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ALABASTER OF ARAGON: THE PAST, THE PRESESENT AND THE FUTURE

(Recommended by S. Shevchenko, PhD (Geol.))

Results of historical and art researches as well as studying of alabaster composition from different objects of Aragon are given in this article. The authors confirmed utilization of alabaster from deposits, which are located in the Basin of Ebro River, as possible sources of raw material during different historical epochs to build the Roma walls, to erect various buildings and to carve nice sculptures during the Renaissance. The authors carried out petrographic observation of alabaster from Aragon, its X-ray studying, measured hardness of alabaster and compare obtained and new data with Miocene alabaster from the Tyras'ka Formation. Modern utilization of alabaster together with new techniques is suggested on possible beginning of the new Golden Age for alabaster.

Key words: alabaster, Aragon, Spain, Ebro, Rome walls, historical monuments, alabaster deposits, modern alabaster art.

Introduction and statement of the problem

The oldest applying of alabaster is known since ancient Assirian, Babilonian and Egyptian Kingdoms. It was also popular during Caesarepochsand the Renascence, period of Ar-Deko development and the modern time to do sculptures and to establish religion buildings, etc. In spite of this, only a few of regions were famous due to alabaster resources for different purpouses of industry, architecture, sculpture, and decorations. In due course not many countries kept their resources and abilities to use alabaster and in our time only Spain and Italy are significant players in this sphere. Expirience of these countries is very significant for development of alabaster processing, creation of different art goods, decorations as well as exploration of alabaster deposits. Knowledge of alabaster history, works of art, and fine features of alabaster is very important for Ukraine, where there are evidences of old alabaster traditions, its resources (Guliy et al., 2018), but activity in this part of industry has been turned only to production of gypsum powder and building mixtures.

Analysis of latest investigations

Detailed geological exploration works at the promising sectors along the Basin of Ebro River were accompanied by studing of similar objects in other sectors of the areas where alabaster –bearing sedimentary formations mainly chemogenic in origin are developed (Escavy et al., 2012). In addition to primary idea about importance of initial anhydrite transformation (Murray, 1974; Ortí et al., 2007) to produce new formed alabaster nodules, a new model of simple direct precipitation of alabaster from saturated brines in chemogenic environment has been proposed (Colas et al., 2009; Fanlo et al., 2007).

At the same time new reports on history of alabaster art, connection to different architectures styles as well as to various political and economical waves in the primary lands of Spain have been appeared in religion, scientific, and cultural literatures (Phillips & Phillips, 2015). So, now there are rich and various materials to try to understand a great fenomen of historically long life of alabaster here.

Pinpointing unresolved issues

Despite very complicated history of Spain with numerouswars, invasions; replacement of religions, ideologies etc.,and alabaster had permanent popularity since ancient time up to modernt time and there is not obvious explanation of the matter. Similar fortune has the Galychyna, but the alabaster destiny here was not so direct and we can see great waves of flights and falls of its popularity.

Alabaster-bearing rocks areregarded as sedimentary formations and it

determinates theirspecific composition and features (Escavy et al., 2012), but alabaster presence itself can't besuggested meaning on its origin as result of secondary processes. The hypothesesof alabaster origin have given placeto better documented models about the primary layer structureand chemogenic nature of the deposits. Atthe same time, data on nodular alabaster finds in some manifestations (Murray, 1974; Ortí et al., 2007) have been stimulated opinions about metasomatic transformation of primary anhydrite concentrations.

Setting objectives

This paper presents results of thesystematic search of alabaster peculiarities from various historical and art complexes of Aragon to determine its main features and origin in sedimentary formations of the Basin of Ebro River. We attempt also to trace geneticlinks between the alabaster finds and hosting its primary rocks, to compare with significant role of mechanical and persistence behavior under natural weathering agents.

Research part and findings validated

Aragon in its own history experienced numerous changes of fortune, including wars, invasions; replacement of religions, ideologies etc., but alabaster had permanent popularity since ancient time up to present day. There is vague information about utilization of alabaster by Carthaginian, and then by Romans to build roads (Jacobson, 1940) or to make vessels from alabaster following the Greek and Egyptian examples. But now, we can see the biggest in the scale evidences of its old application mainly as relics of Roman Wall (1st – 3th century CE) in Zaragoza Old Town (Peña et al., 2010) (fig. 1). Alabaster as massive, fine grained variety of gypsum was popular material for this and other different purposes during the centuries in Aragon.

Owing to the Muslim conquest, architectural style of Zaragoza and surrounding places had been thoroughly changed by following rebuilding of previous religion, state and civil objects. But, due to erection of new alabaster palaces and walls Muslim Saraqusta (modern Zaragoza) was also called "Medina Albaida" (the White City).

Spain has been locked for more than a couple of centuries in those civil wars known as the Reconquista, which ended with the fall of the last Muslim kingdom of Granada in 1492 (Phillips & Phillips, 2015). The monarchs oversaw the final stages of the Reconquista of Iberian territory from the Moors. During next centuries all sides of life had obtained big impulse. It was "Golden Age" for economy, cultural sphere and science. For the next centuries, the Spanish Empire has dominated on the oceans, and Christopher Columbus became the first known European to reach the New World since Leif Ericson (Casey, 1999; Phillips & Phillips, 2015). It was violent growth of the Renaissance that Aragon's alabaster reached its "Golden Age".

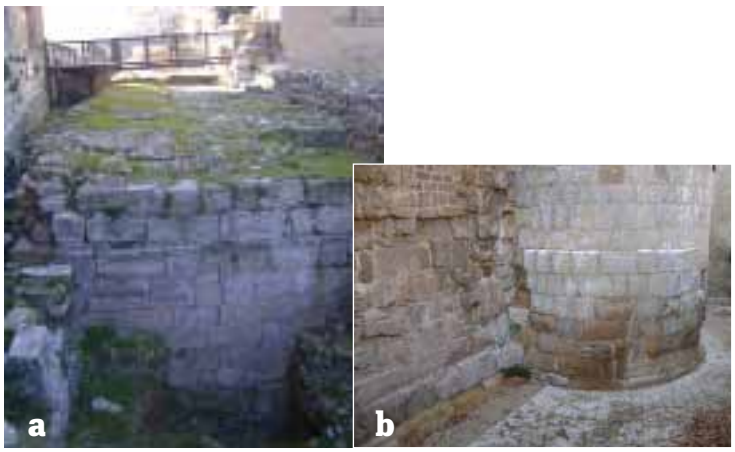

Fig. 1. Relics of the Roman walls in Zaragoza (a, b)

Architectures and sculptors in Aragon have chosen alabaster for their best works due to its qualities and nearest locations of deposits. The valley of the Ebro River was estimated (Byne & Stapley, 1917; Casey, 1999) as a natural route for artists passing mainly to and from Italy, so Zaragoza was no stranger to the new style.

Monumental religion, civil and living buildings with wonderful alabaster decorations, panels and sculptures are objects of interest and delights not only among tourists, but popular for specialists. There are a number of routs to show and explain details for visitors about famous the Basilica of the Pilar (Zaragoza) and Huesca's Cathedral the with main alabaster altarpieces and gallery made by Damian Forment (1480-1540), and the La Seo Cathedral (1316), made with the white stone and decorated carving alabaster by Pere Johan and Piet D'Anso originally from Germany. One more famous example of alabaster application of the Renaissance style is the portal and façade-altarpiece of the Church of Santa Engracia (XV-XVI), which was began by Juan Morlanes and then the son Diego Morlanes or Forment carried it on (Byne & Stapley, 1917; Casey, 1999). Now the Church is widely regarded as one of the most important works of the early Renaissance in the Iberian Peninsula).

The Santa Isabel Church (1681) has monumental and impressible air due to inclusive white alabaster decoration on a dark ground. The church was built and decorated by Jaime Aier and Fransisco Peres. Alabaster sculptures were placed at the church facade (fig. 2). Only dry and hot climate of Aragon could keep in good conditions so fine material.

Fig. 2. The Santa Isabel Church (a) and sculptures fragment at the façade (b). Zaragoza

Fig. 3. Quarry near the La Zaida (right side of the Ebro River) with alabaster layer (a, lower part) and nodular alabaster as an initial material (b)

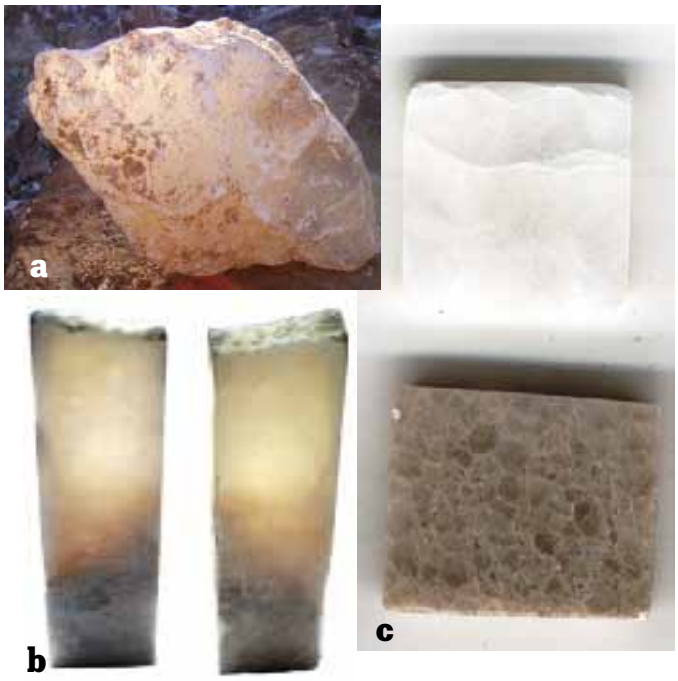

Fig. 4. Semi-transparent alabaster in the sun bright (a).Thin plate of Alabaster sample in two directions (b).Polished slabs of the white and black parts from the plate (c)

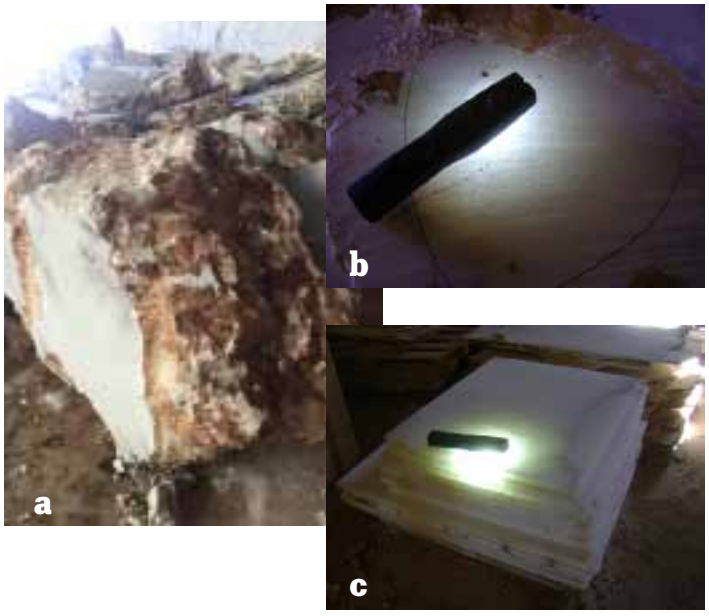

Fig. 5. Cutting of nodular alabaster blocks (a) and testing of alabaster with light (b, c)

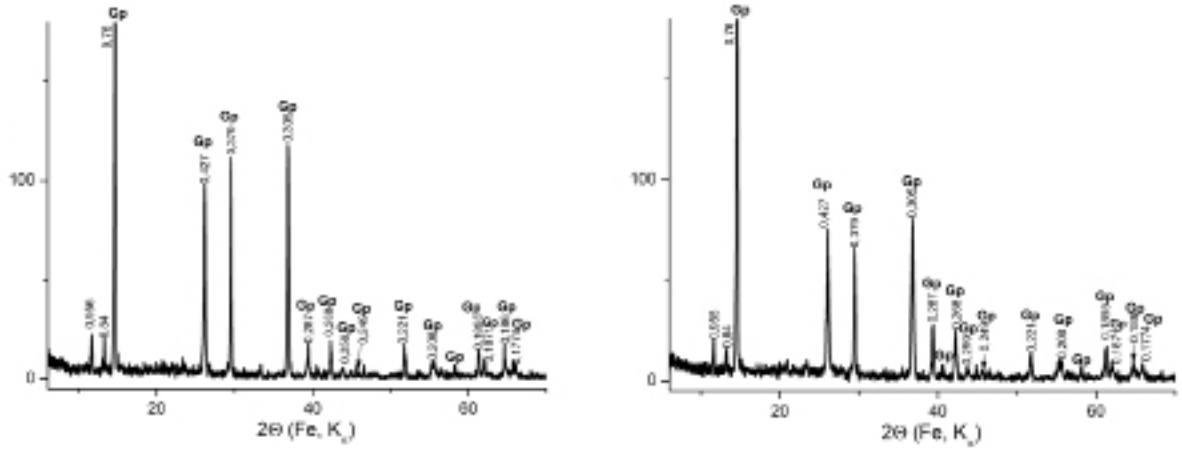

Fig. 6. X-ray diffractograms (a, b) of the alabaster. Vertical axis – intensity of impulses

Initial materials and methods of the investigation

Alabaster is extracted from the quarries in different regions of Spain, which are located within Mesozoic evaporite-bearing and Cenozoic gypsum-bearing units (Escavy et al., 2012). Gypsum beds from the Mesozoic evaporate-bearing formations are up to some dozens m thick, with laminar, nodular and massive facies that represent a playa-lake environment which persisted until Paleogene times. Most of Paleogene and Neogene gypsum-bearing units are continental in origin, and formed during evaporitic sedimentation (Colas et al., 2009; Fanlo et al., 2007). As well as Quaternary sulfate rich sediments, they are significantly developed in Ebro Basin Zone.

The most important for alabaster industry is nodular facies which can be developed for some kilometers along limits of gypsum-bearing units (Ortí et al., 2010). Nodular gypsum (up to couple of meters in diameter) is commonly regarded (Murray, 1974; Ortí et al., 2007) as a result of secondary processes due to replace of primary nodular anhydrite.

In Spain alabaster has been queried in various places, although the present day extraction remains inly at the sites in Aragon. Aragon has the largest known exploitable alabaster deposits which are concentrated in two different geographically separated sites in the Tertiary Ebro Basin and Calatayud-Teruel Basin to the east and south-east from Zaragoza (Colas et al., 2009; Fanlo et al., 2007; Ortí et al., 2010). Alabaster is extracted from the quarries in Fuentes de Ebro, La Zaida, Gelsa, Guinto, etc.

General view of the exploitation front in one of the quarries near the La Zaida shows intercalation of alabaster layer with rich in clay minerals green or red-brown in color horizons under horizontal or very low-dipping beds (fig. 3). Alabaster layer up to 5 meters thick is composed massive nodular material (fig. 3) which is initial source for followed processing. To find impressible massive and semi-transparent fine alabaster broken pieces (fig. 4) is easy here even before washing and cleaning.

In the Catalayud area there are quarries from which alabaster has intermittently been extracted due to the existence of a very thick body of alabastrine-gypsum that includes big boulders (up to 1 m^3) of alabaster (Escavy et al., 2012; Ortí et al., 2010). The occurring varieties of alabaster are dark grey to dark brown and yellowish. They display great compactness and medial translucency.

Transformation processes of the obtained material include cleaning and washing, sawing with circular saws, veneering and sanding (fig. 5). To determine quality of the product commonly are using special lights (fig. 5). Only material free of fractures, broken surface, veinlet etc. is utilized for following fine stages, but some blocks with interesting for artists pictures of alabaster are adapted also. Some additional procedures (for example, coloring) are realizing for special cases.

To estimate a quality of the alabaster we applied a set of instrumental methods, which include studying of thin sections with microscope, X-ray powder diffraction investigation, and direct measuring of hardness of different varieties of alabaster. For alabaster samples from quarries near the La Zaida we got diffractograms with four the most intensive peaks (2Θ - 0.76; 0.427; 0.379, 0.305 nm), which are typical for gypsum (fig. 6). We found no any admixtures of anhydrite.

Hardness of the alabaster was investigated by direct measurements with a PMT-3 micro indention instrument under a load of 20 g. A diamond pyramid with an angle of 136° has been used for the evaluation of the Vickers hardness. Obtained data (table) are homogenous and very high (up to 131 kg/mm^2), which are close to calcite data. There is a big similarity in alabaster hardness for studied samples from deposits of the Ebro River Basin (Spain) and from the Miocene alabaster deposits of the Tyraska Formation (Ukraine) and Lopushka Welka (Poland) (Guliy et al., 2018).

Obtained results and discussion

The annual extraction of alabaster in Spain is relatively stable and output reached about 40 000tap (after IGME: Geological and Mining Institute of Spain). Main sources of this amount are deposits of the Zaragoza and Teruel areas (Fanlo et al., 2007; Escavy et al., 2012; Ortí et al., 2010). According to the Department of Industry and Innovation of Aragon significant part (up to 70 %) of the mined alabaster is exported to different countries of America, Asia and Europe. Among them Italy is significant country (up to 50%) of the transparent alabaster.

Modern techniques and the abundance of alabaster in the region have adapted the market for alabaster on interior design, lighting, architecture, sculptures and small artistic objects (fig. 7). Alabaster from quarries in the Teruel area is one of its main resources, dedicated to both the export and cultural promotion, through routes, meeting craft and art activities, organized annually by the Center for Integrated Development of Alabaster.

Table. Hardness of the alabaster from Spain, Ukraine and Poland

Region	Samples	Hardness	
		Limits/average, Kg/mm^2	Limits/average Mohs's scale
Basin of Ebro River, Spain	1 (21 points)	(57 – 95)/76	(2.7 – 3.2)/2.97
	1-1 (21 points)	(71 – 131)/86	(2.9 – 3.6)/3.07
	2 (21 points)	(46 – 86)/69	(2.5 – 3.1)/2.85
Tyraska Formation, Ukraine	Total (41 pionts)	(58 – 103)/78	(2.7 – 3.3)/2.98
LopushkaWelka, Poland	Total (20 points)	(79 - 95)/83	(2.9 – 3.2)/3.0

The application of alabaster is determined by its features and must be used indoors mostly or be protected against the dampness. The cooling systems need to keep alabaster in good condition with the sun high temperature in the special climate zones.

The great Cathedral in Los Angeles (2002), designed by the Spanish architect Rafael Moneo, has impressive example of combination of fine natural quality of alabaster and using of modern cooling technology to give a long life to give a long life to alabaster and also enjoying of light through the wonderful alabaster windows (fig. 8).

It seems to be a beginning of the new Golden Age for alabaster.

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Fig. 7. Alabaster room (a) of the ARASTONE S.L. and alabaster windows in the main railway station Delicias (b), Zaragoza

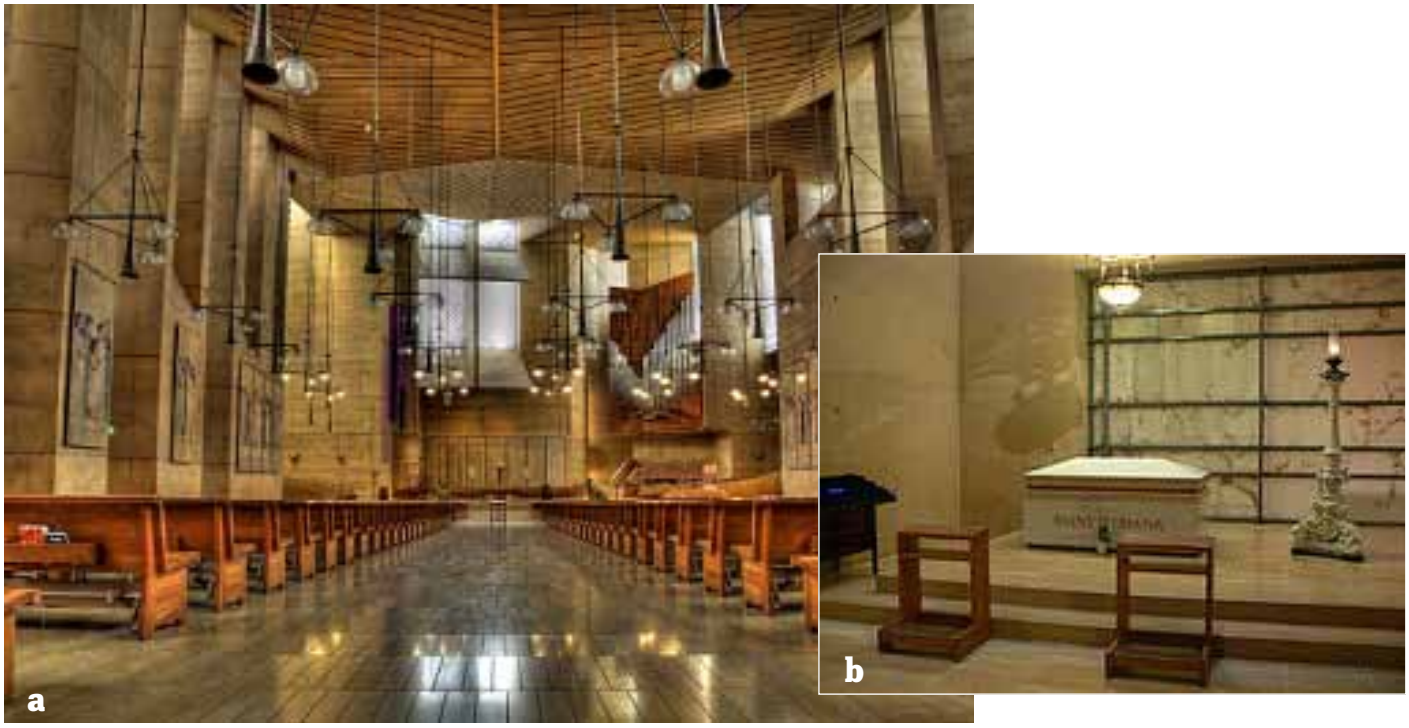

Fig. 8. Alabaster windows in the Cathedral of Our Lady of the Angels, Los-Angeles. Interior of the Cathedral. Photo of Bobby Gibbons (a) [13]. Tomb of Sant Viviana near alabaster panel (b) [14]

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Алебастр Арагону: минуле, сьогодення і майбутнє

У цій статті наведено результати історичних, мистецьких та речовинних досліджень алебастру з різних об'єктів Арагону. Підтверджено використання алебастру з покладів, які розташовані в долині ріки Ебро, як джерела сировини в різні історичні епохи для спорудження захисних стін часів Римської імперії і в епоху Ренесансу. Автори провели петрографічне вивчення алебастру з Арагону, його рентгенівське дослідження і вимірювання мікротвердості, а також порівняли отримані відомості з наявними для алебастру з міоценових утворень Тираської світи. Сучасне використання алебастру в поєднанні з передовими технологіями вказує на можливу нову «золоту епоху» для алебастру.

Ключові слова: алебастр, Арагон, Іспанія, Ебра, римські стіни, історичні пам'ятники, родовища алебастру, сучасне мистецтво алебастру.

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Алебастр Арагона: прошлое, настоящее и будущее

В данной статье приведены результаты исторических, искусствоведческих исследований и анализ вещественного состава алебастра различных объектов Арагона. Подтверждено использование алебастра из залежей, которые расположены в долине реки Эбро, как источника сырья в различные исторические эпохи для сооружения защитных стен времен Римской империи и в эпоху Ренессанса. Авторы провели петрографическое изучения алебастра Арагона, его рентгеновское исследование и измерения микротвердости, а также сравнили полученные данные с имеющимися для алебастра миоценовых образований Тираской свиты. Современное использование алебастра в сочетании с передовыми технологиями указывает на возможную новую «золотую эпоху» для него.

Ключевые слова: алебастр, Арагон, Испания, Эбра, римские стены, исторические памятники, месторождения алебастра, современное искусство алебастра.