Scientific editors:
Quentin Borderie and Ferréol Salomon

Urban Geoarchaeology

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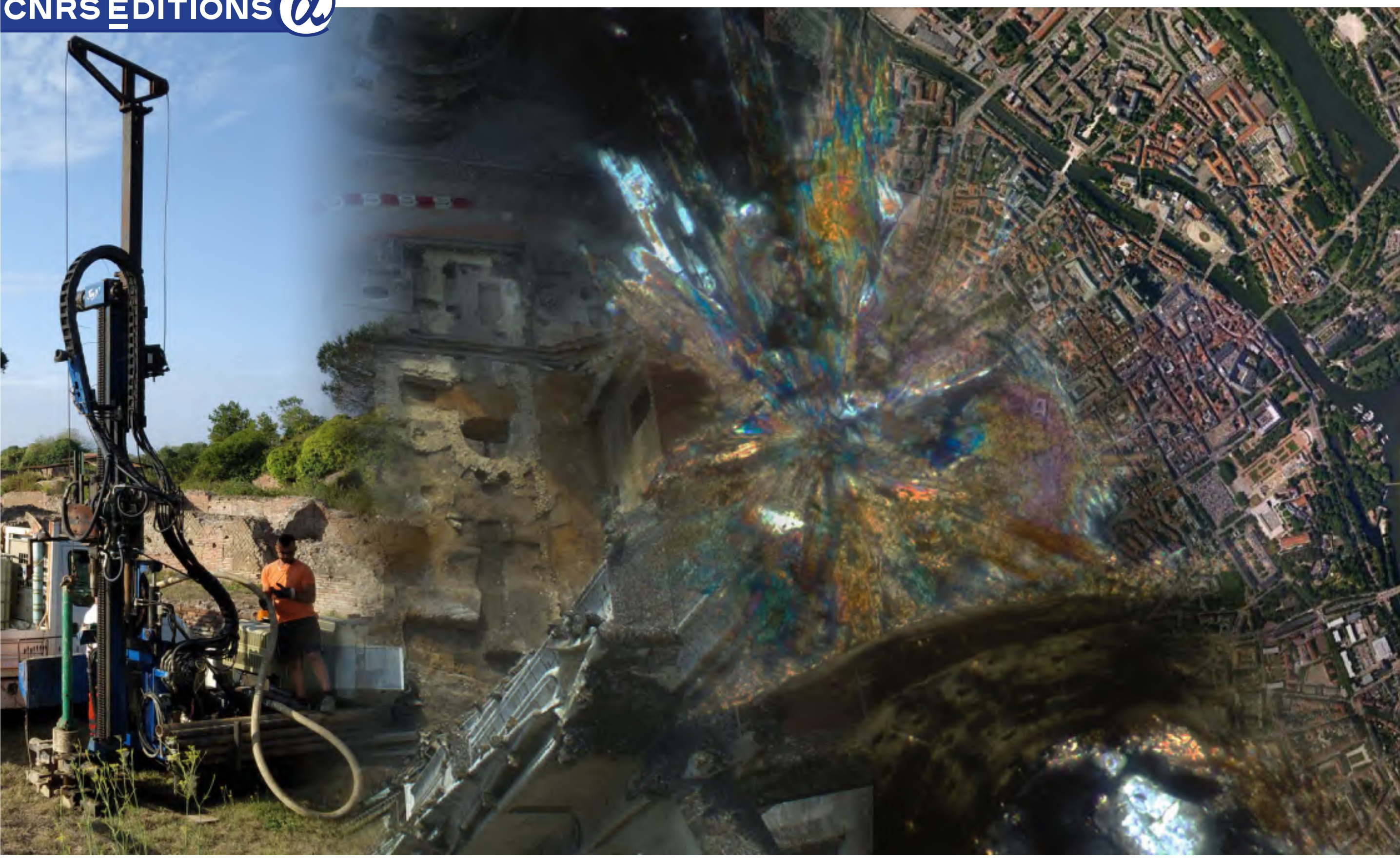

The global spread of urbanisation is having a profound impact on environments, climates and social lives. This gives rise to questions about the sustainability of urban areas, the management of soils and sediments and the socio-environmental construction of spaces. Archaeological investigations show that societies produced a wide variety of different urban forms throughout millennia and across continents. By focusing on human-environment interactions through the study of soils and sediments, geoarchaeological research provides new insights into the different ways of making and living in a city in the long term.
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Cover image:
From left to right: Sedimentary drilling in Ostia (Italy) within the Roman city; archaeological excavation in Beauvais (France) from the top of the 16th century cathedral showing Dark Earths and an 11th century church;
star shaped vivianite crystal and a bone through optic microscope cross-polarised light;
aerial view of Metz (France) and the Mosel River.

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Acknowledgements

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Geoarchaeology in a peri-urban environment: a soil micromorphological case study of the "Land of Aynadamar" in Nasrid, Granada (Spain), the northern outskirts of the last Islamic town in Iberia (13th-16th centuries)

Rowena Y. Banerjea[1], Guillermo García-Contreras[2],
Marcos García-García[3], Luca Mattei[2], Aleks G. Pluskowski[1]

Abstract

Granada (Spain) was the capital of the Nasrid Kingdom, the last Islamic emirate in Iberian Peninsula during the 13th-15th centuries. The Land of Aynadamar is located on a hillside north of the city of Granada, on the third hill in the urban complex. The hill to the south is occupied by the Alhambra, the palatine city where the Nasrid sultans resided. The Land of Aynadamar can be considered as part of the 'castlescape' of the Alhambra and its study contextualises further this iconic monument, even though the Alhambra was a palatine citadel and not only a single castle. This research, which applies soil micromorphological analysis in conjunction with the historical sources, excavation data, and palaeoenvironmental data, demonstrates how the suburban landscape was transformed following the Castilian conquest and the Christian colonisation in the last peri-urban place of al-Andalus. Archaeological soil and sediment micromorphological analysis has identified nuances in the stratigraphic sequences from four separate areas comprising agricultural terraces, peri-urban farmsteads, and a palatine residence, and it has identified periods of abandonment or the disuse of areas that are maybe contemporaneous. These periods of abandonment relate to an important transition in the occupation of the Land of Aynadamar that marks the decline of Nasrid rule and changes associated with the Christian conquest from the 16th century onwards.

Keywords: soil micromorphology, landscape archaeology, terrace agriculture, Medieval, Islamic Archaeology, household archaeology, garden soils, abandonment

1. Introduction

Granada (Spain) was the capital of the Nasrid Kingdom, the last Islamic emirate in Iberian Peninsula during the 13th-15th centuries (fig. 1, A). By the end of the Middle Ages, the city grew and changed its appearance due to both the increasing number of people arriving from other parts of the Peninsula, and the political, economic and environmental decisions about how to manage its surrounding area. According to the written sources, the northern part of the city, outside of the walls, was a very productive area where some *cármenes* (peri-urban farms) and *almunias* (small palaces) were built, partly thanks to water management. It was known as "Land of Aynadamar" and was described as an area with rich houses and farms, vineyards, agricultural terraces, *almunias* and the route of one of the most important water channels of Granada: The Channel of Aynadamar (García-Contreras, 2021a). Granada was conquered in 1492, a date that marked the end of the Christian conquest of the whole Peninsula. After that, at the beginning of the 16th century, parts of these lands in northern Granada were given to the Carthusian order to build a monastery. Subsequently, in addition to the construction of a monumental monastery, the monks became owners of an expansive space replacing the previous Muslim owners, and they decided to change the

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production system, creating dry crops in terraces and enclosing the land, thus transforming the landscape.

Soil micromorphology is not routinely applied in rescue archaeology in Spain. For the first time, it was used alongside the standard range of techniques used in urban archaeology to answer key questions about spatial organisation, function, and use of a peri-urban landscape, which was unclear from excavation alone. During 2013 and 2014, extensive renovation of roads prompted a substantial archaeological excavation in an area which today lies within the Cartuja campus of the University of Granada in the formerly known "Land of Aynadamar" (García-Contreras and Moreno 2017) (fig. 1, B and C, fig. 2). From 2015, this was followed by an excavation of one of the *almunias* in the upper part of the hill, the Albercón (fig. 2, A and B). This research, which applies soil micromorphological analysis in conjunction with the historical sources, excavation data, and palaeoenvironmental data, demonstrates how the suburban landscape was transformed following the Castilian conquest and the Christian colonisation in the last peri-urban place of al-Andalus.

The Land of Aynadamar is located on a hillside north of the city of Granada and it is the third hill in the urban complex (fig. 1, B and C). The hill to the south was occupied by the Alhambra, the palatine city where the Nasrid sultans resided. The central hill is the Albyzín, the original site of the medina that was already occupied in Roman times, then partially abandoned, and became a city again from the 11th century onwards. The third hill, which we will deal with in this work, remained as the peri-urban area described above, with an occupation whose chronology, material culture and architecture is closely related to what is documented in the Alhambra and the Albyzín neighbourhoods. The Land of Aynadamar can be considered as part of the 'castlescape' (Banerjea *et al.* 2019) of the Alhambra, and its study contextualises further this iconic monument, even though the Alhambra was a palatine citadel and not only a single castle. A 'castlescape' is a particular type of 'heritagescape' (see Garden 2006 for definition), often with many buildings, associated with the castle. It has a range of spaces within the castle, each with their own complex life-histories, and with extensive territories beyond the castle, such as agricultural systems, as can be seen in the Land of Aynadamar. The boundaries of hinterlands, and frontiers around the castle, can be fluid and so the presentation and management of the castle landscape should integrate these aspects (Banerjea *et al.* 2019, Banerjea 2021).

2. Historical and archaeological context

2.1. Summary of the historical sources

The first references in the written documentation to these lands of Aynadamar begin in the 13th century, but they are especially abundant from the 14th century onwards. They are documents in Arabic, usually poems or geographical descriptions. We can use one example of those texts written by Ibn al-Jatib, vizir to the Sultan Muhammad V, who describes ca. 1375 how wonderful this area was with marvellous gardens.

"(Aynadamar) is wonderfully situated, with marvellous gardens, unequalled for their mild climate, sweet waters and panoramic views. There stand well-protected palaces, crowded mosques, sumptuous mansions, solidly-built houses and verdant myrtle groves. There, at their leisure, people happily spend their money and do not skimp on their investments –rivalling those of good fortune, sometimes servants of the dynasty- until [such mansions] became wonders of the world and prototypes of beauty." (Original text translated into Spanish by Cabanelas 1979, and into English by the authors).

These lines, which exemplify the typical colourful words from all Islamic sources, provide invaluable descriptions of the landscape during this period. After the Christian conquest, the documentation began to be much more exhaustive, describing the plots of land, the irrigation canal systems, or the houses at the rate that the Carthusian Order acquired them (Torres 2007). Land was repurposed to generate agricultural land for rain-fed crops, mainly olive and almond trees as it has been documented along the whole land of Aynadamar since the first written sources generated by the Carthusian monks (Torres 2007).

2.2. Summary of the excavations

2.2.1. Area 1, the Agrarian Terraces, 15th-16th centuries

Excavations of Trench 22.000 (13.5 m x 4 m) were carried out on the terrace wall that delineates Terrace 2 (fig. 2, A, C and F). They identified a linear and irregular drystone wall which had been built in two different phases. Although this type of construction is difficult to date, typological dating from the construction technique and the ceramic materials in the terrace deposits suggest that the cultivation terrace possibly had an origin no earlier than the mid-16th century, representing a more substantial second phase lasting beyond the 17th century.

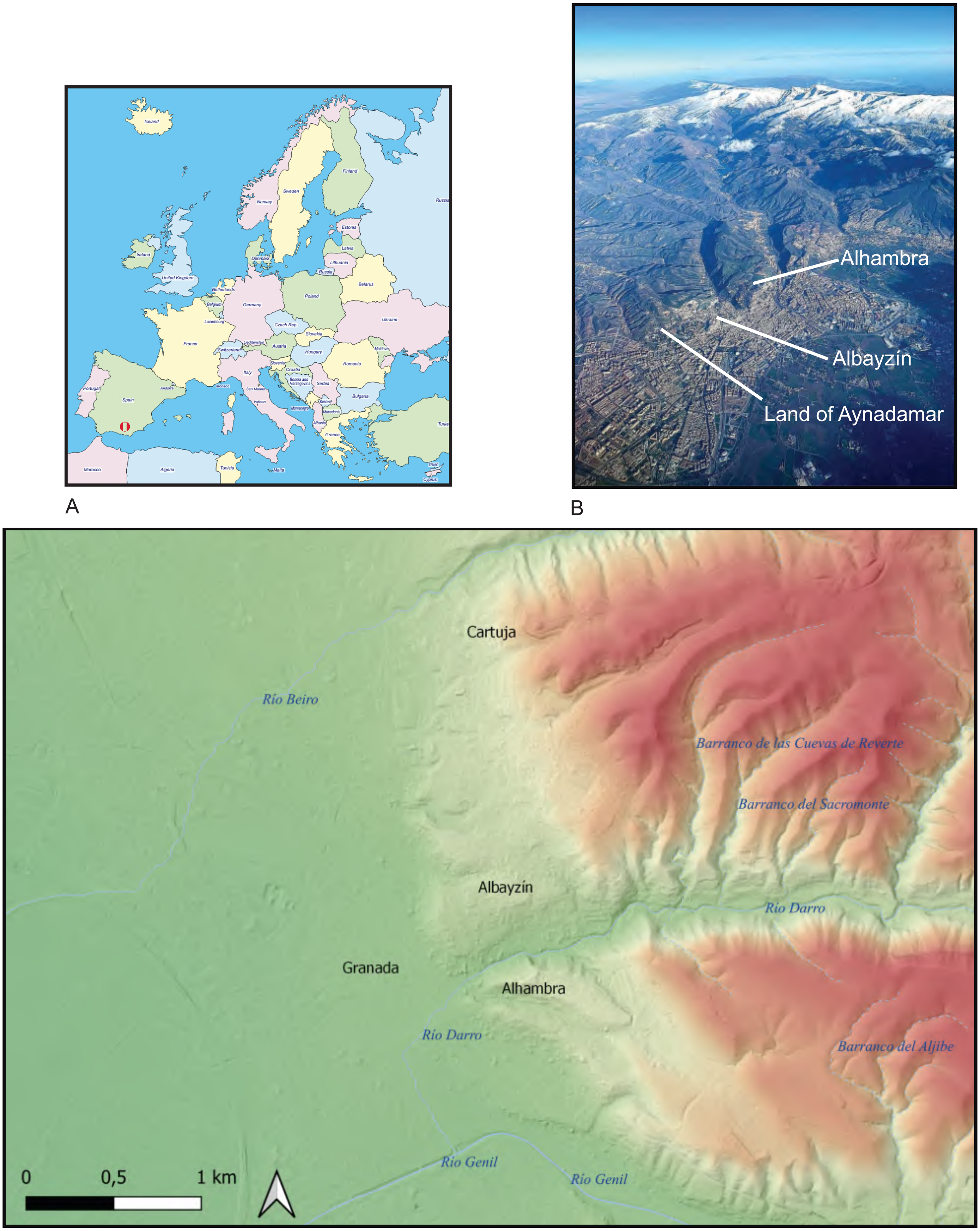

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Figure 1: A. The location on Granada marked in red; B. Aerial photograph of Granada showing the locations of the Alhambra, Albayzín and the Land of Aynadamar; C. Topographic map showing the locations of the Alhambra, Albayzín and Cartuja (site of the University of Granada and area of the historic Land of Aynadamar). Figure by authors Banerjea, Mattei and García-Contreras.

The first phase of construction was the drystone wall made from local stone to develop an agricultural terrace that rested against it in the shape of a wedge (Unidad Estratigráfica/Stratigraphic Unit, henceforth UE 22010, very reddish soil). The wall was extended in the second phase of construction with a diverse type of construction material that includes a row of bricks arranged vertically as well as local masonry, resting directly on the construction of phase 1 (fig. 2, F). The wall may have originally been taller, but the top collapsed and fell downslope or the stones moved post-deposition and subsequently, removed erroneously during excavation. This second phase is associated with the agricultural levels that are within the extension of the wall (UE 22007 and 22006), and the ceramic materials are typologically dated to the 19th century. UE 22005 is the soil of contemporary farmland. Three micromorphology samples were collected to understand the use and management of the terrace structure: sample 1 from UE 22005; sample 2, from UEs 22005 and 22007, and sample 3 from UEs 22007 and 22010.

2.2.2. Area 2, Mid-16th century occupation

In Trench 24.000 (fig. 2, A, C and H), a medieval well was excavated, which was reused as a rubbish pit during the early 16th century. The stratified deposits in the well contained unusual evidence of the transition from the Nasrid to the Castilian period, when this area was largely occupied by a population comprising former Muslims known as Moriscos.

The sequence of the fillings of the well started with a reused architectural element identified as a piece of vaulting in the Gothic style unknown in Granada until the Castilian conquest in 1492, which comes from the construction of the nearby monastery of La Cartuja. On top of this architectural piece, a rubbish dump accumulated, containing Nasrid ceramic typologies (that suggest a predominant date late in the 15th century), as well as a large sample of faunal remains (García- García *et al.* 2021).

The faunal assemblage is dominated by caprines (95% NISP), with cattle only representing 5% of the total sample. The absence of other domestic species is remarkable, particularly chicken and rabbit, two species commonly found in the zooarchaeological record of medieval Iberia (García-García 2019, Grau 2015). The ceramic repertoire is dominated by the presence of tableware such as *ataifores* (large bowls abundant in Andalusi sites that were used for collective consumption around a single dish). The high presence of *ataifores* is particularly relevant, in-so-far as it suggests the persistence of typically Andalusi (or Islamic) commensality habits, consisting in the communal consumption from a single bowl situated in the middle of the group and directly on the floor. Both the total absence of pig remains, and the ceramic evidence provide compelling arguments in favour of this being a typically Nasrid (or late-Andalusi) consumption context. Given the historical and archaeological framework of this horizon, it seems plausible that the rubbish dump reflects the food habits of a Morisco group, demonstrating how some Andalusi families –even if they were forced to officially convert to Christianity– clung to their traditional dining culture (perhaps in an act of resistance) as their world was transformed (García- García *et al.* 2021).

This well lies near an area with three phases of occupation where samples were collected from a profile in the south area for soil micromorphological analysis (fig. 2, H). The first phase of occupation has been typologically dated with ceramics from the late 14th and early 15th centuries (Early Nasrid period). This occupation is characterised by a series of negative features comprising holes, sometimes quadrangular, that were cut into the rock. The second phase of occupation dates to the Late Nasrid period and is characterised, in the southern area, by two walls and a mortar pavement, similar to those identified in Trench 29.000. Its function is unclear, but it may have been used as a watering hole for livestock. The third phase, which may be an agricultural space between the walls that dates to the early Modern period (16th-17th century), but this was inconclusive from excavation alone.

Two micromorphology samples were collected from one of the profiles in the southern part of the platform, next to one of the walls (UE 24187) dating from the Nasrid period, between Terraces 4 and 5. In the area where the samples were taken, there was a vegetal roof (UE 24005), a deposit of orange-coloured sandy earth that remains below and that contained abundant Nasrid ceramic material from the first period (ca. 14th century, UE 24248), below another relatively fine, horizontal layer of earth UE 24253, dark orange in colour, which could be a ground level, overlaying the geological level below.

2.2.3. Area 3, Household occupation 13th – mid 16th century

Trench 29.000 was located on the western profile of the slope that forms a sixth terrace with respect to the archaeology described in Area 2 (fig. 2, A, C and G). This trench revealed masonry walls dated from between their construction in the mid-13th century and abandonment in the mid-16th century, and a drainage channel dating to ca. early 16th century. The occupation deposits in the northern area contained reused material, which is not considered construction from the first period of occupation of the Land of Aynadamar, but rather from a later phase, and rooms

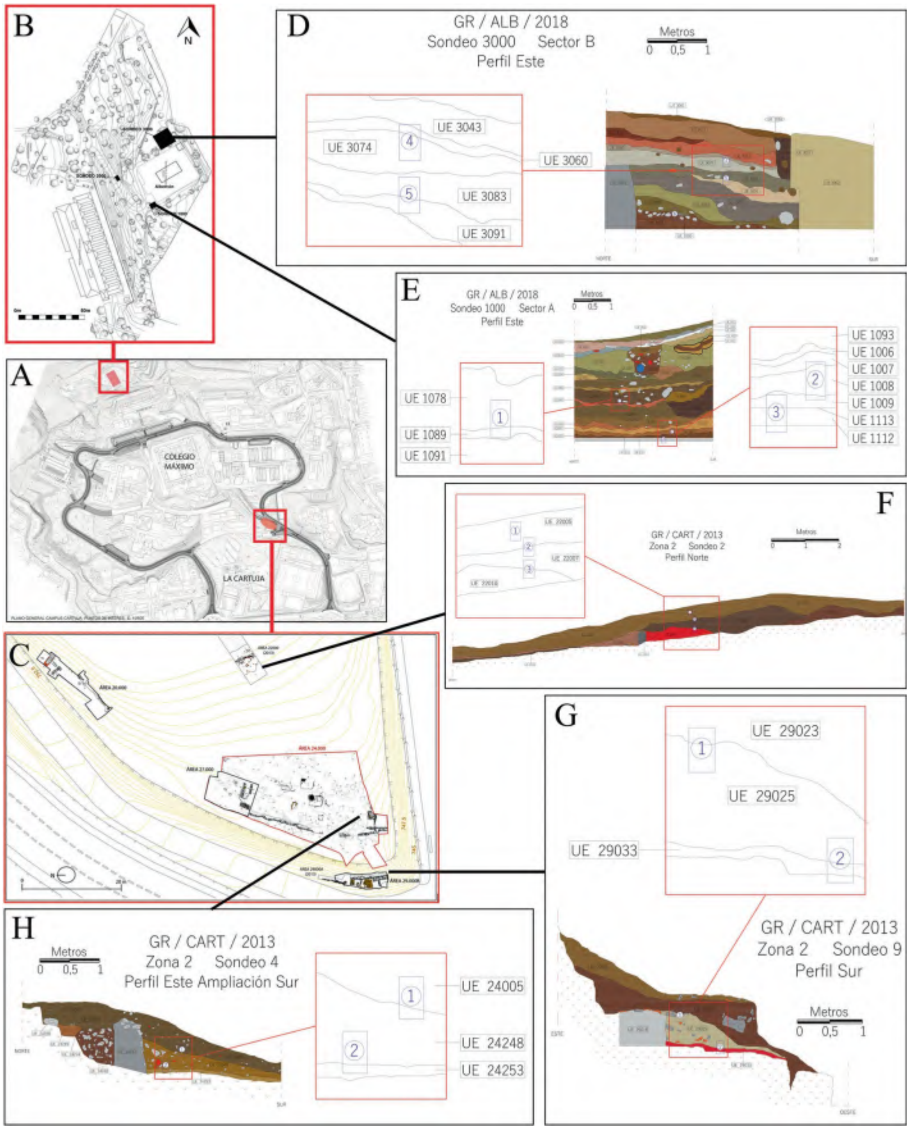

Figure 2: A. Topographic map showing the locations of the Albercón and Cartuja areas of excavation (in red); B. Plan of the Albercón showing the locations of Trenches 1000 and 3000 (in black); C. Plan of the 2013 and 2014 Cartuja excavation area; D. Profile drawing of Trench 3000 and the locations of micromorphology samples M4, M5 and M6; E Profile drawing of Trench 1000 and the locations of micromorphology samples M1, M2 and M3; F. Profile drawing of Trench 22.000 showing the locations of micromorphology samples 22-1, 22-2 and 22-3; G. Profile drawing of Trench 29.000 showing the locations of micromorphology samples 29-1 and 29-2; H. Profile drawing of Trench 24.000 showing the locations of micromorphology samples 24-1 and 24-2. Figure by authors García-Contreras and Mattei.

of Nasrid date, which include a central open courtyard with a room in the north with a hearth.

The structures are not well preserved in the southern end of Trench 29.000 (fig. 2, G). Two micromorphology samples were collected to understand the occupation further from the southern side, from the interior of the room delineated to the east by a masonry wall or, more likely, a plinth that was used to support an earthen wall (UE 29018), and to the west where it is truncated by the interface of a 19th century road. The stratigraphic sequence is: compacted materials (UE 29005), a level of collapse containing construction materials (UE 29023), below this, another collapse level with abundant tiles, ceramics and some masonry (UE 29025), which is underlain with more compacted earth that may relate to the use of the room (UE 29033) overlying the geological strata. The purpose or function of this room is unclear, whereas these aspects are clearer for the courtyard and kitchen. This room was covered with roof tiles, but no floor surface was identified, which may indicate a storage function.

Micromorphology samples were collected to understand further the purpose and function of this room. Sample 29-1 was collected from UE 29023, interpreted during excavation as a level of abandonment, comprising loose earth with some ceramic material and construction material, which could be collapsed rammed earth in the top of the sample, and UE 29025, which is considered to represent the collapse of the building. Sample 29-2 was collected from UE 29025 (top), UE 29033 (middle) and the geology (base), and may represent the use of the room, but no clear floor surface as identified.

2.2.4. Area 4, Nasrid Palace, trenches 1000 and 3000

Trench 1000 is located in the southern part of the complex (fig. 2, A, B and E), resting on the inner face of one of the large rammed-earth walls that emerged above the surface level. It is a 4 x 4 m trench that is located to the south of the Albercón, next to a powerful rammed earth wall of lime and stone that serves as the southern limit of the excavation. Another rammed earth structure that crosses the trench diagonally (SE-NW) and occupies the entire SW corner was identified, which interlocks with the wall that emerged on the southern limit of the survey, both dating at least to the Nasrid period. A floor made with lime mortar was recorded at the base of the NE corner, which had an excellent state of conservation. It was initially considered to be a corridor that bordered the Nasrid pool on the outside, but the subsequent investigation of the modification of the water pool by the Jesuits in the 19th century now confirms that it is the ground level at the bottom of the pool in the Nasrid period, which connects directly with the perimeter mud walls of the pool, dated by the foundation materials to around the 14th century (fig. 3).

These medieval structures were covered by several deposits of sediment from which samples M1-M3 were collected (fig. 2, E), and contained abundant late medieval ceramic material, some metallic elements, notably jewels and coins, and faunal remains, which are immaterial in comparison with those from the medieval well that was reused as a rubbish pit by the Morisco community (García-García *et al*. 2021). The infilling of the pool is considered to have taken place prior to 1640, when documentary sources state that the entire space was converted to a tree plantation (Tito 2018). The later fills contained war material from the Spanish Civil War. Modifications were carried out by the Jesuit order in the 19th century, when it rebuilt the pool but with smaller dimensions, but there is no evidence that this area was not altered by them.

Sample M1 was collected from more consolidated levels below the fills with modern materials, and from what were considered, during excavation, to be cultivated soils (UE 1078 and 1089) and contained medieval and some modern material. Sample 2 was collected from fills containing mixed sediment and medieval pottery (UE 1007, 1008 and 1009), and sample 3 from the base of the lowest fill (UE 1009) and the mortar floor of the Nasrid pool (UE 1112) and a clay lens on its surface (UE 1113).

Trench 3000 (9 m x 3 m) is located to the north of the Albercón, in an elevation of the land next to the wall built in the 16th century and the excavation began in 2017, and it is still in progress (fig. 2, A, B and D). The trench is divided into three sectors by the walls that have been uncovered. A large-rammed earth wall (>1.5m wide and *c.* 2m high), which is parallel to the one described in Trench 1000 and seems to

Figure 3: Photograph of the conservation work on the Nasrid pool, which was visible in Trench 1000. Figure by author García-Contreras.

connect with that of survey 2000, divides sectors A (in the centre) and B (in the south); while a wall founded with masonry and raised in rammed earth with brick buttresses divides sector A from C (the one to the north). This last structure seems to correspond to the remains of a house or carmen containing materials within its foundations and collapse dating to between the end of the 16th century and the 17th century and may correspond to the so-called "Carmen de Teatinos" that is mentioned in the written sources. The area of Trench 3000 is greatly affected by the construction in the 1980s for the conversion of this space into a drinking water reservoir, but without affecting the area where the samples were collected.

Samples M4, M5 and M6 were collected from Sector B (fig. 2, D). The entrance to the palace complex is considered to have been located directly behind Tr 3000 with a path heading towards the trench. The area is hypothesised to have been a path from the Middle Ages. First, around the Nasrid pool (as revealed in Trench 1000) and the palace, possibly leading into the palace, then later, it is still thought to be in existence after the Christian conquest of 1492, *ca*. 1520, when a new house was built in the north of the pool, the so-called "Carmen de Teatinos" (as revealed in Trench 3000), which, according to written sources, was in use until *ca*. 1640.

Sample M4 was collected from UEs 3060 and 3074, which, during excavation, were considered to either relate to a pathway or to the abandonment of the area, but the origin of the materials and formation processes of the deposits were unclear, other than evidence for bioturbation. UE 3074 contained ceramics from the 14th – 17th century. M5 was collected from UEs 3083 and 3091. Both were very similar in composition in the field and thought to relate to abandonment, but this was uncertain. UE 3083 is overlaid by UE 3074. Sample M6 was collected from UE 3094 and UE 3100. Both these deposits contained many stones and lenses of intercalated mortar, which were considered to relate to the construction of a path. The ceramic assemblage was Nasrid in date.

3. Materials and methods: Archaeological soil and sediment micromorphology

3.1. Sample collection

Samples were collected from profiles in Areas 1-4 (fig. 1) and capturing key transitions between the deposits (figs. 2-6). The blocks were cut then wrapped in the profile using gypsum plaster bandages.

3.2. Sample preparation

The procedure for thin-section preparation followed is the University of Reading standard protocol (Banerjea *et al.* 2021). The samples were oven-dried and then impregnated with epoxy resin while under vacuum before being cured in an oven overnight. The cured blocks were then cut, mounted to glass slides and then the thin sections were prepared at the standard geological thickness of 30 μm using a combination of the BROT and Logitech LP30.

Micromorphological investigation was carried out using a Leica DMEP microscope at magnifications between x40 - x400 under Plane Polarised Light (PPL), Crossed Polarised Light (XPL), and where appropriate, Oblique Incident Light (OIL). Thin section description is conducted using the identification and quantification criteria set out by Bullock *et al.* (1985) and Stoops (2003), with reference to Courty *et al.* (1989), Mackenzie and Adams (1994) and Mackenzie and Guilford (1980) for rock and mineral identification, Nicosia and Stoops (2017) for anthropogenic inclusions, and Stoops *et al.* (2018a) for further identification of post-depositional alterations. The tables of results use the descriptions, inclusions and interpretations format following Bullock *et al.* (1985). The full micromorphology dataset and summary table with archaeological and corresponding microstratigraphic units are available as an open access resource (Banerjea *et al.* 2023).

4. Results of archaeological soil and sediment micromorphology

4.1. Area 1, the Agrarian Terraces 15th-16th centuries

Three micromorphology samples were collected to understand the use and management of the terrace structure, construction of which began in the 15th – 16th centuries and its use continued into the 19th century (fig. 2, A, C and F): 22-1 from UE 22005; 22-2, from UEs 22005 and 22007, and 22-3 from UEs 22007 and 22010. Micromorphology has identified two phases of use of the terrace and a 'palimpsest of soil memory' (Federoff *et al.* 2018). The earliest phase is characterised by the foundation of a surface for the terrace (Microstratigraphic Unit, henceforth MU 22010) and an overlying surface soil or (buried) A-horizon (MU 22007a), no subsoil was identified between the A-horizon and the surface of the terrace, which could indicate the deposition of topsoil material rather than a soil forming *in situ* on a parent material. The second phase is characterised by the formation of a subsoil or B-horizon (MU 22007b), which formed on the upper part of lower topsoil as the buried soil was not completely isolated from the surface processes (Cremaschi *et al.* 2018). The lower part of MU 22007b has both crumb peds, characteristic of a surface soil, and sub-angular blocky peds that are characteristic of a subsoil. The upper and lower A-horizons (MU 22005 and 22007a), have a crumb ped microstructure (fig. 4, nos. 1 and 2).

It is possible that soil was repurposed and deposited onto the terrace construction from the local surrounding area. The geological inclusions are broadly similar to elsewhere on the Cartuja/Albercon but with a greater abundance of quartzite rock fragments, 10%, and olivine minerals, albeit low abundances, <5%. The soils also contain fragments of mortar and tapial, like those that were included within the soils used to infill the Nasrid pool in Trench 1000 (see 3.4.1). Low abundances of herbivore dung, <10%, and domestic refuse (fragments of bone, <10%, burnt egg shell, <10%, and charred wood, <5%) occur and may represent soil amelioration, but their inclusion during the deposition of the soil cannot be discounted. No phytoliths that could indicate what types of crops were cultivated were observed in the terrace soils, which may be due to issues of poor preservation arising from alkalinity due to the calcareous nature of the sediment (Piperno 2006).

The terrace soils showed indications of chemical alteration and ongoing bioturbation. The occurrence of iron nodules, impregnative redox pedofeatures that form due to changes in the state of oxidation (Vepraskas *et al.* 2018), that probably arose from cycles of wetting and drying. Rhizoliths, whereby the organic component of root fragments has been replaced by calcite mineral (fig. 4, no. 3), occur in the soils lower half of the profile (22007a and 22007b), and were not observed in the thin-sections from Areas 2-4. Petrifaction or impregnation of root cells by calcite is also common and many carbonate features in soils are attributed to the former presence of plant roots and associated microorganisms (Durand *et al.* 2018). Carbonates are not present in the groundmass of the A-horizon (22007a). Unlike the other units in this profile, it does not have a crystallitic b-fabric and is different in colour (dark orange brown rather than greyish brown or grey and orange, PPL), which may be due to an increased humic content and carbonate leaching from weathering.

4.2. Area 2, Mid 16th century occupation

Micromorphology samples 24-1 and 24-2 were collected next to one of the walls dating from the Nasrid period in an area where the function was unknown and hypothesised to be an agricultural soil (fig. 2, A, C and H). Micromorphological analysis shows the following sequence (base to top): three mixed units of soil and collapse (MU 24253, 24248a and 24248b), which are overlaid by a disuse or abandonment horizon (MU 24005). The mixed units of soil and collapse are similar in origin, sharing sediment attributes. They have a sandy clay loam particle size, the coarse fraction is unsorted, and the fine fraction comprises calcareous clay. The range of geological inclusions within the units is broadly similar, with the exception of fragments of limestone, 20%, in MU 24248b, and similar to other soils studied here from the Land of Aynadamar. The main types of anthropogenic inclusion are fragments of building materials, specifically mortar, 30%, and tapial, <10%, and a very low abundance of fragments of charred wood in 24248b, <5%. Mortar fragments occur in all mixed units of soil and collapse; whereas fragments of tapial mainly occur in MU 24248a. The disuse or abandonment horizon (MU 24005) mainly contains geological inclusions of types similar to all other units in Cartuja, with very low abundances of anthropogenic materials, especially fragments of charred wood, <5%, and unburnt bone, <5%.

Soil forming processes are evident in all units, which have an intergrain aggregate related distribution and a fine crumb microstructure that is moderately to well developed with unaccommodated or partially accommodated peds in MU 24253 and 24248b, and weakly to moderately developed in with accommodated or partially accommodated peds in MU 24248a. MU 24248a also has an embedded related distribution, which could indicate that compaction has occurred in this horizon. There is evidence for bioturbation by earthworm and mite activity through the profile, evidenced by infillings, organo-mineral excremental pedofeatures and the remains of internal chambers from earthworm burrows (Kooistra and Pulleman 2018).

It is possible that the mixed unit of soil and collapse functioned as garden soils, originally deposits of topsoil that included eroded building materials from the adjacent wall, which was then covered by a further, more sterile soil representing the disuse of the area, supporting the hypothesis that this area had an agricultural use.

4.3. Area 3, Household Occupation 13th – mid 16th century

Micromorphology samples 29-1 and 29-2 were collected in the south profile of the trench, from the area that is considered to be an interior space, but with no clear floor surface and deposits that were

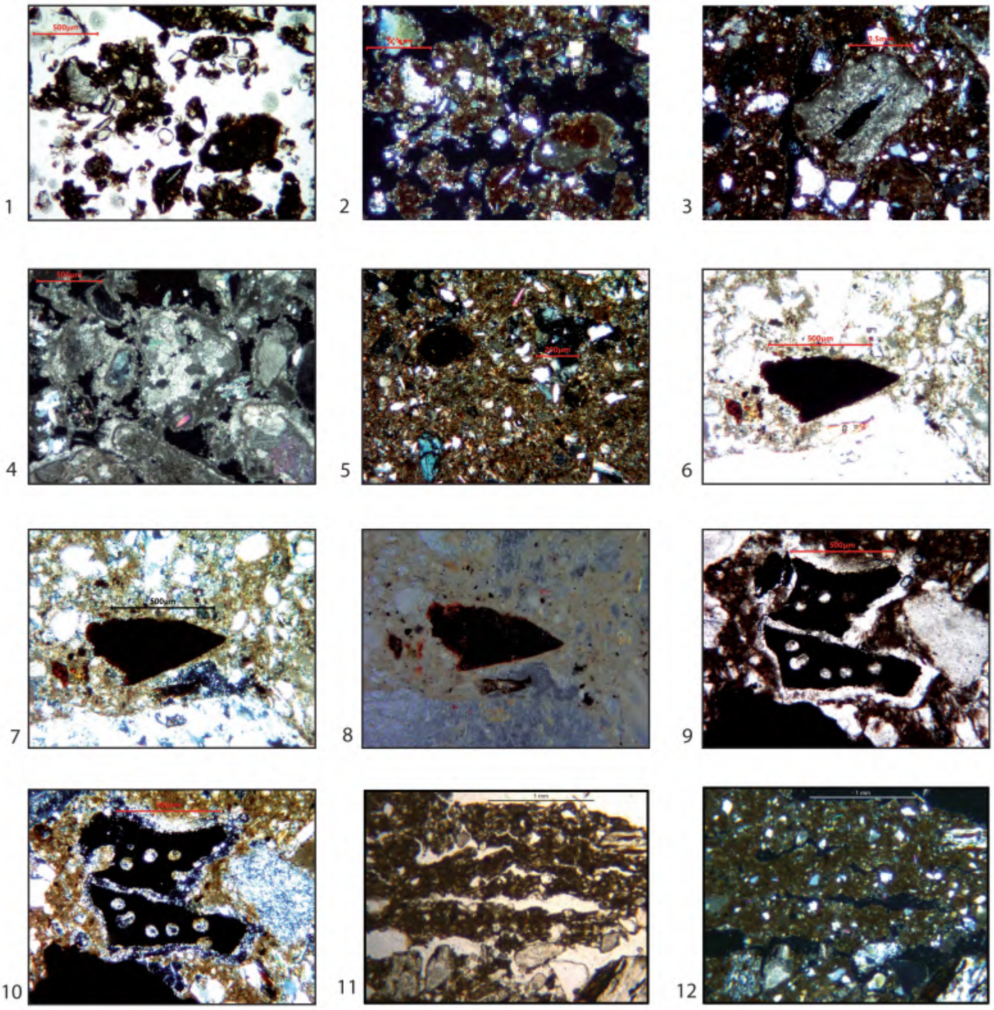

Figure 4: Photomicrographs: 1. Crumb microstructure, MU 22007a, Sample 22-3, PPL; 2. As 1, XPL; 3. Rhizolith, MU 22007a, Sample 22-3, XPL; 4. Fragment of degraded mortar, UE 29033, Sample 29-2, XPL; 5. Gypsum 'desert rose' crystal, UE 1078, Sample M1, XPL; 6. Fragment of metal (Fe), MU60, Sample M4, PPL; 7. As 6, XPL; 8. As 6, OIL; 9. Fat-derived char, MU74b, M4, PPL; 10, As 9, XPL; 11. Lenticular platey ped microstructure, MU74a, MU4, PPL; 12. As before, XPL. Figure by author Banerjea.

covered by collapsed roof tiles. Micromorphological analysis has provided clarity on the interpretation of this sequence (fig. 2, A, C and G). It shows that the two samples comprise three units, which share many similar sediment attributes, but have some differences in the composition of inclusions. A floor surface, which has now been reworked, MU 29c, was overlaid by two episodes of collapse, MU 29b and MU 29a, denoting an 'end-of-life' phase for this building. A floor surface was not identified during excavation. The deposits of collapse are differentiated by changes in the particle size and colour. MU 29a is a coarser sandy clay loam/loamy sand and slightly darker in colour (greyish brown, PPL); whereas MU 29b is a sandy clay loam and light greyish brown (PPL) in colour. The assemblage of inclusions is similar in both deposits of collapse with both, notably, containing fragments of mortar, 20%, and tapial, 10%.

The reworked floor surface, MU 29c, is darker in colour than the deposits of collapse (mid brown in PPL) and contains a greater abundance of mortar fragments (fig. 4, no. 4) than the deposits of collapse and no fragments of tapial. The lower 16.5 cm of the floor contains 30% mortar, possibly from a floor preparation or render, whereas the upper 5.5 cm contains 20%, which may be due to the mortar fragments being reworked by bioturbation and transported upwards through the sequence. It seems that the floor was well maintained in this room as no activity refuse was identified on its surface.

Bioturbation is evident in the sequence by the formation of crumb peds, which are ultra-fine in MU 29a and MU 29c and fine in MU 29b and are indicative of surface horizons (Stoops *et al.* 2018). There are at least two phases of bioturbation that affected this sequence: the first, affecting the floor surface, MU 29 a; the second, after the second deposit of collapse formed. Organo-mineral excremental pedofeatures (Kooistra and Pulleman 2018) occur in all microstratigraphic units. The remains of internal chambers from earthworm burrows occur in the upper part of MU 29b, and biospheroids (Canti 2017) occur throughout MU 29a. The floor, MU 29a, may have laid exposed to weathering and bioturbation processes for a few months before the collapsed materials were deposited.

4.4. Area 4

4.4.1. Trench 1000

Samples 1-3 were collected from Trench 1000 (fig. 2, E). Micromorphological analysis has revealed a sequence of events relating to the end-of-life of the Nasrid phase of the pool and subsequent change of use of the area. UE 1112 at the base of the profile is the mortar floor of the pool, which is overlaid by a thin layer of well-sorted clay sediment, UE 1113 that accumulated on the surface of the floor of the pool as a result of shallow standing water. The sediments overlying this represent two phases of infilling of the pool with material and subsequent profiles of soil formation comprising buried A and B horizons. UE1009, M2, 1078, and 1089, M1, have been classified as buried B-horizons (subsoils), and UEs 1007 and 1008 have been classified as a buried A-horizon (surface horizon).

UE 1009 is the subsoil below UEs 1007 and 1008, which show characteristics of a former surface soil horizon, specifically a moderately developed, partially accommodated, fine crumb microstructure (Stoops *et al.* 2018b), which has subsequently been buried causing compaction (French 2003, 41; Retallack 2001) evidenced by an embedded (porphyric) related distribution. UE 1009 has a weakly to moderately developed, accommodated, or partially accommodated sub-angular blocky ped microstructure and also shows compaction, evidenced by an embedded related distribution.

It is plausible that, prior to the soil forming processes, UEs 1007, 1008 and 1009 were single depositional infilling events that were reworked into a soil profile. In origin, these contexts have a dominant, broadly similar rock and mineral component, with slightly different abundances of fragments of schist, dolomitic limestone, quartzite rock fragments, and quartz, calcite and muscovite minerals. UE 1007 and the upper part of 1008 contain low abundances, <5%, of fragments of charred material (wood and leaves), which may be due to mixing at the boundary between the two units. The sediment descriptions for these two units are comparable and they are only distinguished using soil micromorphology through slight variations in the inclusions. Fragments of mortar occur in all deposits within this profile, <10%. UE 1078, the B-horizon, also contains fragments of tapial, 10%, pottery, 10%, burnt eggshell, 10%, and charred wood, <2%. UE 1089 below, also contains fragments of tapial, 5%, pottery, 5%, and charred wood, 10%, and these micro-inclusions may have been pushed into the unit from above by roots or earthworm activity. Earthworms were present in the profile evidenced by the occurrence of biospheroids (Canti 2017). The inclusions were probably deposited with the sediment that was originally used to infill the pool.

The A-horizon overlying UE 1078 was not sampled, but the profile shows a period of infilling, represented by UE 1007, 1008 and 1009, and a period of stabilisation represented by the formation of a surface soil horizon. This surface soil was buried and compacted below further substantial infilling episodes (UEs 1091, 1092 and 1093), over which UEs 1078 and 1089 formed, which are a sub-soil or B-horizon for a further period of soil development or stabilisation. These deposits were then covered by modern fill events containing material from the Spanish Civil War. Therefore, the micromorphological analysis indicates that the infilling of the pool did not happen rapidly, but in stages, with an initial period of disuse that allowed a surface soil to form, UEs 1007 and 1008.

The formation of lenticular gypsum or 'desert rose' crystals in void spaces in UE 1078 (fig. 4, no. 5), which form whereby gypsum crystallises at or just above the water table and would suggest episodes of wetting and drying (Poch *et al.* 2018) when this was open to the surface during one of the periods of stabilisation. The calcite may have precipitated into 1078 from above to form needle-like calcite infillings within voids (Durand *et al.* 2018).

4.4.2. Trench 3000

Samples M4, M5 and M6 were collected from Trench 3000 (fig. 2, D). Micromorphological analysis shows three possible phases of the path with hiatuses in its use where a soil formed, evidence in MU74b and MU74c, and earlier in MU 100 (UE 3060). UE 3074 and 3094 have been sub-divided into further microstratigraphic units showing the following sequence of events (latest to earliest):

- MU 60 (UE 3060) Buried surface soil (A horizon and end-of-life horizon for the path)
- MU74a Trampled surface of the path
- MU74b Buried surface soil (A horizon)
- MU 74c and 83 Buried subsoil (B horizon)

- MU 91 and 94 all show compaction, possibly from an earlier phase of path
- MU 100 (UE 3100) shows signs of a (buried) surface soil (A horizon), forming.
- MU 97 (UE 3097) shows compaction, again perhaps from the use of the area as a path.

MU 60, 74b and 100 show characteristics of a former surface soil horizon, specifically a moderately developed, partially accommodated, ultra-fine/fine crumb or granular microstructures (Stoops *et al.* 2018), and MU 60 and 74b have an embedded (porphyric) related distribution, which may relate to compaction by burial below later sediment (French 2003, 41; Retallack 2001). The formation of these horizons indicates periods of stabilisation and, in particular, the 'end-of-life' or abandonment of the path. The main hiatus in use of the path occurs in MU 74b, 74c and 83 where both an A horizon and a B horizon form suggesting that the soil was supporting vegetation evidenced by channels in the microstructure of 74c and 83 and the formation of fine sub-angular blocky peds (weakly developed and accommodated), which are features of sub-soils (Stoops *et al.* 2018b). Anthropogenic inclusions, with the exception of aggregates of mortar and tapial, are not abundant and comprise fragments metal, 5-15%, (fig. 4, nos. 6, 7 and 8), charred wood, 5-15%, and fat-derived char (Mallol *et al.* 2017, 305), 10%, fig. 4, nos. 9 and 10).

The clearest evidence for the path comes from MU 74a, which is 0.5cm in thickness and overlies a buried surface soil (MU 74b). It has a lenticular platey ped microstructure (moderately developed, partially accommodated) with planar voids (fig. 4, nos. 11 and 12), which can be features of trampling (Rentzel *et al.* 2017). They can also be features of frost action (Stoops *et al.* 2018), but given the evidence for compaction further below in the sequence, the former may be more likely. The archaeological evidence suggests that this area was a pathway around the Nasrid pool, which was still thought to be in existence after the Christian conquest of 1492, ca. 1520, when a new house was built to the north of the pool.

5. Discussion

Archaeological soil and sediment micromorphological analysis has identified nuances in the stratigraphic sequences from four separate areas, which, in particular, indicate periods of abandonment or the contemporaneous disuse of areas. These periods of abandonment relate to an important transition in the occupation of the Land of Aynadamar that marks the decline of Nasrid rule and changes associated with the Christian conquest from the 16th century onwards. There was a population hiatus from the 9th to the 13th century (there is no continuity since Roman times). The complete absence of written sources in these middle centuries is consistent with the archaeological record. Except for a small village of sunken-floor huts and a necropolis with adults and children that was documented in the upper part of the hill (Román and Carvajal 2018), the rest of the areas excavated in the last two decades show how the Nasrid structures overlie Roman levels, without phases of occupation in between. Perhaps the clearest example is the 13th century ditches that cut through the clay of a Roman pottery pond that had been abandoned in the 4th century (García-Contreras and Moreno 2017, p. 172). In our opinion, the creation of the Aynadamar water channels to supply the city of Granada during the 11th century (Trillo 2003) did not mean the immediate creation of agricultural lands which could explain later medieval conflicts around the use and management of water since the 13th century (García-Contreras 2021). This period is not represented in the microstratigraphic sampling.

The earliest deposits that are represented in the micromorphological analysis are floor materials. From the 13th century, several scattered constructions (so-called *cármenes*) were built. There was a small-scale and self-supply water management in each farmhouse, not dependent on the Aynadamar channel, but through wells, water-wheels, pools and small irrigation ditches. Despite their unsubstantial architecture, they contained evidence of high rank consumption patterns. The remains of a floor surface that was probably rendered by lime or gypsum (MU 29c) was identified in a room in one of these constructions in Area 3, Trench 29.000. This floor had not been observed during excavation and its identification indicates that the room had been regularly cleaned while it was in use, allowing no build up of activity refuse, suggesting that it was used for habitation rather than as a workshop or agricultural space (Banerjea *et al.* 2015). In the 14th century, a large complex was constructed with a big pool on the middle in the top of the hill (interpreted as a palace, estate or *almunia* of ibn al-Jatib), associated with the irrigation channel of Aynadamar. The lime or gypsum mortar base of the pool is represented in Trench 1000 (Area 4), Context 1112, micromorphology sample M3 (fig. 2, D).

In Area 2, there are three, superimposed mixed deposits of soil, which may have been a 'garden soil', containing fragments of mortar and tapial from an adjacent Nasrid wall and low abundances of charred wood and fragments of bone, possibly from the use of hearth ashes and domestic refuse for soil amelioration. A tentative comparison is made here with the creation of anthrosols for cultivation formed as the result of soil enrichment due to the decomposition of habitation refuse such as the rationale behind and the formation processes of *terra preta* in the Amazon (Arroyo-Kalin 2010), European Dark Earths (Devos *et al.* 2022) or garden soils found in urban areas (Davidson *et al.* 2006). As noted by Devos *et al.* (2022), broad classifications as anthrosols (soils modified by long-continued cultivation or addition of material) or technosols (soils that more generally contain a significant amount of artefacts) do not significantly contribute to comprehend formation or archaeological significance. The 'garden soil' in Area 2, Trench 24.000, shows evidence of sediment input, with geological inclusions similar to Areas, 1, 3 and 4, anthropogenic inputs comprising charred wood, bone and building materials, the potential recycling of soil and ongoing pedogenesis. No phytoliths that could indicate cultivation were observed in the thin sections, which may be due to issues of poor preservation arising from alkalinity due to the calcareous nature of the sediment (Piperno 2006), and this issue is also apparent in Areas 1, 3 and 4. In Area 4, the formation of earlier (UEs1007 and 1008) and later (UE 1078) surface soil horizons on sediments used to infill the Nasrid pool could be linked to cultivation activities.

Micromorphological analysis identified abandonment/ 'end-of-life' deposits in Areas 2, 3 and 4, which formed between the late 15th to mid-16th centuries according to the relative dating chronology. In Area 2, the deposit, MU 24005, overlies the possible garden soils that formed adjacent to the Nasrid wall, and mainly contains predominantly geological inclusions, which are similar in composition and abundance to those in other microstratigraphic units in this study indicating a local sediment input, with very low abundances of anthropogenic inclusions, <10%. Adjacent to this, a well was firstly infilled with material including a reused architectural element identified as a piece of vaulting in the Gothic style, unknown in Granada until the Castilian conquest in 1492, then a rubbish dump containing a faunal and ceramic assemblages that reflects the food habits of a Morisco group (Muslims living under Christian rule). In Area 3, the remains of a floor surface (MU 29c) inside a *cármenes* was reworked by bioturbation processes and then covered by two phases of sediment comprising building materials from the collapse of the building and reworking of the floor render. There may have been a period of stabilisation, evidenced by surface soil features, before the second collapse event. Experimental archaeological research has shown that in Northern Europe occupation deposits from an artisan space reused as a stable can turn to soil within 2.5 years after being left without a roof (Banerjea *et al.* 2015). Soil formation over floors prior to the destruction or collapse of a structure is observed at the castle of Molina de Aragón, but no experiment comparable with that conducted in Northern Europe has been conducted in a Mediterranean context (Banerjea *et al.* 2019).

Micromorphological analysis has shown that the disuse and infilling of the Nasrid pool in Area 4, Trench 1000, happened in stages. There was a short period of disuse where sediment accumulated in a shallow puddle of water (1113), either from rain or the final use of the pool, then soils formed *in situ* inside of it, represented by UE 1007 and 1008, and 1009, on sediment deposited during deliberate infilling which took place before 1640. Further infilling took place after this and included modern material culture. These periods of disuse and deliberate infilling could be contemporary with some of the periods of disuse associated with the pathway from the entrance in Trench 3000; however, there are no direct stratigraphic relationships between the units in Trenches 1000 and 3000. MU 97, Trench 3000, may represent the initial path to the pool and its overlying disuse horizon characterised by soil development, MU 100 (UE 3100), may be contemporaneous with the disuse of the Nasrid pool represented by unit 1113.

After the 16th to mid-19th centuries, the creation of a monastery by the Carthusian order and the acquisition of all the lands that ended up inside a defensive fence meant the collapse of the housing structures, the so-called *cármenes*, which did not last beyond the mid-16th century, and the substitution of the agrarian regime, from an agriculture based on irrigation combined with vines, to a rainfed agriculture from the terracing of all the lands of Aynadamar to plant trees (probably olive and almond trees). In Area 1, excavations of Trench 22.000 were carried out on the terrace wall that delineates Terrace 2. Typological dating from the construction technique and the ceramic materials in the terrace deposits suggest that the cultivation terrace possibly had an origin no earlier than the mid-16th century, representing a more substantial second phase lasting beyond the 17th century. The results of soil micromorphological analysis indicate that there were two phases of use, and that soil may have been deliberately repurposed from the local surrounding area and deposited onto the terrace 'cut and fill' construction (Brown *et al.* 2021, fig. 1). The earliest phase is characterised by the foundation of a surface for the terrace and an overlying surface soil or (buried) A-horizon with no subsoil, which could indicate the deposition of topsoil material rather than a soil forming *in situ* on a parent material as no features of a B-horizon were evident in the underlying terrace surface. The second phase is characterised by the formation of a subsoil or B-horizon (MU 22007b), which formed on the upper part of lower topsoil as the buried soil. Rhizoliths, whereby the organic component of root fragments has been replaced by carbonates, occur in the soil's lower half of the profile (22007a and 22007b). These have been observed in Peruvian terraces where there has been deep root bioturbation (Goodman-Elgar 2007). Carbonates in all sediments in this research derive from weathering of limestone geology and of mortar fragments that are included in many of the microstratigraphic units, including in the terrace soils.

In Area 4, there are two further phases of the path that was identified in Trench 3000. MU 91 and 94 show compaction and may represent the path from the conquest period, still contemporaneous with the use of the Nasrid pool in Trench 1000 and the construction of a new house, the so-called "Carmen de Teatinos", which, according to written sources was in use until ca. 1640. MU 74b, 74c, 83 are classified as surface and subsoil horizons relating to the 'end-of-life' of this phase of the path. This 'end-of-life' phase of the path could be contemporaneous with the disuse phase of the Nasrid pool, which is represented by sediment deposited just prior to 1640 (UE 1007, 1008 and 1009, Trench 1000) that then turned to soils. The final phase of the path occurred in the 17th century when the pool was infilled further and is represented in MU 74a, which shows clear evidence for a trampled surface by the formation of a lenticular platey ped microstructure. MU 60, Trench 3000, is the final 'end-of-life' phase for the path indicating that the path and possibly the entrance way that it connected to the pool fell out of use post 17th century.

6. Conclusion

All the archaeological remains were removed (and recorded) by the construction works for the University of Granada, with the exception of the palace (*almunia*) at the top of the hill that has been restored during the year 2021-2022 (fig. 3), perpetuating the orientalist idea of a monumental and artistic Islamic Archaeology, which does not fit with the results of the investigation (García-Contreras 2015 and 2021b). Geoarchaeological sampling is not routinely integrated into rescue excavation strategy in Spain; however, the geoarchaeological analyses arising from these excavations offer an image of the peri-urban landscape dependent on the great fortress of the last lands of al-Andalus (García Pulido 2013). This "castlescape" of the Alhambra allows us to delve into both the Nasrid productive strategies and, above all, the transformations, including periods of disuse and reuse, which took place after the Castilian conquest when the landscape of orchards and vineyards, pools and ditches, was replaced by a centralised model of agriculture of dry land destined to satisfy the demands and commercial needs of the new Christian elite which include the Carthusian monks. A change that took a few decades and was not immediate - something that only high-resolution microscopic analysis can detect -, but which ended up configuring the new landscape of modernity on the outskirts of Granada. Future public presentation of Islamic archaeological heritage should integrate more scientific archaeological data for a holistic portrayal of the dynamics and realities of settlement life and spatial organisation, moving beyond the focus on the monumental architecture and art history.

References

Arroyo-Kalin M. 2010 – Slash-burn-and-churn: Landscape history and crop cultivation in pre-Columbian Amazonia, *Quaternary International* 249, p. 4-18.

Banerjea R. Y. 2021 –Translating geoarchaeology into geo-itineraries, in Barnett C. and Walker T. (eds.), *Environment, Archaeology and Landscape: Papers in honour of Professor Martin Bell,* Oxford, Archaeopress, p. 135-144.

Banerjea R.Y., Bell M., Matthews W., Brown A. 2015 – Applications of micromorphology to understanding activity areas and site formation processes in experimental hut floors. *Archaeological and Anthropological Sciences*, 7, p. 89–112.

Banerjea R. Y, García-Contreras Ruiz G., Pluskowski A. 2023 – Archaeological Soil Micromorphology dataset from excavations of the Campus of Cartuja, Granada, Spain, in 2013- 2019. *figshare*. Dataset. [URL: https://doi.org/10.6084/m9.figshare.21897012.v3]

Banerjea R.Y., García-Contreras Ruiz G., Kalniņš G., Karczewski M., Pluskowski A., Valk H., Brown A.D. 2019 – Geoarchaeology and castlescapes: heritage management case studies in Spain and the eastern Baltic. *Landscapes*, 20, p. 178–201.

Banerjea R., Morandi L., Williams K., Brunning R. 2021 – Hidden husbandry: disentangling a disturbed profile at Beckery Chapel, a medieval ecclesiastical site near Glastonbury (UK). *Environmental Archaeology: The Journal of Human Palaeoecology*, 26 (4), p. 367-387.

Brown A. G., Fallu D., Walsh K., Cucchiaro S., Tarolli P., Zhao P., Pears B. R., van Oost K., Snape L., Lang A., Albert R. M., Alsos I. G., Waddington C. 2021– Ending the Cinderella status of terraces and lynchets in Europe: The geomorphology of agricultural terraces and implications for ecosystem services and climate adaptation. *Geomorphology*, 379. (in press/ available online)

Bullock P., Fedoroff N. Jongerius A. Stoops G. Tursina T. 1985– *Handbook for Thin Section Description,* Wolverhampton, Waine Research.

Cabanelas D. 1979 – Los cármenes de Ainadamar en los poetas árabes*,* in *Estudios sobre literatura y artes dedicados al profesor Emilio Orozco Díaz, Granada,* vol I. p. 209-2019.

Canti M. G. 2017 – Biospheroids Produced by Earthworms, in Nicosia C., Stoops G. (eds.), *Archaeological Soil and Sediment Micromorphology*, Chichester, John Wiley & Sons, p. 47-49.

Courty M. A., Goldberg P., Macphail R. 1989 – *Soils and Micromorphology in Archaeology,* Cambridge, Cambridge University Press.

Cremaschi M., Trombino L., Zerboni A. 2018 – Palaeosoils and Relict Soils: A Systematic Review, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths*. Amsterdam, Elsevier, p. 862- 894.

Davidson D. A., Dercon G., Stewart M. 2006 – The legacy of past urban waste disposal on local soils, *Journal of Archaeological Science*, 33 (6), p. 778-783.

Devos Y., Vrydaghs L., Collette O., Hermans R., Liocq S. 2022 – Understanding the formation of buried urban Anthrosols and Technosols: An integrated soil micromorphological and phytolith study of the Dark Earth on the Mundaneum site (Mons, Belgium), *Catena*, 215. (in press, available online)

Durand N., Monger H. C., Canti M. G., Verrecchia E. P. 2018 – Calcium Carbonate Features, in Stoop, G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths*, Amsterdam, Elsevier, p. 205-258.

Fedoroff N., Courty M. A., Guo Z. 2018 – Palaeosoils and Relict Soils: A Conceptual Approach, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths*, Amsterdam, Elsevier, p. 821-862.

French C. A. I. 2003 – *Geoarchaeology in Action: studies in soil micromorphology and landscape evolution*, London and New York, Routledge.

García-García M., García-Contreras Ruiz G., Alexander M., Banerjea R. Y., Pluskowski A.G. 2021 – The zooarchaeological identification of a "morisco" community after the christian conquest of Granada (Spain, early 16th century): sociocultural continuities and economic innovations*, Anthropological and Archaeological Sciences,* 13 (57).

García-Contreras Ruiz G. 2015 – Al-Andalus en el Museo Arqueológico Nacional: donde arquitectura y artes decorativas prevalecen por encima de la Historia, *Arqueoweb: Revista de arqueología en internet,* 16, p. 292-303.

García-Contreras Ruiz G., Martínez Álvarez C., González Escudero A. 2020 – Un Carmen nazarí en el pago de Aynadamar. El registro arqueológico del desaparecido Cerro de los Almendros en el Campus Universitario de Cartuja (Granada), *Nailos*, 6, p. 241-279.

García-Contreras Ruiz G., Moreno Álvarez A. S. 2017 – La secuencia histórica del campus universitario de Cartuja (Granada) a la luz de las actuaciones arqueológicas realizadas entre 2013 y 2015*, Antiqvuitas*, 29, p. 153-182.

García-Contreras Ruiz G. 2021a – En los márgenes de la ciudad nazarí: paisaje y poder en el Pago de Aynadamar, in García Porras A., Fábregas García A. (eds.), *Poder y Comunidades campesinas en el Islam occidental (ss. XII-XV*), Granada, Universidad de Granada, p. 443-486.

García-Contreras Ruiz G. 2021b – Are postcolonial narratives useful in al-Andalus archaeology?, *Anduli. Revista andaluza de Ciencias Sociales*, 20, p. 179-199. https://doi.org/10.12795/anduli.2021.i20.10

García Pulido L. 2013 – *El territorio de la Alhambra. Evolución de un paisaje cultural remarcable*, Granada, Universidad de Granada.

Garden M.-C. E. 2006 – The heritagescape: Looking at landscapes of the past. *International Journal of Heritage Studies*, 12 (5), p. 394–411.

Goodman-Elgar M. 2008 – Evaluating soil resilience in long-term cultivation: a study of pre-Columbian terraces from the Paca Valley, Peru. *Journal of Archaeological Science* 35 (12), p. 3072-3086.

Kooistra M. J., Pulleman M. M. 2018 – Features Related to Faunal Activity, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths*. Amsterdam, Elsevier, p. 447-469.

Mackenzie W. S., Adams A. E. 1994 – *A Colour Atlas of Rocks and Minerals in Thin Section*, New York, John Wiley and Sons.

Mackenzie W. S., Guilford C. 1980 – *Atlas of Rock Forming Minerals,* Harlow, Longman Group Ltd.

Nicosia C., Stoops G. 2017 – *Archaeological Soil and Sediment Micromorphology,* Chichester, John Wiley & Sons.

Piperno D. R. 2006 – *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*, Lanham, New York, Toronto, Oxford, AltaMira Press.

Poch R. M., Artieda O., Lebedeva M. 2018 – Gypsic Features, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths,* Amsterdam, Elsevier, p. 259- 287.

Retallack G. J. 2001 – *Soils of the past: an introduction to paleopedology,* Oxford, Blackwell Science.

Rentzel P., Nicosia C., Gebhardt A., Brönnimann D., Pümpin C., Ismail-Meyer K. 2017 – Trampling, Poaching and the Effect of Traffic, in Nicosia C., Stoops G. (eds.), *Archaeological Soil and Sediment Micromorphology,* Chichester, John Wiley & Sons, p. 284-297.

Román J., Carvajal J.C. 2018 – Space, shape and recipe. Analysis of cultural change between the late antique and the early medieval period in the area of Granada in light of the pottery of the excavation of the faculty of Economics in Granada (2011-2012). *Menga. Revista de Prehistoria de Andalucía*, 4, p. 493-507.

Stoops G. 2003 – *Guidelines for Analysis and Description of Soil Thin Sections*, Madison, Soil Science Society of America.

Stoops G., Marcelino V., Mees F. 2018 – *Interpretation of Micromorphological Features of Soils and Regoliths*, Amsterdam, Elsevier.

Stoops G., Marcelino V., Mees F. 2018 – Micromorphological Features and Their Relation to Processes and Classification: General Guidelines and Overview, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths,* Amsterdam, Elsevier, p. 895- 917.

Tito Rojo José C. 2018 – Los estanques palatinos en el Occidente musulmán: La Favara de Palermo y el Albercón de Cartuja en Granada, in Navarro Palazón J., Trillo San José C. (eds.), *Almunias. Las fincas de las élites en el Occidente islámico: poder, solaz y producción,* Granada, Universidad de Granada, p. 593–628.

Torres Martín F. M. 2007 – *Libro del prinçipio, fundaçion y prosecuçion de la Cartuxa de Granada,* Granada, Universidad de Granada.

Trillo San José C. 2003 – Aynadamar, la primera acequia de madina Garnata. *Transporte, Servicios y Telecomunicaciones* 6, p. 66-85.

Vepraskas M. J., Lindbo D. L., Stolt M. H. 2018 – Redoximorphic Features, in Stoops G., Marcelino V., Mees F. (eds.), *Interpretation of Micromorphological Features of Soils and Regoliths*, Amsterdam, Elsevier, p. 425-445.