

## **Gypsum in Spanish Levant: history of its production and use in local architecture**

---

**Vincenzina La Spina<sup>1</sup>, Fernando Vegas<sup>2</sup>, and Camilla Mileto<sup>2</sup>**

1. Universidad Politécnica de Cartagena, Spain; 2. Universitat Politècnica de València, Spain

### **Introduction**

Historically, gypsum is a construction material which has played a major role in both rural and urban architecture in the Spanish Levant, although its use is currently limited to rendering or plastering interiors and creating decorative details. In addition, the entire manufacturing process of raw gypsum for use in construction requires a great number of professionals, tools and techniques which have resulted, above all, in a highly characteristic local architecture where the material has many uses, both structural and decorative.

In the Middle Ages it was practically a homemade product, given that following extraction and heating in a furnace or kiln it was crushed using large wooden mallets before finally being sifted. Although the manufacturing process has become more efficient over the centuries, the basic traditional form of heating survived for a long time, and in rural areas the manufacturing process was practically the same as in medieval times up to the mid-twentieth century.

The aim of this article is to succinctly examine the process of transformation of raw gypsum from extraction to its use in various specific areas of the Spanish Levant. Special emphasis is laid on the geological features of the terrain which have encouraged the existence of deposits for extraction and on the traditional production process for powdered gypsum from medieval times until the mid-twentieth century, concluding with a detailed explanation of its multiple applications in local construction.

In geographical terms the areas of production are found in the Valencian Community and the Region of Murcia, specifically Rincón de Ademuz and surrounding areas of the cities of Valencia and Villena. The cities of Murcia and Campo de Cartagena, are places of particular interest in which several studies were carried out.

In addition, in chronological terms the modernisation of the production process due to the introduction of machinery, electric kilns, control systems, etc., and the Spanish Civil War (1936-40) with its generational change and the abandonment of rural areas, are milestones in the gradual oblivion of both traditional gypsum production and local construction techniques.—Hence artisan produced gypsum was eclipsed by the development of new construction materials.

## **Historic deposits, quarries and extraction**

### *Historic deposits and quarries*

Gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) is an evaporite rock formed through desiccation by evaporation of brackish waters and salt lakes or inner seas with no exit to the ocean, with thin water layers and under the effect of a dry climate. In general, this material resource is characterised by poor surface resistance, cleavage and solubility in warm water.

On the Spanish mainland there are numerous deposits of great geological and mineral importance, found mainly on the east side of the country. These formations mostly correspond to the Keuper (Triassic), Oligocene or Paleogene and Miocene (Tertiary) age. Gypsum from the Keuper and Miocene age are the most frequent, but gypsum from the Keuper age is more compact due to the longevity and the pressure it has been subjected to.

In the Valencian Community the deposits of Segorbe (Castellón), Tuejar, Chiva, Cofrentes, Llosa de Ranes (Valencia), Elda, Villena and Argot (Alicante), San Miguel de Salinas and Benejuzar (Alicante) should all be noted for their quality and reserves[1]. However, historically, the most important mine for the city of Valencia was “Niñerola”[2] in the town of Picassent, which already operated in Roman times.

In contrast, the distribution of the main deposits in the region of Murcia is varied but they are mainly found in the Carrascoy mountains, near Aljezares and Torreagüera; in the mountains of La Pila and La Garapacha in the north of the province; in the east in Totana and Lorca in the Espuña and La Tercia mountains, and in the northeast of the Algarrobo mountains in Campo de Cartagena. (Fig. 1)



*Figure 1. Location map of gypsum deposits in Spain (left) and in the Spanish Levant (right). Photo: La Spina. Instituto Geológico y Minero de España (IGME)*

### *The operation of deposits*

In the Middle Ages in Valencia there was full freedom to extract materials from quarries providing they were used for construction according to the privileges granted by King Jaime I in 1239 and included in the city legislation or *Fueros*[3]. This was how raw gypsum was extracted, and production was generally intermittent, as quarries were only opened when there was a need to execute specific construction projects.

This type of operation was carried out mainly in rural contexts, co-existing for many centuries with industrial extraction. There are barely any written records for many of the sites quarried in the Spanish Levant in historical publications on mining or in the *Estadística Minera* censuses from the Instituto Geológico y Minero de España (IGME). This shows that the necessary licenses or permits were not requested since gypsum was extracted in a practically self-sufficient manner for domestic use by the inhabitants of a region as needed[4].

Traditionally, open quarries were the most common as they are less dangerous and more cost-efficient and accessible than underground ones. The 'quarriers' worked the more superficial and shallow sites extracting the gypsum manually with the aid of simple tools, digging and removing rubble until they reached a seam (or '*tetón*' as it is known to Spanish gypsum producers) with the aid of picks, pickaxes, iron and wooden wedges, bars, props, containers, shovels, etc. The material was removed downwards creating terraces that were accessed using survey methods, with the help of explosive charges (gunpowder) placed by '*barreneros*' in charge of drilling and blasting cylindrical perforations in the rock. These perforations were made with '*barrenas*' (rounded iron bars approximately 2.20 metres long and with straight edges at the ends), cleaned with a '*hisopo*' (1.50 metres long metal bar with one spoon-shaped end while the other was used to place a handful of esparto. After the detonation the larger fragments were broken up into smaller pieces using 4 or 5 kg iron mallets called '*almainas*' (or '*almádenas*'). Once the raw gypsum was extracted, either from underground or in the open air, it was transported in carts to installations where it was calcined and ground.

According to the historical literature consulted[5] in the province of Valencia most of the production was surface gypsum extraction, although there are exceptions, like Cerro de las Cuevas in Alfarp which was an underground mine in 1928[6]. Similarly, most of the sites in the Region of Murcia were also open air, for example in Las Yeseras (Campo de Cartagena, Murcia) or the quarry of Torreagüera (Murcia). However, it is worth noting the underground extraction of gypsum in Los Aljezares (Murcia) from large caves, like those in the region of Paris. According to W. Bierhenke[7], the first space in the cave was an enormous room with a 20 metres high vaulted ceiling and a circular opening through which the rock could be winched up from a winding tower with the ropes and baskets tied to the ends of the winch or '*malacate*'[8]. (Fig. 2) In addition, from this first cave other interdependent caves, separated by walls with partial openings forming columns to support the ceiling, were accessed.



Figure 2. Gypsum mine in Aljezares (Murcia) in the early twentieth century. Photo: Bierhenke, Murcia, (Note 7) pp. 223-244.

Finally, the introduction into mining of large-scale machinery from the mid-twentieth century made it possible to work in deeper mines and where possible, even to transform underground mines into open air quarries and enable more earth to be transported.

### **Traditional production of powdered gypsum**

#### *Calcination or dehydration of the gypsum*

The calcination or dehydration of gypsum consists in the removal of quarry water and the crystallisation within the raw gypsum. Traditionally this was carried out in rudimentary kilns, similar to those used to produce lime, known as Arab kilns, and found mostly near quarries, but also near large-scale or costly construction sites as it was possible to control the calcined material and prevent adulteration with earth or ash.

Kilns were generally simple cylindrical dry stone wall constructions of variable height, accessed via an opening at the front and built on sloping ground to facilitate loading and unloading from above, as in the case of those found in Rincón de Ademuz[9] (Valencia) (Fig. 3), in La Garapacha (Murcia) or in Rambla de Torregüera (Murcia) Inside, large pieces of gypsum were used to create a false dome to form a hearth with an opening at the front to fuel the kiln, and on which pieces of raw gypsum were placed in descending order, simultaneously building a wall over the top opening of the kiln, finally filling all the gaps with remains and excess powder. The kiln was fuelled with logs, shrubs and branches, chosen to provide the best flame, although near La Unión and Cartagena '*carbonilla*' (coal residue) or coal was also used. The kiln had to be rendered inside and out with clay to prevent heat escaping from between the joints in the wall. In cases where there was a shortage of wood, kilns were built in a truncated conical shape[10] as in the case of those in Villena. (Fig. 4)



Figure 3. Traditional gypsum kiln in Rincón de Ademuz (Valencia), 2015. Photo: Vegas&Mileto

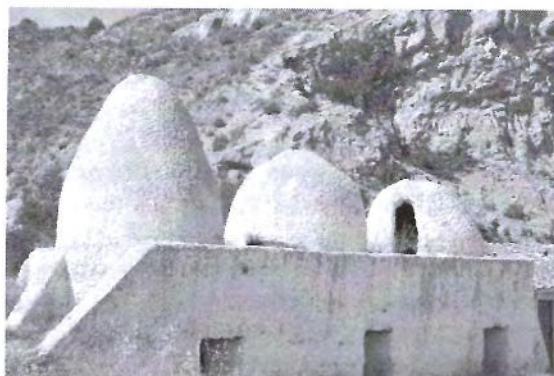


Figure 4. Photograph of a gypsum kiln in Villena (Alicante), 2010. Photo: <http://www.villenaacuentame.com/2010/07/los-hornos-de-yeso-del-cabezo-de-las.html>

The calcination process consisted in first heating the rocks slightly to eliminate humidity and water not resulting from crystallisation, and subsequently increasing the temperature to complete dehydration. Calcination time, which oscillated between six and thirty-six hours, was a highly variable factor given that it depended on atmospheric conditions, the quality of the rock and the fuel used. Once the calcination was completed, whitish marks appeared on the upper part of the kiln, and these were covered in fragments of fine gypsum waste to prevent the escape of fumes and to redirect the draught. This operation was repeated several times and when everything went white the kiln was no longer fuelled [11]. Subsequently, the batch was once again covered with a layer of powder from the same gypsum in order to concentrate heat, ensuring slow and gradual cooling. Temperatures reached in this type of kiln were highly variable, with intervals ranging between 100°C and 1,000°C depending on location in the kiln. Consequently, heating with this method was always irregular since normally the raw gypsum above cooked poorly and the raw gypsum below heated too much, resulting in multiphase gypsum [12].

In short, the correct dehydration of gypsum depended above all on the experience of the gypsum producer who had to assess when the process had been completed, but also on the calcination time and atmospheric conditions,

on the shape of the kiln, on the temperature reached and the type of raw gypsum[13], all of which are determining factors in the subsequent quality of the gypsum.

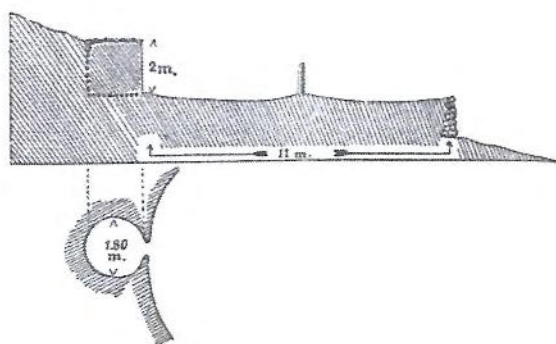
Equally, other types evolved from the simple kiln described, such as those built in Aljezares (Murcia)[14] until the mid-twentieth century. These were typically cylindrical double kilns, side by side, and as they were larger they had buttresses in the centre and on the corners as well as thicker walls made of masonry and 'láguena' earth[15] which were rendered outside and tended to be protected with a roof.

In contrast, in Las Yeseras in Campo de Cartagena (Murcia) it would not be appropriate to only refer to them as kilns. These constructions consisted of a space for grinding and storage. Circular kilns partially embedded in the ground were placed at one end, in the centre a pillar to which the animal who pulled the roller was tied up, and on the opposite end two storage spots, one with a door halfway up the wall to sift the powdered gypsum and the other to store all sorts of gypsum[16].

Finally, similar installations mainly featuring several kilns or different constructions relating to the production of gypsum (mill, store, stacking and loading area) were also frequent in Villena (Alicante)[17].

#### *Grinding, selection and transport*

Once the kiln cooled completely, after approximately ten days, the most frequent action was to grind the calcined gypsum. The oldest method was simply breaking apart the raw gypsum using mallets and sticks, but when there were spaces beside mountain slopes near the kiln animal power was used. The soil was cleaned, prepared and hardened and the raw gypsum was spread once the larger rocks had been broken using mallets and sticks, finally grinding the gypsum in circles with a truncated-cone roller or a cylindrical bolus with a rough stone surface drawn by animals. In these spaces in La Garapacha and Torreagüera (Murcia), there was also a 1.10 metres high post in the centre to tie the animal and force it to go around in a circle[18]. (Fig. 5) However, from the mid-twentieth century these grinding spaces were gradually replaced with chain-driven crushers.



*Figure 5. Diagram of a kiln and surrounding space in La Garapacha. Photo: Bierhenke, Murcia, (Note 7) pp. 223-244*

Once the grinding concluded, the gypsum was removed from the grinding space and sifted, while any gypsum that remained was ground again in the grinding space[19]. Although sometimes it was not sifted, as was the case

in Torrevieja (Murcia), but used immediately after grinding to make mortar and sifted only when the gypsum was going to be used to render walls. In a final phase the product that was ground and prepared for commercialisation was loaded in baskets onto animal-drawn carts and distributed.

When grinding was not carried out near kilns the dehydrated rock was transported to the construction site, as happened during the construction of the Temple in Valencia in 1763 where it was necessary to set up a temporary (see gypsum mill operated by a horse[20], or to more specific establishments known as 'gypsum factories'. The latter were the most frequent in the city of Valencia and there are records of the existence in 1510 of an industry for gypsum production in the "algepsería" in the square by the cathedral[21]. Equally, in later centuries, particularly in the eighteenth century, according to *Ramo de Providencias sobre el Abasto de yeso* in the city and its outskirts there were still gypsum mills, which were mostly simple wheels powered by animals. This was also the case in later times, as can be seen from the nineteenth century files of the *Policia Urbana*, and machines were even invented to obtain a more finely milled gypsum[22]. This continued until 1881 when gypsum factories were banned within a 150 metre distance from any dwelling, probably due to the constant inconveniences caused by this type of activity in the city.

### **Mediaeval supply of gypsum in the city of Valencia**

In mediaeval Valencia, the gypsum market was smaller than the lime market, and more local, which meant that only in regions with an abundance of the material was there a gypsum market with a relatively wide scope of geographical influence[23]. However, the most striking information, without a doubt, is the presence of 'algepçeres' (women gypsum producers). There were even times at which they had the monopoly over the supply of some public works as was the case of Isabel de Córdoba, 'castellana algepçera', who was almost exclusively in charge of supplying for building work on the cathedral in 1438-39. Other 'algepçeres' from the city included Caterina, another woman called Isabel 'algepçera' (probably *castellana*) and na Fariza, who was the wife of Isabel la Castellana's sole competitor for the work in the cathedral. In addition, just like na Fariza, Caterina was a widow and it was not unusual for widows to continue with their husbands' businesses after they passed away. However, these women were not the only suppliers for the numerous works being carried out in the city: documents in the archives show that there were also men, although little is known about them except their names and the amount of material they supplied.

### **Use of gypsum in local architecture**

The widespread use of gypsum as a construction material with numerous uses in the Spanish Levant is undeniable, as attested to by the surviving historic and traditional buildings. This material has been used to render all sorts of interior surfaces, including floors, as well as façades. It has been used to construct interior partitions, built-in furniture and architectural elements such as doorways, windows, stairs, vault ribs[24] or fireplaces, and to execute structural construction elements such as floors, ceilings, vaults, pillars, rammed earth walls, etc.[25][26]

The professionals who took part in its execution varied considerably depending on the purpose of the gypsum: decorative, structural, for furniture, etc. and the location of the constructions, both urban and rural. This means the different construction techniques could be carried out by master builders, bricklayers and labourers, by simple local builders or even by the future owners of the buildings.

*Renderings*

Most of the constructions executed have been rendered on the interior with gypsum or a mix of gypsum and sand in order to maintain inhabited spaces clean. Although at present this is the only type of rendering which is still used in current architecture, historically it was also used to render the exterior of buildings. Evidence of this is found in the renderings of the façades of the historic centre of the city of Valencia from the eighteenth until the mid-twentieth century[27] (Fig. 6), as well as in many other Spanish cities and towns (Cuenca, Ademuz, etc.).



*Figure 6. Image of a historic façade in Valencia rendered in traditional gypsum, 2015. Photo: La Spina*

In these cases, the bricklayers were in charge of pouring the gypsum mix (gypsum and water or gypsum, water and some aggregate) with pointing, rectangular or square trowels. The mix was previously prepared by the '*peón de mano*' (hand labourer) in a trough (even without using any tools except his hands) and was immediately passed on to the bricklayer, who picked it up with a hawk or his hands. After the mixing the labourers had to clean the trough thoroughly with a scraper to eliminate all remains of dry gypsum if they wished to use it again. Equally, once the mix was spread a '*peón lavador*' (washing labourer) had to use wet rags to level out and smooth over any irregularities left by the rectangular trowel, running the rag up and down the entire wall to obtain a perfectly smooth and pore free surface.

In contrast, in rural areas the techniques were even simpler and at times more rudimentary so that gypsum mixes were applied and spread simply by hand in secondary buildings (stables, tool sheds, etc.). Other smoother and finer options were the renderings with trowels or with the help of guides in order to achieve a surface without marks.

*Built-in furniture and indoor partitions*

In the '*barracas*', typical traditional constructions in Valencian and Murcian orchards, as well as in the small rural houses of inland Spanish Levant, such as Rincón de Ademuz, it was not uncommon to find '*alacenas*', built-in cupboards for the storage of different objects. These were usually built taking advantage of the corners of



a room using reeds or flat stones placed against each other and finally polished with gypsum to form a smooth surface incorporated into the wall. Similar techniques were also used to make all sorts of interior partitions or furniture such as 'trojes', spaces defined by low walls used to store fruit and especially cereal (Fig. 7); balustrades, solid ledges; built-in shelves for plates, glasses and other utensils, built-in benches and fireplaces or chimneybreasts above the hearth.



Figure 7. Photo of a 'troje' in a dwelling in Sesga (Rincón de Ademuz, Valencia), 2015. Photo: La Spina

#### Floors, ceilings and roofs

Equally, the traditional floors and ceilings of most of the Spanish Levant are built using wooden joists filled in with gypsum, well-poured on wooden formwork that can be restored, or on vaults made of ceramic brick and gypsum. This type of floor and ceilings, originally dating back to the sixteenth century, is characteristically used to save wood and make the best possible use of gypsum as a building material. In addition, when economic resources were scant, more often in rural areas, the gypsum on top became the floor of the house. For its use in construction the gypsum with a higher anhydrite content[28] was mixed with very little water in order to obtain high resistance gypsum, and oils such as linseed or olive oil were applied for greater waterproofing, an operation which was repeated periodically[29]. (Fig. 8)



Figure 8. Ceiling with wooden beams filled in with gypsum in a dwelling in Sesga (Rincón de Ademuz, Valencia), 2015. Photo: La Spina

*Pillars, walls and rammed earth walls*

In the region of Rincón de Ademuz, traditional constructions characteristically have mass semi-formwork or formwork pillars which spring from bases or perimeter stonework loadbearing walls and which can withstand the load of up to four floors[30]. (Fig. 9)

Generally, pillars were built using vertical guidelines (4 or 6 cm strips of wood) which were placed between the corners of the future pillar to make these perfectly straight and vertical, stonework was subsequently added and secured with gypsum mortar, followed by gypsum rendering. Equally, in Murcia walls of houses were often stonework grouted with gypsum which was not even sifted, and was also rendered in the same material[31].



*Figure 9. Gypsum pillars in a traditional construction from Rincón de Ademuz (Valencia), 2015. Photo: Vegas & Mileto*

Finally, gypsum was also used in the construction of rammed earth walls. In most cases the gypsum was placed on the sides and corners of the moulds, adopting characteristic undulating shapes called 'brenças' (Fig. 10) visible on the façades. With the use of gypsum the earth could be tamped, preventing shrinkage, improving the joints, reinforcing the weaker points and preventing cracks during drying[32].



*Figure 10. Rammed earth wall with gypsum 'brenças' in Rincón de Ademuz (Valencia), 2015. Photo: Vegas & Mileto*

## Conclusion

Without doubt, the great importance of gypsum in construction in the Spanish Levant is the result of two factors combined. It is partly due to the existence of deposits on the one hand, and on the other to the characteristics of the production process and its use in construction. The most notable characteristics are ease of extraction and grinding given the softness of raw gypsum; low fuel consumption as it only needs relatively short calcining time at moderate temperatures; immediate use following grinding as it requires no additional transformation; simple preparation of mixes as it is enough to add water, and the possibility of working with hands or rapid application as it hardens quickly, despite needing a greater number of building professionals working at the same time.

In terms of the calcination process there are slight geographical variations when heating the raw gypsum. The basic concept is the same, the only changes are in the size or shape of the kilns. In connection with this it is worth noting the tendency to unify all the phases of the building process in a single construction: calcination, grinding, sifting and storage, frequent in the area of Villena and Murcia, while in the city of Valencia the norm was to grind near the construction site or in the city, that is to say, near where the construction was to be executed. It is also interesting to note that women gypsum producers in mediaeval times continued the trade of their deceased husbands given that it was not necessary to have extensive knowledge in order to grind the gypsum.

Therefore, it can be concluded that there are many determining factors in the abundant and varied use of gypsum in local architecture. This unique characteristic becomes a trademark in itself, as well as a differentiating factor closely linked to the material resources available in the surroundings.

## References

- [1] D. Sanz Arauz, "Análisis del yeso empleado en revestimientos exteriores mediante técnicas geológicas" (Ph.D. Thesis, Universidad Politécnica de Madrid, 2009), p. 65.
- [2] Also highlighted and supported by well-known Valencian botanist Antonio Cavanilles in A. J. Cavanilles, *Observaciones sobre la historia natural, geografía, agricultura, población y frutos del Reyno de Valencia* (2 vols), Madrid: Imprenta real, 1795. Vol 1, pp. 162-164.
- [3] J. V. García Marsilla & T. Izquierdo Aranda, *Abastecer la obra gótica. El mercado de los materiales de construcción del territorio en la Valencia bajomedieval*, Valencia: Conselleria de Infraestructuras, Territorio y Medio Ambiente, 2013. p. 50.
- [4] V. La Spina, L. García Soriano, C. Mileto & F. Vegas, "Gypsum quarries used in Valencian architecture: Past, present and future" pp. 411-418 in C. Mileto, F. Vegas, L. García & V. Cristini (eds), *Vernacular Architecture. Towards a Sustainable Future*, London: Taylor & Francis Group, 2014.
- [5] Different historical publications and the *Estadística Minera* from 1861 to 1940 (IGME).
- [6] VV.AA., *Estadística Minera*, Madrid: Imprenta Nacional, 1928. pp. 656-657.
- [7] W. Bierhenke, "La obtención del yeso en Murcia", *Revista Murciana de Antropología*, no.16, 2009, pp. 223-244.
- [8] According to the RAE dictionary this machine was often used in mines to extract minerals and water, with a drum above and the levers to which the horses are harnessed below.
- [9] C. Mileto & F. Vegas, *Arquitectura preindustrial del Rincón de Ademuz, Homo Faber*, Casa Altas: Mancomunidad de Municipios Rincón de Ademuz, 2008. pp. 174-178.
- [10] F. Ger y Lobe, *Tratado de construcción civil*, Badajoz: La Minerva Extremeña, 1898. p. 42.
- [11] O. Puche Riart, L. F. Mazadiego Martínez, J.E. Ortiz Menéndez & J. F. Llamas Borrajo, "Yeserías históricas de Morata de Tajuña (Madrid)", *Materiales de Construcción*, vol.57, no.287, 2007. pp. 81-87.

- [12] Sanz, thesis, (note 1) p. 32.
- [13] Not all require the same firing according to seventeenth century Spanish treatise writer Fray Lorenzo de San Nicolás. Fr. L. de San Nicolás, *Arte y uso de arquitectura*, Madrid, 1639. p. 89b.
- [14] Bierhenke, Murcia, (Note 7) pp. 223-244.
- [15] 'Láguena' is a fire-resistant reddish blue earth obtained from grinding soft slate.
- [16] C. Martínez Hernández, "Las Yeseras", un paisaje geográfico cultural en abandono ligado al sistema constructivo tradicional", pp. 464-476 in *Proceedings of the IV Congreso Nacional de etnografía del Campo de Cartagena. La vivienda y la arquitectura tradicional del Campo de Cartagena*, Cartagena: Universidad Politécnica de Cartagena CRAI Biblioteca, 2015.
- [17] C. E. Rizo Antón, J. García Guardiola & A. Luján Navas, *Arqueología Industrial en Villena: Contribución al estudio de las canteras de yeso del término municipal de Villena* (Alicante), Villena: Fundación Municipal José M<sup>a</sup> Soler, 2001.
- [18] Bierhenke, Murcia, (Note 7) p 236.
- [19] Mileto & Vegas, Faber, (Note 9) p. 176.
- [20] J. Villalmanzo Cameno, "El temple de Valencia: Historia de su construcción (1761-1785)" in VV. AA. (eds), *Iglesia y palacio del Temple: Síntesis de Arte e Historia*, Valencia: Del Sènia al Segura, 2008, p. 92.
- [21] A. Nogales Espert, *La sanidad Municipal en la Valencia Foral Moderna 1479-1707*, Valencia: Ajuntament de Valencia, 1997, p. 242.
- [22] One example is the machine designed by the gypsum producer Mariano Gonzalo de León in 1840, AHMV, *Policia Urbana*, file 21, box 57(64), 1840.
- [23] García Marsilla & Izquierdo Aranda, Abastecer, (Note 3) p. 178.
- [24] R. Marín Sánchez, *Uso estructural de prefabricados de yeso en la arquitectura levantina de los siglos XV y XVI* (Ph.D. Thesis, Universitat Politècnica de València, 2014).
- [25] F. Vegas, C. Mileto, V. Cristini, J.R. Ruiz Checa & V. La Spina, "Gypsum as reinforcement for floors: conceptual approach", pp. 389-394, in Mariana Correia et al. (eds), *Vernacular Heritage and Earthen Architecture. Contributions for sustainable development*, London: Taylor & Francis Group, 2013.
- [26] La Spina, García, Mileto & Vegas, Quarries, (Note 4).
- [27] V. La Spina, *Vestigios de Yeso. Los revestimientos continuos históricos en las fachadas de la Valencia intramuros: estudio histórico, caracterización y propuestas de conservación*, (Ph.D. Thesis, Universitat Politècnica de València, 2015).
- [28] Overcooked gypsum which has lost almost all the water from crystallisation and is almost insoluble.
- [29] Vegas, Mileto, Cristini, Ruiz & La Spina, Floors, (Note 25).
- [30] F. Vegas, C. Mileto, M. Diodato, J. García Soriano, C. Grau Giménez, "Traditional structures made with gypsum pillars: a reasoned hypothesis", in R. Carvais et. al. (eds) *Nuts & Bolts of Construction History* (3 vols), París: Picard, 2012. Vol. 2, pp. 509-516.
- [31] Bierhenke, Murcia, (Note 7) p 238.
- [32] C. Mileto, F. Vegas, L. García Soriano & M. Mestre Sabater, "Rammed earth construction in El Rincón de Ademuz (Spain)", pp. 181- 186, in C. Mileto, F. Vegas & V. Cristini (eds), *Rammed Earth Conservation*, London: Taylor & Francis Group, 2012.