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Archaeology and Climate Change: Evidence of a Flash-Flood During the LIA in Asturias (NW Spain) and its Social Consequences.

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ABSTRACT

This paper presents the results of a multidisciplinary study of the impact of climate change during the Little Ice Age on a medieval village in Asturias, Spain. The research focused on tracing evidence for a catastrophic flood that buried the village beneath a thick layer of debris, including examining the remains of structures and agricultural land sealed beneath the debris, and considering the social and economic implications of the event in the subsequent history of the area. First, a series of test pits was excavated within the area of the modern village to map the full extent of the damage. Following this, analysis of the stratigraphy, architectural remains, datable artefacts and radiocarbon dating contributed further details, while historical evidence revealed the privatisation of the agricultural land following the catastrophe. The findings offer a snapshot of climate change and its social contexts in a specific, under-studied area with possible implications for the study of risk behaviour and disaster response in currently inhabited areas.

Introduction

In this paper we present a case study of a flash-flooding event that destroyed a medieval village in the North West of the Iberian Peninsula, forming a large and enduring torrential cone. Through this work we were able to date the flooding event to close to the beginning of the Little Ice Age, most likely between the end of the thirteenth and the mid-fourteenth centuries. Through further detailed analyses of the sites, stratigraphy and relevant historical data we have begun to outline the social consequences of the flooding and the destruction it caused in the short, medium and long term. To this end our archaeological data are supported by a geo-morphological study of the basin and an analysis of morphometric parameters to enable us to examine the likely causes and the nature of the flash-flood and its aftermath.

Van de Noort's essay on archaeological approaches to climate change stated that 'By offering long-term perspectives on human interrelationships with climate change, archaeology is well placed to enhance an understanding of the socio-ecological resilience of communities and their adaptive capacity' (2011, 1046). The idea of an instrumental archaeology at the service of studies of resilience and endurance in the face of environmental disaster is an inspiring one, but we would argue also for a campaigning archaeology of climate change that highlights the human impacts at the points where resilience and adaptation fail.

This paper aims to contribute in a modest way to the growing body of research into global warming that seeks to derive humanistic and socio-politically engaged conclusions, and drive political action. To this end we examine events in medieval Asturias in terms analogous to studies of climate change and its human impacts in the contemporary world, drawing on ideas including Naomi Klein's notion of the 'shock doctrine' and the operating methods of predatory 'disaster capitalism' (Klein 2007).

The Little Ice Age: Climate and Archaeological Context

As will be made clear below, dating evidence places the flash-flooding event described in this paper close to the beginning of the Little Ice Age. The Little Ice Age (here-after LIA) refers to a period between (roughly) 1300 and 1850 AD (Fagan 2000), when temperatures in the northern hemisphere were markedly colder than the preceding Medieval Warm period by an average of approximately 0.3°C, and 0.8°C lower than at the end of the twentieth century (Mann 2002). Alongside temperature changes the LIA was characterised by, inter alia, the growth of mountain glaciers and hydrological impacts including increased rainfall (see Morellón et al. 2011, for a discussion of these changes with a specific focus on northern Spain). While it was initially characterised as a period of consistent low temperature the LIA is now generally understood in terms of variability and instability, with considerable regional variation (Bradley and Jonest 1993; Pfister 1992). In the Atlantic region in particular, changes to the Gulf Stream at the start of the LIA contributed to irregular patterns of rainfall both seasonally and annually, while in the Mediterranean region and the Alps the same period was marked by an increase in rainfall (Benito et al. 2008).

Archaeological studies of the LIA and past climate change in general have tended to operate at regional and larger scales: this is often for sound reasons, including the need to gather large datasets over a wide and varying area to carry out meaningful analyses. This has had the effect of creating a pattern of generalised results at regional levels and above, and has also left a relative dearth of fine-grained studies on a small, settlementlevel scale. Finer-grained local area studies such as this can contribute to an appreciation of regional and temporal variations in the LIA. Studies such as this that link the climatic evidence to socio-economic processes remain rare for the earlier stages of the LIA, when there are far fewer historical sources than for the later periods. It is here that archaeological evidence can be particularly valuable.

Site and Methods

The focus of this project is Villanueva, a concentrated settlement of approximately fifty inhabitants situated in a valley of the Cordillera Cantábrica, the mountainous area in the centre of Asturias, north-western Spain (Figure 1). The village is located on the fluvial terraces of the river Trubia, a tributary of the Nalón river, and was known as S. Romano in the Middle Ages: currently S. Romano is one of its 8 neighbourhoods, seated on both sides of a torrential stream of the same name.

Villanueva is located on the narrow alluvial plain in the valley bottom, 150 m above sea level. The proximity of the river provides a range of cultivable soils. Agricultural and cattle areas are distributed around the village following the classic concentric distribution of European villages of medieval origin, with the orchards dedicated to intensive agriculture closer to the village, followed by the 'veigas' (cereal crops areas of collective regulation), forests and meadows in the slopes, occupying an intermediate position, and finally the uplands dedicated to extensive livestock farming. The total extension of the parish (San Romano) is about 6 km². The orography is very rugged which causes the majority of this small territory present important and large slopes. The climate is oceanic, influenced by the sea, with cool summers, mild winters and abundant precipitations all year rounds. During the Middle Ages, the village was under control of the Tuñón monastery. This was a major power centre at the time, organised and built around an important pre-Romanesque church constructed during the 9th century (Fernández Fernández 2017a).

Starting in 2009 a series of test pits were excavated as part of a project to trace the origins and development of the medieval village, obtaining a quantity of archaeological data including stratigraphic and soil analyses, radiocarbon dates, and material culture dating from pre-history to the present. The initial findings of these test pits forms part of an article published previously (see Fernández Mier et al. 2014). In this paper brief mention is made to evidence for a historic flood found in some of the test pits, and its potentially catastrophic impacts on the village. These flooding layers are the focus of the current analysis, focusing on two major stratigraphic sequence and the resulting geoarchaeological and palaeoenvironmental analyses.

The topography of the torrential cone, formed during the flood and subsequently altered by construction and agriculture, was reconstructed using Lidar data and GIS software. Following this, an analysis was carried out of the morphometric parameters of the S. Romano stream basin, together with estimates of the water velocity based on measurements of the larger stones trans-ported by the flood employing Costa's (1983) equations. Radiocarbon dates were obtained for three samples taken from the excavations: there were calibrated to an accuracy of 2σ with 95.4% probability (Blaauw 2010) using OxCal v4.2.2 (Bronk Ramsey 2009) with atmospheric data intcal09.14C (Reimer et al. 2009).

Results

A series of ten test pits were excavated in and around the location of the medieval village of S. Romano (Figure 2). Traces of flooding were found in seven of the ten, made up of gravel and sand layers and the remains of flood channels. The flood deposits are alluvial, deposited by flood related running water, and forming an alluvial fan. These allow us to trace the shape and extent of the torrential cone, and two test pits in particular (TP CDR and TP MUR) offered particularly detailed insights into the nature of the flood-ing event (Figure 2). Nowadays there is a torrent (S. Romano stream) that incises the medieval alluvial fan. These findings and the stratigraphic and sedimentary analyses of these two test pits are described below.

TP CDR

This test pit was placed on the western side of the research area, towards the centre of the torrential cone. It contained a stratigraphic sequence detailed in Figure 3, beginning with a series of Roman levels (notably from the High-Imperial period) (Fernández Fernández 2014a, 2014b, 2017b).

Above the Roman material were a number of strati-graphic levels and structural features dating from the ninth to eleventh centuries, which matches previous theories on the date of origin of the medieval village. These included a layer of blackened soils, context 010, amortising the first negative structures recorded (S.U. 011 and 012) and related to a period in which seem to have happened different types of agricultural and domestic use. In this layer fauna, black pottery and iron -mainly nails- are intermingled and embedded with abundant carbonised vegetable matter.

Micromorphological and geochemical data from 010 confirm the presence of abundant small fragments of domestic waste as bone, charcoal and dung dispersed in the sediments that could indicate tilling and manuring of an orchard area nearby domestic spaces or structures (Figure 4).

A detailed micromorphological and geochemical study of the medieval archaeological units from some test pits is ongoing. The results and discussion of these data are out of the scope of this paper since they are more related to the characterisation of different medieval agricultural and paleoenvironmental processes identified in the samples (MUR test pit, described below, was not sampled for the micromorphological study since it is very similar to CDR).

Context 009 contained an abundance of charcoal and organic matter but no archaeological material, and it was speculated that this may have been laid down as preparation for the structure evidenced in contexts 008, a paved level, and 007, a floor containing a hearth, both dated to the later medieval period (Figure 5). This floor level varies in thickness between 5 and 10 centimetres, and contains a considerable amount of charcoal. The hearth area is notable for the compaction of clay burned to an orange colour. This layer contained ceramics of a fine-grained fabric, varying degrees of firing and combed horizontal incisions. Faunal remains found in association with the hearth appear to be food-related. A fragment of charcoal from the fire was radiocarbon dated, yielding a date between the mid-thirteenth and mid-fourteenth centuries (Cal AD 2σ 1271–1387).

The contexts above are formed by the flash-flood. Context 006 is a one-off cutting of a channel the under-lying contexts 007-009, and filled by contexts 004 and 005 (Figures 3 and 5). The palaeochannel is filled with ordered gravels of various sizes in a layer more than 30 cm thick: analysis of the lithology and graded of these gravels confirms that their origin is the nearby stream of S. Romano rather than the River Trubia, forty metres from the test pit. Context 004 is composed of sub-rounded gravel in a sandy-silty matrix: context 005 is similar but less ordered. Contexts 004-006 were interpreted as representing two phases of the flash-flood: the first erosive phase destroyed elements of the structure and formed the palaeochannel through the site; the second sedimentary phase saw the deposition of sand and gravels. Contexts 002 and 003 over-lying these flood layers contain early modern ceramic remains dated to approximately the sixteenth century, indicating the resumption of human activity in the area following the destructive flood. Context 001 is the modern topsoil.

TP MUR

This trench is located in the southern part of the research area, closer to the River Trubia (Figures 2 and 6). The excavation is on-going at the time of writing and has not yet reached the river terrace levels, but the most recent phase of work revealed evidence of an occupied structure interpreted as a hut floor, with finds including a grindstone. Postholes associated with the structure have fills, one of which has been radiocarbon dated to between the thirteenth–fourteenth centuries. Above these structural remains there is an agricultural layer with abundant ceramic and organic materials including charcoal and animal bone. Like context 007 and 008 in the previously described pit, this agricultural layer is marked by a number of palaeochannels, and the material culture in both marked contexts is similar, with pottery of equivalent dates. For this reason, it is reasonable to interpret a contemporary late medieval date for both. Above this layer and filling the palaeochannels there are contexts made up of poorly ordered material including stone, ceramic tiles, sand, pottery, bones, gravel and sand. This thick layer appears to have been deposited by a highenergy flow rather than by decantation, and was itself cut by a second set of channels filled in turn by sand, gravel and pebbles (Figure 7).

This layer, context 002, is archaeologically sterile, and key to understand the nature and origin of the process. It is composed with laminated sands interbedded with finer matrices and clayey silts, with pockets of gravels and pebbles ordered by size. Their main lithology includes sandstone, slate and limestone of Palaeozoic origin revealing a different nature than the river Trubia barrages formed mainly by quartzites. This lithological difference means that the origin of these deposits is the stream of S. Romano and not the river Trubia. Considering the structure, morphology and lithology of the pebbles (small size, subrounded) it is concluded that this is a torrential deposit.

These two layers (contexts 002 and 003) are interpreted as phases of the same flash-flood event, a first phase (context 003) resulting from the massive transport of sediment and structures destroyed by a high energy stream in its first phase (debris flow), and a second phase (context 002) composed of deposits of gravel, areas and silt, accumulated in a phase of lower energy.

Context 002 and 003 are sealed by a layer of agrarian soil rich in pottery dating (as with the previous test pit) from the sixteenth century through to the present. Context 003 in this trench contained a number of very large stones, interpreted as building material from the village as they were interspersed with broken roof tiles (Figure 8).

Measurements of these stones were used to estimate the speed of the water flow using the formulae devised by Costa (1983) and the five largest stones (see Table 1). Accordingly with Kehew, Milewski, and Soliman (2010), there are numerous potential sources of error in this type of palaeohydrological analysis which could range from 28% of average error in small drainage basins up to 76% in large drainage basin. In conclusion the estimates presented here would be closer to the lower margin of error for small basins, but it is assumed that Costa's formula is not accurate and is based on estimates. Nevertheless, for our research this information is very useful combined with the rest of the archaeological and stratigraphic data. The result was an average speed of around 3.5 m/s. Even taking into account this probable average error the sheer size of the stones indicates a flow of considerable force, con-firmed in this case by the presence of structures destroyed, displaced and turned over.

Overall we can see four phases in these two trenches that are indicative of a flash-flood. The first are the erosion channels in the underlying contexts, the second is the deposit containing destruction materials from the medieval village structures, the third is a second phase of erosion channels in this deposited layer, and the final is a lower-energy deposit made up of sediments from higher in the flow area, and containing no archaeological materials from the settlement (Table 2).

The most evidence of the flash-flood was the creation of a torrential cone. In the test pits studied there was no evidence of alluvial cone sediments before the event excavated, only terrace sediments, gravels and silty clay, from the floodplain of the river Trubia. For all these reasons it is interpreted that it was a single event with a limited duration and chronologically located between middle and modern ages. This cone has been partly obscured by changes in land use over the intervening period: the present-day neighbourhood of S. Romano covers much of its area, and different phases of construction and landscaping have further affected the topography. Lidar data was used to reconstruct the topography of the original cone, removing the current layers of construction (Figure 2). The resulting digital elevation model allows the proximal and intermediate zones of the cone to be easily identified, while the distal extents have been identified in part through the presence or absence of flood deposits in the test pits as indicated on the map (Figure 2). In this way the size of the cone was found to be 2.2 Ha (0.022 km² or approximately 5 acres).

Most significantly, the area of the cone covers more than half of what would previously have been the most valuable arable land in the village: the fertile, flat area in the valley bottom made up of the lowest river terraces. In mountainous areas such as this, the loss of this arable land and the crops it contained would have had a serious impact on the community, depending on a number of factors including the time of year, the survival of other parts of the arable land, the size of the com-munity, its resilience and resources. The first mention of the village name 'Villanueva', the new settlement built occurs in historical documents near the end of the fourteenth century, while the radiocarbon dates of the flood indicate a date between the thirteenth and fourteenth centuries. We do not have historical documents that refer this episode, nevertheless some information about important floods from other areas of Asturias in the fourteen and fifteenth centuries founts is available. Taking this information into account, we considered the hypothesis that the event recorded in Villanueva could be the ongoing of an important instability climatic stage prior to that reported by the fifteenth century documentation.

The S. Romano Stream Basin

To understand the nature of the flash-flood it is important to describe the geology and topography of the basin of the S. Romano stream. The geological substrate on which the stream basin sits consists of Paleozoic materials ranging in age from the Ordovician to the Carboniferous, with considerable lithological variety including siliciclastic formations, and carbonated and detrital calcareous alternations. On this substrate different quaternary formations associated with gravity processes can be found as scree and colluvium. The streambed itself is extremely steep in places, with a watershed composed of limestone resulting in escarpments in some cases more than 70° and dropping from a peak altitude of around 850 m to just 166 m in the valley of the River Trubia, with an average gradient of 27.3%. Data obtained from the analysis of the morphometric parameters of the S. Romano basin obtained by GIS analysis are shown in Table 3.

The stream is formed within a micro-watershed occupying an area of 1.6 km^2 in the form of an elongated oval. The highest point of the watershed lies to the west, the Canto la Cruz, at an elevation of 850 m. Other peaks surrounding the basin include La Rasa (799 m) El Picu Castru Mayor (665 m) and El Serrón (677 m) (see Figure 9). The

lowest point of the basin is the confluence with the River Trubia mentioned above. The length of the main channel is 1.8 km, and there is one small sub-basin without a permanent watercourse. Today the main channel is an intermittent stream that is strongest in winter and during rainy seasons, and practically disappears during the summer.

The figures in the table above, and in particular the steep gradient of the stream, indicate a torrential basin with considerable potential for sediment transport. In addition, the drainage density of 1.13 indicates a very low hydrogeomorphological capacity in response to extremely high precipitation contributing to the potential for violent flashfloods. Despite this, archaeological data from the test pits indicates a long period of relative stability, with no traces of flooding between the early Roman period and the flash-flood in the Middle Ages. Therefore, there is no reason to think that the zone around the stream would have been perceived to be a vulnerable settlement area during the establishment of the medieval habitation area around the ninth century. The uses of the stream basin during this period appear to have been varied but focused around forestry and livestock management including communal grazing areas and private meadows in a landscape of bocage. The climatic instability around the onset of the LIA may have been exacerbated by agricultural pressure and particularly the resulting deforestation, which would have increased surface run-off and the rapid evacuation of rainwater. This could be considered a warning and cause for concern for the contemporary population of the area.

Impact of the Flood on Buildings and the Village

Flash floods are characterised by their sudden onsets, violent force of water, and substantial residual sediments left in their aftermaths. They can occur in a variety of climatic environments but mountainous areas are particularly vulnerable. While flash floods remain rare events they are the most lethal natural disaster in the Iberian Peninsula, with the death of 87 people on a campsite in the Barranco de Aras (Central Pyrenees) in 1996 a recent example (Alcoverro, Corominas, and Gómez 1999; Garcia-Ruiz et al. 2004). Unlike other violent climatic events the unexpected nature of flash floods and the velocity of the water makes it difficult to warn or evacuate communities in their path. According to the United States Army Corps of Engineers the water velocity in flash floods is also the main contributing factor in

the destruction of buildings in the path of the flood water: in controlled experiments a 1 m depth of water moving at 3 m/s was found to be sufficient to destroy the walls of a typical structure (McBean et al. 1988). In the early stages of a flash flood there is often a quantity of mud and detritus carried along which increases the density of the flow and its ability to transport heavy objects, such as the stones found in the test pits (Fried-man and Sanders 1978).

The archaeological evidence gathered in this article indicates that the medieval village of S. Romano was destroyed during a rapid flash flood, with water velocity around 3.5 m/s exceeding the 3 m/s figure stated above as capable of destroying buildings (Figure 8). The evidence of structural destruction found in the excavations suggests an event likely to have caused human casualties, particularly given the form of medieval buildings and the greater difficulty in emergency evacuation, as well as the limited resources for rescue efforts in the aftermath. The flood is likely to have destroyed the village in a period of minutes or at most hours, covering more than half of the arable land surrounding it in a thick layer of sterile rocky sediment. The effect on the local economy cannot be calculated, but archaeological evidence suggests that it was at least a century before agricultural activities recommenced in the area affected. At around the same time the place-name 'Villanueva' appears in records for the first time, and S. Romano survived in name at least as a neighbourhood of this village. Villanueva was principally situated on the other side of the River Trubia from the flooded area, and farmed a different area of arable land to the north of the old settlement.

People and Place

At the time of the flood it is likely that, in common with similar areas across Spain and Europe, the arable land of the village of S. Romano was managed in common by the community and managed collectively using an 'open field' system, although ownership of the land lay with the Bishop of Oviedo. If similar to the common land in the area at present, the land as a whole would probably have been enclosed within a boundary but within this boundary the division of land between families would have been agreed by custom. However, the management of the larger landscape was probably decided on a collective level, to manage processes such as crop rotation across the entire community.

Some parts of the land in cases of this type were not associated with specific tenant families and were instead allocated to different users for set periods, again by agreement. Common lands managed as open fields were a common feature of agricultural communities in medieval Europe: what is remarkable in the area of Asturias around the study area is the survival of some of these practices into the present, albeit under significant pressure both internally and externally. One of the aims of the fieldwork described in this paper is to trace the origins of these patterns of land management: while the findings remain inconclusive there is evidence to suggest that it emerged in something resembling its current form between the thirteenth and fourteenth centuries.

Changes in the patterns of use and management of common lands can be seen historically and archaeologically in the traces of past agricultural landscapes including redundant placenames, old field boundaries, and palaeoenvironmental evidence of different land uses over time. Around S. Romano today the process continues, as falling population levels lead to common land falling out of use, the breaking of long-standing associations between families and specific plots of land, and the opportunistic enclosure of areas of common land for construction or development by private individuals. The breakdown of traditional practices of common land management and use contribute in turn to a decline in community sense of place that further weakens the connections between people and the land.

The roots of this process of privatisation it is well-attested in Spanish history (Marcos 1999) during the fifteenth-sixteenth centuries when there was a pattern of seizure of agricultural land that was deemed 'vacant' or unused. Therefore, natural disasters, such as the flooding registered in Villanueva there was certainly an opportunity for social elites that followed this strategy.

In an area such as S. Romano with long-standing customary rules regulating the agricultural spaces it is only through the breakdown of these traditions that the more privileged families could privatise the land. After the natural event various acres of vacant lands were 'ready' to be reclaimed by these noble groups.

In the modern era the S. Romano district became the area of the neighbourhood where the village elites lived: this is recorded in early documents and exemplified by the Muñiz-Prada family mansion which sits in the centre of S. Romano. The Muñiz-Prada family line died out in the 1960s but was rooted in the old feudal families of the area: their mansion and private land cover an area almost identical to the space covered by the flood and the debris cone (see Figures 2 and 10).

Why, then, this concentration of social elites in an area destroyed shortly before? It is tempting to com-pare the strategy of land privatisation in the aftermath of the flood to the model of 'disaster capitalism' out-lined by Naomi Klein in her book Shock Doctrine (2007). Klein argues that elites exploit the aftermaths of crises or traumatic events such as wars and natural disasters to enact controversial laws and policies that would normally meet strong popular resistance, but which a traumatised, distracted or displaced population is unable to effectively resist. Following this pat-tern, the privatisation of land in S. Romano in the aftermath of the flood could perhaps be described as 'disaster feudalism'.

Conclusion

This paper presents evidence for a flash flood around the fourteenth century that destroyed the village of S. Romano and its surrounding lands, and buried its remains beneath a layer of rocky sediment. Based on excavations and analyses of the stratigraphy, the local topography and hydrology we have mapped the extent of the debris cone, the source of the floodwater and the likely reasons for the deluge. Due to the unique nature of the event based on excavation evidence we have pro-posed a connection to the onset of the Little Ice Age and the resulting rise in rainfall in the area. There were not alluvial cone sediments before the LIA flood, only terrace sediments, gravels and silty clay, from the floodplain of the river Trubia. In addition, we have sought to understand the human social and cultural impacts of the fload beyond the immediate destruction.

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Table 1. Estimation of water velocity based on the five largest stones from context 003.

Axis of boulders in mm	Velocity of water in metres per second, $V (m/s) = 0.18 \text{ DI}^{0.487}$ (where v is mean velocity and DI is b-axis length, Costa 1983)
540	3.854
410	3.370
510	3.748
430	3.449
400	3.330
Mean velocity	3.5 m/s

Phase	TP CDR	TP MUR
Later context	SU 003, 004. modern soils (TPQ C16)	SU 001. modern soils (TPQ C16)
Phase IV		Depositional. SU 002. Flood deposit (graded bedding)
Phase III	Depositional. SU 005-4. Flood deposits (graded bedding)	Erosive. Formation of torrential channels
Phase II	Erosive phase	Depositional. SU 003. Massive deposits from the medieval village destruction. Water velocity 3.5 m/s
Phase I	Erosive. Medieval buildings destruction and displacement by flash flood. Formation of torrential channels (SU 006).	Erosive. Medieval fields destruction by flash flood and formation of torrential channels
Previous context	SU 007-8. Medieval hut and fireplace. Chronology after s. XIII-XIV	SU 004. Medieval cornfield. Chronology after s. XIII-XIV

Table 2. Identified phases during the medieval flash-flood event registered.

Table 3. Characteristics of S. Romano basin based on GIS analysis

Description Value

Basin surface	1,60 Km ²
Basin perimeter	6,51 Km
Mean elevation	574 m (asl)
Mean slope (%)	26,60 %
Gravelius compactness coefficient. Elongated oval basin	1,44
Length of major axis	1,80 Km
Total basin length	2,5 Km
Initial altitude	850 m (asl)
Final altitude	166 m (asl)
Elevation difference	684 m
Mean stream slope %	27,36 %
Drainage density	1,13



Figure 1. Location of the study area. The bottom picture was taken from North.



Figure 2. A) Image of the village excavated and its surrounding areas with the test pits, intervention codes of two main stratigraphies analyzed and reconstruction of the torrential fan. B) Enlarged image of the excavated areas. C) DEM from Lidar, topography of the torrential fan and profile graph.



Figure 3. Stratigraphy of the excavations: IT-CDR. Radiocarbon samples and dates: S1 Cal. $2 \sigma 900-1146$ AD; S2 Cal. $2 \sigma 1271-1387$ AD; S3 Cal. $2 \sigma 1469-1635$ AD.



Figure 4. Micromorphological features of medieval agricultural activities. 1) Bone fragment. 2) Charcoal fragment. 3) Phosphatic dung nodule with calcium oxalate phytoliths. 4) Goethite hypocoatings in pores indicating iron lixiviation. The random distribution of all these features in the same layer point to anthropic manuring and tilling activity affecting surficial soils in humid environments.



Figure 5. 1) Late medieval hut floor cut by flash flood channel (S.U. 008 and 009) IT-CDR. 2) NE corner, detail of the channel cut. 3) E stratigraphic profile, detail of the channel and torrential deposit.



Figure 6. Stratigraphy of the excavations: IT-MUR.



Figure 7. Stratigraphy of the excavations IT-MUR, detail of the flash flood channels.



Figure 8. Context 003, destruction level, IT-MUR. Zenithal picture and drawing. Tiles are coloured in red.



Figure 9. S. Romano stream basin. Base map is used is a shaded relief raster derived from a DEM.



Figure 10. Muñiz-Prada manor house and its private lands. The fan toe is approximately in the centre of the picture.