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The Basque farmhouses of Zelaa and Maiz Goena: New dendrochronology-based findings about the evolution of the built heritage in the northern Iberian Peninsula

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ABSTRACT

The Basque farmhouse, a characteristic building type for north-western Spain, is an architectural solution that allows the combined management of different rural activities. In addition to providing living quarters and a space for a cider press these farmhouses were designed to function as, among others, stable, barn and warehouse. They were often owned and managed by one family, with no links to ecclesiastic organizations. Architectural studies have established that these buildings first were constructed at the end of the 15th century without previous local precedent. This places their initial construction in a calm and relatively secure period, when the wars between the aristocratic lineages which had started in 1418, and which had resulted in assaults, looting and fires, had come to an end. The timing of their first occurrence has led to the interpretation that they represent a building tradition imported from the North. Dendrochronological research initially confirmed their late fifteenth-century origin. However recent restoration work in two previously undocumented farmhouses at Ezkio and Lazkao (Gipuzkoa territory) has enabled a reassessment of this interpretation. The architectural analysis of these buildings shows that their construction plans, which are quite similar, deviates from the general plan according to which the majority of Basque farmhouses were built. The newly identified model, wholly executed in wood with the exception of the roof covering, is based on the repetition of frames and bays. Together these generate the volume of the building, which is larger than the volume of other farmhouses. We collected a total of 81 oak (*Quercus sp.*) samples from both farmhouses and using Basque chronology ARAB9 as a reference established that these represent trees that were cut down in the spring of 1445 and in 1453 respectively. Since construction most likely took place within a few years after the trees were felled, this indicates that Basque farmhouses began to be constructed decades earlier than expected. At that time wars still raged in the Basque Country. If it is true that the political situation determined the degree of diffusion of non-indigenous architectural concepts in this region, the new findings can be interpreted as supporting the hypothesis that Basque farmhouses reflect a regionally-developed building tradition.

1. Introduction

1.1. Architectural studies in the Basque Country (Spain)

The study of medieval architecture on the Iberian Peninsula mainly has been focussed on prestigious monumental buildings such as cathedrals, monasteries, castles, mosques and synagogues (Torres Balbás, 1949, 1952). A wide variety of studies has been published about this subject from the 19th century onwards. In most of these, buildings have been analysed from an architectural point of view, focussing on typological and stylistic characteristics (Chueca Goitia, 2001).

Domestic architecture in the Basque Country began to be recognized as part of the built heritage in the 1980′s, when detailed architectural studies were included in the rehabilitation plans of the historic old cities. Examples of non-prestigious architecture now are routinely added in such studies because of their ethnographical value and the fact that they contribute to more complete architectural overviews.

Nowadays the scientific study of architecture in the Basque Country has developed towards a more archaeology-based approach, in which the evolution of buildings is considered as a succession of archaeological units. This has profoundly changed the scientific toolbox used in architectural studies. The study of data and materials from all functional

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parts and phases of buildings significantly has improved our knowledge about their initial construction and further development. In addition this more material-based approach is improving the development of conservation and restoration solutions. This development has led to the characterization and classification of Basque farmhouses, which has resulted in new interpretations and firmly has established them as representing outstanding instead of relatively simple rural architecture (Santana et al., 2001a, 2001b).

1.2. The Basque farmhouse

The Basque farmhouse is a type of building that is an integral element of the rural environment of the Atlantic Basque coast. Its concept is expressed through the design of the house and the surrounding land. This design and layout come together to form a self-sufficient farm unit for the farmer and his family. The three-dimensional lay-out of the buildings is based on the model of a single family house: free-standing and compact, without a court yard, balcony or outbuilding. The main characteristic is the integration of a cider press in the interior, especially in the Gipuzkoa territory but also in the Lapurdi and Nafarroa territories, and in some valleys in the Araba and Bizkaia territories (Fig. 1A). The roof has clay-tile roof cladding, a generally moderate inclination and two slopes. The dimensions of Basque farmhouses are substantial and surpass those of other kinds of vernacular architecture in this and adjacent regions. The advantage of the large volume is that Basque farmhouses next to providing living quarters and enabling cider production can accommodate multiple functions such as stable, barn, warehouse, workroom, apiary and dovecote. This design, in which all functions take place under a single roof, is well adapted to the rainy climate of the area. The concept of the Basque farmhouse also had a spiritual component, which made it into a place of domestic worship with links to nature and mythological beings and to the memories of the ancestors. At the same time it granted identity, rights and duties to its inhabitants, thus regulating the relationships with neighbourhoods and the community as a whole (Douglass, 1969). After their initial construction, in all documented cases their use progressively changed, with

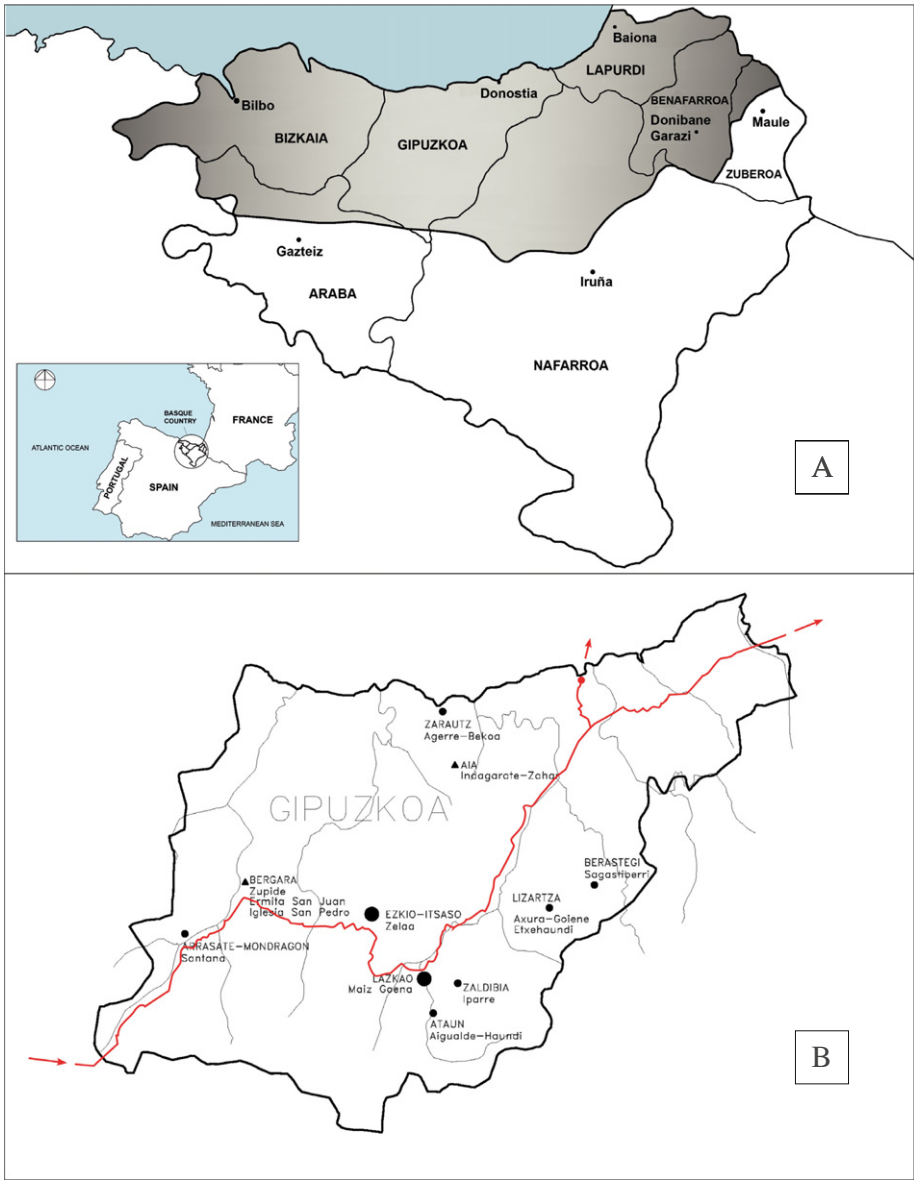


Fig. 1. Spatial distribution of Basque farmhouses. A: General distribution in North-western Spain. B: Gipuzkoa territory map showing the geographical position of dated farmhouses and other sites used in this study; large circles: Zelaa and Maiz Goena farmhouses; small circles: other dendrochronologically-dated farmhouses, triangles: site chronologies used as dendrochronological references. The old Royal Road between Castile and Aquitaine is marked in red.

some functions disappearing and new ones emerging through time, which has affected their final volumetric structure and appearance.

The distribution area of Basque farmhouses is comprised of a 200 km long strip of land, 80 km at its widest, located between the high plateau of Castilla and the French plains at the edge of the first elevations of the Pyrenees (Fig. 1A). During a recent documentary census based on historical documents in this area 40,000 Basque farmhouses have been registered, the majority of which were located in Bizkaia and Gipuzkoa (Santana et al., 2001a).

1.3. Research context

As is evidenced by 18th and early 19th century testimonies of European travellers such as William Bowles (1789) and Wilhelm von Humboldt (1805), the Basque farmhouse as an expression of the country's building traditions has been considered an architectural archetype since late modernity. This building type first was studied from anthropological and architectural points of view between 1924 and 1936 (Yrizar Bernoya, 1934). After having been interrupted by the Spanish Civil War, research recommenced in the 1960′s (Baeschlin, 1968). During the 1980′s new research approaches were introduced within the framework of institutional cataloguing executed in order to legally protect these buildings as heritage examples (Barrio Loza, 2007). The first protection statements were issued some years later, in the 1990′s, and the majority of protection statements were issued early in the 21st century.

At the turn of the millennium, the newly compiled information allowed researchers to develop architectonic classifications based on structural variations of Basque farmhouses. Nowadays 20 types have been identified, together covering a chronological interval that runs from the end of the 15th century to the 20th century, when concrete started to be used as a main construction material (Santana et al., 2001a: 47–172).

According to Santana et al. (2001a, 2001b) the architectonic concept of the Basque farmhouse began to be executed at the end of the 15th century (Fig. 2). These earliest buildings, for which these authors could not identify previous regional precedents except, in a few instances, the presence of remains of a shepherd's hut underneath such a structure (Santana, 1993), were built to a high standard using wood and stone. In the opinion of Santana et al. they were the result of the opening-up of this region to exterior influences, which led to the diffusion of construction techniques, working tools and architectonical models from France, the Low Countries and Germany. Although the authors do not explain the processes behind this phenomenon, according to them two factors appear to have been relevant. The first one is the political and economic situation at the end of the 15th century. This was a period of calm and relative security, as wars between the local aristocratic lineages that began in 1418 had ended in 1456 due to the intervention of King Enrique IV. These wars were more than mere fights among nobles, as they progressively turned into a confrontation between two different formulas for the social and political organization of the territory: the first one defended by the rural lineages and the second one proposed by the urban patricians (García Fernández, 1994). The other relevant factor for Santana et al. is the specific house design of the earliest, late 15th-century farmhouses, which is characterized by timber frameworks for big cider presses that occupied the whole length and height of the buildings. In each farmhouse annually between 3000 and 4500 kg of apples were pressed, producing ca. 1500–3000 l of cider. When added up, this equals an annual regional production of > 15.000,000 l. Cider, with an alcohol content of about 4.5%, was a relatively cheap beverage and in taverns it was considered as a second-class drink. However, domestically about 2 l per person were consumed daily. In addition on ships undertaking transoceanic journeys cider often was included in the rations (Santana, 2005). Together these uses constituted an important consuming market and stimulated the rise of family-scale cider-producing industries expressed by the Basque farmhouse.

Dendrochronological analysis has been applied to a dozen of Basque farmhouses between 2005 and 2014, with the aim to (a) date their construction by establishing the calendar years during which the trees were cut down, and (b) use their measurement series to develop regional master chronologies of oak that are useful as a reference for dating other heritage built with or created using oak from this region (Susperregi, 2007; Nayling and Susperregi, 2014). The number of samples per farmhouse varies from 2 to over 30. The administrative details of the sampled timbers are variable. For some structures due to extensive collaboration with owners and architects the exact position of each sample is known. In other cases at the time of sampling the timber already had been moved due to renovation activities, in which case only the general part of the building where the timber originated from could be recorded (e.g. roof, first floor). Until 2015, dendrochronological dates were obtained for 8 farmhouses (Domínguez-Delmás et al., 2015; Fig. 1B, Table 1). These dates are consistent with the idea that Basque farmhouses began to be constructed no earlier than the end of the fifteenth century.

2. Material and methods

2.1. The Zelaa and Maiz Goena farmhouses

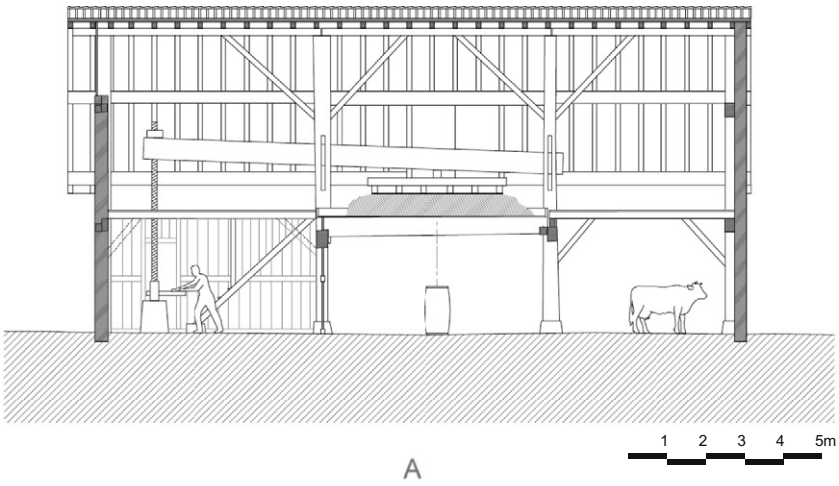
The Zelaa and Maiz Goena farmhouses are located in the Gipuzkoa territory in the high zone of the Oria River basin (Fig. 1B). They are situated on slopes near the old communication network (i.e. the old Royal Road between Castile and Aquitaine), well orientated and protected from the prevailing winds, at altitudes of respectively 410 and 327 m. Restoration work in these farmhouses started in 2012 and enabled detailed architectural documentation. Both buildings showed signs of ancient timber construction, such as single-piece posts from floor level to the top of the roof, and wooden planks in the front façade. For the Maiz Goena farmhouse renovation only was programmed for the roof, however eventually some other structural beams also were affected due to roof levelling. The renovation work in the Zelaa farmhouse was more extensive from the outset and directly affected structural wood such as vertical posts and other elements.

2.1.1. Zelaa farmhouse, Ezkio-Itsaso (Gipuzkoa).

The dimensions of Zelaa farmhouse are 23 × 21 m (plan on ground level), with a maximum height of 9.80 m (Figs. 3, 4). Its structure is composed of 5 parallel frames, which generate 4 bays between the frames. This classifies it as belonging to the group of relatively large Basque farmhouses. The volume is split into two levels: a ground floor and a first floor (Fig. 4A, B). The housing zone is located in the southern part and occupies both levels. The remainder of the volume provided space for the stable (ground floor), and for the barn and storage space (first floor). At present the house is defined by stone masonry walls. These most likely were built from 17th century onwards, when wooden cladding in this region was replaced on a large scale.

The main façade is west facing, where the main entrance to the ground floor is located (Fig. 4A). It communicates with a wide corridor that traverses the farmhouse east to west. The first floor (Fig. 4B) has a large volume, defined by the wooden structure that holds the roof covering (Fig. 4C) and the wooden partitions. Access to the outside is provided by a large door, located near the entrance ramp that connects with the exterior to the north side. Façades played a secondary role in the definition of the volume, since originally they were thin wooden walls, very similar to the internal partitions. The bay's dimensions are 4.74 m (bay A), 5.97 (bay B), 4.95 (bay C) and 4.92 (bay D).

The *masera*, a large wooden tray where the apples were placed to be pressed, is located between the 2 central aisles at bay C (Fig. 4B). Both the press beams (i.e. the big beams that support the pressing) and the small beams of the first floor (secondary structure) are arranged



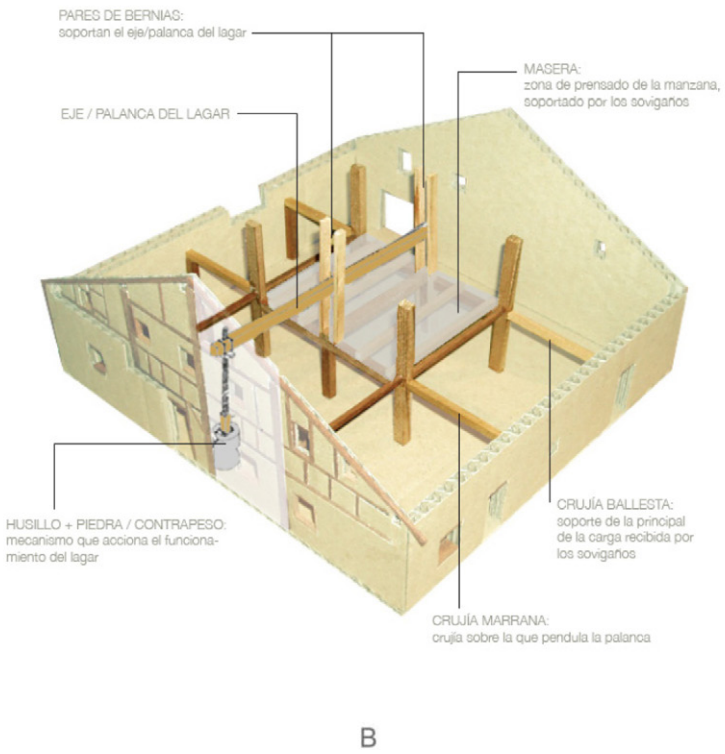


Fig. 2. 16th century Basque farmhouse's model (Telleria, personal communication 2009): a) longitudinal section and b) 3D model of the hypothetic original state.

Table 1
Previously studied Basque farmhouses and obtained dates.

Farmhouse name	Star year	End year	Felling date (absolute)	Derived felling date (*terminus post quem*)
Axura-Goiene (Lizartza)[a]	1489	1724	1724–1745	–
Santana (Arrasate)	1562	1781	1781–1801	–
Iparre (Zaldibia)	1495	1639	1646–1662	–
Etxehaundi (Lizartza)	1489	1613	1613	–
Agerre-Bekoa (Zarautz)	1495	1620	–	1620
Aigualde-Haundi (Ataun)[a]	1579	1742	1742–1775	–
Zupide (Bergara)	1336	1489	–	1489
Sagastiberri (Berastegi)	1284	1464	–	1464

[a] (Susperregi, unpublished data).

Fig. 3. Zelaa farmhouse, exterior and interior views.

perpendicular to the frames. In this manner the beams between the posts on the first floor support the load of the secondary structure.

There are connecting beams that tie the posts between frames on the first floor level. These joining timbers are strengthened by braces, with the aim to stabilize the loads and the operation of the press at work. The purlins of the roofing are supported by the plate beams that rest on the posts perpendicular to the frames. Therefore the main structure of the first floor rests on the frames, while the roofing timbers are arranged perpendicular to the frames (Fig. 4D).

The supports of the plate beams from the covering are reinforced at the support base of the post through long bolsters, and these joints are rigidified by the use of braces of considerable dimensions (diameter: 20 × 20 cm). The result is a large timber box structure, where no direction is clearly predominant, although the posts section seems to have had more relevance. The load transmission produced by the press at work seems to have been larger than the load due to the weight of the first floor and roof covering, and this fact explains the section of the posts.

Through regional government cooperation and with the help of owners and the architect responsible for the renovation works, 41 dendrochronological samples were collected from beams by cutting transversal sections using a chainsaw (Fig. 4, red sections).

2.1.2. Maiz Goena farmhouse, Lazkao (Gipuzkoa).

The original volume of the Maiz Goena farmhouse was created by 3 frames and 2 bays (Figs. 5, 6). Originally the residential component was located on the ground floor and faced east, while the west side of the ground floor was occupied by the stable (Fig. 6A). These different uses were separated by light wooden plank partitions, with the important kitchen room being located in the north-east corner. The first floor provided space for the barn and storage (Fig. 6B).

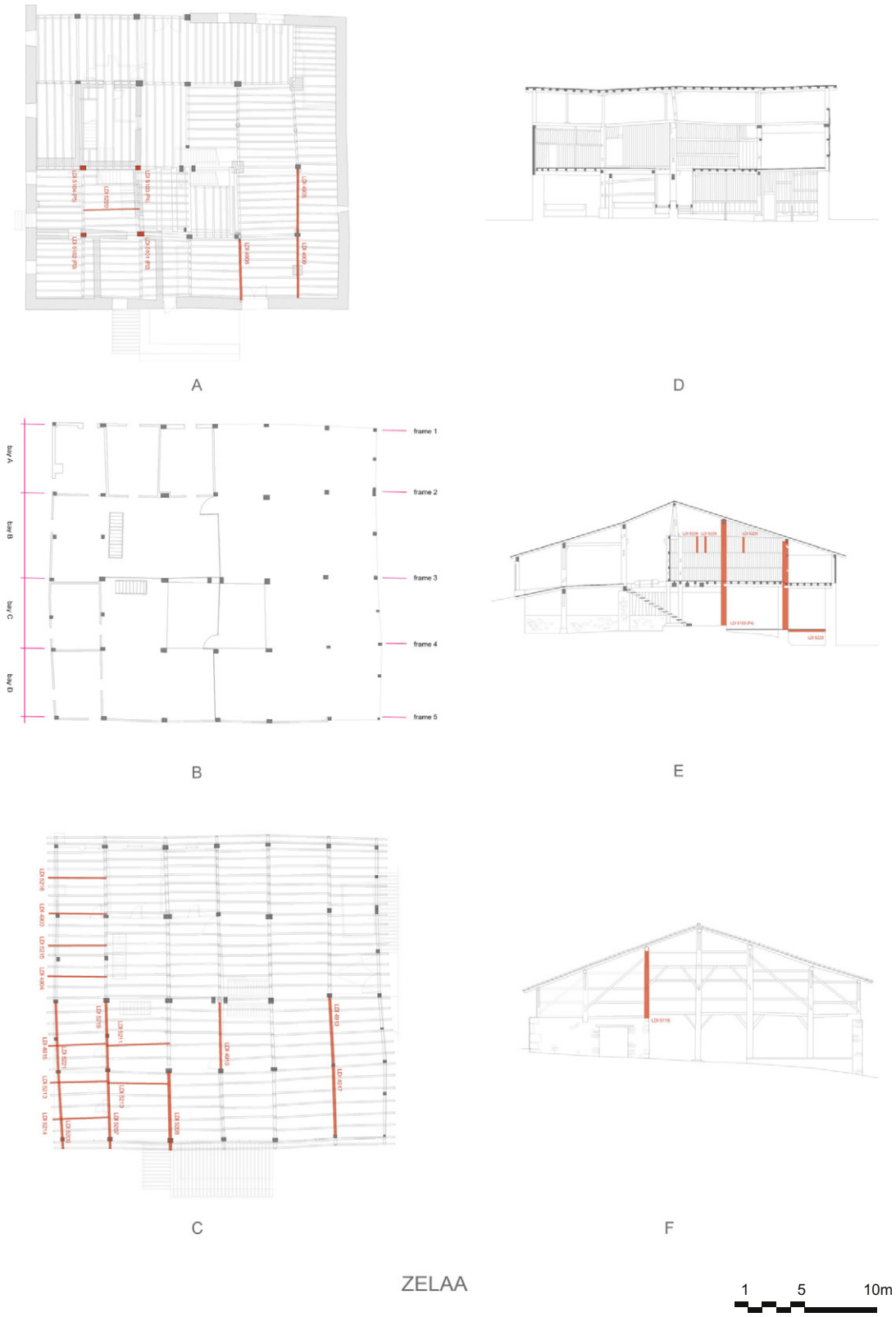


Fig. 4. Zelaa farmhouse: a) ground floor, b) first floor, c) roof structure, d) longitudinal section, e) cross section, f) façade's frame. Bays and frames marked in pink at draw b). Dendrochronological samples marked in red at draws a), c), e), and f).

The *masera* and the big axis of the cider press were located in the two central aisles, structuring the longitudinal layout of the farmhouse. The exterior access to this floor was provided by a bridge located on the southern facade, thus taking advantage of the slope of the terrain (Fig. 6D).

As is the case with the Zelaa farmhouse, the press beams are arranged perpendicular to the frames. Large-section beams attach the posts between frames on this floor level and braces are used to reinforce the joints, with the aim to stabilize the structure when the cider press

Fig. 5. Maiz Goena pictures: exterior and interior views.

was being operated. Again in keeping with the Zelaa farmhouse, at the level of the roofing structure the purlins are arranged parallel to the frames (Fig. 6C).

At the beginning of the 20th century the volume of the farmhouse was expanded with a new north-facing opening (owner, personal communication; Fig. 6B). The theoretical basis of the enlargement mirrors the original design, since a new frame was added which on the ground floor was made with masonry and on the attic level was constructed with bricks. This use of masonry and bricks is confirmed by the architectonical study, as there is no evidence of old structural wooden pieces at this bay. In this manner a new bay was added, with similar dimensions to that of the original three bays. Later during the 20th century some annexes were added to the main building in order to accommodate livestock. This increased the original volume by 50% and allowed an expansion of the residential zone, which now occupies the two eastern aisles on the ground floor. This new space consists of a large entrance, the kitchen and two other rooms, and a mezzanine where the bedrooms are located. The original structure was modified to accommodate the new floor, which is located between the ground floor and the first floor of the building.

Through regional government cooperation and with the help of owners and the architect, using a chainsaw 40 dendrochronological

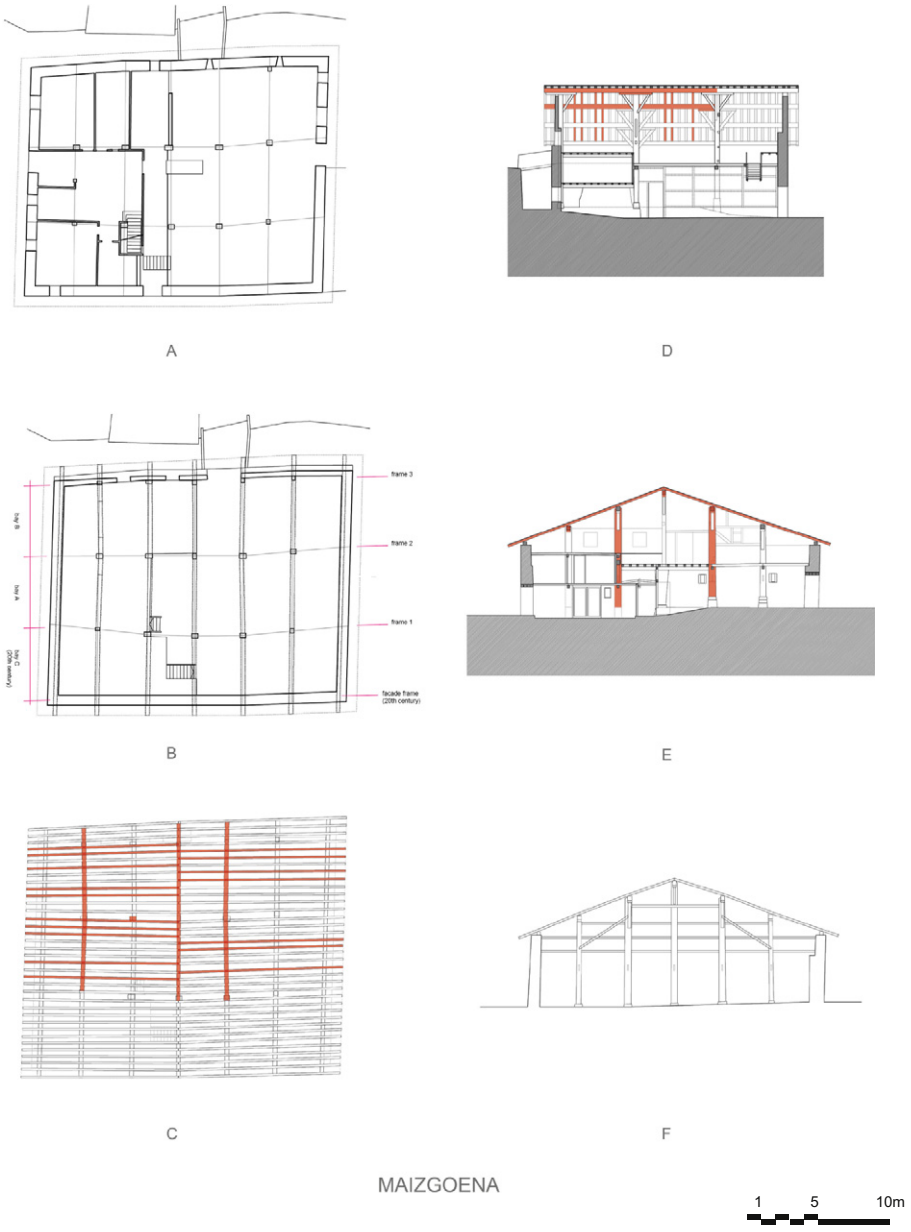


Fig. 6. Maiz Goena farmhouse: a) ground floor, b) first floor, c) roof structure, d) longitudinal section, e) cross section, f) façade's frame. Bays and frames marked in pink at draw b). Dendrochronological samples marked in red at draws c), d) and e).

samples were collected from elements that needed to be replaced (Fig. 6, red sections).

2.2. Dendrochronological methods

The cross sections of the samples were polished with sandpaper with an increasingly fine grain, until the tree rings could be identified and measured. Tree-ring identification was done visually using a binocular microscope and following the methods described by Stokes and Smiley (1968) and Baillie (1982). Ring widths were measured with a precision of 0.01 mm using a LINTAB™ measuring device (Rinn, 2008). Time series were indexed by using an arithmetic function of PAST4 (Knibbe, 2007) which shifts the mean value to 100. The resulting time series were compared to each other using standard dendrochronological cross-dating techniques and variables:

(a) Student's *t*-values t_{BP}, based on correlation coefficients between series indexed by the following formula (1),

$$ybp_i = In\left\{\frac{y_i x5}{y_{i-2}+y_{i-1}+y_i+y_{i+1}+y_{i+2}}\right\} \quad (1)$$

with y_i representing the actual growth increment in year *i*, *1n* being the natural logarithm, and ybp_i representing the derived growth index for year *i* (Knibbe, 2007);

(b) percentages of parallel variation *%PV* (e.g. Baillie, 1982; Jansma, 1995);

Table 2
Reference chronologies used in this study.

Identification	Structure/location	Species	First year	Last year	Author/reference
ARAB9	Construction woods from Gizpuzkoa, Araba and Nafarroa territories	*Quercus sp.*	1277	1849	Nayling and Susperregi, 2014; Susperregi & Jansma, In review
IPB1	San Pedro's church (Bergara)	*Quercus sp.*	1341	1591	Nayling and Susperregi, 2014
EJB1	San Juan's Chapel (Bergara)	*Quercus sp.*	1333	1489	Susperregi (unpublished data)
CZB1	Zupide farmhouse (Bergara)	*Quercus sp.*	1336	1489	Nayling and Susperregi, 2014
IZA	Indagarate-zahar farmhouse (Aia)	*Quercus sp.*	1345	1492	Susperregi (unpublished data)

(c) level of significance *P* based on established values for *%PV*. For these calculations we used software packages TSAP (Rinn, 2008), COFECHA (Holmes, 1983) and PAST4 (Knibbe, 2007).

Series representing the same tree were identified using a statistical threshold value of $t_{BP} > 9$ and on-screen comparisons of plotted graphs, and averaged into single sequences per individual tree. Based on sample synchronization for each farmhouse we developed an object chronology, which was compared to existing reference chronologies of oak from the Basque Country in order to establish exact dates and the provenance of the wood (Table 2).

3. Results

3.1. The chronology of Zelaa farmhouse

Of the 41 samples collected at Zelaa farmhouse (Fig. 4A, C, E, and F, Table 3), 8 were identified as belonging to 3 individual trees. This reduced the dataset to 36 single tree series. Of these, 10 could be dated relatively against each other with an average internal statistical correspondence of $t_{BP} = 7.19$, $\%PV = 71$ and $P < 0.0000003$ (Fig. 7). Comparison of their average chronology with the available reference chronologies yields an end date in 1453 CE, with chronology ARAB9 producing the strongest statistical and visual match (Ibid.).

The dated timbers contain narrow annual growth rings which vary from 0.68 to 1.60 mm. This slow growth usually is found in woods located further to the south. The growth patterns do not contain abrupt growth reductions, suggesting that pollarding and coppicing, which in this region were common practice, were not applied to these particular trees.

Although no bark is present on the studied samples, the chronological distribution of sapwood and calendar dates in this timber group strongly indicates that all trees were felled during this same year (Fig. 7; Table 3). This interpretation is supported by two facts. First, the number of sapwood rings observed in some samples surpasses the average number of sapwood rings in Northern-Iberian oak, which is 10 to 40 (LDI 4904, LDI 4909 and LDI 5116; Table 3). This makes it

Table 3
Zelaa farmhouse: dendrochronological results. Identification = laboratory filename; total rings = total number of tree rings that were measured; sapwood rings measured; sapwood rings observed but not measured; use = function of the timber; start year; end year; felling date (absolute); felling date (*terminus post-quem*).

Identification	Total rings	Sapwood rings (measured)	Sapwood rings (observed but not measured)	Use	Start year	End year	Felling date (absolute)	Felling date (*terminus post quem*)
LDI 4903–4908–4910	149	41	–	Beam/Purlin	1300	1448	–	1448
LDI 4904–4909–5208	175	53	–	Beam/Purlin	1279	1453	1453	–
LDI 4905	210	17	–	Beam	1230	1439	–	1439
LDI 4906	Discarded	–	–	Beam	–	–	–	–
LDI 4907	66	–	–	Purlin	–	–	–	–
LDI 4911	50	Sapwood boundary	–	Beam	–	–	–	–
LDI 4912	58	11	–	Beam	–	–	–	–
LDI 4913	67	11	–	Beam	1363	1430		1430
LDI 4914	50	2	–	Beam	–	–	–	–
LDI 4915	81	13	–	Joist	–	–	–	–
LDI 4916	72	22	–	Unknown	–	–	–	–
LDI 4917–5207	93	–	–	Beam	1333	1428	–	1428
LDI 5101	80	Sapwood boundary	–	Single post	–	–	–	–
LDI 5102	92	12	–	Single post	–	–	–	–
LDI 5103	Discarded	–	–	Single post	–	–	–	–
LDI 5104	115	–	–	Single post	–	–	–	–
LDI 5116	178	57	1	Single post	1274	1452	1453	–
LDI 5209	72	22	–	Beam	–	–	–	–
LDI 5210	55	15	–	Purlin	–	–	–	–
LDI 5211	79	–	–	Purlin	–	–	–	–
LDI 5212	101	–	–	Brace	1290	1390	–	1390
LDI 5213	134	–	–	Purlin	1292	1425	–	1425
LDI 5214	61	9	–	Purlin	–	–	–	–
LDI 5215	61	–	–	Purlin	–	–	–	–
LDI 5216	Discarded	–	–	Purlin	–	–	–	–
LDI 5217	36	3	–	Brace	–	–	–	–
LDI 5218	63	16	–	Brace	–	–	–	–
LDI 5219	74	–	–	Beam	–	–	–	–
LDI 5220	49	16	–	Brace	–	–	–	–
LDI 5221	121	27	–	Beam	1328	1448	–	1448
LDI 5222	172	34	1	Beam	1281	1452	1453	–
LDI 5223	66	13	–	Joist	–	–	–	–
LDI 5224	50	–	–	Plank	–	–	–	–
LDI 5225	37	–	–	Plank	–	–	–	
LDI 5226	42	–	–	Plank	–	–	–	–
LDI 5227	63	Sapwood boundary	–	Single post	–	–	–	–

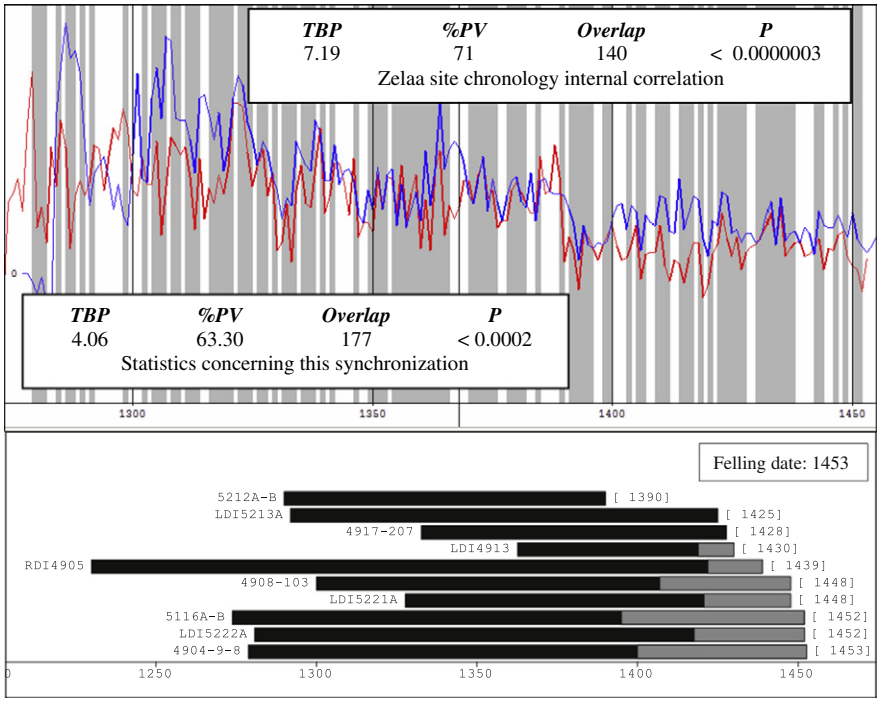


Fig. 7. Top: synchronization between the Zelaa farmhouse chronology (red) and reference chronology ARAB9 (blue). X-axis: calendar years; Y-axis: relative ring width. Intervals of synchronous ring-width variation are marked in grey. Top right: average statistical match between the series included in the Zelaa object chronology; bottom left: statistical match between the Zelaa chronology and ARAB9. Down: chronological position of the components of Zelaa site chronology. Sapwood is marked in grey.

quite unlikely that additional sapwood rings formed after 1453 might have been present on the original elements. Second, after correction for observed, but unmeasured, outer sapwood rings the end date of 1453 is supported by three samples (LDI 4904, LDI 5116 and LDI 5222; Table 3), whereas not a single younger date has been identified in this timber group.

For other regions in Europa it already has been established that no more than a few years passed between harvesting oaks and shaping them into construction elements (e.g. Hollstein, 1980). The main reason is that it is easier and hence cheaper to process oak when it is still 'green'. In such cases the wood dries out further after having been placed in a construction, which results in some in situ distortion and splitting of the wood. Since the Zelaa timbers are characterized by non-symmetrical cross sections as well as splits, the wood was shaped and placed into position when it was still green. This implies that the construction date of Zelaa farmhouse took place in, or shortly after, 1453 CE.

3.2. The chronology of Maiz Goena farmhouse

Of the 40 samples collected at Maiz Goena farmhouse (Fig. 6C, D and E, Table 4), 8 samples were identified as belonging to 4 individual trees. This reduced the dataset to 36 single tree series. Of these, 19 could be dated relatively against each other with an average internal statistical correspondence of $t_{BP} = 5.41$, $\%PV = 68.5$ and $P < 0.001$ (Fig. 8). Comparison of their average chronology with the available reference chronologies yields an end date in 1444 CE, with chronology ARAB9 producing the strongest statistical and visual match (Ibid.).

The dated timbers are characterized by wider tree rings than the timbers of Zelaa farmhouse, with annual growth layers varying between 1.44 and 2.99 mm. This considerable variation suggests that these timbers were collected at different sites. As in the Zelaa case, the lack of abrupt growth reductions suggests that pollarding and coppicing were not applied to these trees.

On the four trees (represented by five timbers) dated to 1444 CE a narrow band of spring vessels is present on the outside of the youngest complete ring of sapwood (Table 4). This incomplete growth ring must have been situated directly under the bark, which indicates that these trees were felled in the spring of 1445 CE. Again the chronological distribution of sapwood and calendar dates strongly indicates that all trees were harvested during this same year. The morphology of the timbers (non-symmetrical cross sections, splits) indicates that they were shaped shortly after the trees were harvested, which implies that construction took place in or shortly after 1445 CE.

3.3. Wood provenance

Since reference chronology ARAB9 was compiled from measurement series of oak from different territories (Susperregi and Jansma, In review), its correspondence with the Zelaa and Maiz Goena site chronologies does not provide accurate information about the geographical origin of the timbers used in these farmhouses. Nonetheless based on the agreements it is quite likely that the timbers originated from, or near to, the territories represented by ARAB9. Comparison to other available chronologies from this region and period does not result in further refinements of the provenance, as no geographical tendency can be detected from the strength of the matches against these chronologies (Table 5). However based on the internal correspondence between the series included in the Zelaa and Maiz Goena chronologies ($P < 0.0000003$ and $P < 0.001$ respectively) it can be argued that Zelaa farmhouse most likely was built with timbers from trees that grew in the same forest stand, whereas Maiz Goena farmhouse was built with timbers from various different origins.

4. Interpretation and conclusion

The present-day vegetation distribution in this region points at the occurrence of deciduous oak forests (*Quercus robur* and *petraea*) near

Table 4
Maiz Goena farmhouse: dendrochronological results. Identification = laboratory filename; total rings = total number of tree rings that were measured; sapwood rings measured; sapwood rings observed but not measured; use = function of the timber; start year; end year; felling date (absolute); felling date (*terminus post-quem*).

Identification	Total rings	Sapwood rings (measured)	Sapwood rings (observed but not measured)	Use	Start date	End date	Felling date (absolute)	Felling date (*terminus post quem*)
LDI 4681	98	16	–	Roof covering	1340	1437	–	1437
LDI 4682	56	–	–	Roof covering	–	–	–	–
LDI 4683–4701	76	–	–	Roof covering	1352	1427	–	1427
LDI 4684	62	6	–	Roof covering	1369	1431	–	1431
LDI 4685	73	–	–	Roof covering	–	–	–	–
LDI 4686	73	14	–	Roof covering	1359	1432	–	1432
LDI 4687	Discarded	–	–	Roof covering	–	–	–	–
LDI 4688	60	22	1	Roof covering	1384	1444	1445	–
LDI 4689	44	15	–	Roof covering	–	–	–	–
LDI 4690	Discarded	–	–	Roof covering	–	–	–	–
LDI 4691–4699	57	22	1	Roof covering	1388	1444	1445	–
LDI 4692	84	19	1	Roof covering	1361	1444	1445	–
LDI 4693	66	–	–	Roof covering	1348	1413	–	1413
LDI 4694	76	10	–	Roof covering	1349	1425	–	1425
LDI 4695	54	–	–	Roof covering	–	–	–	–
LDI 4696	69	–	–	Roof covering	–	–	–	–
LDI 4697	53	–	–	Roof covering	1359	1411	–	1411
LDI 4698–5117	80	15	1	Roof covering/single post	1365	1444	1445	–
LDI 4700	65	–	–	Roof covering	1362	1427	–	1427
LDI 4702	45	–	–	Roof covering	1376	1420	–	1420
LDI 4703	69	15	–	Roof covering	1373	1441	–	1441
LDI 4704	58	21	–	Roof covering	–	–	–	–
LDI 4705	57	–	–	Roof covering	–	–	–	–
LDI 4706	51	Sapwood boundary	–	Roof covering	1374	1424	–	1424
LDI 4707	76	–	–	Roof Plank	–	–	–	–
LDI 4763	58	–	–	Roof covering	–	–	–	–
LDI 4764	69	–	–	Roof covering	1354	1423	–	1423
LDI 4765	68	–	–	Roof covering	–	–	–	–
LDI 4766	77	–	–	Roof covering	1357	1433	–	1433
LDI 4767–4769	77	14	–	Roof covering	1357	1433	–	1433
LDI 4768	50	14	–	Roof covering	–	–	–	–
LDI 5118	Discarded	–	–	Single post	–	–	–	–
LDI 5362	63	Sapwood boundary	–	Ridge beam	1365	1428	–	1428
LDI 5363	47	–	–	Bolster	–	–	–	–
LDI 5364	58	–	–	Roof beam	–	–	–	–
LDI 5365	62	–	–	Roof beam	–	–	–	–

the two farmhouses (Loidi et al., 2011), making it quite likely that these are the oak species used in their construction. The growth patterns of the studied timbers do not contain abrupt growth reductions characteristic of pollarding and coppicing practices. This implies that the trees most likely grew at some distance of existing settlements and farms. Since the exact provenance of these trees cannot be determined, the manner in which they were transported to the construction sites cannot be deduced.

The newly obtained dendrochronological series cover a relatively early time interval, with Zelaa's site chronology even extending back as far as 1230 CE. This will allow the backwards extension by several decades of reference chronology ARAB9, which already functions as the major Basque dendrochronological reference in heritage research. In addition the inclusion of these early series into ARAB9 will improve the sample depth and therefore reliability of its earlier intervals. This improvement of ARAB9 certainly will contribute to the successful analysis of as yet undated Basque wooden heritage, such as ship wrecks, buildings and furniture.

The model of the newly discovered farmhouse type dated to the 1440′s and 1450′s is based on the repetition of frames and bays, which generates the volume of the building (Fig. 9). The structure is composed of a three-dimensional mesh of oak beams, arranged vertically, horizontally and obliquely, which shape the building's volume. Resembling a large barn, its exact size is conditioned by its rural functions. The timber framework is adapted to uneven building sites by the use of masonry walls and earthen embankments which prevented the transmission of damp from the soil to the wooden structure. The first floor is the main level, away from the soil, where crops were stored and processed. Underneath this floor farmers and cattle sheltered in contact with the ground. The original structure and enclosures of this building type were constructed exclusively from wood (with clay tiles used as roof covering), whereas farmhouses from the end of the 15th century and the 16th century were built with a combination of wood and stone.

The starting point of this structural model is the frame, which is very similar in both case studies. The construction dates of the Zelaa and Maiz Goena farmhouses in the 1440′s and 1450′s are so close together that this leads to the hypothesis that they represent the same, previously unidentified, frame-type. Each frame is composed of six aisles of similar dimensions, comprising 7 seven one-piece posts, with the central post being the longest. Since the other posts descend step by step to the outer walls, they form a moderate slope for the pitched roof. A system of horizontal and diagonal timbers joins the main vertical posts, shaping the frames plan. The junctions between the different pieces consist of mortise-and-tenon joints, timber half-lap joints or flush joints, which give the frame its structural strength. The resulting frame looks like a dense network of wooden sections, in which the posts are the main structural elements.

The Basque press system has a Roman origin (Brun and Tchernia, 1999), but whereas olive and grape presses in the Mediterranean region are placed in outdoor structures, in Basque farmhouses the press is placed inside the farmhouse. The pressing occurred on the first floor, with a dynamic load of about 25 tonnes. The dimensions of the original press appear to have dictated the distance of the bays between the

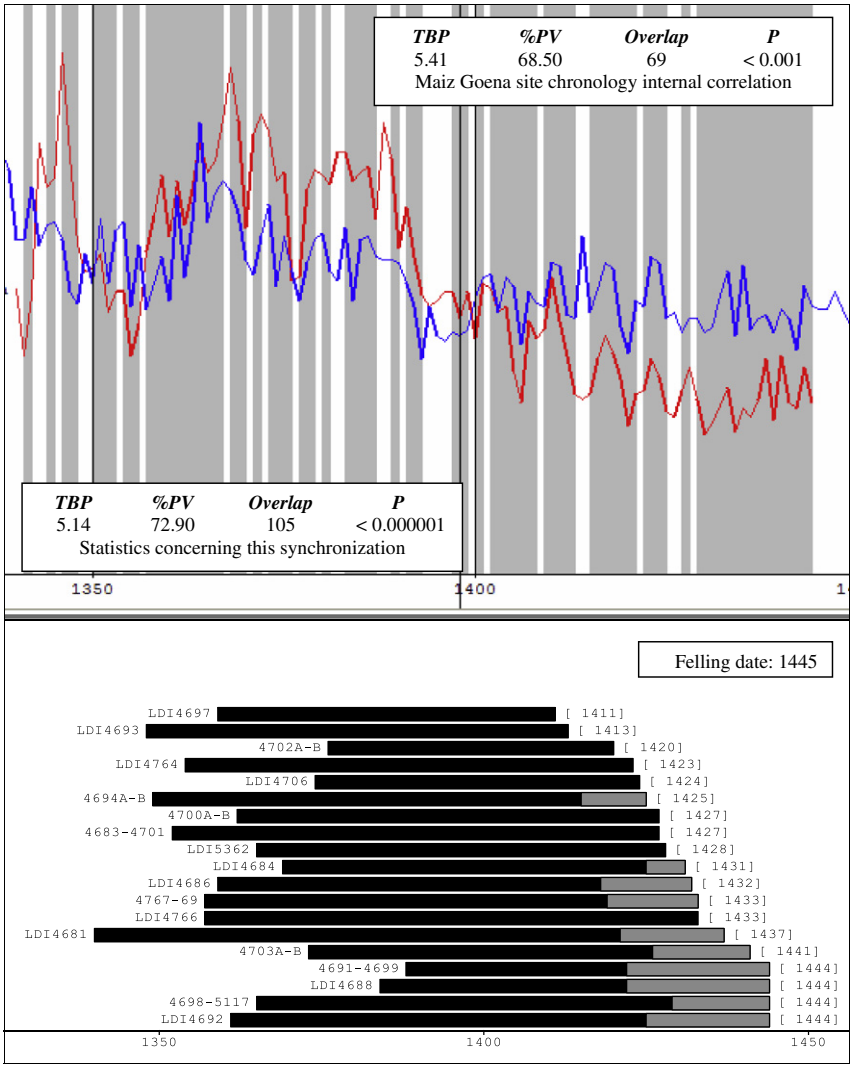


Fig. 8. Top: synchronization between the Maiz Goena farmhouse chronology (red) and reference chronology ARAB9 (blue). X-axis: calendar years; Y-axis: relative ring width. Intervals of synchronous ring-width variation are marked in grey. Top right: average statistical match between the series included in the Zelaa object chronology; bottom left: statistical match between the Maiz Goena chronology and ARAB9. Down: chronological position of the components of Maiz Goena site chronology. Sapwood is marked in grey.

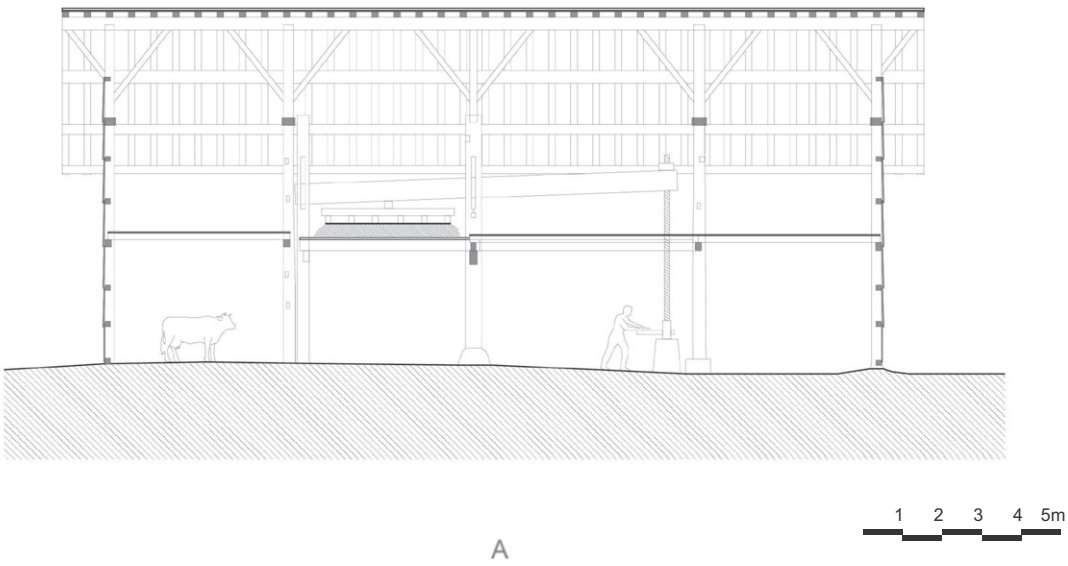
frames, as the physics of this type of mechanism dictate precise dimensions. The parameters that determine this distance are: (a) the measures of the *masera*; and (b) the dimensions of the axis of the press (which works as a lever), that is, the sum of the measures of the two bays which contain the mechanism (Fig. 9). These measures are approximately repeated in the remaining bays, in order to create a symmetrical structure. This system was used until the end of the 17th century and then gave way to other types of presses (Santana et al., 2001a, 2001b).

Previously documented Basque farmhouses in all cases have a height that is dictated by the height of the cider press (Fig. 2). This is different in the newly-established farmhouse type from the 1440′s and 1450′s, since here the height significantly exceeds the height of the cider press (Fig. 9).

The later model, which is more like a farm than a barn, is smaller (lower and more straight) than the earliest ones. Since residential use had become more important, the proportions of these buildings are on a more domestic scale, and mainly in the facades stones began to be used as building material. In addition the ground floor became more valued, which is evidenced by the fact that it now was prepared with a uniform horizontal level and often was paved, and that specific uses of the ground floor already became included in the planning phase of the buildings.

Table 5
Statistical matches between the Zelaa (CZE1) and Maiz Goena (CMG1) chronologies and available regional and site chronologies (also see Table 2).

	ARAB9	CZB1	EJB	IPB1	IZA
CMG1	*t*: 5.14 *%PV*: 72.90 *n*: 105 *P* < 0.000001	*t*: 2.91 *%PV*: 67.60 *n*:105 *P* < 0.0001	*t*: 4.44 *%PV*: 67.60 *n*: 105 *P* < 0.0001	*t*: 2.38 *%PV*: 67.80 *n*: 104 *P* < 0.0001	*t*: 4.57 *%PV*: 61.00 *n*: 100 *P* < 0.01
CZE1	*t*: 4.06 *%PV*: 63.30 *n*: 177 *P* < 0.0002	*t*: 2.13 *%PV*: 68.20 *n*: 118 *P* < 0.00004	*t*: 4.60 *%PV*: 58.30 *n*: 121 *P* < 0.03	*t*: 3.37 *%PV*: 64.20 *n*: 113 *P* < 0.001	*t*: 2.95 *%PV*: 57.30 *n*: 109 *P* < 0.06



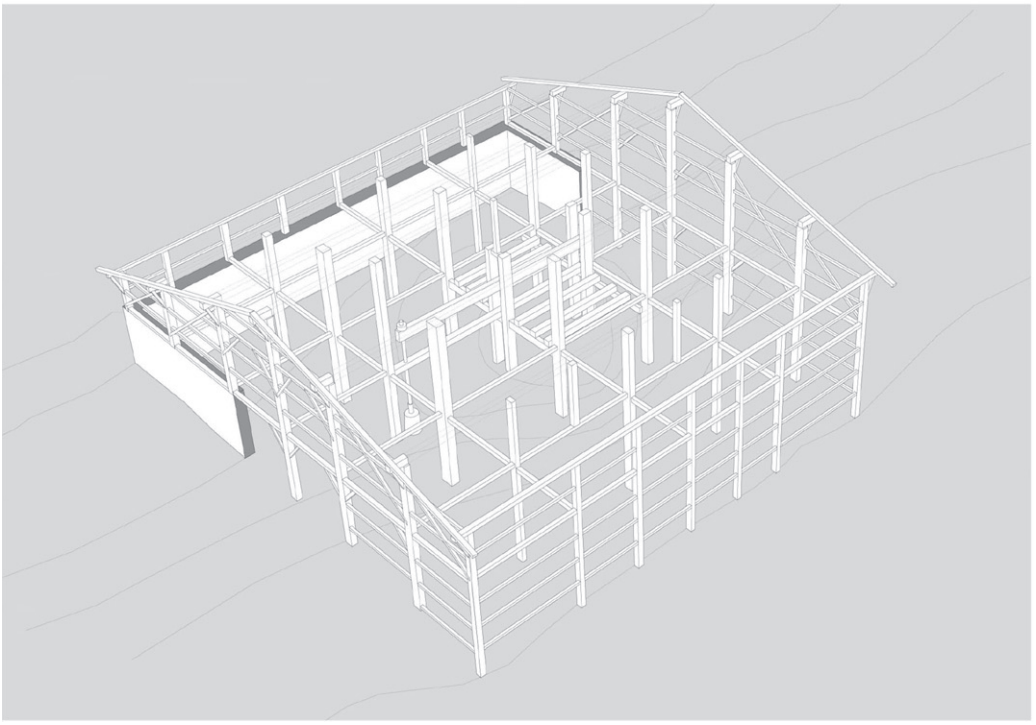


Fig. 9. Mid 15th century Basque farmhouse's model: a) longitudinal section and b) 3D model of the hypothetic original state.

The two newly identified, oldest Basque farmhouses are very similar in terms of their use of frames and bays, and furthermore contain all elements that usually are attributed to Basque farmhouses dated to the late fifteenth and sixteenth centuries (Figs. 2, 9). Their exceptional height and volume sets them apart from the later farmhouses, allowing the conclusion that we are facing a new, previously unidentified, farmhouse model. This model, which contrary to later farmhouses was built exclusively from wood, is based on the frame as the volume-generating element, with the volume (i.e. number of frames) being determined based on the requirements of the building (Fig. 9). This unitary model accommodated different uses and activities under the same roof. The cider press is a relevant element of this model, but contrary to later models did not constitute the key factor that defined the spatial configuration of the volume. Its three-dimensional structure without an axis as the basis for the interior distribution created a space without hierarchy. The roofing is the most important element of this model, through the use of clay tiles providing protection against the changeable weather conditions. The façades are secondary elements and are constructed in the same manner as the internal partitions. The beam system tying the posts to the structure of the facades (Fig. 9) suggests that in this model the facades originally were closed with wooden planks, and that the window opening positions were irrelevant in the façade's plan, functioning as small apertures designed for ventilation and lightning.

The barn-like farmhouse model began to be executed in the 1440′s, whereas the battles between the nobility lasted until 1456 CE, when the

nobles were exiled to the frontier of Granada, their troops were disbanded and their tower houses were demolished. This opens-up a new research line focussed on the hypothesis that Basque farmhouses represent a regional building tradition. This new hypothesis is in bearing with the construction tradition of this territory, which is related to the abundance of oak forests. *Quercus robur/petraea* are the predominant species, but other species also grew here, such as *Quercus faginea* (with an important distribution area within the Araba territory), *Quercus pubescens*, *Quercus pyrenaica* and *Quercus ilex/rotundifolia* (Saez García and Cantero Amiano, 2001). In this region dozens of population concentrations existed within walled-in areas in Gipuzkoa, Bizkaia and Álava. In the 15th century in these areas ca. 6.000 urban houses were built from timber. At the end of the 15th century these buildings began to be replaced by stone houses in order to prevent the massive fires that from time to time destroyed whole townships (Urteaga, 2006). Moreover the carpentry tradition in the region was not confined to domestic construction. Nautical architecture flourished along the Basque coast in medieval times and also later on, resulting in an abundance of shipyards (Odriozola, 2002). Structures devoted to the hydraulic utilization of the many iron factories in the territory, such as river dams, also illustrate the quality of the master carpenters during the 15th century (Urteaga, 2002).

In order to verify the new hypothesis it is necessary to focus research on local phenomena that can help to explain the evolution of the construction techniques used in the Zelaa and Maiz Goena farmhouses. The expectation is that we will uncover intermediate structures built prior to the 1440′s (the accepted theories until now suggest that the houses preceding the Basque farmhouses were just shepherd's huts), which would confirm the regional origin of this tradition. Similar regionally-developed traditions also have been uncovered in other areas in Europe where oak forests were abundant, such as in eastern Belgium where such traditions have been documented based on architectural and dendrochronological research of buildings (e.g. roof constructions) from the 14th and even 13th centuries (Hoffsummer, 2002).

A study by Brady (1997) of medieval English barns also revealed buildings with considerable dimensions, much larger than needed for crop storing, which suggests that their construction was related to the display of power and status. The main difference between the middle 15th-century Basque farmhouses and medieval English and Northern European barns is that they were not commissioned by religious institutions. This difference may support the hypothesis of a regional evolution, as the import of this tradition would be more logical in a context in which the construction of barns and farms was implemented by ecclesiastic organizations with a widespread presence all over Europe. Further research is needed to identify the commissioners of these buildings, bearing in mind that their construction required economical capital and skilled master craftsmen. To this end close cooperation with historians and archivists should be established.

The Basque farmhouses have been of the utmost importance for the preservation of the Basque language and culture (Santana, 1993). The relevance and interest of these buildings are reflected in their names, which after their first construction never change over the centuries, turning them into witnesses of the passage of time. Further research should be designed focussing on their earliest history.

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