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Dating and Characterising the Transformation of a Monastic Landscape. A Multidisciplinary Approach to the Agrarian Spaces of Samos Abbey (NW Spain)

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ABSTRACT
This paper explores the potential of a multidisciplinary approach to understand landscape evolution over the last 1200 years around an important monastic centre, Samos Abbey, in northwest Iberia. Our objective is to test whether or not landscape transformations here – in particular terracing related to agriculture – can be linked to the agency of the monks. Our landscape study combined analysis of written sources with archaeological survey and test-pitting, including OSL profiling and dating of seven earthworks, with pollen and geochemical analysis of three of them. It has been possible to detect at least four main phases of landscape transformation in the immediate surroundings of Samos Abbey. The mid-seventeenth century saw the most recent and visible transformations, partly overprinting earlier landscapes changes from the Iron Age, eighth–ninth and thirteenth centuries AD. The data suggest that landscape transformation had already begun in this area centuries before the abbey was created, but the presence of this power centre from the early Middle Ages resulted in intensive use of the territory over the last twelve centuries.

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Introduction

Monasteries are iconic elements of historic landscapes across Europe and consequently, they have been studied extensively by archaeologists over recent decades (i.e. Destefanis 2011; Gilchrist 2014). However, the role of monasteries as active agents in shaping and transforming their surroundings has often been neglected. The little archaeological research on monastic landscapes has mosty focused on the construction activity carried out by the monks outside the main monastic buildings such as the creation of farms, mills or bridges (Aston 2000; Bond 2003) but has rarely included paleoenvironmental research designed to provide information on land cover/use in the vicinity of a monastery, the long-term modifications to the immediate hinterland (Hall 2006; Roubis et al. 2008) or the role of these institutions in shaping different European historic landscapes (Krasnodebska-D'aughton, Bhreathnach, and Smith 2019; Sánchez-Pardo, Marron, and Cringaci Tiplic 2020).

Recent archaeological research in south-western Europe has shown that agrarian spaces experienced important transformations in the last two millennia, with special intensity during the Middle Ages (Ballesteros-Arias 2010; Fernández Mier et al. 2014; Quirós 2014a; Quirós Castillo and Nicosia 2019). As a consequence, different interpretative models have emerged to explain these changes, most of them emphasising the key role of the peasantry (Quirós 2014b. oltre la frammentazione postprocessualista: archeologia agraria nel nordovest della spagna, archeologia medievale xli, pp. 23–37.). However, none of these studies has explored the transformation of agrarian spaces under the influence of a strong and historically persistent lordly power such as a major abbey which would allow us to discern whether changes here are different or similar to those detected in areas where peasants exercised more agency.

This paper presents a multidisciplinary approach to the study of a monastic landscape in Galicia (northwest Spain), with particular attention to the long-term transformation of agricultural terraces. Terracing is, without doubt, one of the major transformations of rural landscapes. Creating and maintaining a terrace system involves big efforts that imply the movement of earth

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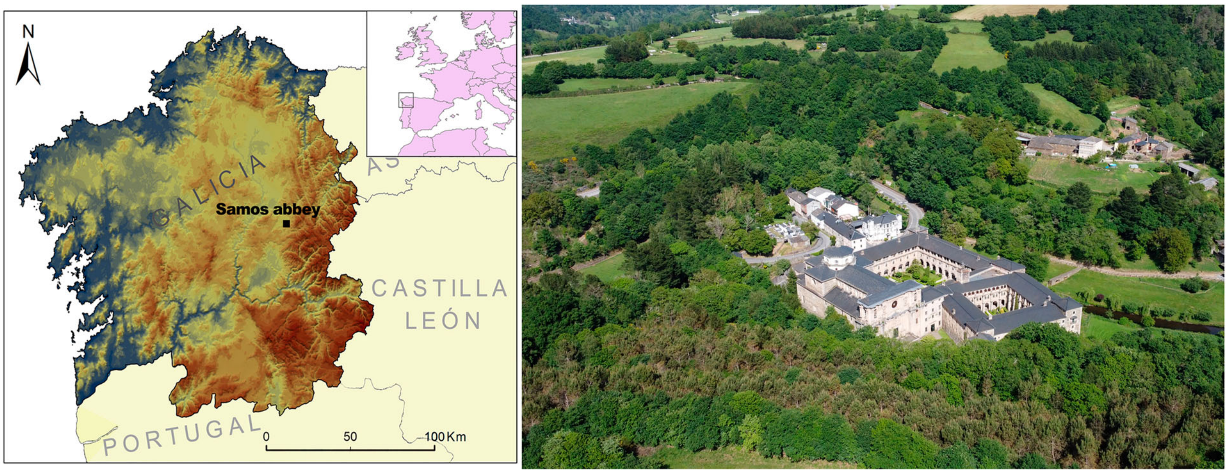

Figure 1. Location map of Samos Abbey in northwest Iberia and aerial view of the area.

packages from one place to another. This makes optically stimulated luminescence profiling and dating (OSL-PD) a suitable dating technique for these contexts. OSL-PD utilises a three-staged approach to appraise and date sediment stratigraphies (Srivastava et al. 2023 ; Turner et al. 2021). First, portable OSL equipment is used to appraise the luminescence properties of bulk sediment in the field, and construct luminescence stratigraphies to aid in the interpretation of the depositional sequences (stage 1; Fig. S2-1). Then, a subset of these samples is progressed to laboratory analysis for calibrated luminescence screening and characterisation (stage 2; Fig. S2-1). This provides the first approximation in the magnitude and range in apparent doses, which might correlate with age. Third, those samples that have archaeological or pedagogical significance for defining a chronology, coupled with promising attributes in stages 1 and 2, are progressed to dating (stage 3; Fig. S2-1).

Our case study encompasses the area around Samos Abbey in the south of Lugo province. The abbey lies at the heart of a hilly region and in a strategic position close to the mountain pass between Galicia and the flat lands of La Meseta (Figure 1). The monastery here existed as early as the seventh century AD (Arias Cuenllas 1992), but it was from the end of the eighth century that it became an important power centre protected by the kings of Asturias-León (Lopez Alsina 1993). During the Medieval and Modern periods, the monastery of Samos was one of the most important seigniorial powers in north-west Iberia, with extensive properties in the eastern part of Galicia and north-west León until the nineteenth century (Arias Cuenllas 1992).

Previous studies at Samos have advanced knowledge of the abbey through archaeological excavations (Ladra 2012) and through historical, artistic and architectural research (Folgar de la Calle and Goy Diz 2008; López-Salas 2015; 2017a; 2017b). However, little was known about the evolution of the agrarian spaces around the abbey, and the possible influence of the history of the monastery in their configuration. This question is especially important in this hilly area where many agricultural terraces of unknown chronology were constructed. The ARPAMED project considered an area which was under the direct control of the monks of Samos Abbey since at least the ninth century (Lopez Alsina 1993). This project combined historic landscape character (HLC) analysis, archaeological interventions, OSL-PD, pollen and geochemical analysis of terraces and soils, together with analysis of written sources. Silva-Sánchez et al. (2022) used a combination of historical sources and palaeoenvironmental analyses on two agrarian terraces, to show that intense environmental and geomorphological transformations occurred at Samos since at least the Iron Age, involving forest clearance, cereal cultivation and very likely also terracing. However, environmental changes at the time the abbey was founded were not preserved in the two agrarian sequences analysed. Here, we present a broader scale study providing OSL-PD dating of seven terraces and earthworks, three of them with paleoenvironmental information, filling the chronological gap that existed for the time of abbey building in the ninth century.

Materials and Methods

Historic Landscape Characterisation Analysis (HLC)

HLC is a specific landscape archaeological GIS-tool for understanding and representing landscapes with particular reference to their historical development through a systematic recording of landscape components using GIS (Dabaut and Carrer 2020; Turner 2018; Turner and Crow 2010). The implementation of HLC in landscape studies provides a detailed multi-temporal map of the region considered, enabling the identification of areas likely to be

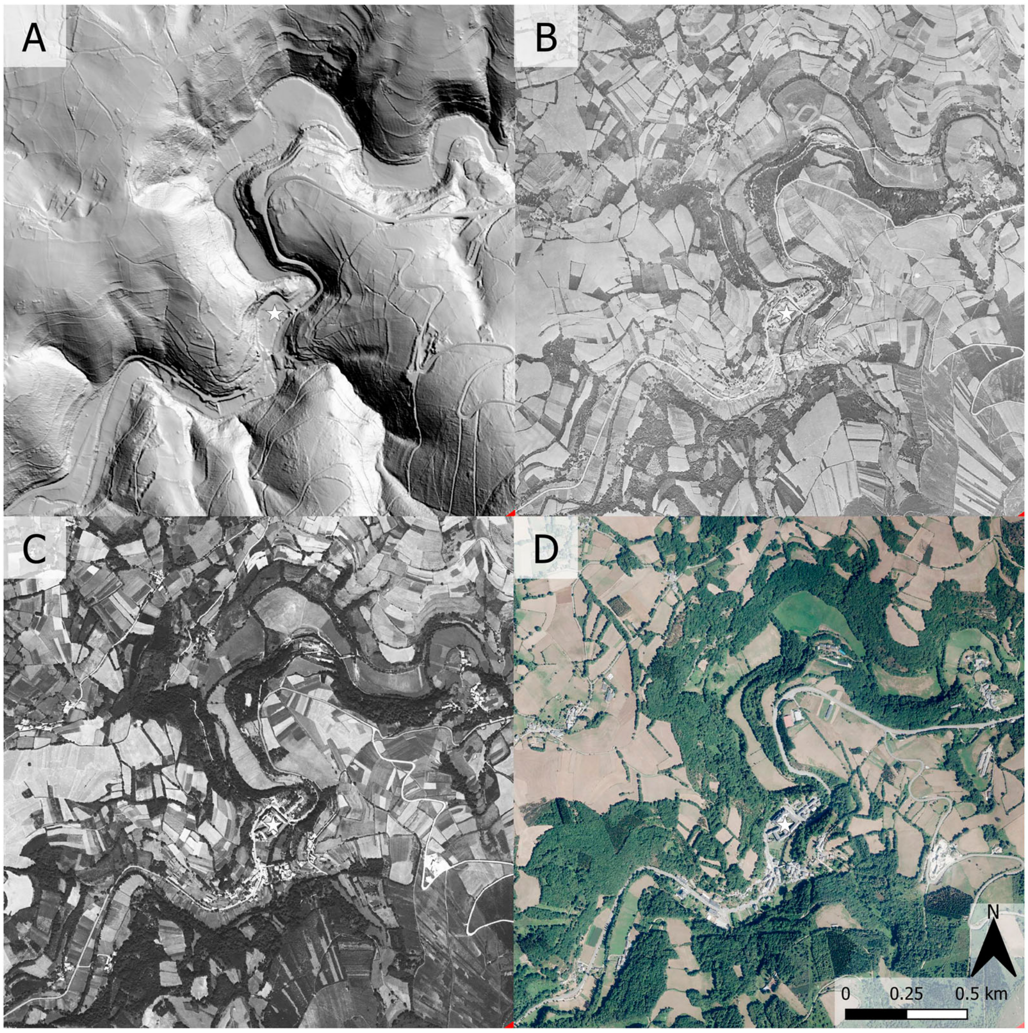

Figure 2. The sources employed to develop the GIS-HLC dataset. A- 2-metre resolution DTM; B- Vuelo Americano (1956-1957); C-KH-9-Hexagon; D- Plan Nacional de Ortofotografía Aérea (PNOA) 2017. The white star indicates the position of the monastery of Samos.

particularly sensitive to future change (Brandolini and Turner 2022). The GIS-HLC dataset was developed by combining modern and historic remotely-sensed imagery with a 2-metre resolution Digital Terrain Model made available by regional geodatabase.[1] These datasets, in association with declassified Cold War Era spy satellite images (KH-9-Hexagon series[2]), enable the creation of a multi-temporal map of historic landscape changes in the study area (Figure 2).

A preliminary HLC analysis was carried out for the Samos area (5 km^2) to identify and map key HLC types in the present-day landscape. The HLC types were defined following an initial field visit and with reference to previous research (Table 1).

Table 1. Samos HLC types.

Fields types	Settlement types
Irregular fields	Hillfort
Rectilinear fields	Settlement
Regular fields	***Industrial types***
Combined fields	Quarry
Strip-fields	Industrial
Meadow	***Rough ground types***
Terraces types	Rough ground
Terraced fields	***Woodland types***
Step-terraces (straight)	Woodland
Step-terraces (contour)	Plantation

Excavation

Based on the results of the initial reconnaissance and the HLC, a total of seven pedosedimentary sequences were identified and excavated in three different areas around the abbey (Figure 3). Three of the sequences were obtained from a terrace system located 200 m east of the abbey building (T1A, T1B and T1C), with another three from two earthworks (T2A, T2C) and a terrace (T2B) located 200 m West of the abbey. Another profile was taken on the path 'Camino de Santiago' (PCS) outside the main abbey building, at the bottom of the west slope in a flat area at the level of the abbey (Figure 4).

Sections T1A and T1B are located partway down the steep slope to the east of the monastery. This slope, which lies approximately 250 m south-east of the main monastic complex, is currently used as pasture

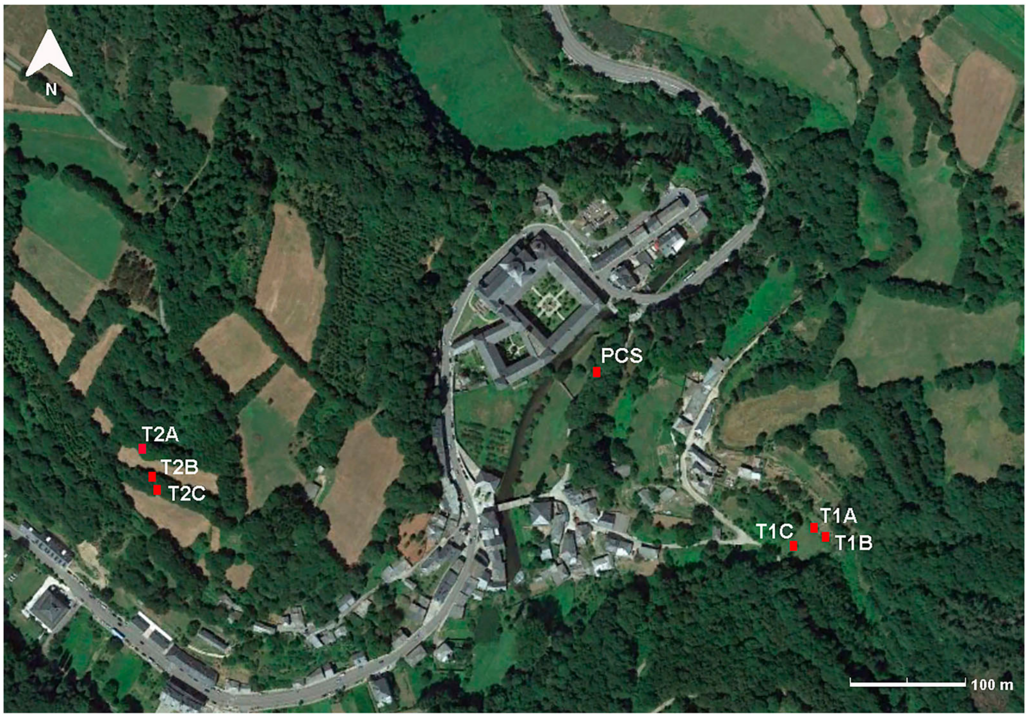

Figure 3. Location of the seven trenches around the abbey.

with a few fruit trees. Historic air photos from the year 1956 show that this area was formerly used as farmland. To the east and south is an extensive oak-chestnut woodland with evidence of many abandoned terraces. Sections T1A and T1B explore the sediment sequences preserved behind the retaining wall, here, built from tabular blocks of slate. The two sections are located along the same terrace wall: at T1A, the retaining wall

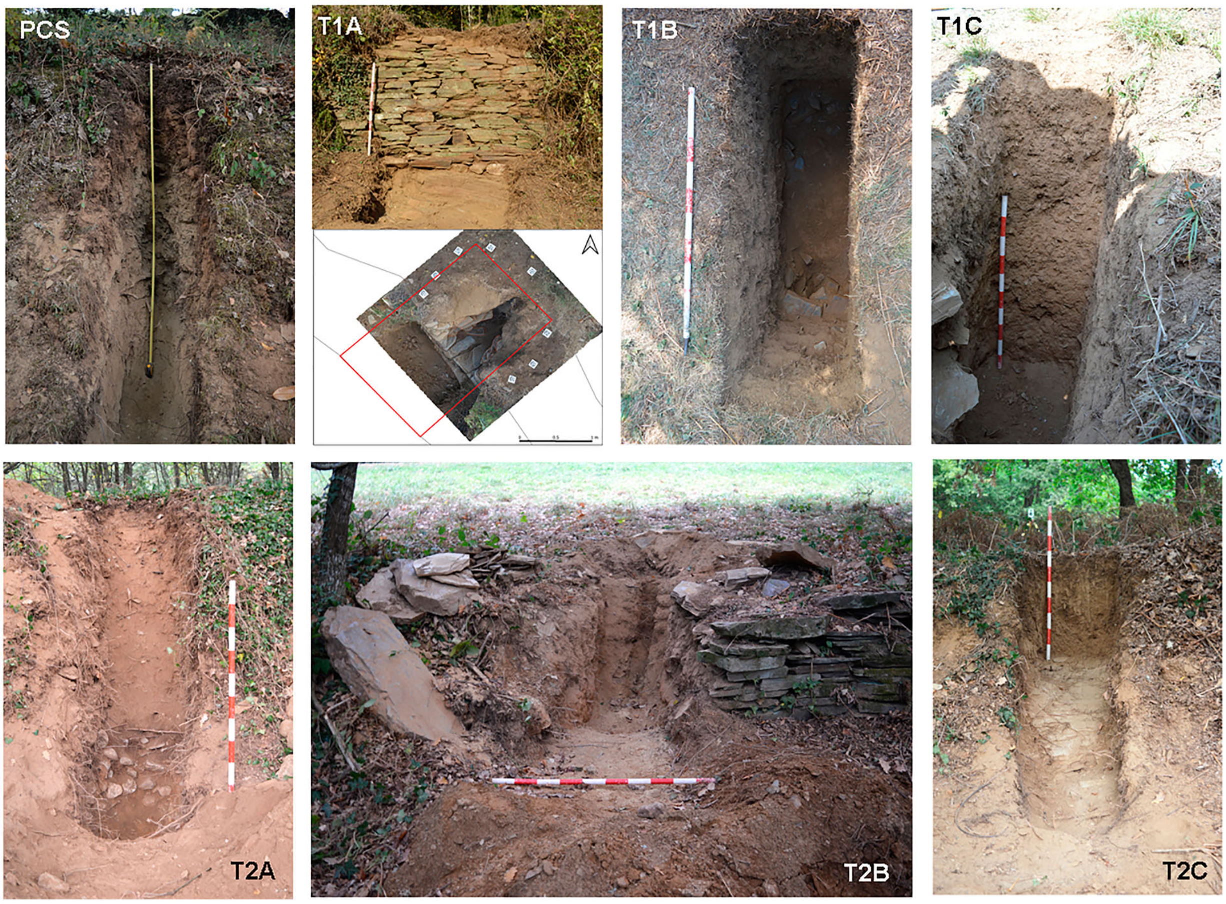

Figure 4. View of the seven trenches excavated.

was partially removed to permit access to the sediments preserved directly behind it; whereas at T1B, the equivalent sediments were examined in a test-pit dug behind the retaining wall. Downslope in the same field is section T1C, a short length (c. 15 m) of retaining wall that terminates partway across the width of the field. It was possible to excavate the sediments directly behind the wall, without moving any of the building stones.

Earthworks T2A and T2C and terrace T2B were collected in the middle of a light slope in a hillside c. 250 m south-west of the monastery. Today, a mosaic of oak-chestnut woodland and grassy field occur in the area, though air photographs show the whole area was in use for agriculture in the 1950s. Section T2A is located furthest up the slope. It examined the sediments in a 260 cm thick earthwork. Section T2B was located on the opposite side of the field, on the downslope side. Here, a small slate wall, standing less than 1 m tall was built to retain the soil. A few metres downslope there is T2C, a c. 60 cm tall earthwork.

PCS (185 cm) was sampled in an earthwork below a chestnut plantation immediately to the west of the abbey.

Sampling

*OSL sampling and profiling (*OSL-PD *stage1)*: Test-pits, 50–100 cm wide, had been hand-dug perpendicular to the feature to allow access to the sediment accumulations associated with each feature. These were cut to a depth where either in situ or weathered bedrock was encountered. Immediately after the test-pits were opened, the sections were covered by opaque black tarpaulins with further cleaning undertaken under this dark cover. At regular intervals 5–10 cm down-profile, bulk sediment was directly sampled into 10 cm-diameter plastic petri-trays, sealed individually in zip-loc plastic bags and collectively, opaque black bags. Within minutes of collection, the samples were measured on site in a SUERC portable reader (Munyikwa, Kinnaird, and Sanderson 2020), which had been set up beside the test-pit, in the shade of a tree or wall. The samples were transported the short distance between the test-pit and the reader in the black bags they were collected in. The samples were removed from the individual zip-loc bag within the opaque bag, then quickly inserted into the reader for measurement. Every attempt to minimise light exposure was taken: such that the samples only had a couple of seconds of potential light exposure between storage and measurement. All samples would have received the same exposure. The measurement cycle consisted of interleaved sequence of infra-red stimulated luminescence (IRSL), OSL and system dark count (background), so that IRSL and OSL net signal intensities, IRSL and OSL depletion indices and the IRSL: OSL ratio were calculated for all samples (stage 1; Fig. S2-1). These data were used to generate luminescence stratigraphies for all the investigated profiles, following the methodologies of Kinnaird et al. (2017) and Turner, Bolos, and Kinnaird (2018). This information was reviewed in the field and used to position samples for dating purposes through the sediment stratigraphies (see supplementary data S1).

Samples for OSL dating were collected by driving 6 cm diameter stainless steel tubes, measuring 15 cm in length, into the cleaned section face. These were extracted, sealed with tape, and stored in sample bags. In situ gamma dose measurements with a GF instruments Gamma Surveyor Vario Surveyor were made at the position of each dating sample.

Geochemistry and Palynology sampling: Sampling for geochemistry and palynology was undertaken in coordination with OSL profiling. Three features were investigated: T1C, T2A and T2B. Bulk samples were taken directly from these sections at 10–5 cm intervals. They were stored in zip-loc plastic bags in the field and immediately transferred to the laboratory for subsequent analysis. A total of 68 samples were studied for granulometry and Loss on Ignition (LOI) (T1C 32 samples; T2A 23 samples; T2B 13 samples) and a total of 31 samples were studied by pollen analysis (T1C 13 samples; T2A 13 samples; T2B five samples).

Geochemistry

Physical properties: colour, granulometry & LOI Granulometry and LOI analysis were determined at the Ecopast facilities in the Biology faculty of the Universidade de Santiago de Compostela. Samples were air dried and sieved, separating the coarse fraction (>2 mm, gravel) and the fine earth (<2 mm). Macrocharcoal were also recovered from the coarse fraction by flotation. Granulometry was completed without previous elimination of carbonates, as recommended by van Reeuwijk (2002). Organic matter was eliminated by heating the fine earth soil sample (>2 mm) at 550°C for 5 h. 10 grams of this ash was then mixed in a 1M HCI suspension for 20 min to break up mineral concretions of Fe and Al. Suspensions were subsequently separated into three fractions by wet sieving: <2–0.2 mm (coarse sand); <0.2–0.05 mm (fine sand) and <0.05 mm (silt + clay).

LOI was performed by heating a fine earth (>2 mm) soil aliquot to 550°C for 5 h. As organic matter is the main constituent of soil that is lost at this temperature, LOI provides an indirect measurement of the soil/ sediment organic content.

Colour was determined using a Munsell chart as reference.

pH and Carbon

pH was measured in bulk soil sample using 1:2.5 water suspensions with a pH metre, following standard procedures (Guitián and Carballas 1976; Urrutia, García-Rodeja, and Macías 1989).

Total carbon was determined using an EA1108 (Carlo ErbaInstruments) CHNS/Oanalyser at Universidade da Coruña facilities.

Palynology

Pollen and non-pollen palynomorph (NPPs) extraction was performed following Barber (1976) at the School of Geosciences at the University of Aberdeen. A minimum sum of at least 300 total land pollen (TLP) was set as the threshold for all sub-samples in order to produce a statistically significant result (Birks and Birks 1980). Data are expressed as a percentage of the TLP, with spores and aquatic taxa excluded from the TLP sum. NPPs were also counted (cf. van Geel 1978), Van Geel, Hallewas, and Pals (1983; 2003; van Geel and Aptroot 2006) and these are expressed as a percentage of TLP plus total NPPs. Rare types in the graphs are indicated by a cross (+), where one cross is equal to one pollen grain or NPP. Pollen samples were spiked with *Lycopodium clavatum* tablets (Stockmarr 1971). Pollen identification was performed at Ecopast facilities at University of Santiago de Compostela and aided by reference keys in Fægri and Iversen (1989), Moore, Webb, and Collinson (1991) and Reille (1992) and a modern typeslide reference collection. Non-pollen palynomorph classification follows the Hugo de Vries (HdV) Laboratory (University of Amsterdam).

OSL Screening and Sample Selection (OSL-PD Stage 2)

The luminescence stratigraphies generated in the field were informative, providing the temporal and spatial frameworks to interpret the depositional histories to the sediment, and suggest hypotheses on the construction of the associated wall or earthwork. However, signal intensities might also be influenced, or controlled, by mineralogy, luminescence sensitivity (a measure of the light release per unit dose), or variations in environmental dose rate and other bulk sediment properties. To assess luminescence sensitivity distributions and provide the first indication of the magnitude and range of apparent dose (which scale to age with environmental dose rates), selected samples were taken forward to luminescence characterisation and screening in the laboratory.

Sample preparation protocols as previously utilised in the luminescence laboratories at School of Earth and Environmental Sciences, University of St Andrews (cf. Srivastava et al. 2023; Turner et al. 2021) were used to obtain HF-etched quartz, which was dispensed to disc in duplicate, and subjected to a single-aliquot regenerative dose (SAR) OSL protocol (following procedures established in Burbidge et al. 2007; Kinnaird et al. 2017). OSL measurements were carried out using Risø TL/OSL DA-20 automated dating systems. The readout cycles comprised a natural readout, followed by readout cycles for a nominal 5, 10 and 50 Gy regenerative doses, all with a 1Gy test dose. A 220̊C preheat held for 10s was used with 60s OSL measurements using the blue LEDs. This provided the first, preliminary assessment of luminescence sensitivities (luminescence per unit dose, counts Gy^{-1}) and apparent dose estimates (Gy) throughout the sampled stratigraphies.

Quartz SAR OSL Dating (OSL-PD Stage 3)

A luminescence age is the quotient of the burial dose (in Gy) over the effective environmental dose rate (in mGy a^{-1}). Here, equivalent dose (De) determinations were made on sets of 16–40 aliquots using the single aliquot regenerative dose (SAR) OSL protocol (cf. Murray and Wintle 2000). Further technical details are provided in appendix S2. Dose rates to these sediments were assessed using a combination of in situ gamma spectrometry and high-resolution gamma spectrometry in the laboratory (appendix S2).

Radiocarbon Dating

Three samples from T2A at 190–195 cm (bulk soil sample), 200–205 cm (charcoal) and 225–230 cm (charcoal) were submitted for radiocarbon dating at Beta Analytic to strengthen the chronological control in the base of the earthwork. Results were calibrated using INTCAL20 database.

Written Sources

A series of early modern documentary sources were explored in this research: a document called *Apeo de la feligresía de Samos* written in 1660, the 1753 *Cadastre of Ensenada*, seventeenth century ecclesiastical texts from the Congregation of San Benito at Valladolid and judicial documents from 1836. All these documents are stored in the Spanish National Historical Archive (https://pares.mcu.es/) and provide valuable information regarding historic land use in the study area, as shown by López-Salas (2015).

Results and Interpretation

Historic Landscape Analysis

Using the HLC the team was able to target fieldwork on examples of locally-prominent types of terrace wall or earthwork that were potentially related to monastic landscape exploitation. The subsequent historical, palaeoenvironmental and chronological analyses facilitated an in-depth understanding of how

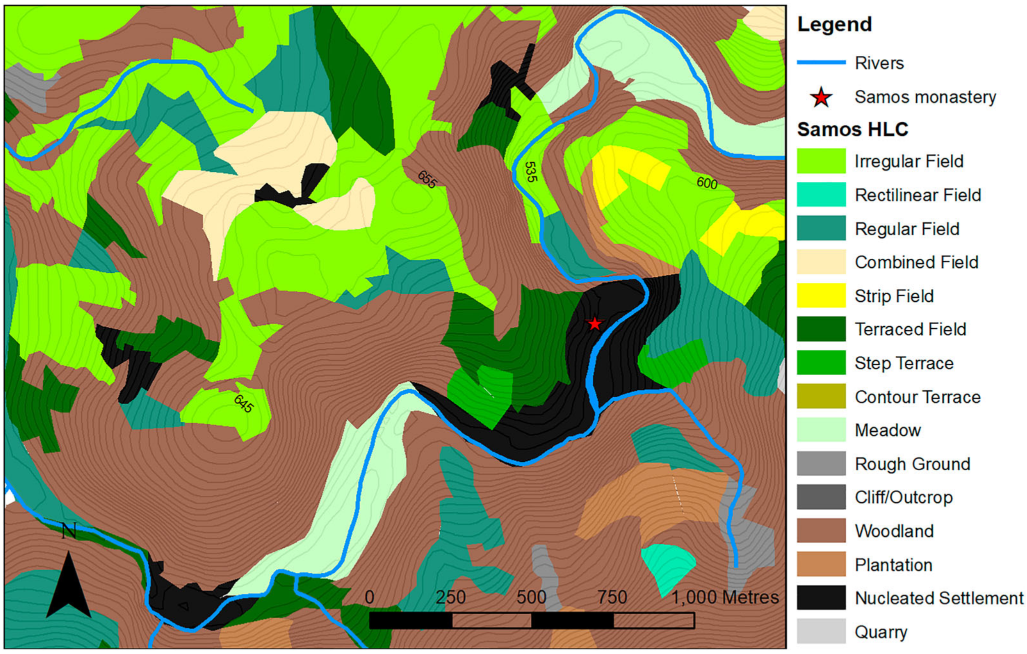

Figure 5. HLC of the modern landscape in Samos area.

the historic character of each feature had developed over time (Figure 5).

Soil Stratigraphy and Physical Properties

The three studied terraces on the east side of the monastery (T1A, T1B and T1C), sampled behind slate retaining walls, lacked darker-coloured A horizons (Table 2). However, on the basis of LOI values, indicative of organic matter content (available for T1C), as well as root presence and porosity, a 20 cm and a 15 cm A horizon can be inferred for T1C and T1A-T1B respectively. At T1A-T1B a single B horizon unit (15–90 cm) could be identified in the field, overlying a thin C horizon (90–95 cm) over slate bedrock with evidence of having been prepared as a flat surface to become the base of the terrace; which points to the fact that the soil over it arrived as a filling, an interpretation that is also reinforced by the abundant presence of small stone inclusions in the B horizon.

At T1C, the granulometry (Table 2 and Figure 7) is highly constant over the sequence with an equilibrated composition between the 'sand' (average 52.6 ± 3.0%) and 'silt and clay' fraction (average 47.4 ± 3.0%). Three different B sub-horizons with a total thickness of 140 cm were distinguished in the field according to colour and surface characteristics with boundaries at 70 and 110 cm, overlaying a saprolite layer. Both B1 (20–70 cm) and B2 (70–110 cm) are defined by a red colour (2.5YR 4/6 for B1 and 2.5YR 5/6 for B2), whilst B3 shows a light reddish brown colour (2.5YR 6/3) and a lustre surface. The retaining stone wall in front of T1C extended from a depth of 60 cm to 128 cm (Figure 4). Five fragments of early modern and contemporary pottery were recovered from the B Horizon at T1A (Figure 6) and four sherds of late medieval and early modern pottery and a fragment of a key were recovered from the B1 layer at T1C (Figure 6). These pieces were dated according to their typologies and production techniques.

The earthwork terraces T2A and T2C, which lacked visible stone facing walls, together with terrace T2B, bounded by a slate wall, were located in the middle of a gentle slope to the west of the monastery (Figure 4). Furthest upslope was T2A (260 cm thickness) which comprised three phases of soil formation (Table 2). T2A average grain size distribution is 71.2 ± 4.2% 'silt and clay', and 28.8 ± 2.6% 'sand' (Figure 8). LOI values indicate a higher abundance in organic matter in the top 50 cm of the soil as well as at 190–210 cm depth in profile.

A layer of large, rounded stones, which seem to have been intentionally placed there to become the base of an anthropic earthwork, occurred from 230–260 cm over the saprolite layer, with a dark yellowish brown (10YR 4/4) layer (220–230 cm), interpreted as an A horizon at above it (3A). A second line of smaller stones from 210–220 with another dark yellowish brown (10YR 4/6) A horizon at 190–210 cm (2A) above, indicated a later construction phase, that would be thereafter confirmed by OSL dating (see section below). Over this, there is the last soil phase consisting of a 20 cm darker A horizon, followed by a B horizon (20–190 cm), both having different chromas in the yellowish brown field.

Terrace T2B, down the slope from T2A, is composed of light yellowish brown and pale brown edaphic materials dominated by the silt & clay fraction (64.2 ± 4.4%, Table 2), over a thick light red saprolite layer (54–87 cm) over the bedrock (slate), occurring below a slate retaining wall. According to LOI, a

Table 2. Physical properties and pH and Carbon values of T2A, T2B and T1C sequences.

Sample code	Depth (cm)	Munsell colour code	Munsell colour name	% Coarse sand	% Fine sand	% Silt & Clay	LOI	C (%)	pH	Stratigraphy
Samos-T2A-1	000–010	10YR 5/4	Yellowish brown	10,3969969	14,8902286	74,7127744	12,116	3,7	4,14	A
Samos-T2A-2	010–020	–	–	–	–	–	–	–	–	
Samos-T2A-3	020–025	10YR 5/6	Yellowish brown	8,31730225	18,0377956	73,6449021	11,789	3,4	–	
Samos-T2A-4	025–030	–	–	–	–	–	–	–	–	B
Samos-T2A-5	030–035	10YR 5/8	Yellowish brown	6,95890411	20,460274	72,5808219	9,375	2,4	4,52	
Samos-T2A-6	035–040	–	–	–	–	–	–	–	–	
Samos-T2A-7	040–045	10YR 5/8	Yellowish brown	3,71076233	14,4058296	81,8834081	11,332	3,1	–	
Samos-T2A-8	045–050	–	–	–	–	–	–	–	–	
Samos-T2A-9	050–055	10YR 5/8	Yellowish brown	13,9268159	19,3227744	66,7504096	8,523	2,2	4,6	
Samos-T2A-10	055–060	–	–	–	–	–	–	–	–	
Samos-T2A-11	060–065	10YR 5/8	Yellowish brown	13,0978027	20,4222318	66,4799655	8,107	1,8	–	
Samos-T2A-12	065–070	–	–	–	–	–	–	–	–	
Samos-T2A-13	070–075	10YR 5/8	Yellowish brown	11,2945265	19,8414422	68,8640313	8,012	1,8	4,61	
Samos-T2A-14	075–080	–	–	–	–	–	–	–	–	
Samos-T2A-15	080–085	10YR 5/8	Yellowish brown	9,19006479	19,1900648	71,6198704	7,741	1,7	–	
Samos-T2A-16	085–090	–	–	–	–	–	–	–	–	
Samos-T2A-17	090–095	10YR 5/8	Yellowish brown	7,05946536	16,2684124	76,6721222	8,651	1,9	4,6	
Samos-T2A-18	095–100	–	–	–	–	–	–	–	–	
Samos-T2A-19	100–105	10YR 5/8	Yellowish brown	5,52093583	14,8791954	79,5998688	8,840	2,0	–	
Samos-T2A-20	105–110	–	–	–	–	–	–	–	–	
Samos-T2A-21	110–115	10YR 5/8	Yellowish brown	9,92961559	18,6139686	71,4564158	7,935	1,8	4,51	
Samos-T2A-22	115–120	–	–	–	–	–	–	–	–	
Samos-T2A-23	120–125	10YR 5/8	Yellowish brown	7,82768301	17,3828547	74,7894623	7,639	1,5	–	
Samos-T2A-24	125–130	–	–	–	–	–	–	–	–	
Samos-T2A-25	130–135	10YR 5/8	Yellowish brown	9,78471475	20,8288482	69,386437	7,341	1,6	4,46	
Samos-T2A-26	135–140	–	–	–	–	–	–	–	–	
Samos-T2A-27	140–145	10YR 5/8	Yellowish brown	9,72978746	20,6557727	69,6144398	7,389	1,7	–	
Samos-T2A-28	145–150	–	–	–	–	–	–	–	–	
Samos-T2A-29	150–155	10YR 5/8	Yellowish brown	7,32127476	23,1804479	69,4982773	7,508	1,8	4,56	
Samos-T2A-30	155–160	–	–	–	–	–	–	–	–	
Samos-T2A-31	160–165	10YR 5/8	Yellowish brown	7,1706684	23,3073762	69,5219554	7,642	1,8	–	
Samos-T2A-32	165–170	–	–	–	–	–	–	–	–	
Samos-T2A-33	170–175	10YR 5/8	Yellowish brown	9,54633412	19,4689314	70,9847345	7,682	1,8	4,48	
Samos-T2A-34	175–180	–	–	–	–	–	–	–	–	
Samos-T2A-35	180–185	10YR 5/8	Yellowish brown	12,9533679	20,2720207	66,7746114	7,480	1,8	–	
Samos-T2A-36	185–190	–	–	–	–	–	–	–	–	
Samos-T2A-37	190–195	10YR 4/6	Dark Yellowish Brown	7,23311547	22,08061	70,6862745	8,347	2,0	4,44	2A
Samos-T2A-38	195–200	–	–	–	–	–	–	–	–	
Samos-T2A-39	200–205	10YR 4/6	Dark Yellowish Brown	9,63094315	22,0879973	68,2810595	10,459	3,2	–	
Samos-T2A-40	205–210	10YR 4/4	Dark Yellowish Brown	10,6220202	21,9647411	67,4132387	10,366	2,9	–	
	210–220 (line of stones- no soil sample)	–	–	–	–	–	–	–	–	Stones
Samos-T2A-41	220–225	10YR 4/4	Dark Yellowish Brown	12,2516193	21,5720716	66,1763091	9,001	2,2	–	3A
	225–230	10YR 4/4	Dark Yellowish Brown	11,8023887	21,4875136	66,7100977	7,928	2,0	–	
Samos-T2A-42	230–260 (line of stones- no soil sample)	10YR 4/4	Dark Yellowish Brown					–	–	Stones
	saprolite									saprolite
Samos-T2B-1	000–005	10YR 6/4	Light Yellowish Brown	16,9	19,0	64,1	7,2	2,2	4,15	A
Samos-T2B-2	005–010	10YR 6/4	Light Yellowish Brown	15,5	16,8	67,7	6,9	2,0	4,22	
Samos-T2B-3	010–015	10YR 6/5	Light Yellowish Brown	12,3	24,3	63,4	6,2	1,7	4,21	B
Samos-T2B-4	015–020	10YR 6/6	Light Yellowish Brown	15,1	23,5	61,4	5,5	1,4	4,40	
Samos-T2B-5	020–025	10YR 6/7	Light Yellowish Brown	13,0	23,5	63,4	5,1	1,1	4,51	
Samos-T2B-6	025–030	10YR 6/8	Light Yellowish Brown	7,0	24,8	68,2	5,1	1,0	4,72	
Samos-T2B-7	030–035	10YR 6/9	Light Yellowish Brown	6,3	29,0	64,7	5,2	1,0	4,74	
Samos-T2B-8	035–040	10YR 6/10	Light Yellowish Brown	9,6	24,0	66,4	5,0	1,0	4,87	
Samos-T2B-9	040–045	10YR 6/10	Light Yellowish Brown	10,0	25,0	75,0	5,0	1,0	4,83	
Samos-T2B-10	045–050	10YR 6/3	Pale Brown	10,6	31,7	57,7	4,4	0,6	5,06	
Samos-T2B-11	050–055	10YR 6/3	Pale Brown	5,8	32,3	62,0	3,7	0,3	5,15	
Samos-T2B-12	055–060	2.5YR 7/6	Light Red	5,7	32,0	62,3	3,5	0,2	5,25	C
Samos-T2B-13	060–065	2.5YR 7/6	Light Red	6,9	34,9	58,2	3,4	0,3	5,14	

(*Continued*)

Table 2. Continued.

Sample code	Depth (cm)	Munsell colour code	Munsell colour name	% Coarse sand	% Fine sand	% Silt & Clay	LOI	C (%)	pH	Stratigraphy
Samos-T2B-14	065–070	2.5YR 7/6	Light Red	–	–	–	–	–	–	
Samos-T2B-15	070–075	2.5YR 7/6	Light Red	–	–	–	–	–	–	
Samos-T2B-16	075–080	2.5YR 7/6	Light Red	–	–	–	–	–	–	
Samos-T2B-17	080–085	2.5YR 7/6	Light Red	–	–	–	–	–	–	
Samos-T2B-18	085–090	2.5YR 7/6	Light Red	–	–	–	–	–	–	
										R
Samos-T1C-1	000–005	2.5YR 4/6	Red	25,2	27,5	47,3	8,15	3,5	5,52	A
Samos-T1C-2	005–010	2.5YR 4/6	Red	25,8	25,6	48,6	6,54	2,7	5,21	
Samos-T1C-3	010–015	2.5YR 4/6	Red	28,5	25,6	45,9	5,67	2,1	5,32	
Samos-T1C-4	015–020	2.5YR 4/6	Red	26,0	27,0	47,0	5,21	2,0	5,22	
Samos-T1C-5	020–025	2.5YR 4/6	Red	23,6	27,2	49,2	5,42	1,9	5,21	B1
Samos-T1C-6	025–030	2.5YR 4/6	Red	29,5	25,6	44,9	4,97	1,8	5,30	
Samos-T1C-7	030–035	2.5YR 4/6	Red	26,2	26,6	47,2	4,79	1,8	5,26	
Samos-T1C-8	035–040	2.5YR 4/6	Red	27,4	27,0	45,6	4,55	1,6	5,30	
Samos-T1C-9	040–045	2.5YR 4/6	Red	21,9	30,2	47,9	5,04	1,5	5,31	
Samos-T1C-10	045–050	2.5YR 4/6	Red	29,2	26,7	44,1	4,08	1,4	5,35	
Samos-T1C-11	050–055	2.5YR 4/6	Red	22,3	28,9	48,8	4,21	1,4	5,17	
Samos-T1C-12	055–060	2.5YR 4/6	Red	25,3	27,4	47,3	4,07	1,2	5,30	
Samos-T1C-13	060–065	2.5YR 4/6	Red	25,1	27,9	47,0	3,75	1,2	5,46	
Samos-T1C-14	065–070	2.5YR 4/6	Red	31,3	28,5	40,2	2,92	0,7	5,41	
Samos-T1C-15	070–075	2.5YR 5/6	Red	26,8	30,8	42,5	2,86	0,6	5,46	B2
Samos-T1C-16	075–080	2.5YR 5/6	Red	29,2	28,4	42,4	2,93	0,6	5,46	
Samos-T1C-17	080–085	2.5YR 5/6	Red	28,9	27,1	44,0	2,87	0,6	5,59	
Samos-T1C-18	085–090	2.5YR 5/6	Red	26,8	28,6	44,5	2,94	0,6	5,57	
Samos-T1C-19	090–095	2.5YR 5/6	Red	31,2	23,7	45,1	2,95	0,7	5,62	
Samos-T1C-20	095–100	2.5YR 5/6	Red	28,2	28,0	43,8	3,05	0,7	5,60	
Samos-T1C-21	100–105	2.5YR 5/6	Red	22,4	28,3	49,3	3,31	0,7	5,63	
Samos-T1C-22	105–110	2.5YR 5/6	Red	27,6	26,1	46,3	3,08	0,7	5,73	
Samos-T1C-23	110–115	2.5YR 5/6	Red	23,3	28,3	48,4	3,12	0,7	5,60	B3
Samos-T1C-24	115–120	2.5YR 5/6	Red	23,2	25,6	51,2	3,27	0,8	5,59	
Samos-T1C-25	120–125	2.5YR 5/6	Red	22,5	26,8	50,7	3,21	0,7	5,55	
Samos-T1C-26	125–130	2.5YR 5/6	Red	23,6	28,7	47,7	3,14	0,7	5,46	
Samos-T1C-27	130–135	2.5YR 6/3	Light Reddish Brown	25,2	26,0	48,8	3,10	0,7	5,63	
Samos-T1C-28	135–140	2.5YR 6/3	Light Reddish Brown	21,6	29,2	49,2	3,23	0,7	5,72	
Samos-T1C-29	140–145	2.5YR 6/3	Light Reddish Brown	21,6	26,7	51,6	3,19	0,7	5,67	
Samos-T1C-30	145–150	2.5YR 6/3	Light Reddish Brown	18,1	30,2	51,8	3,29	0,7	5,77	
Samos-T1C-31	150–155	2.5YR 6/3	Light Reddish Brown	20,2	28,4	51,4	3,28	0,7	5,65	
Samos-T1C-32	155–160	2.5YR 6/3	Light Reddish Brown	17,8	29,6	52,6	3,53	0,8	5,81	

10 cm A horizon was identified (Figure 9). The presence of such a thick saprolite layer could be considered as evidence that the foundations for this were cut into an original early Holocene soil formed over the bedrock at this point of the slope.

The earthwork at T2C (63 cm) was excavated a little further downhill, immediately below T2B. It has a darker A horizon 11 cm thick and a B horizon (11–63 cm) directly lying over the bedrock (Table 2). The absence of a thick saprolite layer in a soil sequence so close to T2B, might be indirect evidence that, probably, the sediments in earthwork T2C were intentionally deposited there as a filling.

PCS (185 cm) is an earthwork located to the east of the abbey, on the upslope side of the Camino de Santiago path (now paved with slate). It is in the area of a chestnut plantation. The A Horizon (0–15 cm) is composed of dark brown earth with abundant roots. The B horizon (15–50 cm) was lighter in colour with fewer roots, but from 50 to 180 cm, the materials show a light brown colour with numerous slate fragments, that were interpreted in the field as possible evidence of reworking, later confirmed by OSL.

Further details on the interpretation of the formation process of all the terraces and earthworks mentioned in the text will be addressed in the OSL and discussion sections.

OSL-PD Stage 1: Relative Luminescence Stratigraphies

The luminescence stratigraphies that were generated in the field are shown in Figure 10. Most of the luminescence profiles showed a signal progression with depth, with the magnitude and dynamic range in signal intensities providing an indication of relative age, and the means to link the sediment depositional histories to the constructional sequences(s) of the agricultural terraces and earthworks.

The environmental section sampled by the path Camino de Santiago (PCS) contained a long and complex chronology. The luminescence profiles suggest a

Figure 6. Late medieval and early modern pottery recovered from T1A (left) and T1C (right).

gradual accumulation of sediment over the first 50 cm depth down profile; re-deposition and re-working of the sediment profile through 50 to c. 140 cm depth; before a return to *in situ* and gradual accumulation below 140 cm. The implication of this for interpreting the pollen sequence is that between 50 and 140 cm, the assemblage is likely mixed. Samples for dating purposes were thus positioned above and beneath the re-deposited unit.

The sediment stratigraphies associated with the agricultural terraces in the east, and for the most part the earthworks in the west, were characterised by similar minima and maxima in signal intensities, which implied that these sequences span similar chronologies, with the earthworks having a marginally longer chronology preserved. In all, the intact B horizons show progressions from minima at c. $1–2 \times 10^4$ counts to maxima at $4–5 \times 10^5$ counts in OSL; when inflections in the signal-depth

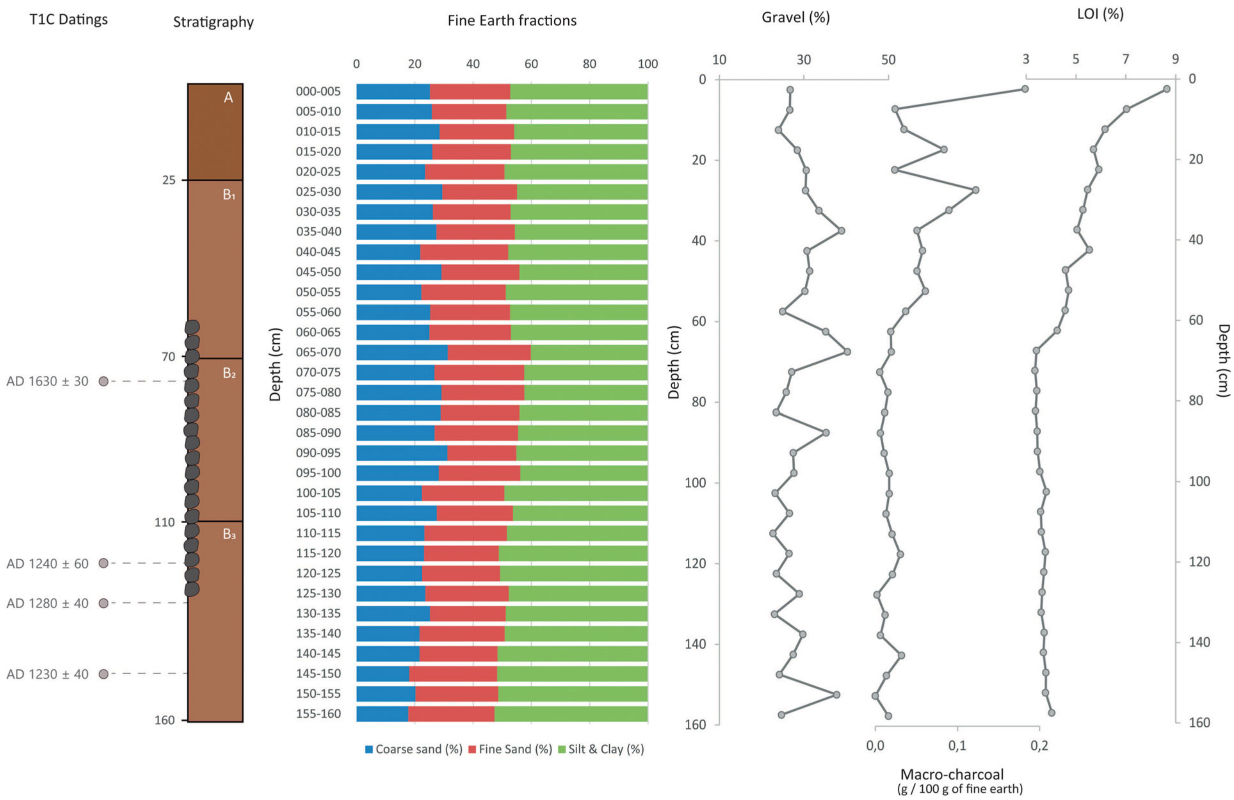

Figure 7. Soil physical properties (granulometry and LOI) from T1C. OSL dates are indicated in the stratigraphy diagram by grey circles.

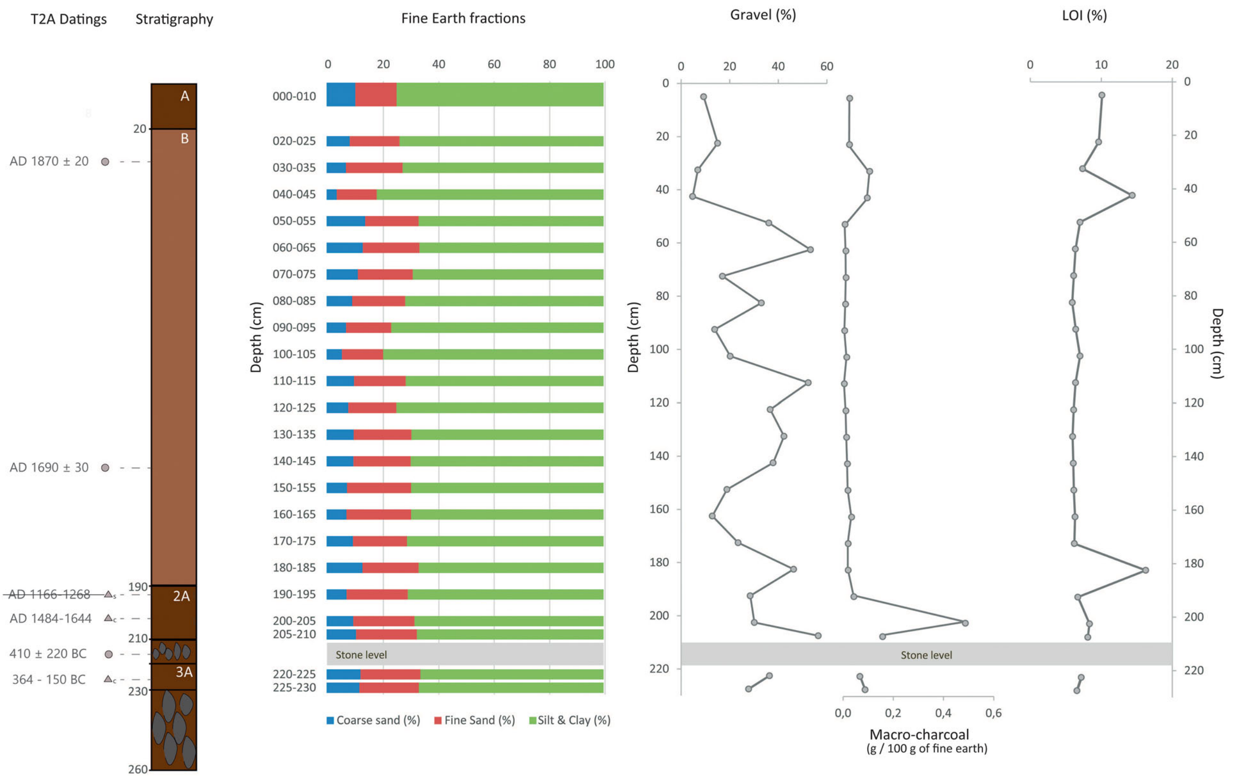

Figure 8. Soil physical properties (granulometry and LOI) from T2A. OSL dates are indicated in the stratigraphy diagram by grey circles, whereas radiocarbon datiangs are represented by grey triangles (c: performed on charcoal; s: performed on pedosedimentary material).

progressions correlate with the coarser fills and packed stone horizons, then these potentially indicate the parts of the sedimentary profiles disturbed (and reset) during terrace or earthwork construction. The signal intensities for these horizons tended to be lower than the maxima observed in the corresponding section – 7×10^4–2×10^5 counts in OSL. When the luminescence profiles show exception to this, they indicate the parts of the sedimentary sequences which are likely to have been re-deposited without bleaching. This information was used to position samples for dating purposes during fieldwork.

Figure 10 highlights the relative temporal associations between the terrace walls (T1A, T1B, T1C and T2B), earthworks (T2A and T2C) and environmental section (PCS): clearly, the oldest sediment present is preserved in section PCS (>10^6 OSL counts), whereas the youngest sediment is preserved behind the terrace walls (~1.7×10^4 OSL counts).

OSL-PD Stage 2: Sensitivity and Apparent Dose Distributions

Following Kinnaird et al. (2017), a sub-set of these profiling samples was taken forward to further laboratory characterisation and screening (see S1): 80 samples from sections PCS, T1A, T1C, T2A and T2C.

For the environmental section sampled adjacent to the path Camino de Santiago (PCS), the palaeodose

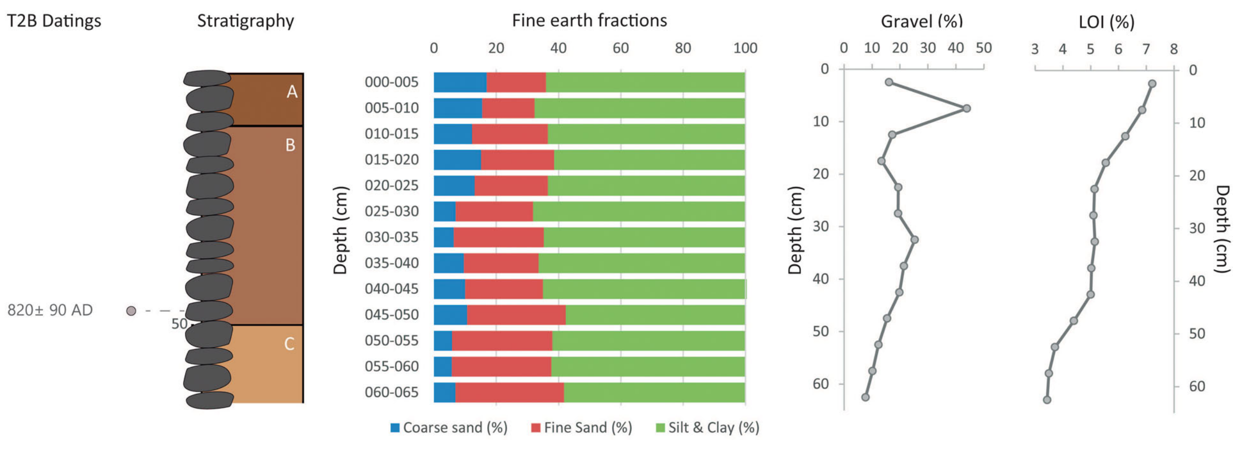

Figure 9. Soil physical properties (granulometry and LOI) from T2B. The OSL dating is indicated in the stratigraphy diagram by a grey circle.

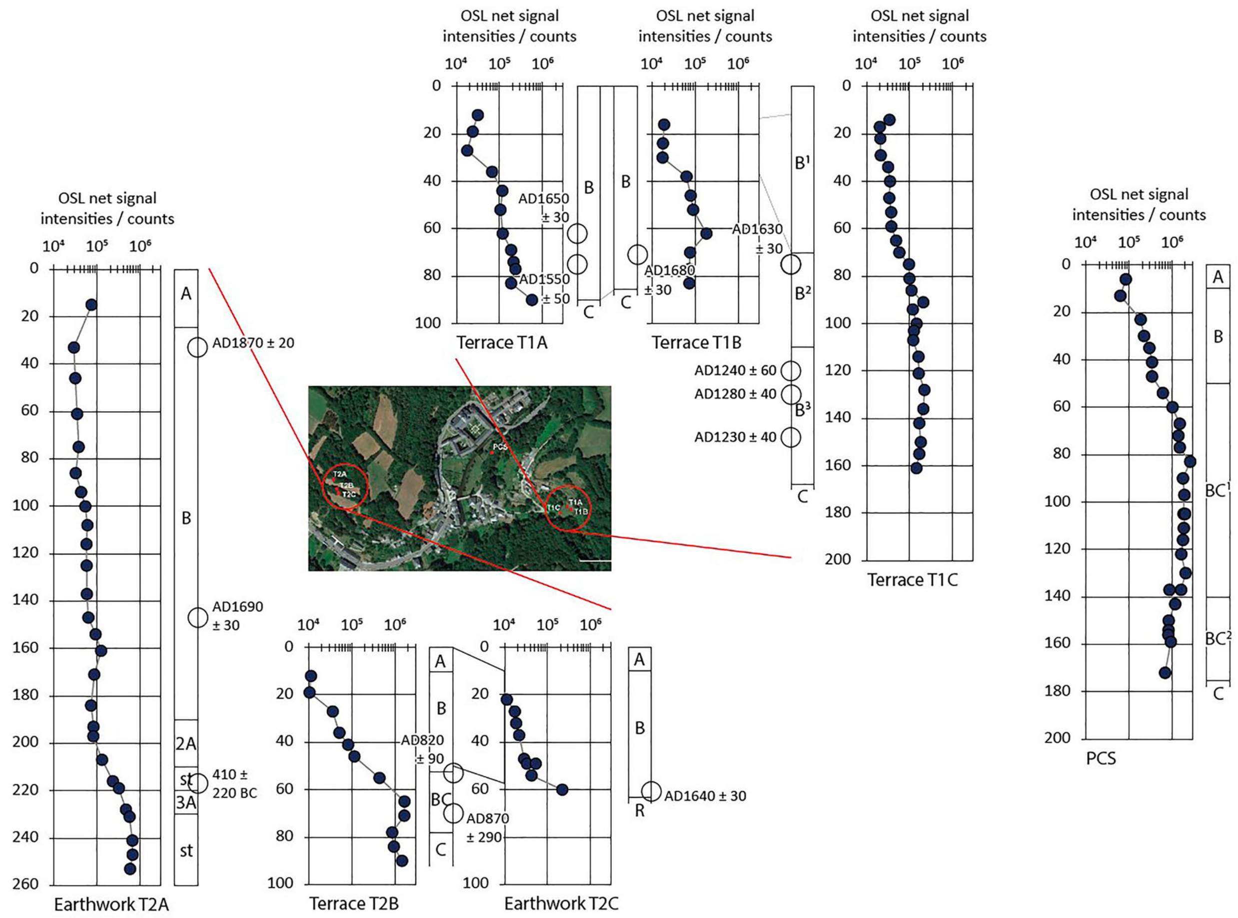

Figure 10. Luminescence stratigraphies and OSL depositional ages.

estimates ranged from c. 3.7 Gy at the top, to c. 40 Gy at the base, indicating that these sediments do preserve a long chronology, most probably encompassing the whole of the Holocene.

For the sediment stratigraphy explored behind the wall of T1A, the progression in palaeodose estimates with depth is more complex: (a) samples from the B horizon range from 0.7–0.8 Gy at the top to 0.8–1.0 Gy at the base; whereas (b) the 'constructional' fills are characterised by maxima in palaeodose estimates; before, (c) a return to lower apparent dose at the base, 0.6 Gy. This implies that the sediment at the base of the section was disturbed at the time of construction, and that the dating samples positioned here will provide terminus post quem (TPQ) for construction.

For the sediment stratigraphies associated with the construction and 'development' of the earthworks in the west (T2C and T2A), the palaeodose values show a progression with depth from c. 0.3–0.7 Gy to a maxima of c. 4–5 Gy at depth (T2C). For T2A, the calibrated profile stops short of the corresponding units, but estimating palaeodose values based on the stratigraphic trends observed in the field profiles suggests values in excess of 4–5 Gy.

OSL-PD Stage 3: Quartz SAR OSL Dating

After full consideration of the field profiles, validated by the calibrated dataset, two agricultural terraces and three earthworks were selected for dating (Table 3). Sediment chronologies were constructed from 15 individual quartz SAR OSL dates and augmented by 53 apparent ages from the calibrated dataset. Unsurprisingly, given the broad spectrum of landscape features examined, the investigated samples enclose sediments re-set to various degrees at deposition, from those well-bleached and dating construction (the agricultural terraces in the east), to those poorly bleached and showing a mixing between substrate and agricultural soils (the earth banks in the west).

In the case of the earthworks profiled to the west of the monastery, where the boundary between the agricultural soils and substrate was gradational, the samples positioned at depth were characterised by broader De distributions, reflecting the mixing of older strata with the more modern, agricultural soils (see also the luminescence stratigraphy/sediment ages for the earth bank at PCS). The luminescence stratigraphies generated in the field allowed us to recognise which horizons were better bleached at deposition, where the luminescence had likely to grown in situ post-burial, and the horizons poorly bleached at deposition, where luminescence inherited from prior depositional histories would complicate the equivalent dose (and age) distributions. Dating samples had been positioned accordingly. In a number of the sections investigated, samples had been positioned at the substrate-soil boundary, with a view to assessing the

Table 3. Summary of OSL depositional ages. The burial doses, environmental dose rates and corresponding depositional ages are provided in the supplementary data files.

Field Profile ID	Depth /cm	Description	Calendar years (+AD/-BC)	Archaeological significance?	CERSA lab code
PCS OSL1	**77**	B/C horizon; beneath prominent spike in IRSL/OSL signals	~135,000 years BP	n/a	**83**
PCS OSL2	**153**	B/C horizon, beneath textural change at 140 cm depth in profile; return to IRSL/OSL signals in line with age depth progression	41,000 years BP		**84**
T1A OSL1	**62**	B horizon: packed materials at base of profile; beneath stone layer related to construction?	AD 1650 ± 30	TAQ for construction of terrace wall	**85**
T1A OSL2	**75**	B horizon: base of packed materials; above substrate – marked by spike in OSL/IRSL intensities	AD 1550 ± 50	TPQ for construction of terrace wall	**86**
T1B OSL1	**71**	B horizon: top of packed materials at base of profile; beneath stone layer related to construction?	AD 1680 ± 30	TAQ for construction of terrace wall	**87**
T1C 75	**75**	top of B2 horizon; at change in gradient in IRSL/OSL signal-depth progression	AD 1630 ± 30	temporal constraints on soil catena	**92**
T1C 120	**120**	B3 horizon	AD 1240 ± 60	further constraint on age of terrace wall	**93**
T1C OSL1	**130**	Colour change at B3 horizon	AD 1280 ± 40	TPQ for construction of terrace wall	**88**
T1C OSL2	**148**	B3 horizon	AD 1230 ± 40	TPQ for construction of terrace wall	**89**
T2C OSL1	**63**	Base of the B horizon, above bedrock at 64 cm depth	AD 1640 ± 30	TPQ for construction of terrace wall, assuming bedrock cleared in construction	**90**
T2A 33	**33**	top of B horizon; beneath 'disturbed' horizon – marked by inverted IRSL/OSL intensities	AD 1870 ± 20		**97**
T2A 147	**147**	near base of B horizon; at change in gradient in IRSL/OSL signal-depth progression	AD 1690 ± 30		**98**
T2A OSL1	**217**	buried A horizon; above stone horizon	410 ± 220 BC	date buried soil	**108**
T2B OSL1	**53**	brown sandy loam at the base of the B horizon above C horizon at 55cm	AD 820 ± 90	TPQ for construction of terrace wall, assuming bedrock cleared in construction	**109**
T2B 70	**70**	C horizon; near change in gradient in IRSL/OSL signal-depth progression	AD 870 ± 290	temporal constraints on soil catena	**102**

relative proportions of substrate- and soil-dominated luminescence signals (and if the latter could be identified and isolated, obtain a lower constraint on the soil catena). The minimum constraint on the age of the agricultural soil in T2B was AD820 ± 90. Meanwhile, the sediment ages at depth in T2C and T2A provide depositional ages from the mid seventeenth century AD (AD1640 ± 30 and AD1690 ± 30, respectively).

The luminescence stratigraphies and sediment chronologies associated with the agricultural terraces east of the monastery are less complex. Individual sediment ages fall within two distinct temporal sets: an early set, around the mid to late thirteenth century AD, for the sediments at depth associated with T1C, and mid to late seventeenth century AD, for the sediments at depth associated with T1A (and its lateral equivalent, T1B).

Radiocarbon Dating

In order to augment the sediment chronologies, and to obtain temporal data for the bottom of the T2A sequence, three radiocarbon dates from two charcoal and one sediment samples were performed at Beta Laboratory (Miami, USA). Results are shown in Table 4.

Palynology

The T1C palynological record (Figure 11) proved sterile below 62.5 cm, due to the predominance of less acidic - > 5.5 pH- conditions at this point (5.60 ± 0.11). Above 62.5 cm, the palynological composition of T1C was homogeneus: *Castanea* was the most dominant pollen type with percentages varying between 37.5% and 83.1%. The remainder was dominated by Poaceae (7.3–30.4%), with shrubs just testimonial (<1.6%). Cerealia undiff. and *Secale cereale* are present but in small amounts. Higher percentages of Cerealia unidiff. occurs at 22.5 and 32.5 cm coinciding with the lowest *Castanea* values. Coprophilous fungi *Sordaria* and *Sporormiella* also show their highest values at these depths. Particular macrocharcoal increases (see geochemistry section) at these depths point to increased fire activity at the same time.

Table 4. Radiocarbon datings performed at T2A.

Material	Lab ID	Depth (cm)	Conventional radiocarbon age	Calendar years (95,4% probability)
Sediment	Beta – 588463	190–195	830 ± 30 BP	1166–1268 cal AD
Charcoal	Beta – 588462	200–205	320 ± 30 BP	1484–1644 cal AD
Charcoal	Beta – 616102	225–230	2180 ± 30 BP	364–150 cal BC

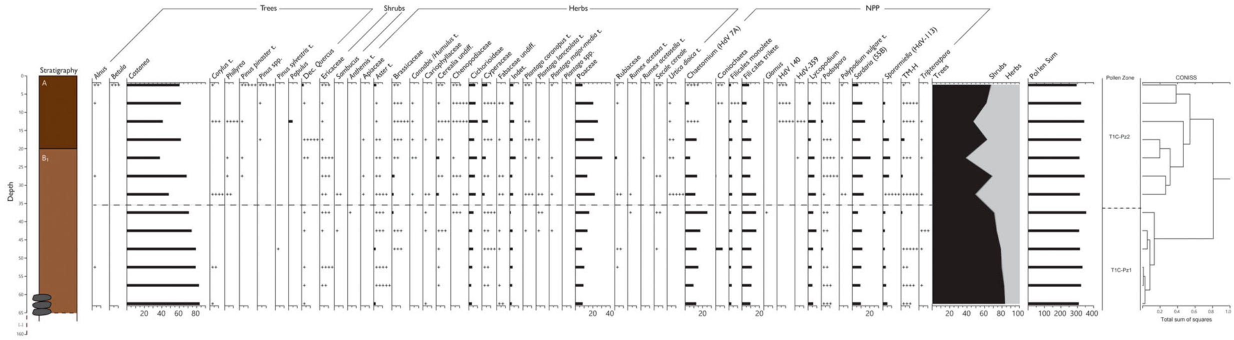

Figure 11. Complete pollen diagram of T1C sedimentary sequence.

In T2A, two pollen zones were distinguished with a clear boundary at 200 cm (Figure 12). The dominant signal in both zones was from herbs (47.9–87.3%), with Poaceae (35.3–64.2%) the main constituent. In the 0–200 cm zone, trees formed around 20% of the TLP, with shrubs just testimonial; however, from 200–230 cm depth, these percentage of TLP increase (around 30 and 10% respectively). The topmost sample also showed trees at around 30%. In the whole record the signal of trees was dominated by deciduous oak, whereas the dominant shrub taxa were *Calluna* and *Erica* t. Cereal undiff. and *Secale cereale* t. were higher (3.7–14.9%) in the 0–200 cm section.

The palynological signal of T2B is quite homogeneous (Figure 13). Herbs dominate the signal (73.7–83.4%) with *Poaceae* the most abundant pollen type. Cerealia undiff and *Secale cereale* were quite common throughout this sequence, notably at 32.5 cm depth with *Secale cereale* rat 11.1% and Cerealia undiff. at 4.1%. Among trees (13.5–25.7%), *Castanea* (7.8–2.3%) and to a lesser extent decidious *Quercus* (2.4–4.1%) were the most important taxa. Shrubs were mainly testimonial (<3.1%).

Written Sources

The study of the *Apeos* text from 1660 showed that T1C was placed in an agricultural plot with four different parts: farmland, forest, a *chousa* (small plot) and a *lamelo* (wetland) and that a big chestnut woodland existed in the proximities (López-Salas 2015). The same text also shows that T2 area was used for rye farming in that time. The other documents offer information regarding the number of houses in the area in the seventeenth and eighteenth centuries, as it will be explained in the discussion.

Discussion

The Evolution of the Agrarian Spaces Around Samos Abbey

A total of 6 OSL absolute dates demonstrated that the middle of seventeenth century was an important moment of creation (T1A, T1B and T2C) and transformation (T1C and T2A) of agrarian terraces and earthworks around the abbey. Pollen and geochemical information together with written sources have provided information about the agrarian landscape in the area from that moment until the present. However, remains of earlier phases of landscape modification, to some extent masked by these seventeenth century developments, were also detected.

Excluding the PCS profile, which did not provide evidence of human activity (with OSL datings of 135,000 years BP at 77 cm and 41000 years BP at 153 cm), it is the palynological composition of the T2A-3A horizon which provides evidence of the oldest anthropized landscape in this area, with high presence of cereal pollen (∼ 4%) and a reduced forest cover. This fact, together with the regular row of stones at its base, suggests an anthropogenic origin for the T2A sequence (Figure 12). Charcoal from this 3A horizon yielded a radiocarbon determination of 364–150 BC (Table 4) while the OSL date from the stone layer above (at

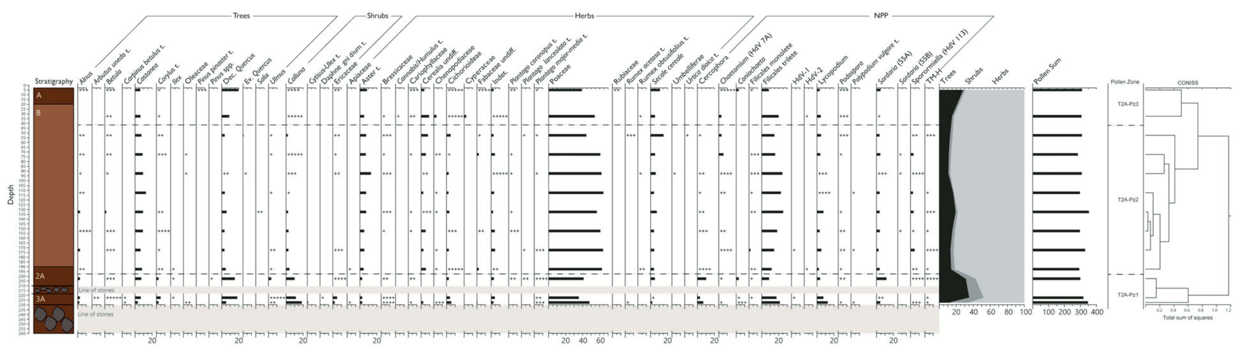

Figure 12. Complete pollen diagram of T2A sedimentary sequence.

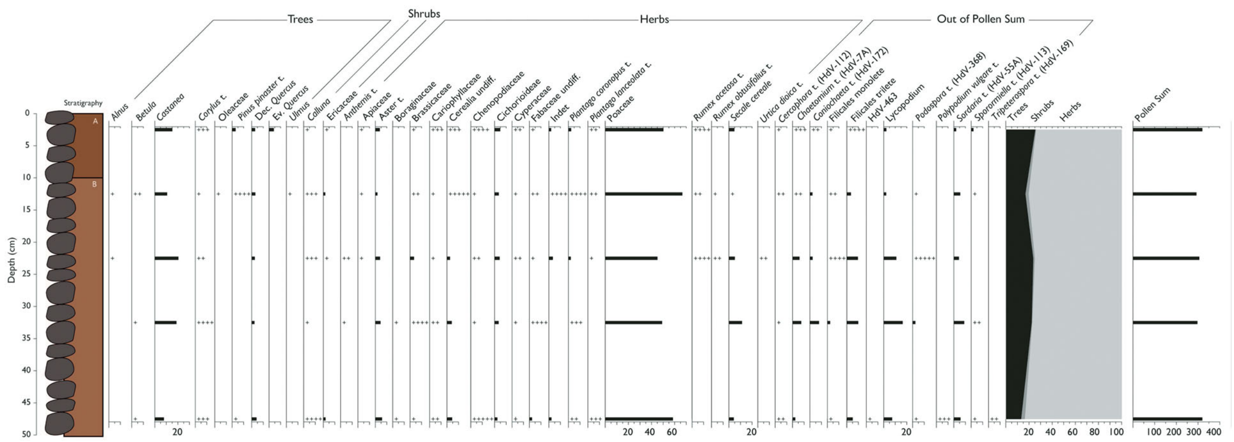

Figure 13. Complete pollen diagram of T2B sedimentary sequence.

217 cm) it offered a chronology of 410 ± 220 BC, so it seems likely that T2A was already an agrarian terrace in the Iron Age (Silva-Sánchez et al. 2022). Evidence of prehistoric terracing is still scarce in northwest Iberia (González et al. 2016), and this is one of the few examples supported with *in situ* cereal pollen evidence. The municipality of Samos has one of the highest densities of Iron Age hillforts in northwest Iberia (Rodríguez Fernández 1994), so terracing was probably already a necessary activity for the population of this area more than 2000 years ago.

The two OSL dates from the bottom of the T2B sequence (at 53 and 70 cm) provide environmental evidence from around 1000 years later, showing that this small terrace was created between the eighth and ninth century AD. Pollen data from these levels shows, once again, an anthropized and deforested landscape, with *in situ* cultivation and a low percentage of tree pollen (Figure 13). It is interesting that the construction of this terrace coincided with a crucial moment in the history of the monastery, which was refounded at this time with endowments of land in the surrounding area from the Asturian kings. The earliest surviving written records from Samos Abbey date to this time (Lopez Alsina 1993). However, the Early Middle Ages seem to have been an important time for terrace construction across northwest Iberia (Ballesteros-Arias 2010; Fernández Mier et al. 2014; Quirós Castillo et al. 2014; Quirós Castillo and Nicosia 2019), so it is difficult to be certain whether the creation of terraces was part of a global trend or whether it was a specific initiative of the abbey.

The three OSL dates from the T1C-B3 horizon, which were taken from positions in the sediment stratigraphy beneath the wall, and equivalent to the basal section of the retaining wall, consistently indicated a thirteenth century age (AD1230 ± 40; AD1280 ± 40 and AD1240 ± 60). Unfortunately, this layer resulted palynologically sterile. The creation of the terrace at T1C coincides with the construction of the new Romanesque church of Samos Abbey, which was itself probably finished in the first quarter of the thirteenth century (Pérez González and Valle Pérez 2018, 1187–1190). It is possible that construction work on the abbey may have entailed the need for more intense exploitation of the agrarian spaces, and the creation of terraces for this purpose.

The most recent and visible phase of landscape transformation around the abbey took place in the seventeenth century. At T1C, the sharp changes detected in physical properties (Figure 7) at 70 cm (colour, granulometry, LOI and pH) together with an OSL date obtained at 75 cm depth demonstrated that exploitation of the slope led to mass wasting related to a second construction phase of the terrace in the middle of the seventeenth century (AD1630+−30). Pollen data showed that chestnuts were dominant at least from this time to the present (Figure 11), and seventeenth century chestnut cultivation in this sector was also confirmed by the *Apeos* text from 1660 (López-Salas 2015). The same document confirmed that T1C was placed in an agricultural plot with four different parts: farmland, forest, a *chousa* (small plot) and a *lamelo* (wetland). The last two were in the upper part of the property, with T1C located in the lower part, so it could have been an area used for agriculture or as woodland. Though extensive areas on adjacent properties were producing wheat, the area of T1C may have been used for rye, because the written description specified that the property produced seven bushels of rye. Low concentrations of cereal pollen here do not suggest intensive cultivation, although the presence of coprophilous fungi may be related to the presence of livestock or the use of organic fertilisers.

The steady but fast progression of OSL ages at the T2A sequence (almost 2 m of pedosedimentary accumulation in the last 300 years) indicates that an increased soil erosion from upper parts of the slope occurred in the last centuries (Figure 8). Environmental data from this earthwork indicates, in the mid-seventeenth century, a deforested landscape comprising a mosaic of dispersed deciduous trees (20% of

TLP), localised agriculture (3.7–14.9% pollen of *Secale cereale* and *Cerealia* undiff. at 0–200 m.), animal husbandry and use of fire (macrocharcoal level) (Figure 12). According to the *Apeos* text, in AD 1660 the area where T2A, T2B and T2C are located was mainly used for rye farming and in the surrounding plots, there was a significant number of trees, with a clear dominance of oaks and fruit trees of different types, and a smaller presence of chestnuts.

It is interesting also to note that T2A, T2B and T2C are situated close to a neighbourhood of Samos, known today as A Torre. In the *Apeos* of 1660 only one building was mentioned here, a house built by Eufrasio López. However, the Cadastre of Ensenada shows that A Torre had grown to eight houses by 1753. This neighbourhood was probably created in the first half of the eighteenth century following a visit in 1698 by the general visitor of the Congregation of San Benito de Valladolid. He ordered that houses in the central area of Samos should be demolished because of the low value of rents they generated for the abbey (an order repeated in 1702 and 1704). The Cadastre of Ensenada reveals that there were eight fewer houses in the central village in 1753 compared to 1660, which is also the number of houses built in A Torre. It seems likely that the displaced residents had been relocated to A Torre, about 150 m towards the southeast of the sites at T2A, T2B and T2C, and this new settlement led to increased soil erosion.

The creation and reconstruction of extensive agricultural terraces in the seventeenth century coincides with other major transformations that took place around Samos Abbey in this time, including the probable construction of a large enclosure wall (López-Salas 2015) and the creation of a road and new rooms in the abbey (Ladra 2012). Although all the terraces and earthworks studied here lie outside the monastic wall (with exception of PCS), they were part of the abbey's territorial property, and we know that Samos monks exercised strong control over any landscape transformation in this area (López-Salas 2017a; 2017b). It is even possible to suggest that Mauro Vega, who was Abbot of Samos between 1633–1637 and 1641–1645, was behind these transformations, since we know, from some written references from his time, that he promoted major works in the abbey (Arias 1950, 222).

Spatial and Temporal Heterogeneity in the Construction of the Agrarian Spaces at Samos: A Comparative Overview

Given the characteristics of the 6 terraces and earthworks studied here, it is possible to gain new insights on how constructive methods have changed through time at Samos. At the base of T2A (Iron age), a fill was placed over a preparation base of round stones (Silva-Sánchez et al. 2022). At T2B (Early Middle Ages). The presence of a thick C horizon and the OSL profiling seems compatible with a process of terracing by soil cutting whereas at the nearer T2C (seventeenth century), with much narrower vestiges of the original C horizon, it seems that excavation and filling occurred. At T1A and T1B (also in the seventeenth century), a filling was deposited over the parent rock carefully cut. Whereas at T1C, although the constructive method for the thirteenth-century phase it is difficult to infer, at least for the seventeenth century phase a filling was placed there. This variety of techniques reflect different resources and objectives involved in the creation of these agrarian structures in each period, as found in other areas of north Spain (Fernández Mier et al. 2014).

In this sense, the spatial and temporal comparison of the environmental signatures inform us about these different objectives (land use) of the agrarian spaces. As noted above, the lower section of T2A preserved Iron Age deposits below the Early Modern sediments (Figure 12). Even though the temporal sequence here was interrupted, the important environmental changes between the Iron Age and Modern times can be examined. This transformation was already analysed in Silva-Sánchez et al. (2022) but now we can include new data from T2B and its early medieval levels. In general terms, there is a clear reduction of trees and shrubs between the Iron Age, the Early Middle Ages and the seventeenth century, which suggests increasing deforestation and clearance for agrarian activities in the area during, at least, the last twenty-five centuries.

It is also important to highlight that T1 and T2 areas are c. 500 m apart but have very different pollen signatures. This says much about the very small pollen source areas of soils, and how varied over short distances was land use. In this sense, it must not be a casualty that the earliest chronologies were obtained in the agrarian spaces of T2 area, which have a better orientation (South) and thus, higher insulation than T1. Cereal levels from T2 area are higher than those from T1, which shows that T1 area had different land use objectives, mainly linked to chestnut production. There are even micro-local differences, as shown in the abandonment phase at B1 horizon of T1C, which indicates that it remained without use earlier than T1 and T2, which were still under cultivation only 30 years ago, probably because of its lower productivity.

In a broader context, the results from Samos are consistent with other cases study in Iberia and western Europe, whether or not they were in areas controlled by important monasteries. For example, this was the case in Álava, where geoarchaeological research has dated the origin of several terrace systems to the early Middle Ages, with important transformations or even destruction in later periods, particularly between the sixteenth and seventeenth centuries (Quirós Castillo et al. 2014; Quirós and Nicosia 2019, 11). In Catalonia, recent OSL-PD research has demonstrated a long chronology for terrace construction, with dates from the thirteenth century onwards, including a seventeenth century phase (Kinnaird et al. 2017). Meanwhile, palynological studies carried out in Ireland and Iceland have shown that medieval monasteries were often founded in areas with previously well-established ecological strategies, and it is usually from the twelfth–thirteenth centuries AD that a real environmental impact linked to the monasteries can be identified (Hall 2006; Lomas-Clarke and Barber 2004; Riddell et al. 2022).

In this sense, what seems distinctive from the Samos case study is the magnitude and scale of the seventeenth century transformations. These include not only the creation or reconstruction of massive terraces, but also a genuine territorial re-organisation which can only be explained in terms of the power of the abbey in this period (López-Salas 2015).

Conclusions

The combination of different approaches provides a new vision of the landscape changes that took place in Samos in the last centuries. From a methodological point of view, one of the main results of this project is the coherence between OSL, radiocarbon, geochemical, pollen and historical data. From an archaeological perspective, the main conclusion is that the seventeenth century AD was a key era in the transformation of the monastery's immediate surroundings, with the construction of large and complex terrace systems on both sides of the valley. However, there was also evidence of earlier phases in the transformation of this landscape from the Iron Age, the eighth–ninth and the thirteenth centuries AD. This suggests that the creation of the agrarian landscape around the monastery was a long-term process with several phases of creation, use and reconfiguration of agrarian structures. The comparison among the environmental signatures from each period reveals increasing deforestation and clearance for agrarian activities in the area during, at least, the last twenty-five centuries. Our research has also shown that different terracing systems were used in each period, probably linked to different resources and objectives.

The data obtained so far suggest that the Samos area witnessed similar trends to monastic and non-monastic estates in other parts of Iberia, at least until the early Modern period. However, available data are still scarce and further interdisciplinary research is needed to discern whether the specific impetus for change came from social or religious elites or the peasantry. In any case, it is important to recognise the high level of planning behind the collective effort that the construction of the agrarian terraces implies in each period (Quirós Castillo et al. 2014, 66) allowing both the monks and the village community to create and benefit from agricultural spaces of vital importance.

Notes

1. http://mapas.xunta.gal/portada.
2. USGS EROS Archive – Declassified Data – Declassified Satellite Imagery – 3. (n.d). Retrieved December 13, 2021, from https://www.usgs.gov/centers/eros/science/usgs-eros-archive-declassified-data-declassified-satellite-imagery-3.

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