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Contents

Roman military settlements in the Northwest of the Iberian Peninsula. The contribution of historical and modern aerial photography, satellite imagery and airborne LiDAR[1]

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The origins of a discipline

The relationship between Roman military archaeology and aerial photography is not new in the Iberian Peninsula. In the early 20th century J. R. Mélida commissioned to the incipient Spanish military aviation a photographic flight over Numantia (González Reguero 2007: 239). Some of the camps of the famous scipionic siege could have been then identified. The military get involved in the aerial surveying of several archaeological sites in the following years, including the republican camp of Cáceres el Viejo (Almagro Basch 1943).
After World War II the Spanish government commissioned to the USAF two stereoscopic flights covering the whole country (1945-6 and 1956-7). The second one, named "*Vuelo General de España Serie B*" (USAF AST6 54-AM-78), was repeatedly used by archaeologists. The discovering of new camps as those of Castrocalbón (Loewinsohn 1965) and Valdemeda (Sánchez-Palencia 1986) was possible thanks to the reviewing of those old photographs.

During the decades of 1990 and 2000 aerial photography also played an important role in the awakening of the Roman military archaeology as a discipline in Spain. The planning of flights sensitive to the archaeological methodology allowed the discovery of new camps as well as the detailed study of other previously known (del Olmo 1995; García Merino 1996; Peralta 2011). At this very moment, the popularization of aerial and satellite photography, GIS and airborne LiDAR opens a new phase in which low-cost specific methodologies are blooming (Menéndez Blanco *et al*. 2013a).

[1] This contribution results from a poster presented in AARG 2015 in Santiago de Compostela, which can be downloaded through this URL: http://hdl.handle.net/10347/13563

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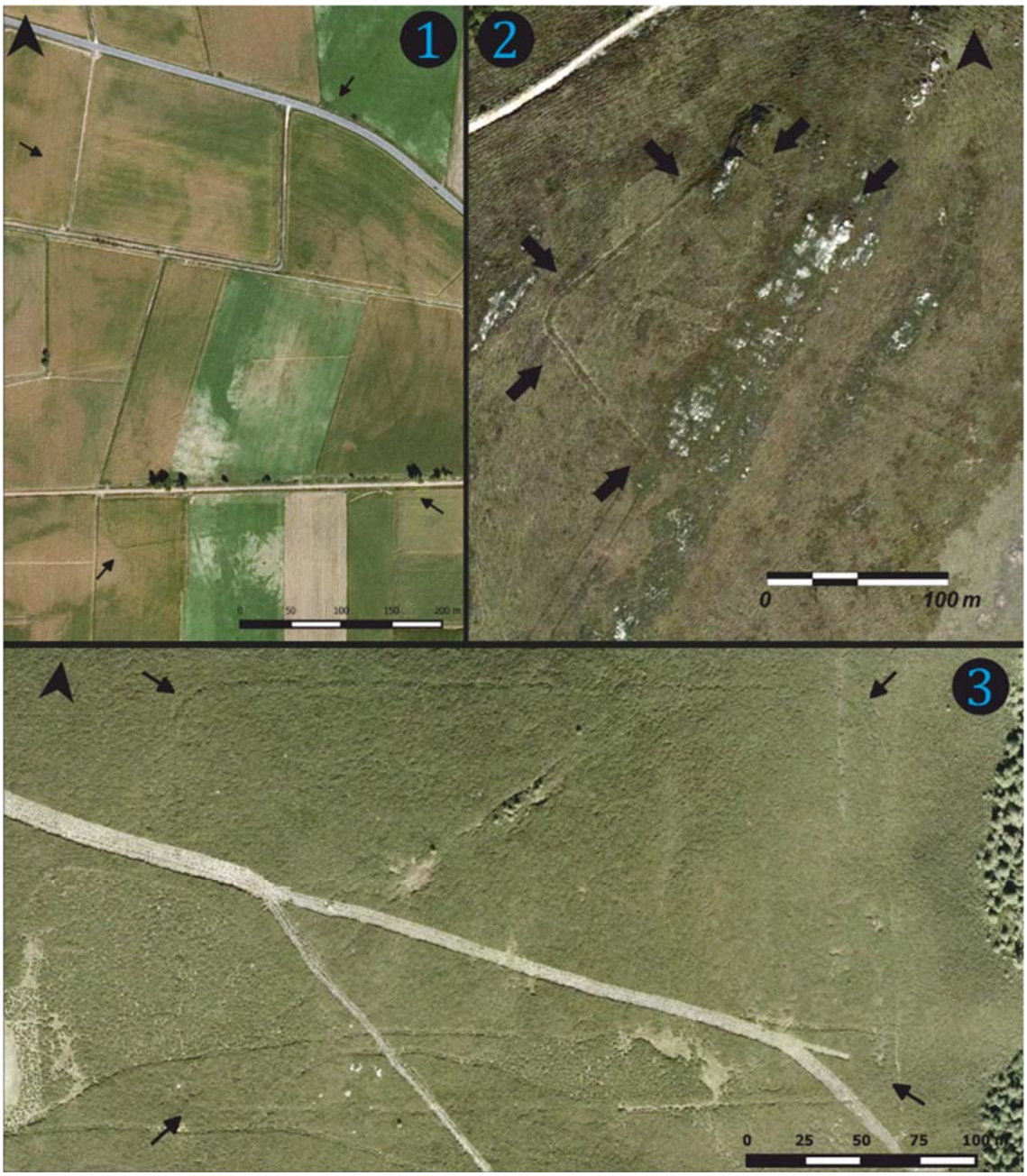
Camps of Cáceres el Viejo (1) (mid 1940s), Valdemeda (2) (1957) and Villalazán (3) (early 1990s)

The use of modern aerial photography

Since 2004, the *Plan Nacional de Ortofotografía Aérea* (PNOA) aims to obtain digital aerial orthophotos of the entire Spanish territory with a resolution of 25 or 50 cm and with an annual temporal resolution adapted to each autonomous region (http://pnoa.ign.es/). While these data are open access in Spain, in Portugal a comprehensive coverage of digital orthopohotos with 50 cm resolution is only accessible through web-mapping services supported by the National Geographic Institute (www.igeo.pt).

In the recent past, the open access to PNOA data has allowed us to develop a systematic survey method, especially effective in mountainous areas without dense vegetation canopy (i. e. Asturias or León). Sometimes the ancient earth ramparts were still visible and could be

remotely detected, other times the ditches were tracked due to the differential accumulation of moisture. After locating those potential sites, we planned their archaeological field survey. In this way, we discovered many *castra aestiua* such as Moyapán, Huerga de Frailes, El Mouru, Valbona, A Granda das Xarras, A Rechacha, A Pedra Dereta, Chao Carrubeiro, Picu el Outeiro or Serra da Casiña (Costa et al. 2015Gago & Fernández 2015; González Álvarez *et al*. 2008, 2011-2012; Menéndez Blanco *et al*. 2011a, 2011b, 2013b, 2015).

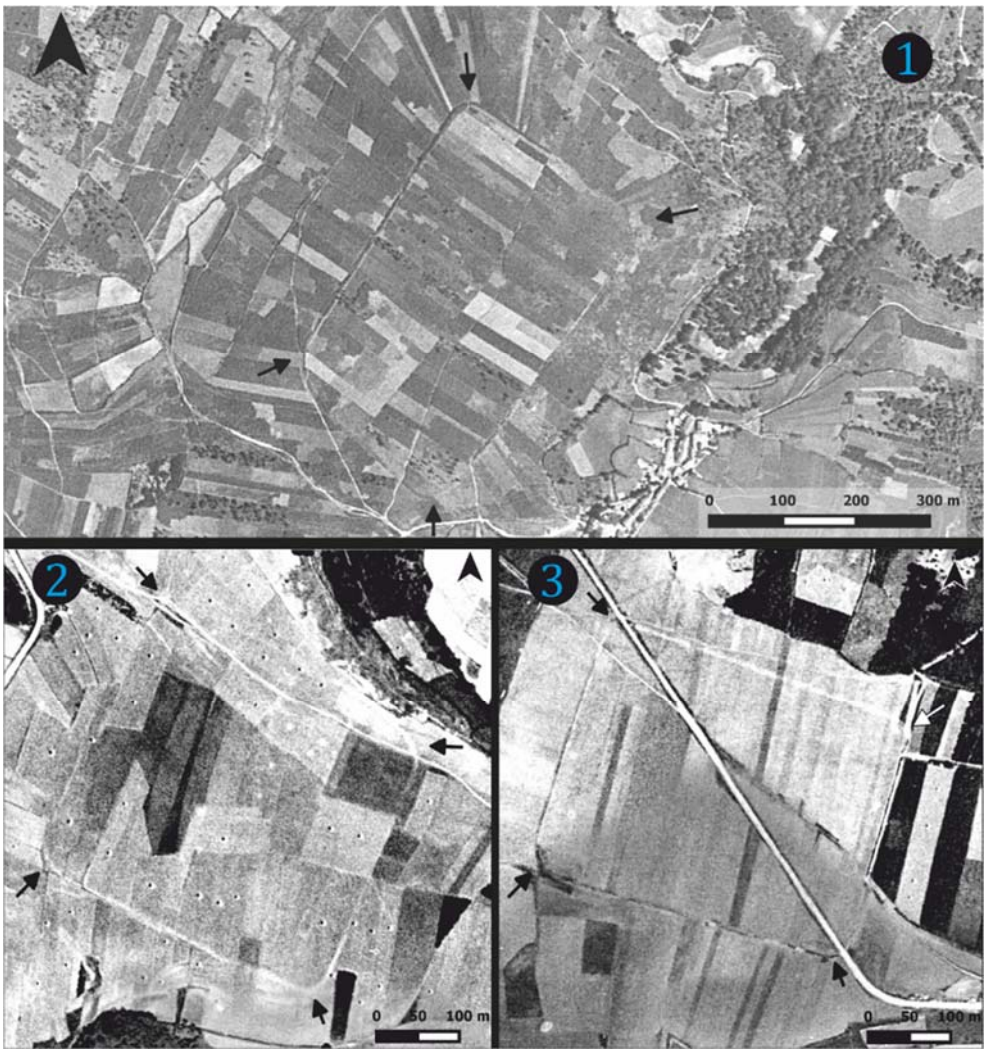


Some camps detected by using recent PNOA flights: Huerga de Frailes (1) (2006), Moyapán (2) (2006) and A Granda das Xarras (3) (2008)

The contribution of historical aerial photography

The PNOA also offers a Digital Photo Library service in which several photogrammetric flights from the 1930s onwards can be located (http://fototeca.cnig.es/), including the two already mentioned USAF flights. Although this information is open access, sometimes the photos have not been accurately orthorectified. In Portugal, similar data can be obtained by request from the *Secção de Fotografia Cartográfica* of the Geographic Institute of the Portuguese Army (https://www.igeoe.pt/).

The use of historical aerial photos introduces a significant diachronic factor in the study of Roman military sites: many of these camps have been hidden or destroyed in recent times mainly because of the impact of anthropogenic activity. That is the case of Campos, razed during the construction of an industrial park (Costa García *et al*. 2015a). Reforestation plans or the mechanization of farming have also damaged the camps of Cornado, El Pico el Outeiro, Huerga de Frailes, Monte dos Trollos, Monte da Modorra, Cabianca and Monte da Chá in a different degree (Costa García *et al*. 2015b; Gago & Fernández 2015; Menéndez Blanco *et al*. 2011b, 2013b).



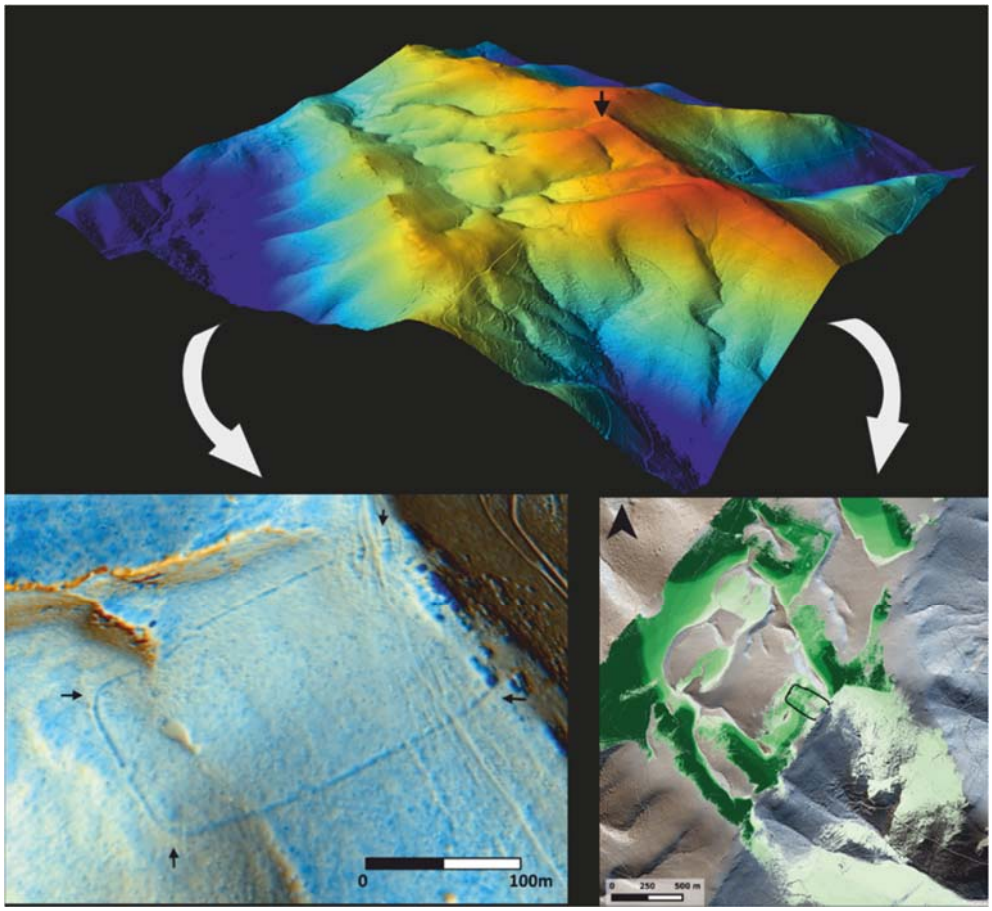
Some camps detected after reviewing USAF 1956-7 historical aerial photos: Cornado (1), Monte da Modorra (2) and Monte da Chá (3)

Structure from Motion (SfM) photogrammetry has been also employed to orthorectify and georeference historical aerial photos from the 1940s and the 1950s. The production of photogrammetric cartographic data, namely Digital Surface Models (DSM) and orthophotos, has been vital to the study of some of those sites.

Airborne laser scanning

In areas densely forested, the identification of archaeological features is still very problematic (Doneus *et al*. 2008). The introduction of airborne LiDAR has helped to overcome this problem because of its unique capability to penetrate vegetation canopies, making it possible to document the underlying topographic surface and to identify any cultural remains on it (Opitz & Cowley 2013).

However, the identification of archaeological features on LiDAR-derived DEMs is very dependent on visualization techniques that can enhance our perception of anthropogenic features. Different methods have been proposed, from simple hillshading to more complex calculations like Sky View Factor (Kokalj *et al*. 2011) or Local Relief Models (Hesse 2010). These visualization techniques have been compared (Bennett *et al*. 2012; Chalis *et al*. 2012; Štular *et al*. 2012) and the results confirm that no single method outperforms the rest in all types of terrain. Therefore, a combination of these techniques is the only way to obtain the maximum volume of information on potential archaeological features. Among the more



Chao de Carrubeiro: DTM, resampling filter and GIS visibility

effective are the trend removal procedures (Hesse 2010; Štular *et al*. 2012) based in the theoretical assumption that when a smoothed surface is compared to its original, local small-scale topographic features are contrasted from large-scale landscape forms.

In Spain there is an almost complete LiDAR coverage (http://pnoa.ign.es/coberturalidar), with all the data freely available. The LiDAR data are already classified, so we only have to isolate the ground points from which we have obtained a Digital Terrain Model (DTM). Although in most of the cases we have used hillshade as a visual technique, the Resampling Filter available in SAGA GIS software (Conrad *et al*. 2015) has proved to be a very effective solution for the detection of Roman military sites. This is a trend removal technique that allows us to represent local small-scale elevation differences, similarly to Local Relief Models (Hesse 2010).

Towards a new low-cost methodology

In order to understand the landscape in detail, we have combined airborne LiDAR data with historic and modern aerial photos and satellite imagery. This is a valuable method since each technique reveals different features, making it possible to maximise the results (Crutchley 2009). The combination of these tools with field surveying and GIS allowed us to develop new low-cost methodologies especially effective when dealing with these kinds of structures in almost every type of terrain (Costa García *et al*. 2015b). Moreover, we were able not only to detect new archaeological features but also to develop new morphological and landscape analysis for the study of Roman military sites by using GIS tools (Costa García 2015).

Bringing Archaeology to the people

Our main aim now is to consolidate this research line but we are also aware of the important role people should play in archaeological and heritage research.

The research group united around romanarmy.eu (http://romanarmy.eu/en/) appears as a result of two natural dynamics. On one hand, it tries to exploit the potential of this research line, to explore its possibilities and to reinforce it where it shows its weaknesses. In summary, to better understand the Roman military presence in these regions by adopting multidimensional perspectives. On the other hand, it is the way in which the paths of a set of young researchers and their worries about the divulgation of our archaeological and cultural heritage converge. Through a narrative and visual language, we try to disseminate our research to the public and to make them participants. Our web page (http://romanarmy.eu/en/) and social media profiles (https://www.facebook.com/romanarmynw/) are the windows we have opened to the world.

Print screen from the RomanArmy.eu web page

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