that "airborne laser scanning technology is able to provide centimetre-level detail on the signature spatial patterning of neighbourhoods and individual households, which offers us the possibility of 'scaling up' very fine-grained data from focused excavations to create demographic models for vast urban areas" (Evans, 2016). Likewise, the search for structures in the forests of Belize (Chase and Chase, 2017), Yucatan (Ringle et al., 2021), Guatemala (Canuto et al., 2018) or Bolivia (Prümers et al., 2022), have offered similar results, allowing to identify terraces, canals, roads, cities, temples and walls. The most recent projects focus on automatic recognition using artificial intelligence (Wouter, 2020), such as that carried out in France which identified megalithic structures "by performing object segmentation using a deep CNN approach combined with transfer learning" (Guyot et al., 2021).

In Spain, free, up-to-date and public altimetric data have been available since 2014 and are beginning to be used in a pioneering way in the detection of megalithic mounds, Phoenician temples, pre-Roman towns and Roman military camps (Cerrillo-Cuenca and López, 2020). The first studies looked at the pre-Roman 'castro' at Irueña, Salamanca, combining surface surveys with LiDAR and GIS technology (Berrocal-Rangel et al., 2017), megalithic mounds in Galicia (Carrero-Pazos et al., 2014; Carrero-Pazos and Vilas Estévez, 2016) and an extensive area of the Portuguese Alentejo and Spanish Extremadura with known fortified sites and ditched enclosures (Cerrillo-Cuenca and Bueno Ramírez, 2019). The same LiDAR datasets obtained in the facilities of the Spanish National Geographic Institute (IGN, in its Spanish acronym) were used to map the topography of Iron Age, Ancient and Medieval Cordoba, the amphitheatre of the Roman city of Torreparedones, and also to suggest a new location for the Phoenician temple of Melkart (Hércules) in San Fernando, Cádiz, combining laser altimetry with sonar bathymetry (Monterroso-Checa, 2017, 2019, 2021). Other recent examples are the reconnaisance of 135 Iron Age 'castros' (hillforts) in Galicia, including 25 previously unknown ones, that showed buried features, ditches, pathways, field boundaries and levelled defensive elements (Parcero-Oubiña, 2021). Other findings from a study of the Roman military presence in the northern fringe of the Duero basin include 66 new archaeological sites, discovered thanks to the combined use of different remote sensing techniques and open access geospatial datasets, predominantly aerial photography, satellite imagery and airborne LiDAR (Menéndez et al., 2020). A very recent line of work looks at the development of algorithms for the automatic detection of archaeologically relevant microtopographies, performed through data mining and artificial intelligence. This has led to the successful location of thousands of megalithic mounds (Cerrillo-Cuenca, 2016; Berganzo-Besga et al., 2021).

2. Methods

The aforementioned experiences of implementing ALS technologies to archaeological prospection have allowed to establish a methodology that features well-defined phases, processes and parameters and offers proven results (Lozic and Štular, 2021). The usual workflow in these investigations consists of a methodological sequence organized in five phases: capture, processing, analysis, interpretation and representation (Fig. 1).

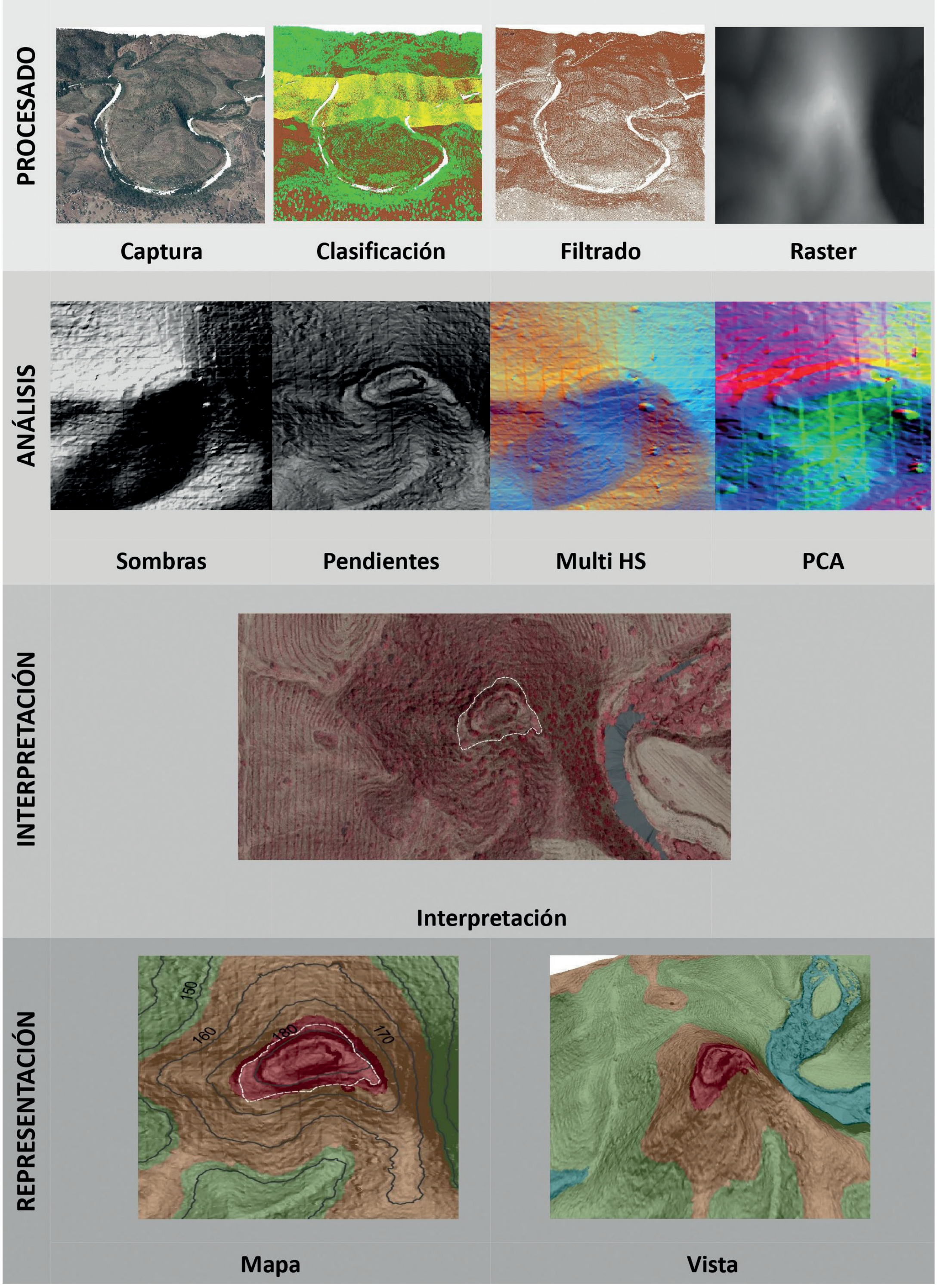

Figura 1 – Usual workflow in an archaeological project with airborne laser scanning (ALS).

The capture of the altimetric data is done by means of a sensor aboard an aerial platform – aircraft, helicopter or drone – used to measure the time difference between the emission of a series of pulses of polarized infrared light and their rebounds on the ground. The multiplication of this delay by the speed of light results in the relative position of the impacted object, which also requires knowing the position, speed and orientation of the sensor itself using differential GPS and inertial systems in order to convert it to earth coordinates. The scanning frequency determines the density of points, which in the case of the analysed area in the province of Huelva, the LiDAR datasets from the IGN offer an average density of 0.76 points/m², 1.15 m of distance between points and 32º maximum angle.

A very important treatment of the returns is their classification according to the type of object impacted. The Full-Waveform (FWF) analysis technique is used for this purpose, which consists of decomposing the reflected wave into the various echoes that form it, assigning an altitude to each echo. Thus, each pulse is divided into several types of returns – first, intermediate or last – which are combined with the intensity of the reflected signal allowing to distinguish whether the object is vegetation coverage, a building, bare ground, water, etc. (Doneus and Briese, 2006). In the analysed area of the province of Huelva, 43.5% of the returns are classified as land, while 14% correspond to vegetation coverage and 42.3% are considered unusable and defined as noise, overlap or unclassified. The point clouds all throughout the Spanish territory (Lorite et al., 2017) are distributed from the National Geographic Information Center (CNIG, in its Spanish acronym), available for free download in 2x2 km grids, in LAS format and licensed for any legal use citing authorship under the name of "© LiDAR-PNOA 2014 CC-BY 4.0 scne.es".

The analysis phase requires the conversion of the 3D point clouds from LAS format into raster formats in order to obtain a Digital Terrain Model (DTM) exploitable using map algebra. This conversion can be done by using all points to obtain a Digital Surface Model (DSM), or by using only class 2 (ground) to derive a bare DTM, filtering vegetation and buildings. This filtering is usually problematic as, if the classification is inaccurate, it is not possible to obtain sufficient resolution. If it is erroneous, many ground measures assigned to vegetation may be lost, or vice versa (Doneus, 2020). In the case of the analysed area, which has a starting density of 0.76 p/m² and a class 2 proportion of 43.5 %, the DTM derivation with a resolution of 1 m was performed by interpolation.

Once the points have been converted to a raster format, the relative differences in altitude can be analysed using various algorithms for microtopographic highlighting, from simple shading (Hillshading) to more complex techniques based on slope and orientation calculation, such as Sky View Factor (SVF), Openness, Local Relief Model (LRM), Principal Components Analysis (PCA), Local Dominance (LD), Cumulative Visibility (CV), Multi-scale integral invariants (MSII), Laplacian-of-Gaussian (LoG) or Red Relief Image (RRIM) (Kokalj and Hesse, 2017). In any case, in order to identify archaeological structures, it is necessary to use a combination of several of these techniques depending on the usefulness of each factor, such as the size of the structures, the terrain slope, the use of the land or the degree of alteration (Costa-Garcia and Fonte, 2017). In our case, the most useful techniques turned to be Slope, SVF, PCA and RRIM.

The image interpretation phase, either visual or automated (Guyot et al., 2021), addresses the identification, inventorying and planimetric representation of archaeological elements. This is done differentiating those with polygonal geometry such as enclosures, terraces, ponds or villages, from those in which a linear track is recognized such as paths, canals, slopes or walls, and those that can be traced only as points (Sánchez and Villalón, 2011). In the interpretation of LiDAR data and aerial photographs, Historic England uses a classification according to relief morphology, distinguishing four types: structure, ditch, bank and slope. The last phase of the archaeological projects using ALS consists in the representation of the identified structures, for which it is usually resorted to the shading of relief through low illumination, between 10º and 35º and 315º azimuth, or through perspective views in 3D virtual environments (Historic England, 2018).

3. Results

The evaluation of this methodology, using the IGN's LiDAR data available for the Spanish territory, has been carried out using the site of La Zarcita in Huelva as the case study, which offers diverse and well documented archaeological evidence. The Sierra de la Zarcita comprises a small foothills located in the western end of Sierra Morena, in the sector of Andévalo in the province of Huelva. The chain of hills is situated in an east-west direction, between the villages of Santa Barbara de Casa and Paymogo, close to the Portuguese border. North of this area are the Peñas de Aroche, and to the south the area known as Faja Pirítica (Fig. 2).

Figura 2 – Area analyzed in the southwest of the Iberian Peninsula.

The purpose of this evaluation is not to carry out a remote prospection to detect new archaeological evidence, but to confirm the extent to which it is possible to identify the structures already known in this site using LiDAR, as well as the level of detail or precision offered. That is, taking into account the resolution available in the public data from the IGN. In this respect, it is necessary to consider that the main archaeological projects developed in Spain implementing ALS have focused on the Neolithic and the Iron Age (Cerrillo-Cuenca and López, 2020). This technology has not yet been used for the Copper or Bronze Ages (Sánchez et al., 2022), even though the villages of this time featuring strong wall structures and in high-altitude locations are susceptible to tracking in the current microtopography (García and Morales, 2004). To this end, various types of typical Chalcolithic archaeological structures have been tested using LiDAR, such as villages, roads, burials or arable fields.

3.1. Settlements

The Chalcolithic settlement in Sierra de la Zarcita is represented by the village of Cabezo de los Vientos, excavated between 1981 and 1987 by the ill-fated Fernando Piñón Varela (Piñón, 1986), who documented a settlement of 0.75 ha bounded by a 36 m long on the east-west axis and 26 m wide on the north-south axis walled enclosure. In its interior and attached to the wall, there were found round or oval-shaped huts with a diameter of 3 m and a central sector with fireplaces and ovens. The most outstanding architectural element of the village is the wall, with a width between 1.5 and 2.5 m and an estimated height of 2.5 m. It features tilted outer sides built by means of slate masonry with mud mortar in its lower body, and tapial in the upper body. Attached to this wall are four circular bastions, some hollow and others solid, of between 5.5 and 7 m in diameter, located at the breaks in the defensive perimeter and guarding the gates. The existence of an occupation prior to the fortification of the citadel led Piñón Varela to differentiate two phases in its use: a purely Neolithic one at the end of the 4h millennium[1] contemporary of Papa Uvas IV, and another one in the first half of the 3rd millennium "ya fortificado, como desarrollo de la anterior, equiparable al horizonte metalúrgico precampaniforme de los poblados del Alentejo y Algarve" (Piñón, 1986, p. 323). Among them are mentioned Monte da Tumba II-III, Ferreira do Alentejo, Odivelas, Mestras, Joao Marqués, Santa Justa and São Brás. In any case, this fortification would have a short life, since there is no evidence of campaniform elements or occupation in the Bronze Age.

In the surroundings of Cabezo de los Vientos, other settlements similar in terms of type of location, morphology and chronology have been identified, as they are also "povoados de altura" defended by walls and dated to the 3rd millennium (Piñón Varela, 1989). The closest, 8 km to the South, is El Castillito, which in addition to the natural defence provided by a closed meander of the river Malagón has a wall measuring 125 x 75 m in diameter accessible from the eastern side of the enclosure through a bent gate. It has been recognised as having been used during the Copper Age and as a *castellum* during the Roman-Republican period (Pérez Macías, 2011). Also, in the municipality of Paymogo is the village of Charco de las Herrerías, with a platform of 25 x 16 m at the top and two external wall circuits that form several terraces, forming a total dimension of around 60 x 35 m. To the south of these settlements are the villages of Junta de los Ríos and Cabezo Juré, 16 km and 26 km from Cabezo de los Vientos, both sharing the same chronology (between 2800 and 2400 and from 2800 to 1900, respectively), as well as a metallurgical specialization. Junta de los Ríos has a large 50 m long perimeter wall enclosing the east and west sides, while Cabezo Juré, with a surface area of 2 ha, features an enclosure wall on the north side, 1.5 m wide and more than 2 m high, three levels of terraces and an upper platform with a 1.60 m deep reservoir (Nocete, 2004).

There have also been identified villages from this period in the northern sector, although none of them have been excavated (Martín, 1994). To the northeast, 26 km from Cabezo de los Vientos, is located the village of El Torrejón with an area of 0.8 ha, surrounded by a wall with bastions at the ends and flanking a curved entrance to the east (García, Hurtado and Márquez, 2011). To the northwest, 15 km away, in Portugal, the 3.6 ha settlement of Passo Alto has two lines of walls and a ditch; although it has been dated to the Late Bronze Age (Monge, Antunes and Deus, 2012). Also, to the northwest, but far 40 km from Cabezo de los Vientos, is the important village of Cerro dos Castelos de São Brás, forming an elliptical shape of 120 x 60 m delimited by two fortification lines and a very early chronology, circa 3370-2930 (Parreira, 1983). Elsewhere, 54 km to the southwest, is located Cerro do Castelo de Santa Justa with a size of 40 x 18 m and a fortification reinforced with 9 towers and an east-facing bend entrance, dated between 3390 and 2620 (Gonçalves, 1982). In other fortified settlements in southern Portugal where it has been possible to precisely date the construction phases of the walls, such as Monte da Tumba (3330-2900), São Pedro (2880-2620), Penedo do Lexim (2890-2620), Escoural (2850-2810) or Porto das Carretas (2880-2610), there can be found similarities with Cabezo de los Vientos in regards of this fortification dynamics. "que terá sido algures dentro do primeiro quartel do III milénio a.n.e. que um amplo movimento de "encastelamento" se expande rapidamente por todo o Sul e Oeste peninsular, de Los Millares ao Zambujal" (Mataloto and Boaventura, 2009, p. 59).

Given that the LiDAR data available for the Spanish territory offer a metric resolution, the most easily identifiable structures in these "povoados de altura" are the terraces, since the walls

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[1] All chronological references and dates refer to calibrated dates before our era.

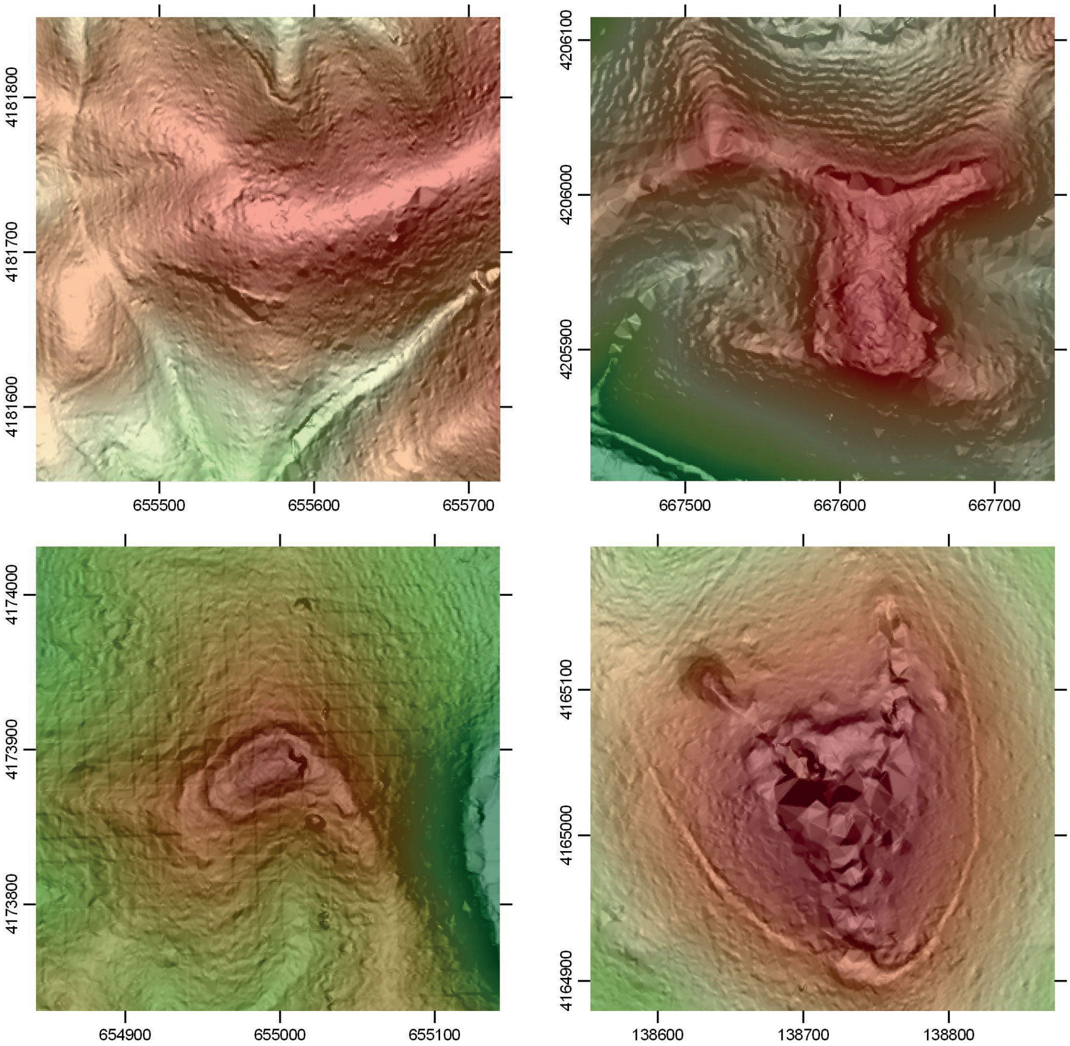

Figura 3 – Hypsographic map from Lidar data of Cabezo de los Vientos, El Torrejón, El Castillito y Cabezo Juré settlements. Coordinates: EPSG 25829.

are not wide enough. In fact, in the villages of Cabezo de los Vientos or Cabezo Juré, the detectable microtopographies correspond to the piles of earth resulting from the excavations carried out in them, without any identifiable traces of the walls. In contrast, in El Castillito and El Torrejón, the outline of both settlements can be seen thanks to the contrast between the steep slope of its defensive perimeter and the flattened surface of its terraces (Fig. 3).

3.2. Burials

In the vicinity of Cabezo de los Vientos and in spatial and chronological connection with the settlement, there is an important megalithic complex formed by 4 *tholoi*. On the hill adjacent to the settlement itself and only 225 m to the west is the *tholos* of Cabezo del Molino, excavated in 1980 (Piñón Varela, 2005). Its tumular structure has a maximum diameter of 14 m and is encircled around its perimeter by a masonry wall with two stepped fronts, filled with soil and slate slabs. The 4.7 m corridor, flanked by slate orthostats and oriented at 148º, leads to a chamber with a 2.4 m diameter that preserves the bearing wall of the false dome. Also on a hill, 520 m to the north, is the *tholos* of Cabezo del Tesoro, named "La Zarcita" by Carlos Cerdán who excavated it in 1946. It features a 19 m mound and a 4 m in diameter chamber without a corridor, composed of 1.4 m high vertical slabs that supported the false dome made of slate slabs, now refilled after its excavation.

It is noteworthy that this *tholos* offered rich grave goods, in which a copper axe stands out, which served Cerdán and Leisner to define a "La Zarcita culture" with North African influences (Cerdán, Leisner and Leisner, 1952).

On a hill overlooking the Monteviejo creek and 720 m north of Cabezo de los Vientos is located the dolmen of La Suerte del Bizco, first excavated by Carlos Cerdán in 1946 and again by Piñón Varela in 1981. This dolmen has 9 m in diameter and 1.3 m in high marked circular mound, made of slate slabs, in which a 3.7 m corridor oriented at 161º leads to a 2.2 m chamber partially excavated in the substratum, also with a false dome of slate. Next to it and near to the Monteviejo riverbed, is the Charco del Toro burial site, also documented by Piñón Varela in 1981, with a tumulus of 17 m in diameter and the remains of a corridor oriented at 85º. The corridor gives access to a circular chamber 2.80 m in diameter, with three lateral small side chambers, all delimited by 0.7 m thick walls that only preserve 5 or 6 rows of slate barely 0.3 m high (Piñón Varela, 2005).

This series of megalithic burials, which make up the necropolis associated with Cabezo de los Vientos, are susceptible to identification and measurement by ALS, given that their tomb structures have a decametric size and are therefore detectable with the available LiDAR data, which reach a metric resolution (Cerrillo-Cuenca and Bueno, 2019). In fact, the four *tholoi* closest to Cabezo de los Vientos are visible in the DTMs, although elements such as the corridors or chambers cannot be detected with the level of detail available, except for the case of El Molino (Fig. 4). The analysis of its link with the Cabezo de los Vientos settlement from the altimetric data also allows us to recognize that the burial sites of El Molino, Tesoro and Suerte del Bizco are visible from the settlement, as the walking distances between the settlement and the *tholoi* are in all cases less than 10 minutes.

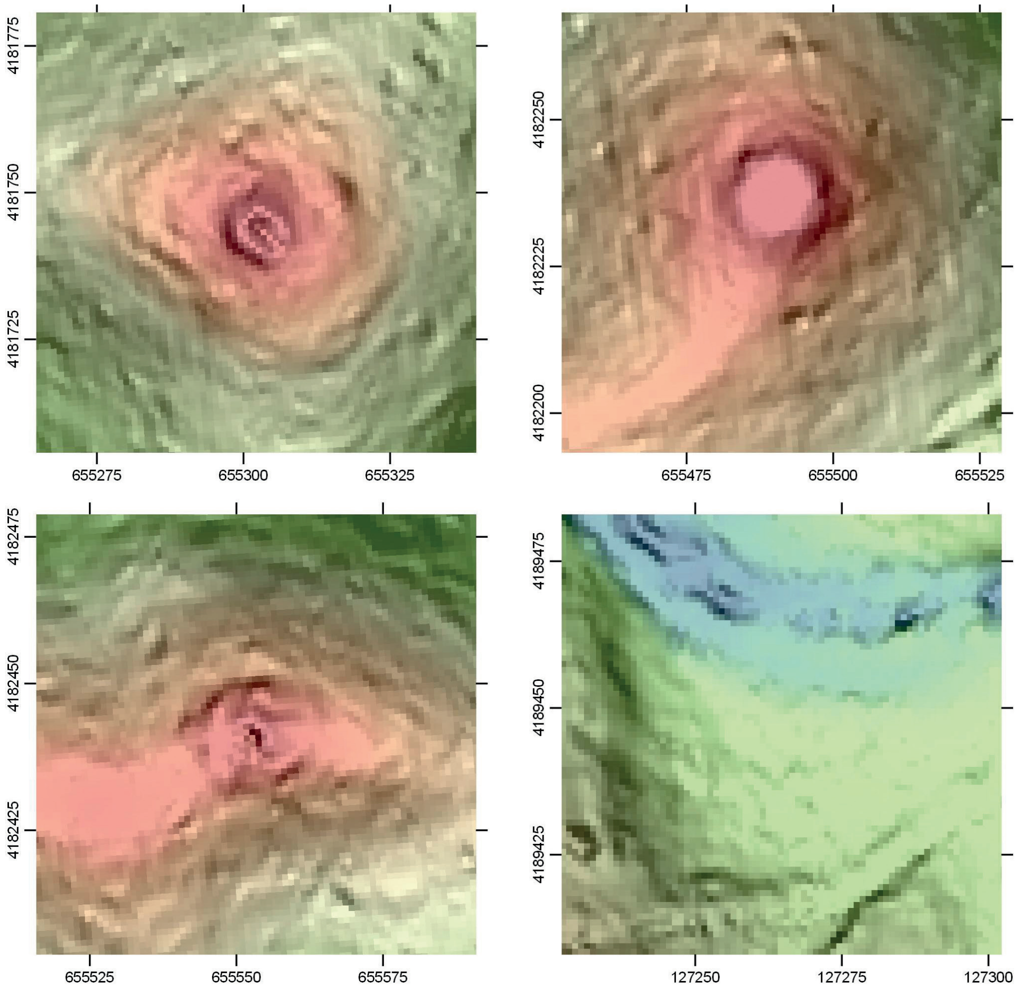

Figura 4 – Hypsographic map from Lidar data of Cabezo del Molino, Cabezo del Tesoro, Suerte del Bizco and Charco del Toro burial mounds. Coordinates: EPSG 25829.

3.3. Arable areas

The availability of land suitable for cultivation is a determining factor in the location of any Neolithic settlement, given its economy based on the agriculture of cereals (*Triticum aestivum/durum* and *Hordeum vulgare var. nudum*) and legumes (*Lens culinaris, Pisum sativum* and *Vicia faba*). Even though in the Huelva region of Andévalo the lithology of Paleozoic slate and quartzite entails that the soils have little arable capacity and have traditionally been used for forestry and livestock, the surroundings of Cabezo de los Vientos do have land with a soil, slopes and watercourses that would allow agricultural exploitation with the technological levels corresponding to the Final Neolithic and Copper Ages. Immediately south of the Sierra de la Zarcita lies the area of La Raña, a sedimentary basin from the Quaternary ages formed by clay illuviation that, in addition to its richness in nutrients, has a gentle slope (<8%), which has favoured the development of Leptic Luvisols (LV-le) type soils, very suitable for cultivation and exceptional in the Western Andévalo. In contrast, in the rest of the area, on a lithology of Paleozoic shales and schists, the typical Andévalo soils of Eutrophic Cambisols and Regosols (CM-eu, RG-eu) dominate, with low strength and high acidity, which only allow natural vegetation of scrubland and Mediterranean sclerophyllous forest (Bellinfante, Martínez-Zavala and Paneque, 2000).

The site of La Raña is the sector with the greatest agricultural capacity in the surroundings of La Zarcita and one of the most extensive cultivable areas in the Andévalo with a size of 6 x 2.5 km. Additionally, as Piñón Varela pointed out, the Cabezo de los Vientos settlement itself is located in a site with a preferential visual control of La Raña due to "su condición de otero desde el que dominar

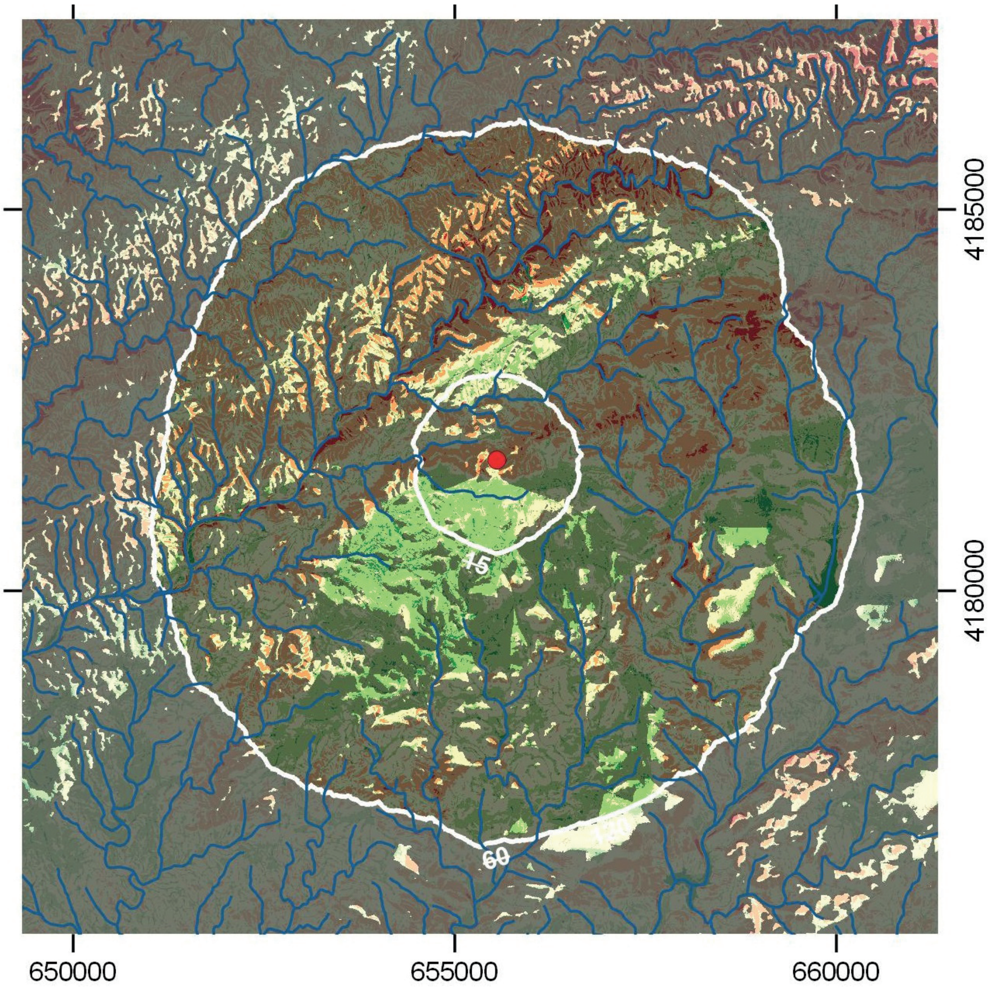

Figura 5 – Map of slopes (green to red), visibility (bright or dark), and isochrones (min) in the Cabezo de los Vientos catchment area. Coordinates: EPSG 25829.

no solo el suave paisaje de colinas que se extiende al norte y oeste, sino también la amplia y feraz Raña, situada al pie de su ladera meridional" (Piñón Varela, 1986, p. 317).

The LiDAR altimetry analysis of these variables concerning agricultural capacity, accessibility, visibility or slopes shows that this fertile Luvisol sector of La Raña is accessible in less than an hour's walk from the village and is located within its visual range (Fig. 5). This confirms Piñón Varela's assessment in regards to the location of the Cabezo de Los Vientos settlement, stating that it has a territorial logic linked to the agricultural exploitation of La Raña. Thus, comparing the resource catchment areas within different isochrones (Gilman and Thornes, 1985), it can be noted that the settlement has sought the proximity to the flatter and more topographically regular areas (Table 1).

Minutes	Area (ha)	Mean (°)	Median (°)	Deviation (°)
15	382	6.69	5.28	4.72
60	6318	7.64	6.63	5.00
120	19936	8.98	7.81	5.70
240	74552	10.76	8.84	7.65
>240	191039	11.51	10.06	7.60

Table 1 – Slopes in the isochronous areas around the Cabezo de los Vientos settlement.

3.4. Roads

The Sierra de la Zarcita is not close to any of the main corridors that connect the southwest of Iberian peninsula. These corridors were organized around the main rivers, with the Cala stream serving as a link between the Guadalquivir valley and the Meseta, the Múrtigas river as a means of penetration towards the Alentejo and especially the Guadiana River as a connecting axis between the Algarve coast and the inland (García, Hurtado and Márquez, 2011). For this reason, the main historical roads that pass near the Cabezo de los Vientos operate on a regional scale, connecting the highlands of the Peñas de Aroche with the lower course of the Chanza stream. The cattle routes that run nearby have an east-west orientation, such as the Vereda de la Trocha de los Peros that crosses La Raña only 1.5 km south of the village or the Vereda del Jarrillo 5 km to the north.

On a more local scale, Cabezo de los Vientos is located next to the road that nowadays connects the Monteviejo creek with La Raña and runs between the settlement and the Cabezo del Molino *tholos*. In fact, this road must have served as a daily connection between the settlement, the tombs linked to it and the nearest water supply point. Using LiDAR altimetric data to calculate the Least

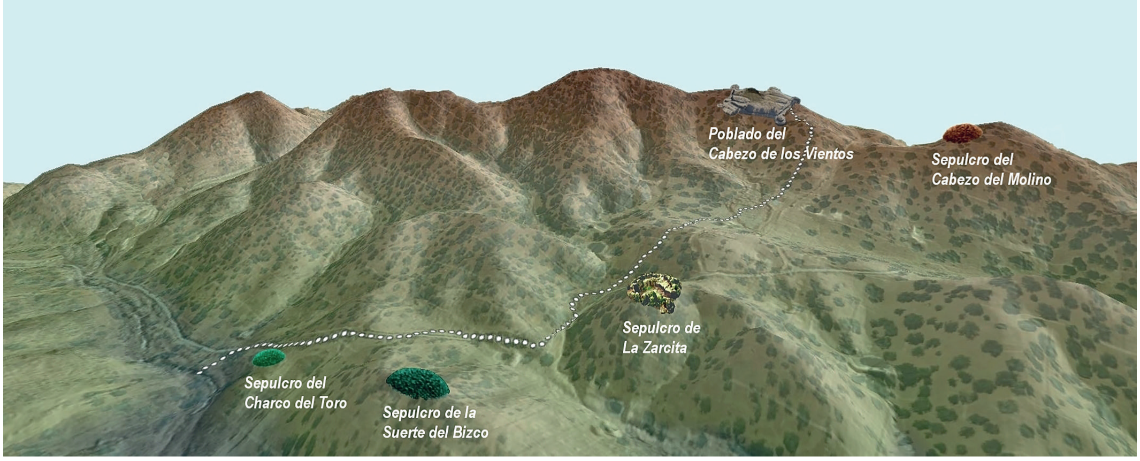

Figura 6 – Settlement, burials and paths in La Zarcita landscape.

Cost Path (LCP) between the village and the nearest ford on the Monteviejo stream, located 11 minutes away at Charco del Toro, it is possible to obtain a path that runs along the foot of the four burial mounds (Fig. 6). Based on these relationships between settlement, necropolis, hydrography and road, a fairly common pattern is observed in Chalcolithic settlements, in which burial mounds usually mark the landscape by visually dominating the main access roads to the settlements.

4. Conclusions

The use of airborne laser altimetry data for the identification of archaeological structures is proving very useful as a source of complementary information in prospection or spatial analysis projects, especially in areas where vegetation coverage hinders recognition by aerial photography or field work. Its limited yet fruitful use in the Iberian Peninsula is making it possible to evaluate the types of structures that are detectable, the levels of resolution that are useful and the data treatment processes that need to be applied. The use of the IGN's public LiDAR data available for the Spanish territory in this area of the Andévalo in Huelva makes it feasible to obtain some first conclusions about its possibilities of archaeological use in Mediterranean climate environments.

The first conclusion is that in intensely prospected areas such as the southwestern peninsula, LiDAR will hardly detect archaeological evidence not recognizable by surface prospection. In fact, the ALS projects that have offered the most spectacular results have been performed in jungle environments where prospecting is difficult due to dense vegetation. In this regard, it is interesting to note that in areas of dehesa with Mediterranean sclerophyllous forest the vegetation is very penetrable by laser pulses, whereas in areas of dense scrubland, such as thicket of gorse, few rebounds are obtained on the ground.

The second conclusion concerns the type of structures detectable by analysis of variations in microtopography. Thus, it has been found that in the settlements the defensive structures such as walls or bastions are difficult to detect with the metric resolution currently available, while the terraces and acropolis defining the "high-altitude settlements" are more identifiable. Regarding the megalithic sites, menhirs and cromlechs do not appear, unlike the dolmens and tholoi's tumuli that are recognizable.

The third conclusion concerns the possibilities of using DTMs derived from point clouds for landscape archaeological analysis. In this sense, the calculations of accessibility, visibility, least cost paths or resource capture areas by isochrones prove to be very accurate thanks to the new three-dimensional models that reach metric resolution and decimeter accuracy, compared to those previously available that offered decametric resolutions.

The fourth conclusion is directly related to the levels of resolution. Although the availability in Spain of public data with point densities between 0.5 and 1.5 pulses/m^2 is very valuable, archaeological ALS projects such as those developed in Yucatan, Cambodia or Britain have been designed with resolutions of up to 21 p/m^2 to derive 25 cm DTMs. These resolutions are also influenced by the accuracy of the point classification process by FWF, which in the Spanish case leaves almost half of the returns unclassified.

As a final conclusion, it should be noted that this same methodology, here applied to archaeological structures of the Copper Age, can be extrapolated to the analysis of the settlement in other periods such as the Bronze or Iron Ages, especially when ALS surveys are carried out with higher resolution in small areas and for specific archaeological purposes.

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