# ALABASTER IN ARAGON (SPAIN)


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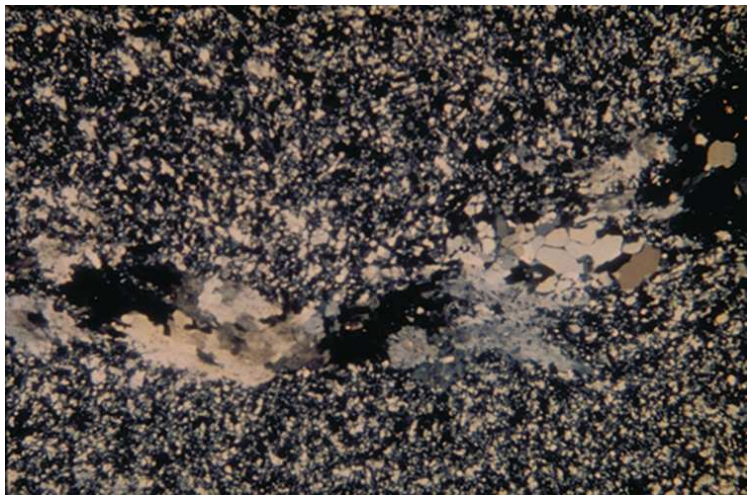
## 1 WHAT IS ALABASTER?

Alabaster is the stone of art *par excellence*, a much-appreciated resource for sculptors and architects who, from antiquity until these days, have been able to take advantage of its characteristic features, above all the ease with which it can be worked and polished and its translucency, a property as rare among rocks as effective in magnifying their natural beauty.

"Alabastron" was the name of a village in Old Egypt, located near the city of Thebes, in which a calcareous-type translucent stone was extracted. It seems that the term also referred to objects (e.g. vessels, cups) originating from that place, which, originally, were made with this material. Eventually, the term began to refer only to the white translucent rock used in art and in the manufacturing of much-appreciated vessels.

Today, the term alabaster refers to a massive, competent, translucent gypsum variety, with very low porosity and displaying very light colours. It consists of microcrystalline gypsum aggregates, with sizes ranging from 10 to 80 micrometres, which form an irregular mosaic. Aggregates of finest grain size are the best quality and most translucent. Impurities among the aggregates, above all clays and other salts that could have accumulated with the gypsum, are common and can colour and pattern the set.



Alabaster under the microscope

Head made with alabaster. 3rd - 1st century BC.

Alabaster Boulder

## 1.1. COMPOSITION

The chemical composition of alabaster is the same as that of gypsum: i.e. dihydrate calcium sulphate: $CaSO_3*2H_2O$.

Gypsum can become dehydrated and lose the water molecules in greater o smaller proportion. If it dehydrates completely, the new mineral is called anhydrite (calcium sulphate, $CaSO_3$). Although gypsum is more stable under normal environmental conditions, it can coexist with anhydrite and, to a lesser extent, with bassanite.

When temperature or humidity is increased the composition of this substance can be altered. Indeed, the ease with which calcium sulphate becomes hydrated or dehydrated due to pressure, temperature and humidity conditions is decisive to alabaster genesis.

## 1.2. HOW DOES ALABASTRER FORM?

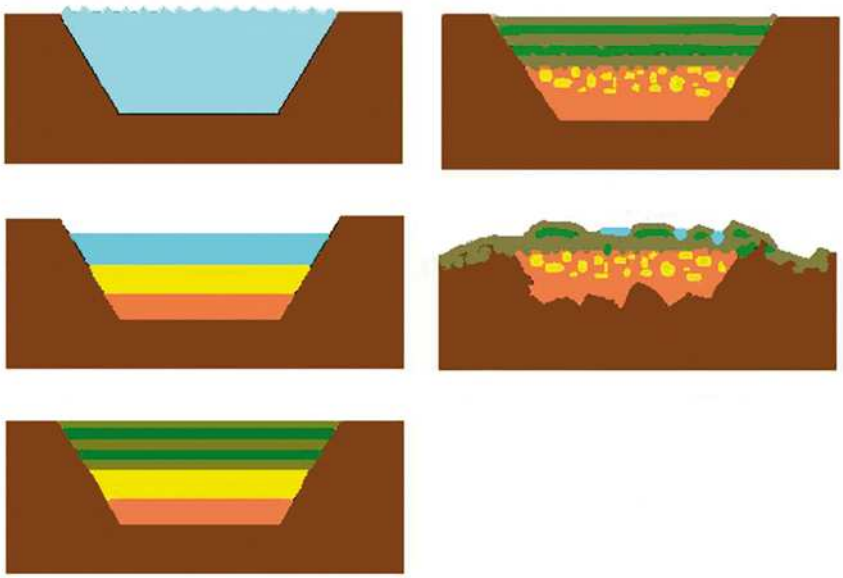
Gypsum is a salt formed by precipitation in lakes and ponds subjected to intense evaporation (evaporite basins). As the water mass decreases, the saturation degree that is needed for the different salts to precipitate is reached (2). The accumulation of small gypsum crystals at the bottom of the lake triggers the process that finally will lead to the formation of alabaster.

The gypsum deposits at the bottom of the lake are progressively buried under new sediments (3). This leads to a change in the pressure and temperature conditions, which will favour the loss of water molecules in the small crystals, thereby transforming gypsum into anhydrite, which is more stable in such environmental conditions. It is estimated that those changes occur at a depth of around 200m. The process implies a reduction of approximately 40% in the initial volume (4), due to both water loss and structural reorganization.

If environmental conditions change once again (due to elevation and erosion of the terrain) and pressure and temperature decrease in presence of water, the inverse mineralogical process in the crystalline structure can take place, i.e. the water molecules are recovered and anhydrite transforms into gypsum (5).

When alabaster is exposed to rainwater, it dissolves and grooves develop. Source: Myriam Gonzalez Cavazos

DIAGRAM SHOWING ALABASTER GENESIS



Two extreme forms of crystallization will result depending on the way this process develops. If water is slowly recovered, there will be sufficient time for well-developed crystals with defined forms and large sizes to be formed. However, under rapid dehydration conditions there is no sufficient time for large crystals to be formed, so that growing crystals are linked to each other providing a consistent microcrystalline framework, i.e., alabaster.

## 1.3. PROPERTIES AND CHARACTERISTICS

Alabaster is characterized by the crystal size (less than 0.05 mm) disposed in an intimate framework that confers alabaster translucency and compactness. The first of these qualities provides alabaster with its characteristic beauty; the second one, combined with gypsum's low hardness, is what makes this material so valuable. On the other hand, alabaster is easily stained with iron oxides.

Yet, alabaster also has disadvantages. As previously stated, due its propensity to lose water molecules, the mineralogical composition of a sample can be partially or completely modified when applying heat (alabaster starts to decompose at 50ºC) or if samples are exposed to special humidity conditions. It should also be taken into account that alabaster is a water-soluble salt, which results in a limitation of use depending on the environmental conditions to which it is going be exposed.

Alabaster is usually found in more or less spherical pieces that reach up to 1m in diameter. As a consequence, alabaster professionals use the following terms:

• **Boulder**: It is the raw stone, as extracted from the quarry, or cleaned from clays or loose fractions, with no other treatment.

• **Veins**: Bands of colour that is different from the colour at the base. They may be more or less continuous along the block. Generally *veins* are the result of the existence of clay impurities and they do not involve mechanic discontinuities in the stone.

• ***"Aguas":*** More or less translucent patterns may appear within the base colour, which are due to the size and packing of the microscopic crystals, can be occur. They do not involve mechanical discontinuities in the stone.

• "**Frías (or fleas)**": Mechanical discontinuities in the rock. They are clay veins that cross the rock dividing it into separate blocks.

• **Salts**: Bands or nodules integrated by gypsum crystals.

• "**Coquera**": Holes that appear inside the stone. They are normally smaller than 4-5 cm and their walls may be draped with gypsum crystals.

Alabaster with large selenite crystals (crystalline gypsum). Azaila, Teruel

## 1.4. CLASSIFICATION

Sometimes, varieties of alabaster are defined on the basis of their origin, but it is normal to use mixed classifications in which other criteria are also introduced, such as historical or artistic ones, appearance and composition.

On the basis of its composition, we can refer to calcareous alabaster (when a high proportion of calcite exists) and gypsiferous alabaster (or alabaster *sensu stricto*), which is the alabaster found in Aragon.

If we take into consideration their presentation on the mineral deposits, there exist two generic types of alabaster in Aragon:

**Asian alabaster or transparent alabaster**

It displays a variable, but always remarkable, translucency. The maximum sizes of the blocks are larger, and blocks of $1m^3$ can be obtained.

**"Buñuelo" (alabaster bun)**

It owes his name to its appearance when it is extracted from quarries. Its translucency is lower, and it commonly displays "aguas" and veins. Blocks size is smaller. It is less commercially appreciated.

**Classification According to Origin**

• Old alabaster. It displays a milky white colour and is also known as "alabastrite", from the city of Alabaster (Egypt).

• Milky white alabaster, from the Southern Pyrenees.

• Milky white alabaster, from the Northern Pyrenees.

• Alabaster from the Niso River in Sicily.

• Alabaster of Taormina (Sicily), with reddish to dark yellow waves.

• Whitish alabaster from Riquevire, Alsace (High Rhine).

• Alabaster from Gozo island (near Malta). It is light yellow and translucent, with white waves.

• Alabaster from Lagny (Paris, France). It is yellowish white and semi-transparent.

• Velterren alabasters (Italy).

• English alabasters.

• Aragonese alabasters

## 2 THE ROUTE OF ALABASTER

The first known alabaster objects came from the Near East, although in ancient times any rock was named as such as long as it was translucent, thereby making no discrimination between calcite or gypsum.

### 2.1. A BIT OF HISTORY

References to alabaster are old and are associated to Egyptian jars (*alabastrones*), which were made of polished rock and used throughout the Mediterranean. These containers are mentioned in the Bible on several occasions and the archaeological remains are numerous.

The translucency of alabaster made it ideal for use in wall openings and windows. It was used throughout the Middle Ages in many churches and cathedrals in Europe for this purpose.

From the 13th century onwards it began to be appreciated for sculptural works once again, but it was during the artistic blossoming of the Renaissance that it became a basic raw material for altarpieces, sarcophagi and sculptures of all kinds. The reputation of alabaster as a luxury material for use in decorative elements has remained for centuries, though today its applications are more diverse.

### 2.2. RESEARCH AND EXTRACTION

Alabaster occurs among sedimentary rocks formed in basins where evaporation has been significant, which has led to salts accumulation (evaporite basins). Series with plenty of gypsum are looked for, and the possible existence and likely location of alabaster beds are assessed.

After checking *in situ* by field survey and sampling and, when appropriate, pit opening, mining possibilities are assessed by considering topography, waste rock volume, mineral deposit richness, accessibility and mineral price on the market.

When the interest of the site is determined, the extraction of alabaster is performed by carrying out the following tasks:

1. The removal of the covering materials until the alabaster is reached can be performed:

    Down the hill
    Down the slope
    Digging up a trench

2. Simultaneously to the excavation the waste materials extracted are used in the construction of high, medium-degree sloped or filled embankments.

3. Preparation of the esplanade or work platform at a level suitable for placing mining machinery.

4. Extraction and staking of the bolulders.

5. Husking by using pneumatic chipping hammers. Between 30% and 75% of material is lost in this operation depending on the alabaster type, quarry features, the hammer used and the labourer. The final destination of the waste matter is the local landfill.

6. Transportation of the boulders to the sawmill.

7. Restoration of the site, which can be developed simultaneously to the mining in those areas already exploited and in finished embankments. The final goal is to leave the site in a condition that strongly resembles the original one, or at least a condition that does not alter the original landscape significantly.

In Aragon there are many sites that have become degraded as a consequence of alabaster mining. Both extraction following the contour mining method, which extends over hills and slopes, and the wide dispersion of active and abandoned exploitations that have not been restored, or have been very poorly restored, have resulted in serious environmental damage, which has affected large areas.

To this, we have to add the steppe's difficult environmental conditions, since they do not encourage the rapid growth of new vegetable cover. These are sites with highly valuable habitats hosting species that have become adapted to extreme environmental conditions and the saline soil's chemical characteristics, so that the environmental impact of these activities is highly noticeable.

Much of the world's alabaster extraction is performed in the centre of the Ebro Valley. Elsewhere, it has either been depleted, or its extraction is so difficult that it has almost been abandoned or is carried out at a very high cost.

In Spain, alabaster has been extracted in various places, although these days extraction remains only at the sites in Aragon.

Alabaster extraction under process

## 2.3. TRANSFORMATION PROCESSES

### The cut

The work carried out at the sawmill can be described as follows.

• ***Peeling*** with manual tools, like hammers, mallets or spikes. The useful fragments are classified in terms of size and quality for subsequent operations.

• ***Sawing,*** with circular saws. Slabs or slices with specific thicknesses or types of surface can be obtained depending on the dimensions of the boulders and the requirements set by the final recipient.

• ***"Atochado",*** Once the slices have been produced, "*tochos*" can be extracted, which are alabaster cylinders of different diameter and length depending on the thickness of the slice. The tool used in this process is the "*tochadora*", a fixed drill with vertical movement through zip. The core drills are interchangeable and they come in a range of diameters. The "*tochos*" are eventually used for lathe carving.

• ***Veenering*****,** From these slices, and through more precise sawing, plates of different sizes whose thickness ranges from 1 to 3 cm can be obtained.

Types of alabaster

Remains of the alabaster façade in Aljafería Palace (Zaragoza)

The name of Saraqusta inscribed in alabaster

Different stages in the alabaster cutting process

**The processing**

• **Sanding**
The work piece is polished with steel wool in order to obtain a homogeneous texture that may remove the marks of cutting or turning.

• **Colouring**
Although the stone variety provides certain hues, some features of the stone can be highlighted or color added through the addition of pigments, depending on the taste of the manufacturer. In any case, the type of alabaster should be taken into account, or even main type of stone in the piece, since discontinuities often display higher porosity. Therefore, they will absorb a greater amount of color, thereby highlighting it even more, while the opaque areas of the stone will display less saturated shades. The paint may be oil-based, water-based or alcohol-based.

Regardless of the type of paint that is going to be applied, a particular technique is widely used in the staining of alabaster, which is quite useful in highlighting texture and veining. A base of nigrosine is laid, upon which the desired layers of paint will be applied. The application of nigrosine is often carried out through baths lasting 1 to 1 ½ hours. Likewise, a brown coloration can be achieved through immersion of the piece in a previously-heated solution of chromic acid.

• **Adhesives**
Since alabaster occurs in relatively small boulders, removable pieces are always of limited size. Adhesives are used in order to obtain larger pieces.

• **Waxes and other treatments**
Waxes are typically used to brighten the stone, and they may be colored or colorless. There are no specific waxes for alabaster, so those used for floorings and wood are also used for alabaster. Vaseline, paraffin and whale oil are used for the external protection of the stone as they provide it with color, textures and shine.

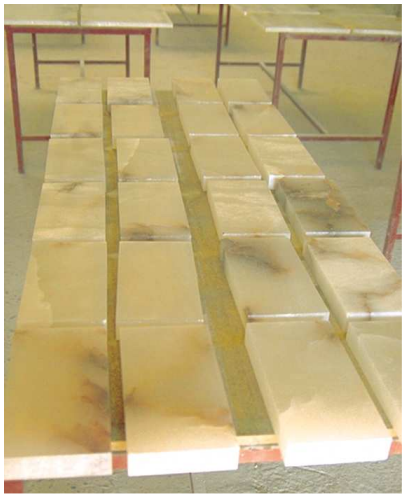
• **Varnishes** are a special kind of paint. They are usually colourless and provide a

layer that covers the entire object protecting it against external agents. They tend to affect the original properties of the stone, such as brightness or texture. An associated problem is that they eventually degrade since they become darker and crack, thereby losing their protective properties.

• **Satin**
When treating alabaster with water at a given temperature for a specified time period, some of the properties of the stone can change. Externally, translucency is partially lost. Also, the colour changes to intense satin white and the brightness becomes wax-like.

• **Cleaning**
Depending on the exposure of the stone to external agents, large amounts of dirt and grease may accumulate on it, so that degreasers have to be used in order to clean the stone. The product used must be non-ionic, pH-neutral or slightly basic, and non-abrasive.

• **Water-repellents**
The main function of this product is to make sure that water or other liquids damage the stone. They are usually transparent and leave no traces once they have dried.


Alabaster blocks


Many different final treatments are applied in alabaster processing

## 2.4 THE USES OF ALABASTER

The uses of alabaster are determined by its features: it must always be used indoors, or protected against of rain, sometimes it is used to facilitate the entrance of daylight thanks to its translucency. Due to its relative scarcity and the size of the boulders, its use has been limited, which now revolves round the creation of small artistic objects.

The use of new techniques in the treatment of the stone, along with its use in combination with other materials, has diversified the market for alabaster, which focuses on the following fields:

• **Sculpture**. Arts and crafts are the oldest and noblest applications that humans have given to this material. The beautiful appearance of alabaster after polishing makes it similar to marble, to which it compares favourably in various respects: it is easier to sculpt and stain, and it offers the possibility of creating translucent effects. Conversely, it has the drawback that it must not be exposed to water without having been treated first.

• **Lighting**. The use of cold light bulbs enhances the warmth of alabaster's translucent effect.

• **Interior Design**. In interior design, the current trend is combining alabaster with other materials so that it has become by now an important element in decorative lighting, objects and furniture. The existing protection treatments against moisture or wear, together with new laying techniques, have increased the range of applications for alabaster.

• **Architecture**. Thanks to its translucency, alabaster offers a wide range of possible new applications when used in combination with new materials or building techniques, and it still offers plenty of scope for experimentation.

Alabaster lamps

Turning alabaster columns

Alabaster walls. A closer view of the inside of the CREA building

## 3. ALABASTER IN ARAGON

### 3.1 EXTRACTING SITES

Aragon has the privilege of having the largest known exploitable deposits. There are two different sites, which are geographically separated, though both are located in Tertiary basins. The most important one corresponds to the Fuentes-Azaila area, in the Tertiary Ebro Basin. The other area where this resource is present is the Calatayud-Teruel Basin, which divides the Iberian Range in two main sectors (NW and SE).

**The Fuentes-Azaila area**

This mineral can be found in an area limited to the North by the villages of Fuentes de Ebro and Pina de Ebro, and the Zaragoza-Barcelona national road, reaching the village of Albalate del Arzobispo and the Martín River to the South; to the East this area extends towards the Alborge-Bujaraloz road, and to the West towards the village Belchite, covering a wide area of ca. 120,000 Ha.

This area corresponds to the Tertiary continental rocks of the Ebro Basin. The stages in which traces of alabaster appear are the Oligocene and the Miocene, and materials are arranged in either horizontal or very low-dipping beds.

It is precisely the horizontal arrangement of the rocks that makes it easier to exactly determine the heights at which the alabaster levels are located: at 185m; at 230m; between 245-250m (great quality and high-transparency alabaster) and, finally, between 280-290m. The beds in which alabaster occurs are up to 1m-thick, and they can attain up to several hundreds, indeed thousands, of metres in length, even though there can be considerable changes in thickness and colour among nearby areas.

The minimum thickness for a bed of alabaster to be considered exploitable is around 35-40cm because the alteration film surrounding the nodules must be removed before clean alabaster may be extracted.

The two aforementioned Aragon varieties (transparent and "*buñuelo*" -bun-) correspond in turn to two different geological sites. The transparent-type alabaster integrates more or less continuous bodies with slight changes in thickness at quarry scale. On the other hand, the "*buñuelo*" -bun- type appears as isolated ovoid-shaped nodules immersed in the clay mass surrounding the nodule and conform continuous levels of boulders at quarry scale.

The estimation of resources for the Fuentes-Azaila area in Aragon, according to 1990 data from ITGE (nowadays IGME: Geological and Mining Institute of Spain) is approximately 31,362,295 possible tons and 22,006,151 exploitable tons.

The location of alabaster is precisely at the centre of the Ebro Basin, where the confluence of various factors, such as extreme climate conditions, geographic isolation and the presence of saline soils, have given rise to a steppe that is highly rich in biodiversity.

These adverse climate conditions, together with the poverty of soils, hinder the natural or man-induced regeneration of the vegetation in the areas affected by mining. Apart from this, a further two circumstances must be considered:

Alabaster is extracted from the quarries in Fuentes de Ebro. General view of the exploitation front in one of the quarries

The exploitation of alabaster requires wide concessions in which a large area is affected in order to obtain only a limited volume of resource, which makes environmental restoration difficult.

There are numerous old exploitation sites that became abandoned before current environmental protection law was implemented, which has degraded the environment.

**The Calatayud Area**

It comprises a fringe along the Jiloca River extending from the town of Calatayud to the village of Villafeliche. In the areas surrounding the village of Fuentes de Jiloca there are quarries from which alabaster and gypsum have intermittently been extracted thanks to the existence of a very thick body of alabastrine-gypsum that includes big boulders of alabaster.

This gypsum was also formed in an evaporitic sedimentary environment during the Tertiary, in the Miocene. The gypsum levels can attain between 4-12m in thickness.

The gypsum levels include brown silica nodules and kidney-shaped alabaster nodules. The alabaster ones may reach $1m^3$. The occurring varieties of alabaster are dark grey to dark brown and yellowish. They display great compactness and medial translucency. There seems to be a considerable volume of reserves.

## 3.2 THE USE OF ARAGONESE ALABASTER

The abundance of alabaster in our region must have been crucial for its use in architecture, sculpture and decoration. There is no record of likely use by pre-Roman cultures, so perhaps the first ones to use alabaster in Aragon were the Romans, who produced vessels with alabaster following the Greek and Egyptian models.

It seems that since the reconstruction of the Roman Wall in Zaragoza in the 3rd century AD with alabaster, the use of this material became common in building for centuries. Muslim Saraqusta (today, Zaragoza) was also called "Medina Albaida", the White City, due to the appearance of its alabaster walls and palaces, which stood out among gardens, groves and orchards by the Ebro and Huerva Rivers. The oldest remains in the Aljafería Palace, together with other interesting elements like capitals, reliefs and inscriptions, were made using alabaster.

But it was during the artistic and economic blossoming of the Renaissance that Aragonese alabaster reached its Golden Age. In the 16$^{th}$ century sculptors in Aragon chose alabaster for their best works. They were adept at exploiting its lighting qualities and generally speaking the finished art pieces retained their natural color.

Major artists have used alabaster in Aragon: Damian Forment (main altarpiece in the Basilica of the Pillar in Zaragoza and in Huesca's Cathedral), the Gil Morlanes brothers (altarpiece in Montearagón Monastery and façade-altarpiece of the Church of Santa Engracia in Zaragoza, which is widely regarded as one of the most important works of the early Renaissance in the Iberian Peninsula), Juan de Anchieta and Guillén Salvan (San Miguel altarpiece in la Seo Cathedral in Zaragoza, and Trinity altarpiece in Jaca's Cathedral), Juan de Talavera and Esteban de Obray (façade of the Santa Mara Collegiate Church in Calatayud).

Façade-altarpiece of Santa Engracia Church in Zaragoza

Altarpiece in Huesca’s Cathedral

A closer view of the façade in Santa Engracia (Zaragoza)

Sculpture of Eternal Father, made in alabaster, part of the Trinity group in Jaca’s Cathedral chapel.

Due to the reputation of alabaster as a high-quality material this material was widely used during this period in buildings for prosperous families (Sástago Palace and Infanta's Courtyard, Zaragoza).

In Romanesque art in Aragon, alabaster was abundantly used for windows in churches, chapels and cathedrals. From the 13th century onwards, alabaster became the preferred material in Gothic sculpture, but by then its used has diversified to include funerary monuments, sarcophagi and gravestones, as well as decorative elements in doorways and façades, such as the rose window in the main entrance to the Gothic Church in Valderrobres.

Of special relevance was the work of such notable artists as Pere Moragues, who in the 14th century sculpted Archbishop Lope Fernández de Luna's sepulchre in La Seo in Zaragoza.

During the 15th century, there was an important artistic development linked to the creation monumental religious works. It was then that various artistic schools appeared led by artists such as Pere Johan and Hans Piet D'Anso. They were the authors of the most important altarpiece in La Seo Cathedral in Zaragoza. The use of alabaster provided it with extremely beautiful quality and transparency, which combined with partial polychromy.

In later centuries, this material was used in the sculpture of crests and coats of arms. It has always preserved its reputation as a scarce and well-appreciated material associated to the arts. Today, alabaster maintains this character: the quality of Aragonese alabaster is widely recognized by famous sculptors such as Chillida, who usually look for raw material for their creations in the Aragonese quarries.

Among the great works of architecture present in Aragon, it is worth mentioning the Aragon Pavilion for the Universal Exhibition in Seville, with 2,600$m^2$ of alabaster, or the 1,300$m^2$ of alabaster installed in Zaragoza's Auditorium. Both works were designed by the architect Jose Manuel Pérez Latorre.

The use of alabaster has been significant in restoration works, as was the case for the altarpieces in the Pilar Basilic in Zaragoza or in Huesca's Cathedral, the main façade in Santa Engracia's Church, or the Palace of the Dukes of Sástago.

Aragon has excellent alabaster artisans, who are able to enhance the virtues of this material with their designs. The transformation of alabaster boulders is also carried out in sawmills in the provinces of Tarragona and Navarra.

Nowadays, almost 50% of the transparent alabaster produced in Aragon is exported to Italy, where it is used in the manufacturing of elaborated alabaster. Other important importing countries are the USA, Mexico, Canada, France, the UK, Germany, Belgium, Iraq, China, the Philippines and Taiwan.

Current architecture takes creative advantage of the interesting possibilities of Aragonese alabaster. Noticeabe recent examples are worth mentioning, such as the building for the Miró Foundation Museum in Palma de Mallorca, designed by Rafael Moneo, where stone combines with sunlight and the play of water moved by wind, or the building of the Madrid Assembly (by Juan Masco), both built with Aragonese alabaster. The colossal cathedral in Los Angeles, designed by the Spanish architect Rafael Moneo, with 27,000 square feet of alabaster in its windows, is an example of current trends regarding the use of alabaster in architecture.

CREA building (Zaragoza)

Façade of Santa Isabel Church (Zaragoza)

A closer view of the San Bernardo altarpiece, carved in alabaster, in La Seo Cathedral

A closer view of the alabaster window in the CREA building (Zaragoza)