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# Experimental Archaeology at L'Esquerda – Crops, Storage, Metalcraft and Earthworks in Mediaeval and Ancient Times

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## 1. Introduction

The archaeological site of l'Esquerda is placed in the inlands of Catalonia, in the town of Roda de Ter, county of Osona, 70 Km north from Barcelona. The site occupies a big peninsula of 12 ha over the river Ter. It is situated in the intersection between a fertile and plane plateau called Plana de Vic, and some scarped and bushy mountains named "Les Guilleries", crossed by the river Ter on its way to Girona and the coast. The site is only accessible from the north face where the walls were built and its particular placement makes it be an outstanding strategic location in the inlands of Catalonia, with natural protection.

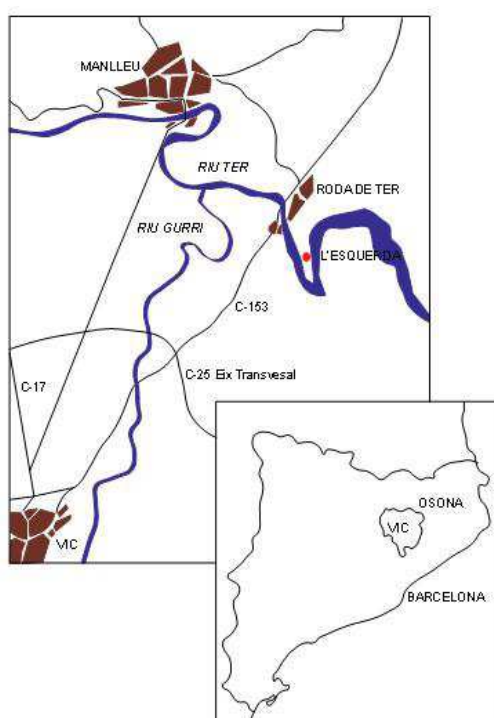


Fig. 1. Location map of the site of l'Esquerda



Fig. 2. Aerial view of the site of l'Esquerda, surrounded by the river Ter

The site was inhabited during a long period. The earliest evidences are dated back to late bronze-age, by some hand-made potteries. The hypothesis of an early Iberian phase has been recently established for the site (Rocafiguera-Ollich-Ocaña, 2011).

Later, in the 5th century BC, a strong *oppidum* was built there. The structure takes profit of the natural geology of the environment and a big wall was built in the northern face. It is a huge barrier-shaped wall, with two massive towers in its front. All the structure is made on coarse rough stones without mortar. From an archaeological insight of the destruction levels, the highest part of the structure is presumed have been built in clay.

The fortification was the main pattern of urbanism in the whole site along the centuries. Between the two entrance towers, there is a NS two-metre-wide street, with different levels of pavements. The street and walls set up a reticular plan that is followed until 13<sup>th</sup> century AD in the site (Ollich-Rocafiguera, 2002). This Iberian *oppidum* lasted until the end of the 3<sup>rd</sup> century BC. Some new constructions or architectural changes in the site have been discovered for this time. The main one corresponds to the end of the fortress. In this latest period, all the defences were strengthened: some gates were closed, some *armora* were built and even the street could have been closed by a slope wall in stone (Ollich-Rocafiguera, 2001). All of these changes seem to be due to the general instability of the Iberian Peninsula in late 3<sup>rd</sup> and early 2<sup>nd</sup> century BC, caused by Punic wars, the Roman victory and the indigenous revolutions in the earliest roman period, in which *Ausetani* took regularly part.

At the end of this convulse period, in early 2<sup>nd</sup> century BC, the *oppidum* of l'Esquerda was completely destroyed. Even though there are no evidences of direct fighting, all the walls,

towers and other defence structures were totally destroyed and became completely unusable. Afterwards, a little late Iberian town was built over the ruins, taking profit of the same prime materials. This little town with small houses, and a possible new wall weaker than the primitive one, was active during the 2<sup>nd</sup> and 1<sup>st</sup> century BC. Little archaeological information has remained from this period because of the modern agrarian fieldworks carried out in the site from 17<sup>th</sup> century, which have seriously damaged these archaeological levels.

During the Roman period there was not any occupation in the site that might have been in ruins by this time. Meanwhile, a new roman city, *Auso*, was growing 5 km southwest - where now is Vic (the mediaeval *Vicus Ausonensis*), the new capital of the county.

L'Esquerda site was newly occupied during Visigothic times (from 5<sup>th</sup> to 7<sup>th</sup> centuries AD). Presumably this new occupation was due to the instability in the area caused by the crisis of Roman Empire. A big silo field, dated by Radiocarbon from those times, has been found in the backside of the old walls. At the present time, 66 silos have been dug, but the silo field seems to be much bigger. The silos were built inside the Iberian levels, and only their bottom part has remained. These pits were used for grain storage, as palaeocarpological analysis reveals. In some of them the covering rounded-shape stone has also been recovered. However, they were used as garbage holes at last, when being out of use for storage. They are all filled with stones, pottery and specially with a lot of fauna bones recently studied (Valenzuela, 2008). This silo field seems to have been in use for a long time, since there are some structures built over some others which were already destroyed, and it seems to correspond with a visigothic settlement, probably the *Rota Civitas* mentioned in written sources (Ollich, 2000)

In late 8<sup>th</sup> century BC the place of l'Esquerda was occupied by Frank Carolingians in order to establish a frontier in the river Ter against Muslims. They tried to stop them going to northern Europe through Pyrenean mountains. At l'Esquerda, Frank people probably reused the ancient Iberian and Visigothic stone-made fortresses, but they also built some new ones made with wood. The post-holes and spaces carved in the rock seem to correspond to this phase, when some round wooden towers were built to control the river and the land around it. L'Esquerda is really well located, with a complete view from the south to the Pyrenean Mountains and the way to the north. Also, in this point, the river goes to the east, to Girona and the coast. So, for Carolingians was so critical to control this place, to defend Girona (that was given itself to Carolingian Empire of Charles the Great in 785 AD) and to stop the Muslim armies in their way to Narbonne. L'Esquerda was called *Rota civitas*, using the old visigothic name.

All these first Carolingian wooden structures at l'Esquerda were destroyed in 826 AD, during the rebellion of Aissó, a pro-muslim indigenous chief that tried to get out Carolingian, occupied the site and controlled the river until 875 AD. At that moment both the county of Osona and the bishopric of Vic were reorganised. Documentary evidences mention a first church in l'Esquerda in 927 AD, and archaeological works had shown the remains of its *presbiterium* and its stone altar. This high-mediaeval church was surrounded by a necropolis with anthropomorphic graves. Some little stone houses gradually grew around it too (Ollich, 2006).

At some point between 10<sup>th</sup> and 11<sup>th</sup> century, l'Esquerda began a complete urban reform and a new church, consecrated around 1040 AD, was built. It followed the new norms of

Romanesque art that bishop Oliba of Vic had introduced in the region. At the same time, some new stone houses were built inside the *sacraria*, a sacred space of 30 meters around the church in order to profit of its protection. They used both stone and clay for walls, with wood timbers and tiles for roofs. Archaeological works show this was a very good period for l'Esquerda: all the town was growing around the church, with a square and a long street with stone buildings in each side, a smithy, a granary, some water tanks and other structures. This low-mediaeval village expanded until last 13<sup>th</sup> century, when some problems of agricultural production began, and some fights between the feudal lord of Cabrera and the King took place. In 1314, during one of these fights l'Esquerda was absolutely destroyed and its population moved to the new parish near the bridge (Ollich et al., 1995)

## 2. Principles of experimental archaeology

The discovery of a 13<sup>th</sup> century granary belonging to the latest period of the mediaeval village of l'Esquerda, and the palaeocarpological data obtained from the sediment found inside opened the chance to research about experimental archaeology. The first step of the project was to get in touch with Dr. Peter J. Reynolds, director of the Butser Ancient Farm (Petersfield, England), a research centre devoted to experimental archaeology. In collaboration with Butser Ancient Farm members, the basis of the project of l'Esquerda were established, together with the theoretical principles that would be followed in the site (Reynolds, 1988, 1996).

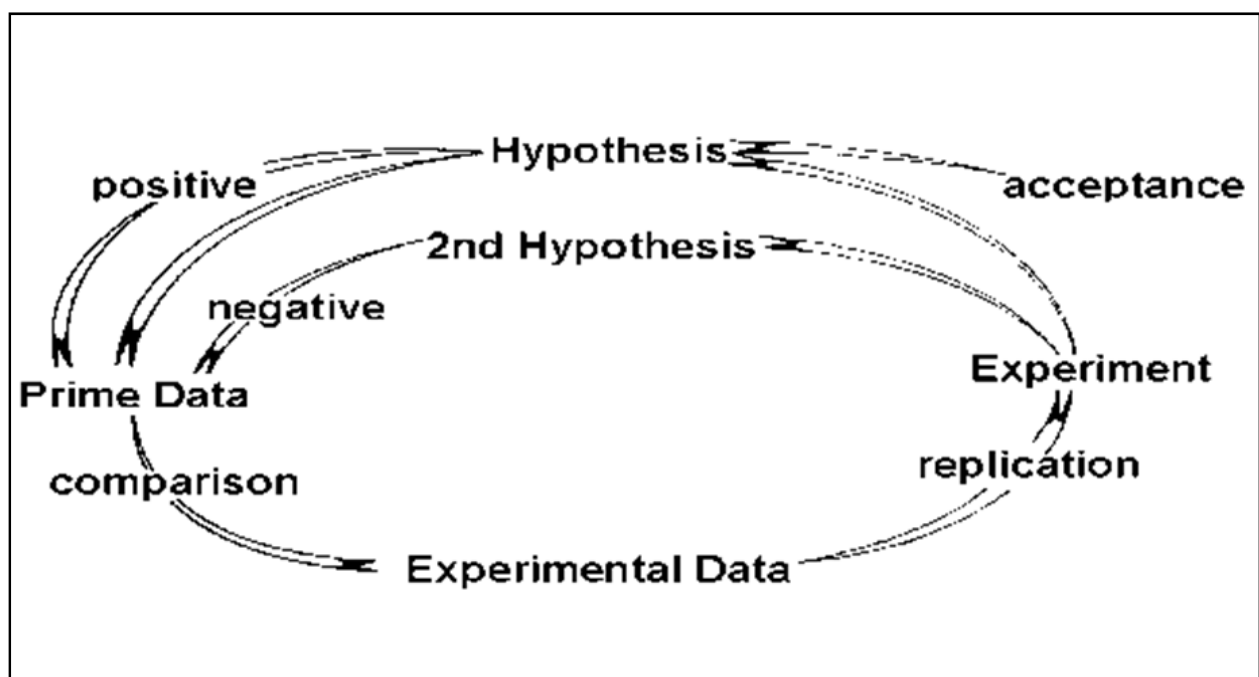


Fig. 3. Principles of Experimental Archaeology, by P.J.Reynolds

Thereby, in the site of l'Esquerda, experimental archaeology was directly learnt from Dr. Peter J. Reynolds who became a member of the research team. Experimental archaeology is a scientific research method to get experimental evidences by experimenting to verify or deny archaeological hypotheses. The methodology is always based in experiment - an

organised in a systematic way of proving or disproving a specified hypothesis- that must be previously planned, and capable of replication. Hypotheses from archaeological data must be proved only by empirical data obtained through experimentation. In 1991, a long-term project of experimental archaeology was started in l'Esquerda. We named it LEAF Project. Since then, five three-year research projects have been carried, all of them funded by Spanish *Ministerio de Educación y Cultura* (DGICYT Projects).

All the research works are carried on in the AREA (Archaeological Research Experimentation Area), a land in front of the site, specially consecrated to experiment in archaeology, that was gently given to us by the Town-Council of Roda de Ter. There is also a laboratory to work in. All together is used as an Open Air Area to research, to learn and to teach about experimental archaeology.

The first project, *Experimental archaeology, application to mediaeval Mediterranean agriculture* (DGICYT, PB90-0430), aimed to establish the basis of a long-term agricultural study. The design of the experiments consisted on four fields where 3 year and 2 year rotation were studied, together with autumn and spring sown. In the same project a haystack was built, and also two ditch-and-bank structures to study the processes of erosion and sedimentation.

The second project, carried out simultaneously with the agricultural one, was named *Experimental Archaeology. Storage constructions in Middle Ages* (DGICYT, PB94-0842), and had the goal of building an exact real-sized replica of a 13<sup>th</sup> century granary identified at the site, and some underground silos. The aim was also to solve a lot of questions about mediaeval framework and constructive techniques.

In the third project - *Experimental archaeology: Tools and agricultural techniques in Middle-Ages* (DGICYT, PB98-1241) - the aim was to deep insight all the necessary implements for the agricultural process, from the ploughing to the storage in granary and silos. This third project, together with the discovery of a blacksmith's in the mediaeval site, opened the need to learn more about metal craftwork. This was the most important goal in the fourth project: *Experimental Archaeology: technologies of metallurgical production in mediaeval agriculture* (DGICYT, HUM2004-5280/HIST). In this time an iron furnace was built and experimentally used, and also a bronze smelting kiln was built and tested.

Finally, the fifth project *Experimental Archaeology: ethnoarchaeological application to experimental agricultural processes in Middle Ages* (DGICYT, HAR2008-00871/HIST), wants to close the experimentation about the agricultural cycle and its ethnoarchaeological aspects. So, new experiments have been carried about building and burning haystacks, about evolution and reparation of agricultural structures, like the granary, the silos and the iron smith's, and also to food processing, with experiments of milling, and cooking bread in a hand-made bread oven.

Twenty years of experimental archaeology in l'Esquerda have given a great amount of results, and also some new solutions for the interpretation of archaeological data in the site. So, experimentation has been demonstrated as a very important way to the knowledge of some aspects of the history that otherwise would have been impossible to clarify.

### **3. The LEAF agricultural project: 20 years of experimental crops**

Among all the experiments carried out at l'Esquerda, the growing of ancient species archaeologically registered in the site is the most important one. The origin of this

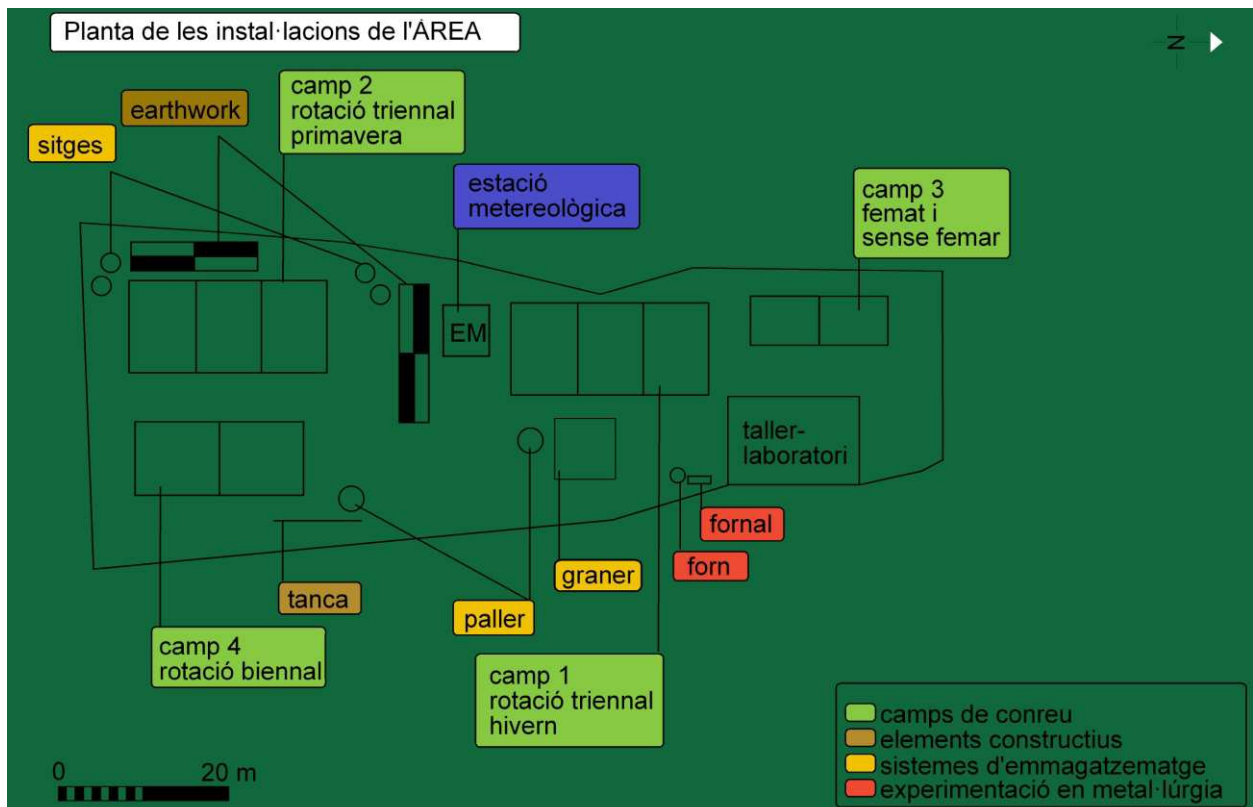


Fig. 4. View and map of the AREA (Archaeological Research Experimental Area) at l'Esquerda

experiment is related to the discovery, in 1986, of a mediaeval granary with a lot of evidences of the kind of seeds that were cultivated in the zone during Middle Ages. The experiment reproduces in the AREA the three-field rotation system (cereals-fallow-beans) in winter (Field 1) and spring sown (Field 2), the two-field rotation system (cereals-fallow) (Field 4), and crop production in manured-fertilized and non-fertilized soil (field 3 A & B).

All the cereals planted were detected within the palaeocarpological analysis of the granary soil. The main species identified, and consequently plated in the experimental fields, are: emmer wheat (*Triticum dicoccum*), einkorn wheat (*Triticum monococcum*), spelt (*Triticum spelta*), rye (*Secale cereale*) and barley (*Hordeum vulgare*). In the three-field rotation system, emmer wheat, einkorn wheat and barley are combined with beans (*Vicia faba* var. *major*), together with fallow (Cubero et al., 2008; Ollich-Cubero, 1989, 1990).

During the crop's season a set of controls are developed: the ploughing of the soil has eventually made by a traditional plough pulled by a mare. In these cases we studied how the soil was removed and how deep reaches the plough into the soil. Then the same kind of ploughing has been usually reproduced by mechanic means.

There are two ways for planting, both of them registered in ancient agriculture. One is throwing the seed, like is shown, for example, in the Bible (Mt, 13); the other is planting the seeds in 30 cm apart furrows. This last technique is widely registered in medieval times, especially in areas and periods with difficult life conditions. Planting in furrows, even though requires a longer time for planting, requires much less expertise and allows saving a lot of seed. In l'Esquerda planting is made in this second way that allows, in addition, being more precise in the yield analysis (Ollich-Rocafiguera-Reynolds-Ocaña, 1998).

During the growing of the plants, their average measurement and eventual information about insects, weeds and meteorological events are weekly controlled.

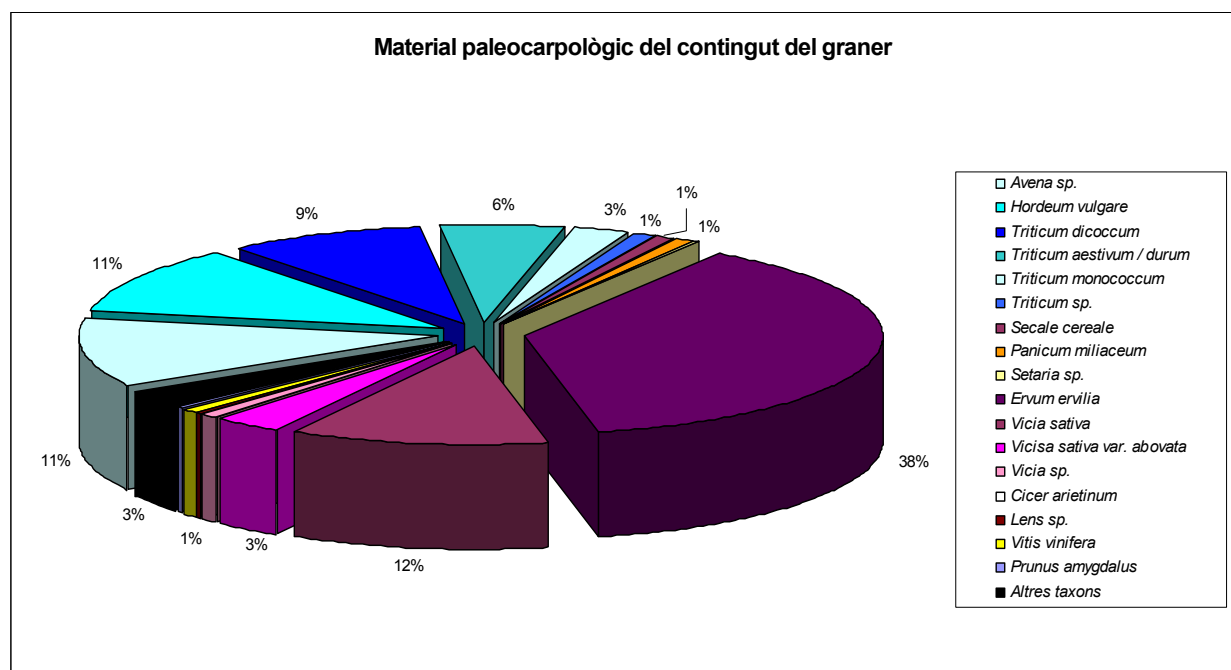


Fig. 5. Palaeocarpological seeds identified at the mediaeval granary



<b>CEREALS</b>	UBIQUITY (N:15)	TOTAL (NR:413)
<i>Avena cf. sativa</i>	1	19
<i>Avena sp.</i>	1	4
<i>Hordeum vulgare</i>	3	19
<i>Panicum / Setaria sp.</i>	1	1
<i>Panicum miliaceum</i>	3	5
<i>Setaria sp.</i>	1	1
<i>Triticum aestivum / durum</i>	5	35
<i>Triticum dicoccum</i>	5	14
<i>Triticum sp.</i>	4	7
<b>LEGUMES</b>		
<i>Ervum ervilia</i>	2	5
<i>Lens sp.</i>	2	2
<i>Vicia / Lens sp.</i>	1	1
<i>Vicia / Pisum sp.</i>	1	12
<i>cf. Pisum sativum</i>	1	1
<i>Vicia sp.</i>	1	1
<b>FRUITS</b>		
<i>Prunus sp.</i>	1	1
<i>Vitis vinifera</i>	6	84
<b>ADVENTICIOUS</b>		
<i>Agrimonia eupatoria</i>	1	1
<i>Agrostemma githago</i>	1	2
<i>Anthemis cf. praecox</i>	1	30
<i>cf. Aphanes</i>	1	1
<i>Asperula arvensis</i>	1	2
<i>Bromus cf. sterilis</i>	1	2
<i>Caryophyllaceae</i>	3	3
<i>cf. Chenopodium</i>	1	1
<i>Galium aparine</i>	2	2
<i>Gramineae</i>	5	27
<i>Lithospermum arvense</i>	1	2
<i>Lolium sp.</i>	2	74
<i>Nigella sp.</i>	1	1
<i>Plantago lanceolata</i>	2	2
<i>Rubus fruticosus</i>	1	1
<i>Rumex cf. crispus</i>	1	3
<i>Urtica dioica</i>	1	2
<i>Veronica hederifolia</i>	1	2
<b>OTHER</b>		
<i>Avena sp. (raquis)</i>	1	3
<i>Gramineae ( base espigueta)</i>	1	7
<i>Gramineae ( fragment espigueta..)</i>	1	2
<i>Gramineae ( pellofes, glumes, canya..)</i>	1	50
<i>Gramineae ( raquis)</i>	1	6
<i>Hordeum vulgare (raquis)</i>	1	10
<i>Triticum sp. (base espigueta)</i>	1	5
<i>Triticum sp. (raquis)</i>	1	1
<i>Vitis vinifera (peciol)</i>	2	2

Fig. 6. List of plants at the AREA of l'Esquerda



Fig. 7. Seeding, growing and harvesting process in the fields of l'Esquerda

A further set of measurements is made before the harvest. The most important one is the average stand heights of a statistical part of the plants (500 or 300 per field). These data allow comparing the annual process of growing, and contrasting this process with the meteorological data in order to obtain also information about the process of soil depletion. At the same time a survey of weeds growing into the fields and around is made in order to obtain information about variations in the weather and correlations with some weeds and good harvests or crop failures. An average extension of 5 m<sup>2</sup> is harvested separately from the rest of the field. For each squared metre of planting, all the ears are cut, counted and weighed. A sample of them will be chosen for a more fine analysis to recover the amount of fruiting heads, and the net weight of the production.

Harvest is made in a traditional way. The ears and the straw are cut together with a sickle. They are put together in sheaves that allow the grain becoming completely dry. Then, at the threshing hall they are threshed with a wooden engine named *batolles* in Catalan –similar to a flail- that permits to put apart the straw from the grain. In l'Esquerda straw has been used for building haystacks and to experiment with them, and the grain is analysed and is used for the next season planting.

Emmer wheat in autumn sown in a three field system is the most regular species that has a better yield (between 1:9 and 1:18); in contrast, barley in winter sown has totally

disappeared. Spelt and rye used to grow properly when other crops have been fallen, and spring sown, even though has a minor return, helps to strengthen the annual harvest when winter has been too dry or too cold for the autumn sown crops.

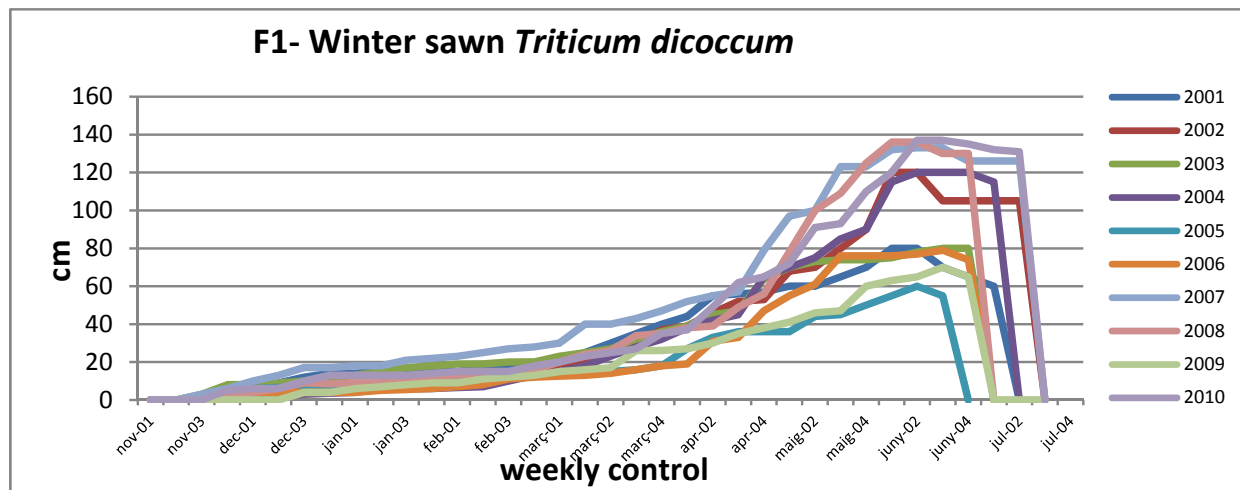


Fig. 8. Growing of *Triticum dicoccum* per months

Nowadays, after 20 years of crops, we have obtaining promising results that supply some lacking information about crop yields, the process of soil depletion, and the total link between agriculture and climatology in ancient times. The most important conclusion is that there is an absolute correlation between meteorological data and production crops, especially with variation in rainfall and temperatures during a 20-years-long period; besides, depletion of the soil is not significant during the same period. The annual yields are very variable and no regular pattern has been observed. There are many crop failures, in different species; that makes totally necessary the polyculture. Some total crop failures have been obtained in 2005 and 2006, not for any particular cataclysm occurred, only due to a bad storm before harvesting.

#### 4. The building and storage experiments in silos and in a granary

In the archaeological site of l'Esquerda two storage systems have been documented: in silos -underground pits- and in a built granary. The granary found in the site dates back to middle ages, in 12<sup>th</sup>-13<sup>th</sup> centuries AD, and the silos mostly belong to 6<sup>th</sup>-7<sup>th</sup> century AD, in Visigothic times. Some Iberian silos are also found in the far end of the meander.

In order to know better how those grain stores were built, how they were working, and how much efficiently their function was, some replica of them have been made in the Area of Experimental Archaeological Research at l'Esquerda. In 1993 two silos were excavated in the soil and the rock and they were filled with modern barley. These silos have been submitted to different tests: they were filled, emptied, cleaned, burnt, etc. In 1997 the building of a full-scale granary was started, following the hypotheses generated by archaeological data.

##### 4.1 The underground silos

The first storage experiment in the area took place between November 1993 and December 1994. It was a storage experiment with modern barley in two silos excavated in the soil, in

order to check the evolution of the grain in a six month period and 12 month period respectively.

Silos were excavated in the soil in a depth of 90 cm and 1 meter until reaching the bed-rock. Two different layers were dig out; the first one was arable soil, and the second one contained a great deal of marl – eroded calcareous rock- fragments. They have a pear-shape, with the shore narrower than the bottom. No kind of plastering has been applied around edges. Both were filled up with grain, covered with a round-shape thin rocky cap, and they were sealed with clay and topped with soil. Some engines to measure the inside temperature were placed there (Reynolds, 1998).

The first silo was filled up with 275 Kg of barley. It was opened in June 1994, after 6 months of storage. The grain was in excellent conditions with a post-germinability of 90% in the central sample of the silo, and of a 87,8% in a side sample, nearer to the edge. The calculated lost index is lower than 4%. The grain is only lost when it is directly in touch with the silo edges, the soil and the cover. There were no evidences of microflora contamination, except for the interficies between the grain and the silo edge; nor were they evidence of rodents or microfauna attacks.

The second silo was filled up with 400 kg of barley and was opened and emptied in December 1994, after 12 months of storage with similar results.

After that, a new experiment was planned, in order to clean the silo of grain remaining in the inside wall after being emptied, and to prepare it for further uses. The aim was to burn it. During that June we were suffering a really hot summer and so was a very dangerous period for firing, so this operation was delayed until September. This experiment was planned because in the surroundings of archaeological excavated silos and inside them, a test of magnetic susceptibility suggested that these structures could have been submitted to high temperatures. Consequently we presumed that silos might have been burned to be cleaned and reused.

The result of this burning process has been also very interesting to see how fire behaves inside a silo. The fuel was made with little bits of dry grass and small tree branches in the bottom. After some half an hour, the husks of the seeds start to carbonize, and only some quarter of an hour later fire explodes inside the silo, with some meters high blazes.

When fire stopped, all the rests of grains were completely burned, and so did the possible insects and microorganisms. In a few hours the pit could be completely cleaned, giving it a scrape around the entire wall and throwing away the ashes. And then the silo was ready to be used again.

Many other experiments have been carried in the silos after this one. They have been refilled many times, in different durations, different periods and different species. One of the silos was filled up and left *ad infinitum*; another one was emptied after 1 year and a half. This time ashes coming from the burning were put over the barley seeds together with topsoil, in a 5-6 cm layer. They also remain ash evidences in the edge of the silo. This could be the explanation of this kind of remains inside the archaeological silos, which are often interpreted as a preparation of the silo's walls before a new storing.

After ten years of the abandonment *ad infinitum* of the silo, in June 2004, it accidentally collapsed under a person's weight. The silo appears totally empty, with very clean edges.

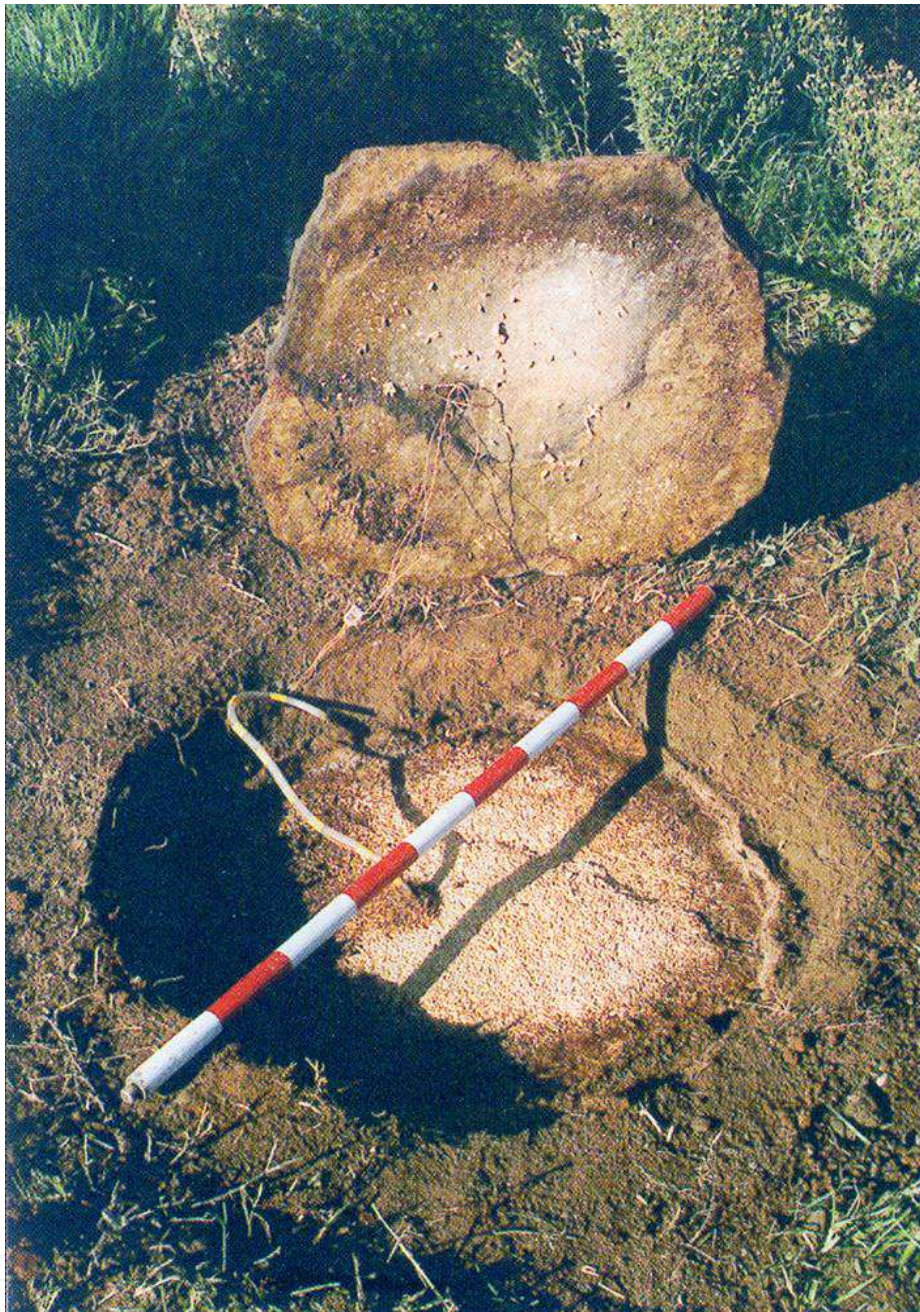


Fig. 9. Silos's opening process after six months of experimental storage

The covering stones and soil had totally disappeared. Some samples of the sediment have been taken, in order to check if there are still remains of seeds. This datum is especially interesting, because Peter J. Reynolds assumes that the life of a silo can be around 10 years. Even though this assessment is not demonstrated, the author uses economical reasons to this statement (Reynolds, 1988: 111). He rather refers the deterioration that silos can experiment after continuous processes of filling and emptying, that has also been demonstrated experimentally. Silo number 2 was filled in 2005 and in 2007 in one-year storage process. Both experiments failed. Probably the silo has ended its life. It is, however, very interesting that a long-term abandoned silo and a continuously used one were lost in the same period of time.

#### 4.2 Building and using the granary

The construction of a full scale replica of the granary is based upon the archaeological excavation, done in 1986, of a building identified as a mediaeval granary. It had an initial rectangular plant that, after a fire, had been transformed into a squared plant. The result was a 5 x 5 m building. The excavation gave light about its function, features and contents, and the stratigraphy was very clear: (1) the upper part showed the arable soil on the top; (2) under the topsoil there was a demolition layer from the walls with freestones and clay, and with remains of burned wooden timbers and tiles from the roof; (3) under this layer, a 5-10 cm thick burnt level was found, situated over the soil rock (4). There was also a very thin layer of plaster over all the inside walls, and a lack of common domestic material, like pottery or animal bones, was observed (Ollich-Cubero, 1990). All the sediment samples were kept separately by sectors to be analysed, and up to 32 different plant species have been identified (Ollich-Cubero, 1992). The soil was also protected by plaster and in the doorway there was a clay mortar 5 cm thick layer. In the rock soil there were many little carved holes, put in a strict order which were limiting rectangular spaces (1 x 1,50 m approx.) to divide the room into compartments.



Fig. 10. The granary of 13<sup>th</sup> century in process of excavation

Concerning the building framework, archaeological remains showed a structure built with stone base walls, measuring about 1 metre high and 70 cm width. As in other medieval structures, the rest of the wall would have been built with adobe wall (Cat. *Tàpia*; Fr. *pisé-de-terre*), and the covering would be made by oak wooden timbers and tiles. Inside, the building presented a plastered soil and stone wall, and a set of compartments or containers

separated each other by a vegetal fence sustained by posts and post-holes carved in the rock. These containers were covered with chalk to protect and isolate them. This kind of fence has been deduced from post-holes, little burnt branches, and also from the wooden prints left in the burnt clay, that have been conserved inside the granary. The door opened to the south and it was protected by a clay step of 30 cm width and 5 cm high. This step had 3 little squared holes that seemed to correspond to a closing-system for the door. No wooden remains have been found into them.

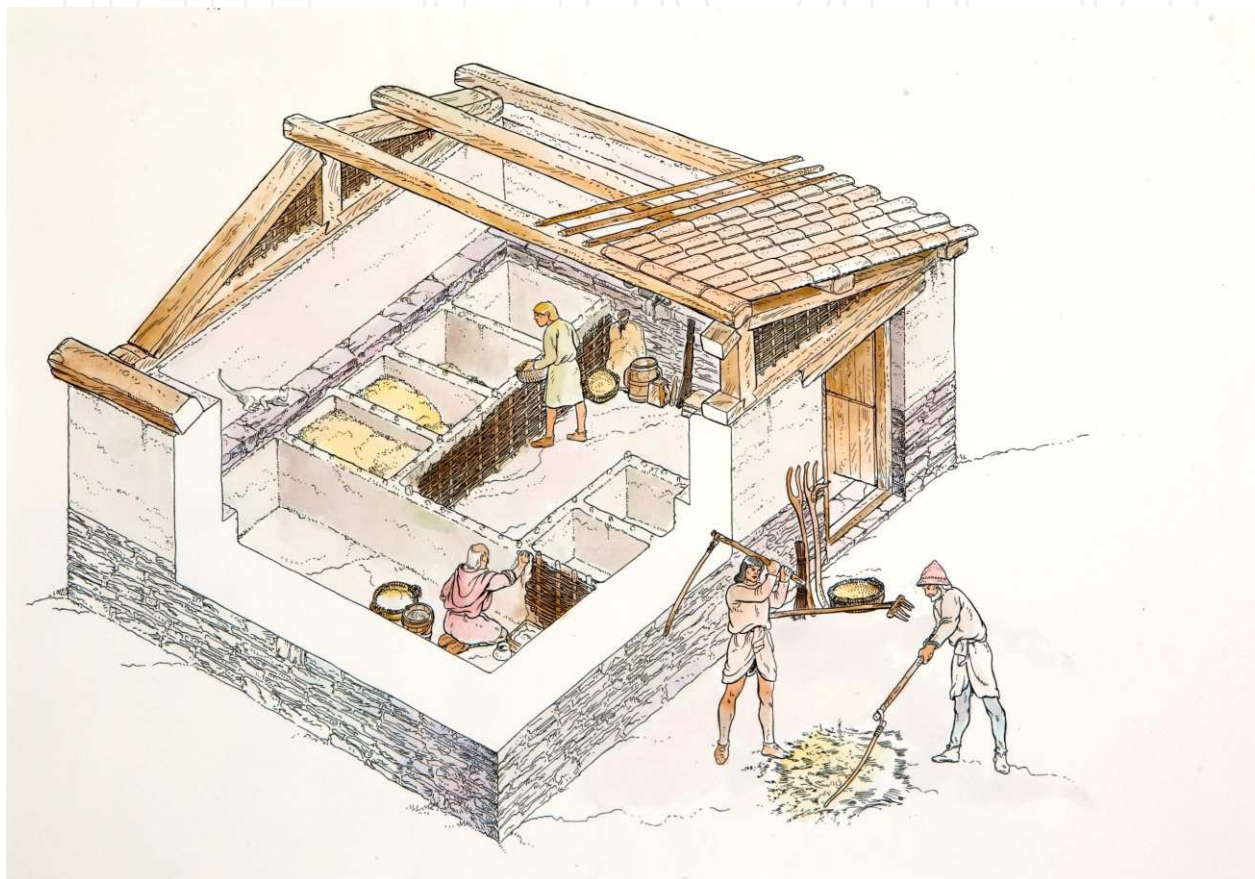


Fig. 11. Hypothetical restitution of the mediaeval granary (drawing: F. Riart)

In 1997 the full-scale replica of the granary was started. The full process ended in 2000. Ten years later, in 2010, different reparations have been needed. During the experiment, the amounts of stone used and the chalk and sand needed for mortar could be evaluated. Wooden formworks, in Catalan called *tapires*, were made in order to build the *tàpia* or adobe walls, using local clay soil, after a deep research in traditional architecture. The appropriate kind of roof needed also to be discussed, because, apart from materials that appeared in archaeological levels, the final shape of the roof is based in hypotheses.

Once the granary was finished, one of the containers was filled up with modern barley in order to start the experiments of storage in an aerial structure. The first container was emptied in 2003, and the loss and conservation of seed were analysed. The data obtained could be compared with the storage's experiments in underground silos.



Fig. 12. Building the experimental granary at l'Esquerda in 1998, with P.J. Reynolds standing near the adobe wall



Fig. 13. The experimental mediaeval granary and haystack real size at l'Esquerda

## 5. Metallurgy and production of agricultural tools

In 1996 a mediaeval blacksmith's was discovered in the archaeological site of l'Esquerda, which provided a lot of information about the mediaeval process of metallurgy; in the Iberian part of the site, also a blacksmith's had been found (Ollich-Rocafiguera, 2000). Moreover, the site has provided a great number of iron instruments and artifacts used in the agricultural tasks (sickles, hoes, billhooks, knives) and in agrarian construction (nails, bolts,



etc.). All of these findings present a very interesting research line in experimental archaeology in order to know the infrastructure, the workshop, the materials and techniques to made metallic implements.

Archaeometallurgical study of agricultural tools found in the site has allowed knowing the composition or the techniques of working with metals, by means of metallographical analysis. For instance, the metallographical observation of a small sickle found in the blacksmith's confirms that it was in transformation process (Amblàs-Molera-Ollich, 2008).

In the experimental Area of l'Esquerda, the inner structures of the 13<sup>th</sup> century mediaeval blacksmith's have been reproduced: a smith furnace for forging iron and a bucket furnace for smelting bronze and other metals.

The smith's furnace is very simple: it is made by a small depression surrounded by coarse stones, where charcoal is placed. In one edge there is place for a bellows that will allow reach the right temperature for heating iron to be worked (800-1000°C). An anvil to hammer the hot iron and a water tank for tempering the iron, are all infrastructure that is needed for making iron tools.

The bucket furnace is made of clay mixed up with grog (Fr. *chamotte*), in order to reach high temperatures without cracking. It has a tubular shape, with a small entrance on the low front part and a hole in the top for the smoke. Its fuel is also vegetal charcoal. Bronze, copper or lead are shattered in small bits and put in a stone crucible. Furnace reaches the 1000-1100°C necessary for smelting the metals. The liquid metal is poured into a mold, and polished after cooling.



Fig. 14. Experimental smith's furnace and bucket furnace at l'Esquerda

All these experiments on ancient metallurgy, largely reproduced, have allowed us verifying archaeological hypotheses about production process of metallic instruments, and they have evidenced the little infrastructure that is needed for the forge of agricultural tools and for the production of smelt copper alloy objects. Data supplied from experimental archaeology and archaeometallurgy must be completed with an ethnoarchaeological study, paying special attention in the use of the tools: the moves, the techniques and the work organization. All this information can be compared with archaeological remains.

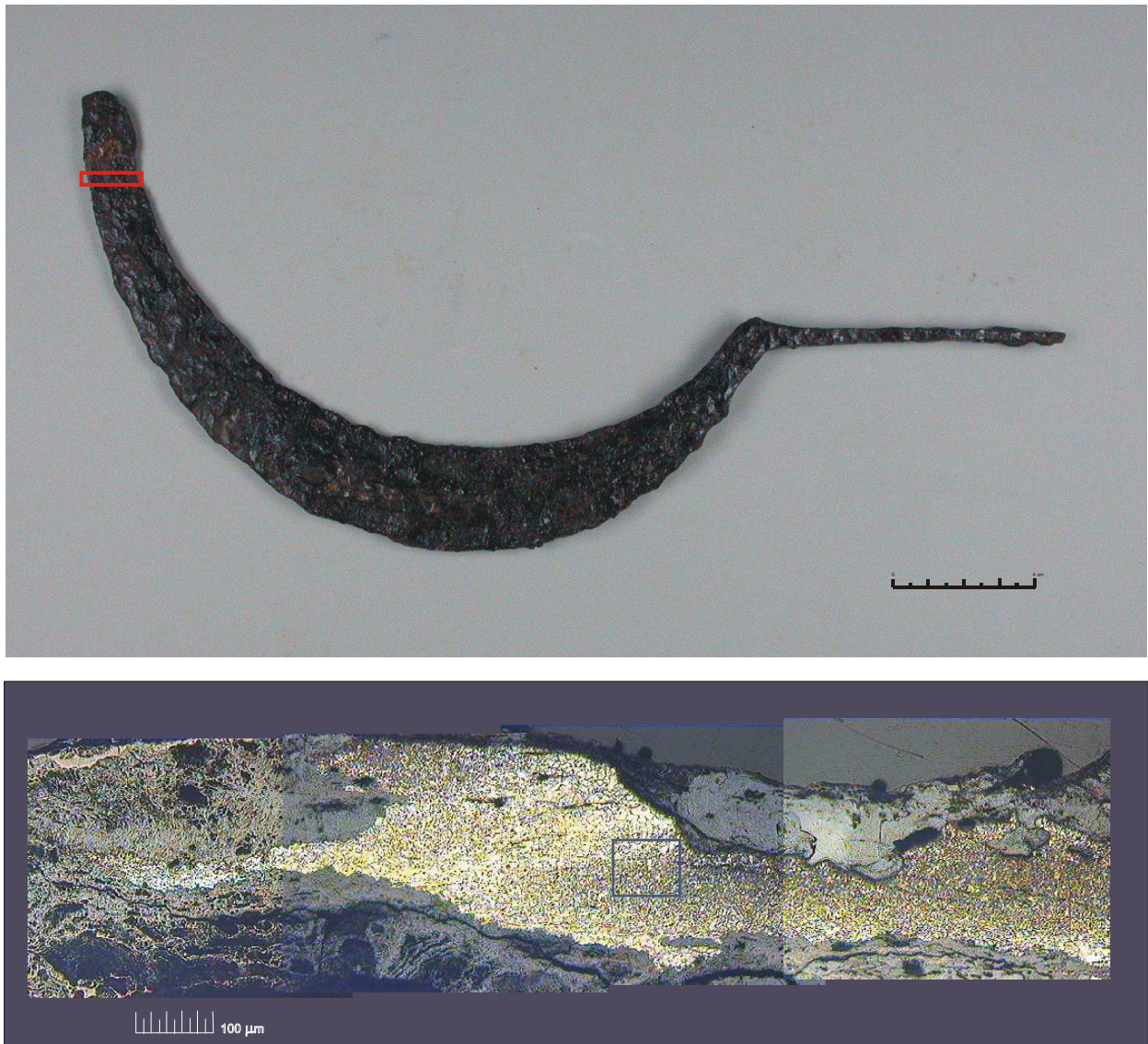


Fig. 15. Iron sickle found at the mediaeval site of l'Esquerda and its metallographic analysis



Fig. 16. Experimental process of an iron sickle forging and production

## 6. Other experiments about erosion, sedimentation and burning

Many other experiments are carried in the Area of l'Esquerda. Since 1991 a set of experiments about erosion, sedimentation and destruction of structures are in process.

### 6.1 The earthworks

The earthworks at l'Esquerda are two ditch-and-bank structures built between 1993 and 1994, one in North-South direction and the other one in East-West, that have been built to control their own process of erosion and sedimentation. Both of them are divided in four parts, in order to control the erosion under all conditions. The East-West ditch measures 16 m long per 1,50 m wide per 1,50 m deep (Ollich-Reynolds-Rocafiguera, 1993), and was carved into the rock, so its soil level was the bedrock itself. The eastern part has the bank in the south, made of soil and the broken rocks obtained from the ditch. A half of its part has a berm, and in the other one the bank lies directly in the edge of the ditch. The western part has the bank in the north and it is also divided in two parts, one with a berm and other without it. The North-South ditch was carved into the soil and has the same structure and the same measures of East-West one. The bank in the northern part is in the East and it is also divided in two, and the southern part has the bank in the West.



Fig. 17. Ditch-and-bank East-West

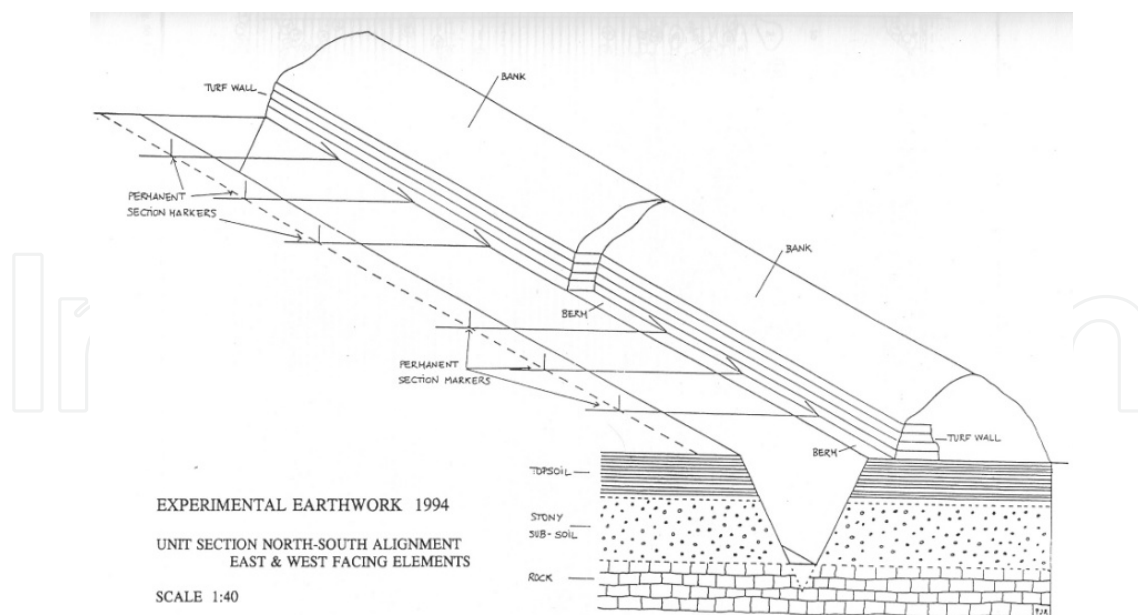


Fig. 18. Experimental earthwork at l'Esquerda, with the ditch-and-bank (Reynolds 1998)

The aim of this experiment is to check if this kind of defensive structures, which are very common in northern Europe, could also work in the Mediterranean areas. The *a priori* thought was that, because of the Mediterranean variable climate and the stronger rainstorms, ditches would be quickly filled up in a little time, so the structure would be unusable. The experiment was designed in order to be compared with the ditch-and-bank structures built by Dr. Reynolds in England: one in the grounds of the National Science Museum Reserve Collection at Wroughton, near Swindon in 1985; a second one in the grounds of Fishbourne Roman Palace, Chichester, Sussex in the same year; and a third one was built at Butser Ancient Farm at Bascomb Down (Charlton, Hampshire) in 1992 (Reynolds, 1998: 154).

Since 1994 a study of plant colonization is carried every year in spring, and a profile of the erosion of the ditch into the bank is outlined. The fact is that even though the weather is less stable in Catalonia than in England, plant colonization is much faster, so plants are ready to contain the soil erosion much earlier. Fourteenth years later earthworks were totally stable and fully colonized by plants. The last part of experiment is still to be done. In the near future, the two ditches will be surveyed and fully excavated in order to recognize how their stratigraphy has been formed.

## 6.2 The wooden fence

In 1995 a wooden fence of 6,60 m long and 1,20 m high has been built in the experimental area of l'Esquerda, as a long-term experiment. Twelve post-holes of 10 cm depth have been carved in the rock, following a serial of post/holes found near the castle of Savassona, a site near l'Esquerda. New experimental posts were made of oak (*Quercus pubescens*) timber, and the fence with hazelnut (*Corylus avellana*) outbreaks cut in early spring in a place near the site at the river (Reynolds, 1998c).

Since its building, the fence has been under control, in order to study its degradation process. No reparations and no maintaining works have been done. After three years of

stability, the degradation process has started by plant colonization, mostly by blackberry plants. Now most of the long hazelnut timbers have disappeared, and also have done some oak posts. In a few years, when the process of destruction will be completed, this area will be surveyed and excavated. All the data obtained will be useful to research perishable structures in archaeological sites.



Fig. 19. The wooden fence at l'Esquerda in process of erosion

### 6.3 The haystacks

Haystacks are organic and perishable structures which take part of any cereal agrarian landscape, even though mechanization has made them disappear from modern fields. Inside the experimental archaeology project developed in the AREA of l'Esquerda, some of these structures have been built with a double purpose: first, as a necessary part of the agrarian storage project, second, to recognize the evidences of these structures in the archaeological soil.

An experiment about destruction is been carried with haystacks. Two of them have been built in 1992 and 2000, the first one made with hay and the second one with straw. After building, they have been abandoned and the degradation process has been under control (Ollich, 1998). Nowadays, the first one is almost disappeared, due to organic decomposition. The other one is still in putrefaction process.

In July 2010 a third haystack was built with straw. It measured 2,50 m high per 3m diameter, and 600 kg straw was used to build it. Seven months after its building, in February 2011, this haystack was burnt in order to study the complete combustion process and the archaeological evidences remaining in the soil. All of the registers about the process have been taken. In November 2011, burnt soil has been surveyed by geo-radar. Then the half south part of the haystack surface has been excavated. The other half part will be excavated in the future, when it would be more degraded (Ollich/Rocafiguera/Ocana 2011& 2012). The study and comparison of all these data will allow us to recognize some little archaeological burned evidences or some post-holes in relationship with perishable structures like haystacks.



Fig. 20. The haystack n.3 in process of building and burning

## 7. A perspective of future

The LEAF project about Experimental Archaeology carried out at l'Esquerda since 1991 until nowadays allowed us to obtain a lot of data that can be compared with archaeological remains. So in the next future, we will carry on with new experiments.

The results of the experiments about ancient crops, storage and earthworks are very useful to understand how and what did ancient people for building, planting and storing. After twenty years of experimental research, we know a little bit more about the field production and its relationship with meteorological conditions, the people's diet, their techniques to work wood, stone and metal, and the framework and organisation of their living. It is critical for the research to understand that Experimental Archaeology allows us a good empirical tool to verify archaeological hypothesis and, at last, to understand History better. As Dr. Reynolds wrote some years ago in his book, experimental archaeology is a perspective of future.

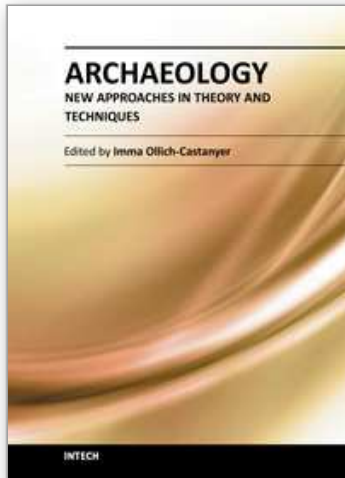
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The contents of this book show the implementation of new methodologies applied to archaeological sites. Chapters have been grouped in four sections: New Approaches About Archaeological Theory and Methodology; The Use of Geophysics on Archaeological Fieldwork; New Applied Techniques - Improving Material Culture and Experimentation; and Sharing Knowledge - Some Proposals Concerning Heritage and Education. Many different research projects, many different scientists and authors from different countries, many different historical times and periods, but only one objective: working together to increase our knowledge of ancient populations through archaeological work. The proposal of this book is to diffuse new methods and techniques developed by scientists to be used in archaeological works. That is the reason why we have thought that a publication on line is the best way of using new technology for sharing knowledge everywhere. Discovering, sharing knowledge, asking questions about our remote past and origins, are in the basis of humanity, and also are in the basis of archaeology as a science.

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