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Archaeometry analysis of early medieval pottery sherds from Idanha-a-Velha (Portugal)

Análisis arqueométrica de fragmentos cerámicos Alto Medievales de Idanha-a-Velha (Portugal)

KEY WORDS: Beira Interior, Glazed pottery, XRD-XRF, Archaeological sciences, Pottery production.
PALABRAS CLAVES: Beira Interior, cerámica vidriada, XRD-XRF, ciencias arqueológicas, producción cerámica.
GAKO-HITZAK: Beira Interior, beiraztutako zeramika, XRD-XRF, zientzia arkeologikoak, produkzio zeramikoa.

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ABSTRACT

Since 2017 there has been studies about the Early Medieval Ages (5th to 12th centuries) pottery from Idanha-a-Velha, integrated within a research project directed in analyzing the classical and early medieval city. The archaeometry study presented here had the objective of determining if there was a local production of pottery during the Early Middle Ages and/or the presence of exogenous vessels. There were analyzed 24 samples of pottery from different contexts and chronologies, in terms of mineralogy and chemical composition. We were able to determine that there was in fact a local production during the entirety of the period analyzed and some vessels from outside the local/regional raw material. The study demonstrated that Idanha-a-Velha was indeed a pottery production center during the Early Middle Ages and that it remains in the commercial routes even after the end of the circulation period of the *Terra Sigillata*.

RESUMEN

Desde 2017, se han llevado a cabo estudios sobre la cerámica de la Alta Edad Media (siglos V al XII) en Idanha-a-Velha, como parte de un proyecto de investigación dirigido al análisis de la ciudad clásica y altomedieval. El estudio arqueométrico aquí presentado tuvo como objetivo determinar la existencia de producción local de cerámica durante la Alta Edad Media y/o la presencia de vasijas exógenas. Se analizaron 24 muestras de cerámica provenientes de diferentes contextos y cronologías, evaluando su mineralogía y composición química. Los resultados confirmaron la existencia de producción local a lo largo de todo el período analizado, así como la presencia de algunos fragmentos que no correspondían a la materia prima local o regional. Este estudio demuestra que Idanha-a-Velha fue un centro de producción cerámica durante la Alta Edad Media y que mantuvo su relevancia en las rutas comerciales incluso después del cese de la circulación de la Terra Sigillata.

LABURPENA

2017az geroztik, Goi Erdi Aroko (V. mendetik XII.era) zeramikari buruzko azterlanak egin dira Idanha-a-Velhan, hiri klasikoaren eta Goi Erdi Aroko hiriaren azterketara zuzendutako ikerketa-proiektuaren parte gisa. Hemen aurkeztutako azterketa arkeometrikoaren helburua Goi Erdi Aroan tokiko zeramika-produkziorik eta/edo ontzi exogenorik ba ote zegoen zehaztea izan zen. Hainbat testuinguru eta kronologiatako zeramikazko 24 lagin aztertu ziren, mineralogia eta konposizio kimikoa ebaluatuz. Emaitzek berretsi egin zuten bazegoela tokiko produkzioa aztertutako aldi osoan, bai eta tokiko edo eskualdeko lehengaiari ez zegozkion zati batzuk ere. Ikerketa honek frogatzen du Idanha-a-Velha zeramika-produkzioko zentro bat izan zela Goi Erdi Aroan, eta bere garrantzia mantendu zuela merkataritza-ibilbideetan, baita Terra Sigillata-ren zirkulazioa eten ondoren ere.

1. INTRODUCTION

The village of Idanha-a-Velha, where it was located the old city of Egitânia, is certainly one of the main archaeological sites in Portugal (Fig. 1). It was founded by the romans on the 1st century BC as Civitas Igaeditanorum, being the main roman center on the interior of the province of Lusitania. It became known as Egitânia later, in the Early Medieval period, when it was an important Suevic (and later Visigothic) city, becoming a bishopric at least since the 6th century (but probably earlier) and a *ceca* of golden *tremisses*. Some of the most ancient Christian remains in Portugal, such as a baptismal pool from the end of the 4th century, are located on this site (Fernández *et al.,* 2019).

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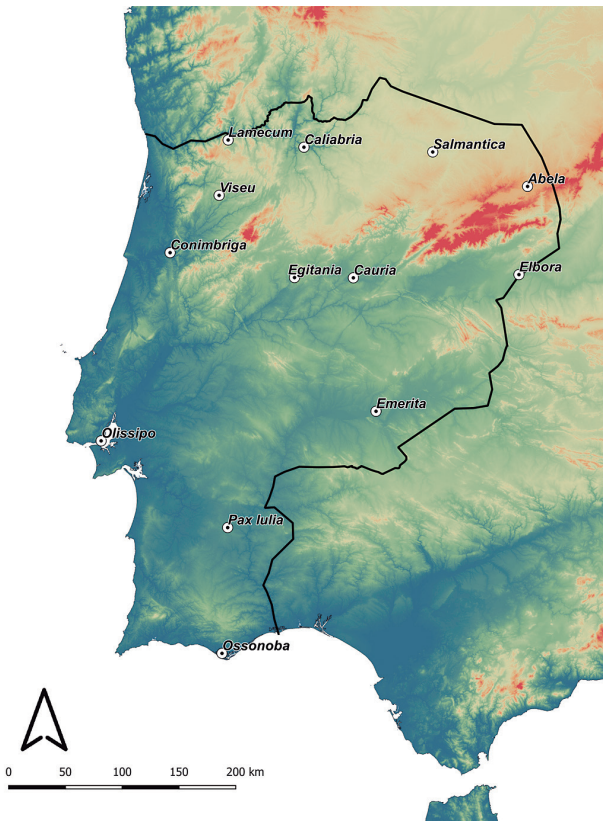

Fig.1. Location of Egitânia in the limits of the ancient roman province of Lusitania. /Localización de Egitânia en los límites de la antigua provincia romana de Lusitania.

The site has been studied since the end of the 19th century and excavated since the fifties of the previous century. However, despite the long running investigations about the city, there had been almost no publications about the medieval pottery and contexts of ancient Egitânia. Furthermore, the more recent excavations promoted by the municipality, mainly between 1998 and 2005, didn't had written reports or publications. Beginning in 2017, in the context of the investigation project IGAEDIS (From the civitas Igaeditanorum to Egitânia. The construction and evolution of the city and the definition of its territories from the Roman era until the donation of the Templars -1st to 12th centuries), several archaeological activities have been carried out in the historic village of Idanha-a-Velha. The project had several aims, including the review of the previous archaeological interventions, studying the stratigraphy, the correlated archaeological artefacts and promoting several types of analysis, such as radiocarbon, OSL analysis and chemical analysis on pottery. Also part of this project was a doctoral thesis focusing in the common pottery from the city in this time period, from one of the authors of the current paper (Souza, 2024). It was as part of the investigation for this thesis and the project that there was the opportunity to analyze a set of pottery samples from the collection at Idanha-a-Velha. The current paper focuses on the results of the analysis of these pottery sherds, specifically of early medieval levels, between the 5th and 12th centuries.

There were analyzed 24 samples (see Fig. 7) from different contexts and chronologies inside the ancient city, in terms of mineralogy and chemical composition. We had several objectives and questions that we wanted to answer with this line of investigation. Our first objective was to verify if there was a local production during the early Middle Ages, its percentage in the collection and what would characterize it. Another objective was to verify if exogenous vessels continue to reach the city, since we knew that there were commercial circuits of *Terra Sigillata* (Hispanic and north African) that included Idanha-a-Velha at least until the second halve of 5th century, beside some *Terra Sigillata* imitations (from Braga) until the beginning of the 6th century. If there were exogenous vessels, it would be important to chemically characterize those productions, in an effort to pinpoint their geographical origin and, in doing so, to define possible trade routes. In relation with this last question, we had several glazed sherds, of Islamic tradition, analyzed. Our objective in this case was to determine their origin and characteristics, which would be very important in our comprehension of the Islamic influence and presence in Idanha-a-Velha. All these questions were important for the development of the project, providing essential information for the correct interpretation of the medieval pottery collection and, in doing so, for the development of a new or revised historical discourse on medieval Egitânia.

2. ANALYTICAL METHODOLOGY

In the context of the previous mention doctoral thesis, we had the opportunity of reviewing pottery collections from 20 different archaeological excavations, analyzing the complete assemblage, from the roman period to the contemporary vessels. From this base of study, we had the budget to select 24 samples for the mineralogy and chemical analysis, from the Early Medieval levels.

The selection process began with the definition of the minimal number of vessels (MNV) from the totality of the pottery sherds. We had almost 17 thousand sherds, from which we selected 637 vessels for the MNV. Once defined the general MNV, we selected the most secure excavations and levels, to be sure about the chronology of what we would be analyzing (Table 1). Of the 20 different excavations analyzed, several were smaller interventions, without proper records and descriptions of the stratigraphy. Therefore, only 334 of the MNV were considered for further study, been from excavations with better records, drawings and description. From these, we selected even further, to have the most important excavations and layers.

There were two main excavations areas in Idanha-a-Velha before the IGAEDIS project: the zone called

CODE	EXCAVATION	EU	CHRONOLOGY	TIPOLOGY	BODY COLOUR	GLAZED	GLAZE COLOUR	OBSERVATIONS	GROUP
NMR007	LOG1	3/4	IX-XI	Unknow	Grey-Red	yes	Yellow-green/Green	Both sides glazed	6
NMR021	LOG2	3/4	IX-XI	Unknow	White	yes	Green	-	3
NMR024	LOG2	3/4	IX-XI	Jar	Beige	no	-	-	2
NMR026	LOG2	3/4	IX-XI	Jar	Red/Beige	no	-	-	2
NMR049	LOG3	3	XI-XII	Pot	Browm/Red	no	-	-	1
NMR054	LOG3	3	XI-XII	Jar	Black	no	-	-	1
NMR071	LOG3	7	VI-VII	Pot	Black/Red	no	-	Black core	6
NMR076	LOG4	3	XI-XII	Pot	Red	no	-	-	1
NMR088	LOG4	7	VI-VII	Pot	Black	no	-	-	1
NMR207	POTERNA	15	VI-VII	Pot	Black/Browm	no	-	-	1
NMR213	CCI	24	XII-XIII?	Bowl	Browm	yes	Browm	-	4
NMR214	CCI	24	XII-XIII?	Pot	Red	no	-	-	1
NMR221	CCI	40	VII-IX	Jar	Browm	no	-	-	1
NMR231	CCI	42	V-VI	Pot	Black/Browm	no	-	-	2
NMR236	Ent. Cabos	-	VI-VII	Jar	Browm/Grey	no	-	Black earth	2
NMR237	Ent. Cabos	-	VI-VII	Bowl	Black	no	-	Black earth	4
NMR338	CCII P4	4	XI-XII	Pot	Black	no	-	-	6
NMR354	CCII P4	4	XI-XII	Pot	Black/Red	no	-	-	6
NMR365	CCII P4	5	IV-VI	Pot	Black	no	-	-	1
NMR383	CCII P7	2	IX-XI	Unknow	White	yes	Green/ Browm	Both sides glazed	3
NMR386	CCII P7	11	VI-VII	Pot	Black/Browm	no	-	-	1
NMR407	CCII P8	6	VI-VII	Jar	Red	no	-	-	5
NMR409	CCII P8	6	VI-VII	Pot	Browm	no	-	-	5
NMR413	CCII P8	7	V-VI	Pot	Black	no	-	-	1

Table 1: Description of the analyzed samples with the respective chronology and groups of production. / Descripción de las muestras analizadas con su respectiva cronología y grupos de producción.

Chão dos Cardos (divided in two sections, CCI and CCII) and the *Logradouro* (LOG), both carried out by José Cristóvão (Idanha-a-Nova Municipality). The first zone was, in antiquity, an area of domestic buildings, starting in the roman period and until the 12th century. In CCI, we selected samples from three layers, namely from 42 (the abandonment layer of a late roman domestic structure), 40 and 24 (these two were filling layers from the medieval period, with discard pottery from close by houses). In CCII, the area was divided into eight different test pits, and we selected samples from pits 4, 7 and 8, where there were the most materials. In pit 4, the layers were connected to a medieval domestic structure, while the others are filling layers with domestic waste. The second zone, called *Logradouro*, was the biggest in terms of excavated area, with almost five meters between the current surface and the rock base, and the one with the most ceramic fragments. The samples from this excavation came from two phases. Layer 7 served as the foundation for the construction of a new medieval structure, build after the abandonment of the previous roman *Domus*. A radiocarbon dating analysis was conducted on a fauna fragment from this layer, yielding a chronology close to the late 5th or early 6th century (1590 ± 30 BP). When calibrated with 95.4% confidence, the results indicate a range between AD 418–548, with the median date near AD 500. Some of the pottery from this level could push chronology closer to the 6th-7th centuries. Layers 3 and 4 are more recent, from after the 9th century. The area was probably a discard zone for a domestic structure excavated just to the north of *Logradouro*, that was abandoned in the 12th century.

Besides samples from these two main areas, we selected some fragments from other two smaller excavations, namely *Enterramento dos Cabos* (Ent. Cabos) and *Poterna* (see Fig. 3). In the first case, the context is small but very precise. There are good records, and the selected layer is the foundation of a rock paved road leading to the St. Mary church. The materials were dated to the 6th-7th centuries. In the case of the *Poterna*, it is a small gate in the western part of the city wall, which was closed, also in the 6th-7th centuries. The sample, from NMR207, is from the level that closed the gate.

From these contexts, we try to have as many "pottery groups" as possible, based on the macroscopical analysis that suggested that we had between 8 and 10 different fabric groups. As stated before in this paper,

we also send samples from glazed vessels, four to be more specific. In the context of medieval Idanha-a-Velha, the pottery of more obvious Islamic tradition (glazed or with white/black paintings) represents a minority of the collection, with 0,3% of the total of fragments and 1,7% of the MNV. However, we opted to have several of them analyzed because of their importance in terms of interpretation of the site, and to try to determine their origin and how different they were compared with the possible local productions.

From a technical perspective, the mineralogy was identified in Powder X-Ray Diffraction (XRD) with a Philips PW1710 diffractometer (Bragg-Brentano θ/2θ vertical goniometer, 2,2 kW tube generator, cooper anode, graphite monochromator, proportional detector PW1711/10; Measurement conditions: 2 a 65º de 2θ, step: 0,02; 3 s/step; Semi quantification software: DIFFRACplus, de Bruker AXS), following the principals from Heimann (1989).

The chemical composition was measured in Energy Dispersion X-Ray Fluorescence Spectrometry (XRF) with two own-USC spectrometers (primary anode of Mo and Ag; secondary anodes of Fe and Pyrografite, N_2(l) refrigerated Si (Li) detectors; Measurement conditions: 5-10 s/sample/mode); Calibration with international reference standards NIST.

The Statistical analysis (Hierarchical cluster) was made with IBM SPSS Statistics (version.24.0.0.0). Clustering method: link between groups; Interval measurement: Squared Euclidean distance. Data standardization by Z-scores.

3. ARCHAEOMETRIC RESULTS

On the mineralogical analysis, the detected minerals were quartz, K feldspar, plagioclase, muscovite, amphibole, pyroxene, gehlenite, mullite, hematite, dolomite (?) and anatase (Fig. 2, Table 2). The most frequent and abundant minerals were quartz, K feldspar and plagioclase while amphibole, pyroxene, hematite, anatase and dolomite were only detected as minor components in a few samples. All of them are probably part of the ceramic raw material. Gehlenite and mullite, only detected in NMR054, are newly formed minerals resulting from the ceramic firing process.

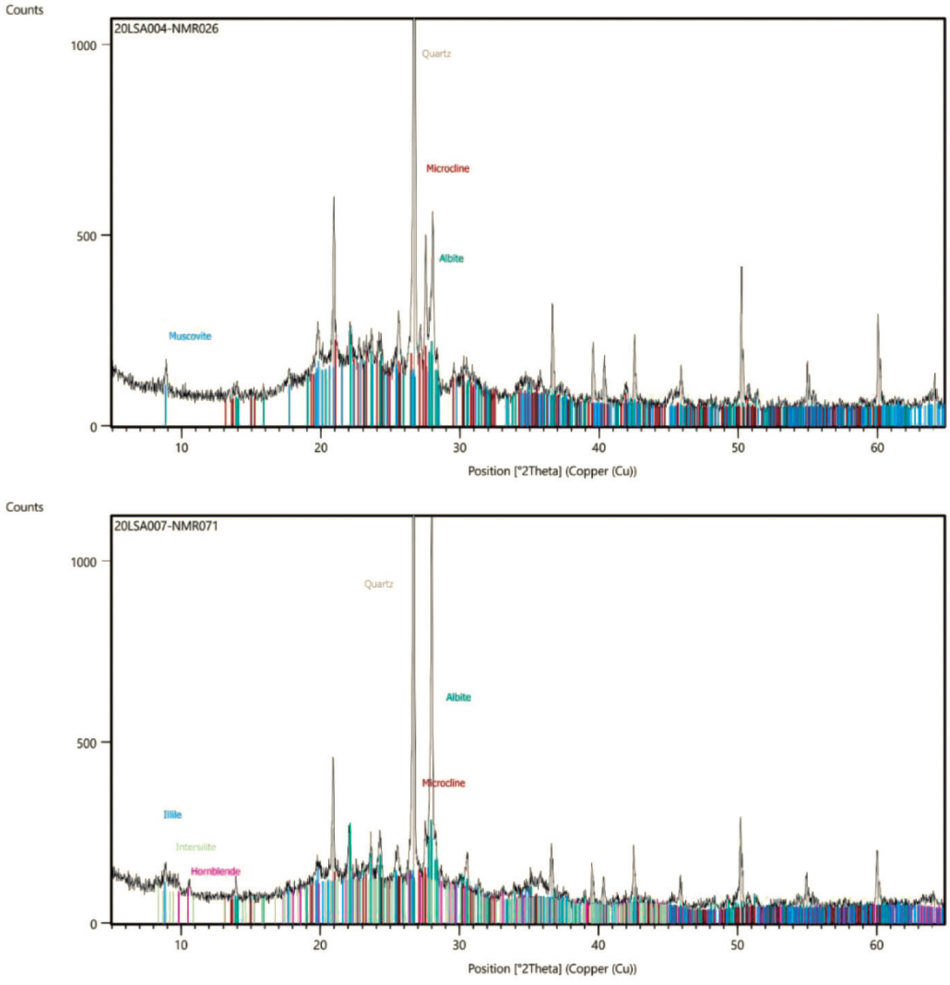

Fig.2. Two examples of diffractograms. NMR026: classical granitic composition (quartz, K feldspars, plagioclase, muscovite) and NMR071: amphibole composition (quartz, plagioclase, amphibole, mica). / Dos ejemplos de difractogramas. NMR026: composición granítica clásica (cuarzo, feldespatos potásicos, plagioclasa, moscovita) y NMR071: composición anfibólica (cuarzo, plagioclasa, anfíbol, mica).

CODE	Quartz	K feldspar	Plagioclase	Muscovite	Amphybol	Piroxene	Gehlenite	Mullite	Hematite	Dolomite	Anatase
NMR007	XXX	XX	XX	-	-	XX	-	-	tr	-	-
NMR021	XXXX	X	X	-	-	-	-	-	-	tr?	-
NMR024	XXXX	XXX	XXX	-	-	-	-	-	-	-	-
NMR026	XXXX	XXX	XXX	X	-	-	-	-	-	-	-
NMR049	XXXX	XXX	XXX	XX	-	-	-	-	-	-	-
NMR054	XXXX	X	tr	-	-	-	XX	?	-	-	-
NMR071	XXX	-	XXX	X	X	-	-	-	-	-	-
NMR076	XXXX	XX	XX	?	-	-	-	-	-	-	-
NMR088	XXXX	XXX	XXX	XXX	-	-	-	-	-	-	-
NMR207	XXX	XXX	XXX	XXX	-	-	-	-	-	-	-
NMR213	XXXX	-	XX	XX	-	-	-	-	tr	-	-
NMR214	XXXX	XX	XXX	XXX	-	-	-	-	-	-	-
NMR221	XXXX	XX	-	XX	-	-	-	-	-	-	-
NMR231	XXXX	-	XX	XXX	-	-	-	-	tr	-	-
NMR236	XXX	XX	XX	XX	-	-	-	-	-	-	-
NMR237	XXX	-	XXX	X	-	-	-	-	X	-	-
NMR338	XXXX	XX	XXX	XX	-	-	-	-	-	-	-
NMR354	XXXX	XX	XX	XX	-	-	-	-	-	-	-
NMR365	XXXX	XX	XXX	X	-	-	-		-	-	-
NMR383	XXXX	X	-	-	-	-	-	-	tr	tr?	tr
NMR386	XXXX	-	XX	XX	-	-	-	-	tr	-	-
NMR407	XXXX	-	XX	X	-	-	-	-	X	-	-
NMR409	XXXX	XX	-	X	-	-	-	-	X	tr?	-
NMR413	XXX	X	XX	XXX	-	-	-	-	-	-	-

Table 2: Semi quantification (crystalline fraction) of the detected minerals in the analyzed samples. / Semicuantificación (fracción cristalina) de los minerales detectados en las muestras analizadas.

In the chemical analysis, it was measured the concentration of 25 chemical elements: Na, Mg, Al, Si, P, S, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr, Ba and Pb (Table 3). Most of them have concentrations in the same range with some exceptions:

- Eight samples have high values of phosphorus: NMR221, NMR365, NMR007, NMR413, NMR338, MNR071, NMR354 AND NMR949. We must discard a direct source of apatite because it was not detected as mineral and because de levels of calcium are too low.
- Three samples have strangely high values of sulfur: MR007, NMR221, NMR213. We have to discard a gypsum source for this sulfur because these minerals were not detected, and the levels of calcium are too low. Maybe a galene (PbS) source for the glazed NMR007 and NMR213.
- Four samples have high levels of lead (in the ceramic body): NMR007, NMR021, NMR383, NMR213. These are the four glazed ceramics.
- About sodium, this element is badly detected in XRF (data are expressed in area) and only if it has a very high concentration, can it be well quantified. In all these samples it must have low concentrations.
- The rest of outliers are NMR338 (high arsenic and low zirconium), NMR071 (high magnesium, calcium, cooper, and nickel), NMR354 (high zinc and arsenic) and NMR007 (high magnesium, calcium, manganese, nickel and cooper).

The high concentration of phosphorus and sulfur found in some samples suggest a post depositional contamination. In the case of phosphorus, the origin could be nearby past burials or contributions of agricultural fertilizers. In the case of sulfur, in some cases there could be nearby contributions of agricultural treatments. Considering the excavation areas (see Fig. 3), the zone called *Chão dos Cardos* I (CCI) and *Chão dos Cardos* II (CCII) are places of recent agriculture activities, but the areas of *Logradouro* and *Enterramento dos Cabos* are not, and the samples especially with high phosphorus concentration belong to both. The samples from CCI and CCII have high levels of phosphorus and/or sulfur. Also, there are no known burials in these areas. In the current state of knowledge, it could be suggested as a hypothesis past agricultural

CODE	Na	Mg	Al	Si	P	S	K	Ca	Ti	V	Cr	Ba	Mn	Fe	Ni	Cu	Zn	Ga	As	Br	Rb	Sr	Y	Zr	Pb
NMR007	n.d.	0,77	7,69	24,53	2227	2422	2,56	3,72	0,35	56	72	884	1542	4,53	65	77	152	n.d.	n.d.	n.d.	210	229	171	223	7601
NMR021	n.d.	0,23	13,48	27,20	n.d.	653	1,38	0,11	0,41	6	62	689	82	1,42	22	15	42	n.d.	5	n.d.	138	65	40	167	211
NMR024	28	0,31	13,99	27,41	n.d.	578	2,22	0,18	0,15	n.d.	23	408	159	2,15	2	4	40	71	30	n.d.	149	45	15	97	34
NMR026	n.d.	0,34	14,58	25,77	23	587	2,76	0,48	0,26	25	8	300	153	2,38	11	6	68	65	5	n.d.	149	117	12	131	29
NMR049	n.d.	0,48	9,28	25,98	595	381	2,34	0,38	0,30	76	33	320	184	3,35	24	16	81	47	37	n.d.	150	107	24	181	26
NMR054	80	1,05	8,98	34,73	n.d.	383	2,14	0,10	0,36	35	81	449	188	5,38	27	33	78	51	29	n.d.	112	41	26	203	21
NMR071	n.d.	1,20	8,74	25,36	1940	295	1,27	1,16	0,65	108	149	794	492	5,90	67	60	70	62	96	1	69	262	23	200	21
NMR076	n.d.	0,82	9,85	32,86	n.d.	546	2,06	0,31	0,36	133	86	468	290	4,97	37	26	71	50	14	n.d.	106	72	27	220	23
NMR088	n.d.	0,90	10,22	30,66	n.d.	361	2,49	0,56	0,30	49	58	475	285	3,33	15	32	72	50	36	n.d.	143	107	26	153	28
NMR207	n.d.	0,85	11,74	26,26	n.d.	703	1,63	0,94	0,31	33	28	533	302	2,80	5	7	35	46	8	1	67	137	22	115	21
NMR213	n.d.	1,22	8,37	26,35	48	1592	2,04	0,25	0,41	n.d.	82	684	293	3,56	64	29	107	n.d.	36	n.d.	133	80	38	231	414
NMR214	n.d.	0,96	11,97	27,01	n.d.	616	2,27	0,66	0,42	26	60	576	365	4,03	21	15	76	55	22	n.d.	115	92	34	222	20
NMR221	n.d.	0,24	7,53	26,29	5407	1697	2,01	0,25	0,31	61	68	400	84	2,90	23	33	152	28	23	n.d.	116	121	21	159	43
NMR231	122	0,39	11,42	25,77	n.d.	540	2,51	0,24	0,22	n.d.	45	185	132	2,79	10	24	75	67	67	n.d.	229	43	24	139	31
NMR236	44	0,25	10,78	26,30	3757	441	2,26	0,46	0,20	50	34	568	50	2,16	8	7	64	44	67	1	172	142	17	92	34
NMR237	n.d.	0,70	6,69	26,43	n.d.	851	1,36	0,65	0,24	29	36	389	373	6,99	38	11	91	30	70	n.d.	83	139	22	167	28
NMR338	n.d.	0,47	10,52	31,17	1312	717	2,29	0,23	0,06	n.d.	0	333	209	4,30	11	14	184	83	154	n.d.	352	93	21	45	10
NMR354	n.d.	0,69	10,57	25,56	2102	339	1,98	0,34	0,54	129	67	729	982	5,14	22	46	363	12	152	n.d.	160	111	34	242	87
NMR365	n.d.	0,61	9,79	30,38	7634	553	2,61	0,63	0,22	119	33	370	182	2,77	16	15	121	54	41	n.d.	172	240	20	123	26
NMR383	44	0,21	12,52	23,24	n.d.	509	1,72	0,20	0,46	54	75	209	81	1,87	25	20	65	n.d.	7	n.d.	163	75	44	176	550
NMR386	n.d.	0,52	11,05	27,36	n.d.	674	2,26	0,27	0,34	87	42	600	121	3,37	16	24	58	33	51	n.d.	145	59	24	211	75
NMR407	n.d.	0,49	10,17	25,19	n.d.	645	1,70	0,13	0,41	150	94	755	83	5,11	33	24	87	45	12	n.d.	66	40	29	218	27
NMR409	n.d.	0,14	9,82	20,21	n.d.	372	2,32	0,28	0,31	126	86	827	93	5,90	55	32	150	64	66	n.d.	151	68	34	238	33
NMR413	28	0,73	10,55	27,19	1594	541	1,62	0,98	0,34	62	35	881	175	3,09	16	13	44	53	16	2	66	214	15	122	17

Table 3: Quantitative (wt%) analysis of chemical elements. / Análisis cuantitativo (peso %) de los elementos químicos.

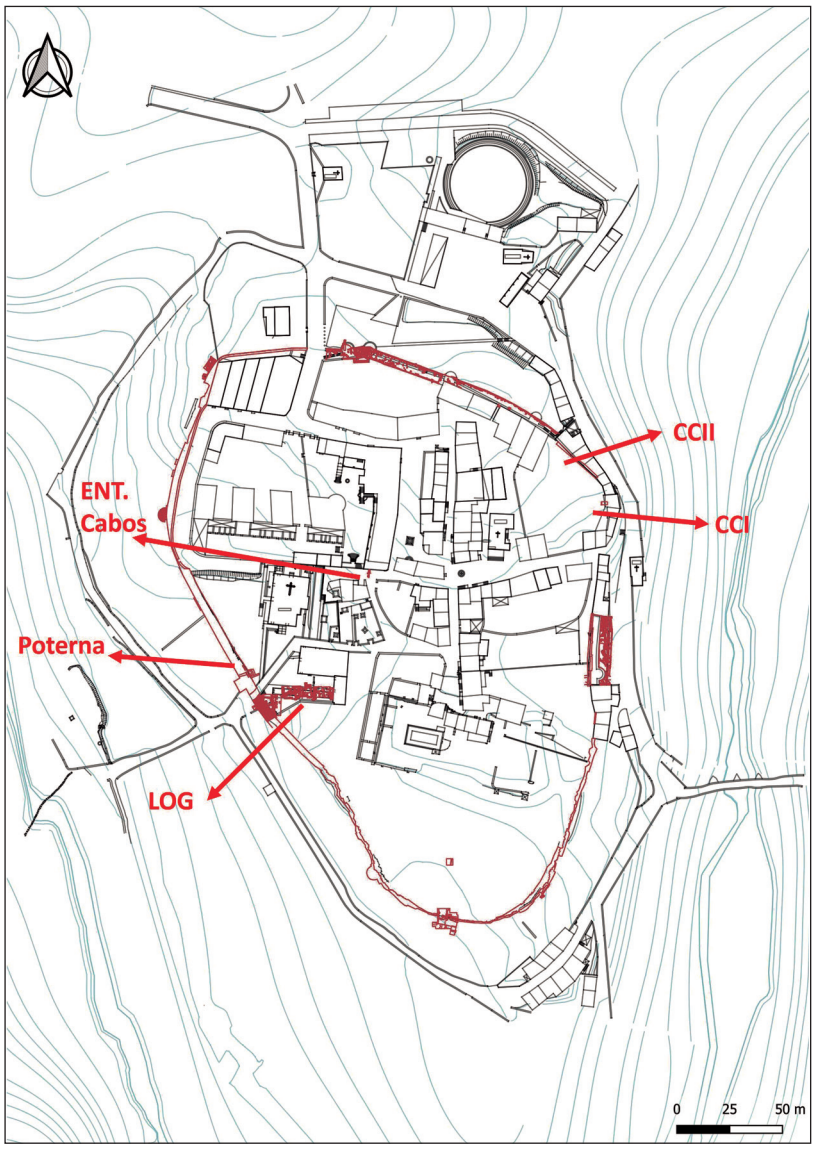

Fig.3. Location of the excavation sites mentioned in the paper on a plant of Idanha-a-Velha. / Localización de los sitios de excavación mencionados en el artículo sobre un plano de Idanha-a-Velha.

activities or some unknow contextual factors that could explain these high levels.

The firing temperature can be estimated for the presence/absence of certain minerals. In all the pottery analyzed, the kaolinite is absent which indicate a firing temperature above 550 ºC (this clay lost the crystallinity and transforms into meta kaolinite, "invisible" to X-ray diffraction). In the sample NMR054 was detected gehlenite and probably mullite. The presence of these minerals indicates a firing temperature above about 800-1000 ºC. In the rest of the ceramics, without these minerals, the estimated firing temperature is between 600-800/900 ºC. These estimates are in line with some of the investigations and publications about this subject in the northwest area of the Iberian Peninsula. In the analysis done on ceramic samples from the Upper Mondego area, the results were virtually the same in terms of firing temperatures (Tente, Lantes, y Prieto, 2014, 117). It is the same with samples from the Galicia region, in the Early and Late Middle Ages (Martínez, Lantes, y Toucido, 2018, 106), and from the medieval coarse ware of Évora (Camara *et al.,* 2023, 2224).

There were four samples with glazed decoration. In these samples the lead from the leaded glazes diffused to the body of ceramics increasing the average lead concentration from 10 to 200 times. Even if you don´t analyze the glaze themselves, you could deduct a possible lost glaze analyzing the ceramic bodies. This type of high-lead ceramics is in line with what we know of the Islamic glazed pottery technology from the 10th and 11th centuries, including in Portugal, were there is some parallels from cities in the Alentejo and Algarve regions in recent studies (Camara *et al.,* 2023). The sulfur of NMR213 and NMR007 could proceed of galena (PbS) used to glaze the ceramics.

4. RAW MATERIALS SOURCES

To obtain patterns and a good geochemical fingerprint of the ceramic raw material, a statistical hierarchical cluster was made with the chemical concentrations but eliminating sodium (bad quantification), phosphorus and sulfur (post depositional origin) and lead (from the glaze). The samples constitute six groups (Fig. 4):

- Groups 1 and 2 are clearly granitic (quartz, K feldspar, plagioclase and muscovite), representing 58,2% of the samples. It denotes clay with high presence of relatively fresh granitic temper.
- Group 3 is fundamentally quartzite and represent 8,3% of the samples. It denotes a more meteoriced granitic clay (more kaolinitic with residual quartz). Both vessels of this group are glazed and with white pastes. They have a clearly Islamic tradition but are very close to the local production in terms of chemistry, having the same general granitic composition, instead of a more calcarean composition, which would be the case if they had an Andalusian of Sevillian production origin.
- Group 4 is granodioritic (high plagioclase and without of K feldspars) and represent 8,3% of the samples. It is interesting to note that the two vessels of this group are bowls, but very different from each other in terms of format, paste color and chronology. One is from the 11th or 12th century and glazed, while the other is from the 6th or 7th century, with a black paste color. Based solely on a macroscopic analysis, it would be almost impossible to connect these two pieces.
- Group 5 is mixed granitic-granodioritic also representing 8,3% of the samples, being in general very similar to the previous groups. The two vessels in this group are from the same layer in the CCII excavation, with a chronology between the 6th and 7th century. As noted in group 4, the vessels from group 5 are different in terms of paste color and typology (one is a jar and the other a pot), demonstrating that there is not a distinction of groups in terms of typologies.
- Group 6 really is a miscellaneous group, representing 16,6% of the samples. MNR007 is pyroxenitic (whit high level of certain metals) and MNR071 is amphibolic (with high level of certain metals). Both NMR338 and NMR 354 have granitic compositions, like the previous groups, but with high differences in arsenic and zirconium, which distinguish them from the others.

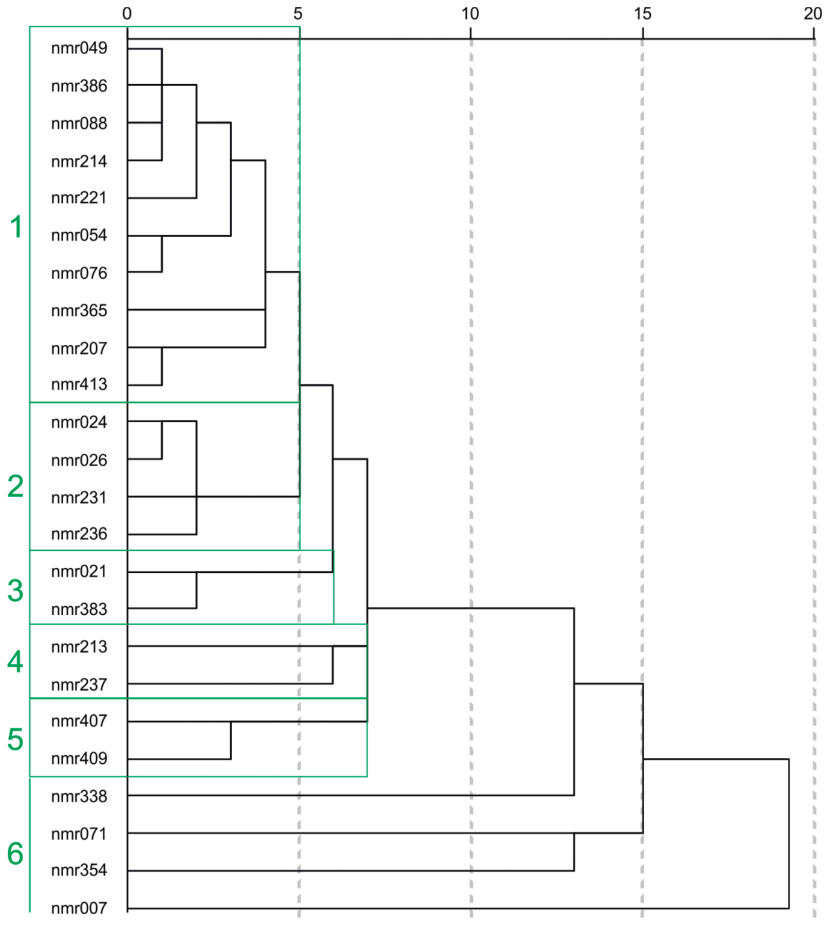

Fig.4. Hierarchical cluster made with IBM SPSS Statistics (version.24.0.0.0) base on Mg, Al, Si, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr and Ba concentration of the ceramic bodies. The closer the samples are, the greater the compositional affinity. / Clúster jerárquico elaborado con IBM SPSS Statistics (versión 24.0.0.0) basado en las concentraciones de Mg, Al, Si, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr y Ba en los cuerpos cerámicos. Cuanto más próximas están las muestras, mayor es la afinidad composicional.

The geological area of the Idanha-a-Velha site is basically compound of schists, granitic rocks, and tertiary sediments (Fig. 5). These tertiary sediments, conglomerates from Sarzedas with arcosic sands from Silveirinha de Figos and the arcosic conglomerate have levels of clays which come from the meteorization of the schists and granites around. They could be a very coherent source for the clays which were used to elaborate the ceramics of the group's 1 to 5.

The sample NMR071, with amphibolic composition, could have its clay source in the amphibole rock from Morais and Bragança, about 100-120 km N from Idanha-a-Velha. However, it is important to note that there could be small quantities of amphibolic rocks in the areas of connection between schist and granite, which may hint at different locations. The sample NMR007, with a pyroxenitic composition and with no amphibole, has a clay source from a more southern area, a topic that we will discuss in more detail in the next part of the article.

5. DISCUSSION

Our analysis identified six distinct chemical and mineralogical groups, fewer than the initial macroscopic analysis suggested (see Fig. 4 and 7). Groups 1 and 2 likely represent local productions, utilizing raw materials sourced from sites near Egitânia. This inference is based on the consistent mineralogical signatures matching the local geology. In contrast, Groups 3 to 5 appear to be of regional origin, sourced from slightly more distant locations yet still within the broader geological context of the region. Group 6 is unique, consisting of exogenous vessels with distinct mineralogical compositions suggesting northern and southern origins. This classification aligns with known trade routes and historical records, indicating Egitânia's commercial connections during the Early Middle Ages.

The study confirmed the existence of local pottery production in Egitânia during the Early Middle Ages, addressing one of our primary research questions. Groups

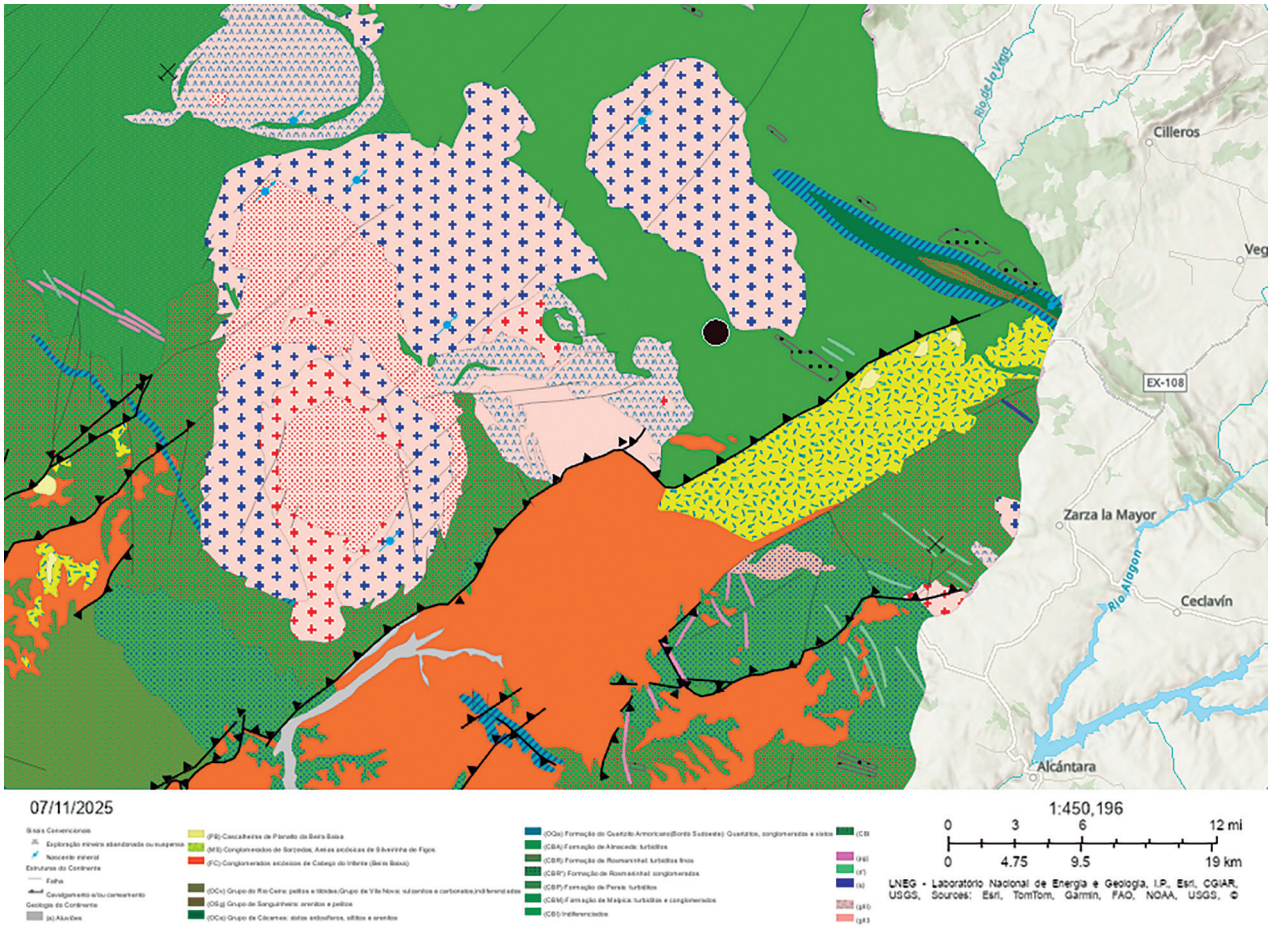

Fig.5. Geologic Map of the studied area (Idanha-a-Velha). Green: acid schists. White: granitic and granodioritic rocks. Blue and purple: quartzites and other acid rock veins. Yellow and Orange: Tertiary sediments (with clay levels, formed by the erosion of nearby acid schists and granitic rocks). Idanha-a-Velha coordinates (WGS84): -7,142450 (long), 39,998177(lat)). Source and details in: https://geoportal.lneg.pt/mapa/#. / Mapa geológico del área estudiada (Idanha-a-Velha). Verde: esquistos ácidos. Blanco: rocas graníticas y granodioríticas. Azul y violeta: cuarcitas y otros filones de rocas ácidas. Amarillo y naranja: sedimentos terciarios (con niveles arcillosos, formados por la erosión de esquistos ácidos y rocas graníticas cercanas). Coordenadas de Idanha-a-Velha (WGS84): -7,142450 (long.), 39,998177 (lat.). Fuente y detalles en: https://geoportal.lneg.pt/mapa/#.

1 and 2 include samples from the entire analysed period, from the 5th to the 12th century, indicating that potters used the same raw material sources for several generations. This suggests a consistent transmission of knowledge among potters, unaffected by the political or stylistic changes of the time.

Several additional observations can be highlighted:

- No clear pattern was found between composition, chronology, and typology. For example, groups 1 and 2 include samples from all analysed chronologies and various typologies, indicating diverse formats within the same groups.
- Post-depositional signals suggest influences from agricultural activity or burials, but there is no clear correlation across all samples and sites.
- Most ceramics were fired between 600 and 900 ºC, with the exception of jar NMR054 from the 11th or 12th century, which exceeds 900 ºC.
- All glazes are lead-based, possibly applied using galena in some cases.

There is a high coherence between the mineralogy and the chemical composition of the ceramics, considering that the mineralogical analysis represents the composition only of the temper (the crystalline fraction) and the chemical analysis represents the global elemental composition (temper and sinterized clays). It could be proposed a local or regional origin for most of the ceramics, with a general granitic composition in their ceramic bodies, the different geochemical groups represent slightly different sources, therefore specific areas of collection. The biggest exception are two mafic foreign samples: the glazed medieval ceramic NMR007 and the Early Medieval pot NMR071.

For NMR071, the nearest compatible source is likely around 100 km to the north, though this is not certain. The only certainty is that it originates outside the region covered by groups 1 to 5. Notably, during the broader study of ceramic collections, similarities were observed between the pottery from Idanha-a-Velha and those from Galicia and the Douro Valley, particularly during the 6th and 7th centuries. Additionally, pottery from Braga, in the form of Terra Sigillata imitations, was identified (Souza 2024). A working hypothesis is that these findings indicate a commercial network within the Suevic kingdom, centered in Braga and extending to the frontier, including Egitânia in the southeast corner.

The case of NMR007 is particularly interesting. The fact that we had an initial indication of a more southern origin lead us to look for parallels, especially from more Islamized cities in the Alentejo and Algarve regions. We gave a especial emphasis on the case of Évora, since it had a recent publish study on the archaeometry of some high lead glazed samples that we already mention in this article (Camara *et al.* 2023). To make a compositional comparison, the chemical data of this work were expressed in percentages of elemental oxides and represented graphically (Fig. 6).

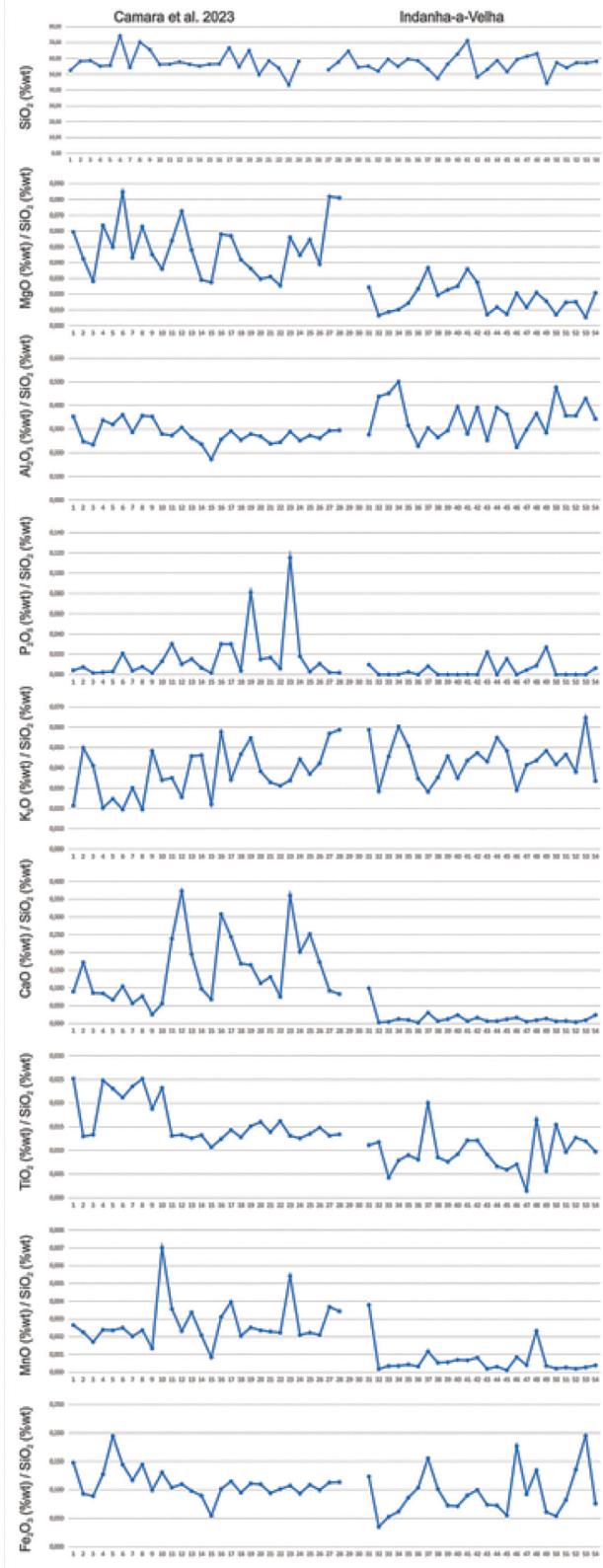

Fig.6. Comparison of the chemical compositions of the high lead glazed samples from Évora and the Idanha-a-Velha samples, from the Camara et al. 2023 article and the current article. / Comparación de las composiciones químicas de las muestras con vidriado de plomo alto procedentes de Évora y de las muestras de Idanha-a-Velha, según el artículo de Câmara et al. (2023) y el presente estudio.

A comparison allows us to observe that there is similarity between both groups in the concentration of SiO2. Due to this fact and to minimize matrix effects and the differences caused by the instrument used, all data are represented relative to SiO2 concentration. In the graph, it can be seen how no notable differences are seen between groups for Al2O3, P2O5, K2O and Fe2O3. However, clear differences can be seen for MgO, CaO, TiO2 and MnO, where these chemical elements generally present lower concentrations than in glazed ceramics from Évora. Mineralogically, all the samples from Idanha-a-Velha (except NMR007 and NMR071) do not contain amphiboles and pyroxenes while the samples from Évora are characterized by high levels of these mineral content. This difference clearly demonstrates that the types of ceramic fabrics are different between both groups. These geochemical differences, at the mineralogic level, must be caused by the absence of amphiboles and pyroxenes in the Idanha-a-Velha samples.

It was, then, only possible to think of a common source of raw materials for the samples NMR007 and NMR071. In the case of NMR071, there is an absence of potassium feldspars and there is some presence of amphibole, which could indicate granodioritic type sources. In Évora they do detect amphiboles in many of the samples analyzed, but in these samples' potassium feldspars are always abundant and they also present calcite, which is absent in all samples from Idanha-a-Velha. This makes it unlikely that NMR071 has a compositional origin with the compared group. That was not a surprise, since the higher possibility is that this vessel comes from a northern site, based on its chemical composition.

In the case of NMR007, a honey glazed ceramic, a high concentration of pyroxenes and absence of amphibole were detected. We verified that both at a chemical and mineralogic level there is a compositional similarity between this sample from Idanha-a-Velha and the some of the samples from Évora study, namely EVR11, EVR13, EVR14, EVR17 and SIL27. This compositional coincidence indicates that there may be a common source of raw materials between these samples from

Fig.7. Photografic record of the vessels selected for the samples analysed in this article. Images from the author. / Registro fotográfico de los recipientes seleccionados para las muestras analizadas en este artículo. Imágenes del autor.

Évora and the NMR007, which is certainly the most compositionally different from the group of ceramics analyzed in this work and shares the same fact of being honey glazed with the mention Évora samples. Based on the published article, the five samples mention are from PF groups 2 and 3, which the authors identify as being produced in the city of Silves, in the Algarve (Camara *et al.,* 2023, 2223). Another element that these samples from Évora (but produce in Silves) had in common in that the firing temperature range can be settled between 950 and 1100 ◦C, in a subgroup that they called G2B (Camara *et al.*, 2023, 2224). Even though we have not been able to determine a high firing temperature for NMR007, with the current data, the coincidence to the Silves made wares must make us consider the possibility that it too had a firing temperature similar to the others, from 950 to 1100 ◦C.

The presence of a vessel produced in Silves found in Idanha-a-Velha is significant, indicating a commercial connection between the two cities, likely facilitated through other trade centers. Was this connection via Évora, where the comparable samples were found, or through another site like Mértola or Lisbon/Santarém? If pottery reached Idanha, what other goods were traded, and what was given in exchange? While we cannot yet answer these questions definitively, they open intriguing avenues for future research.

Our analysis also identified glazed pottery produced at a regional level, with pastes very similar to those produced in Idanha-a-Velha. This unexpected result suggests the existence of a production center in the Beira Interior region, previously undocumented in scientific literature. Where was this production center located? What was its distribution level across the Iberian Peninsula? These questions remain unanswered, highlighting an important challenge for future investigations.

Considering the four vessels from fabric group 6, but especially NMR007 and NMR071, we have evidence that Idanha-a-Velha continues to be part of some commercial circuits after the end of the *Terra Sigillata* commerce in the site, even if possibly occasional or not very dense. That applies for the Early Medieval period, between the VI and VIII centuries, but also for the next centuries, as NMR007 implies. And the commerce of the period after the IX century included not only fine wares, like NMR007, but also common wares like NMR338 and NMR 354. Therefore, these samples help to answer another of the research questions that we had, confirming the connection between ancient Egitânia and the regions around.

6. CONCLUSION

In this paper we addressed the issue of archaeometry analysis done in 24 samples from medieval levels of Idanha-a-Velha, ancient Egitânia. This is a subject that was not a priority in past research but has been gaining track and becoming ever more important, with new data and publications every year showing the many possibilities and dept of these type of studies (Grassi y Quirós Castillo, 2018; Salinas y Pradell, 2020; Salinas Pleguezuelo y Pradell, 2020; Salinas Pleguezuelo y Amorós-Ruiz, 2024). For this article and set of analysis, there were two major questions that we wanted to answer: is there a pottery production during the Early Middle Ages in Idanha-a-Velha? And are there commercial connections between Idanha-a-Velha and the regions around after the end of the trade of *Terra Sigillata?* Of course, both these questions lead to follow up inquiries, which we have addressed through this article, but the focus was those two questions.

Our study considered samples from different digs and periods inside the Medieval Age, covering most of the city, but all from secure levels with good chronology indicators. The analysis carried out was XRD and XRF, with the statistical analysis (Hierarchical cluster) being made with IBM SPSS Statistics. Based on the results reported in this paper, the following conclusions can be drawn:

- Six different fabric groups were identified, fewer than the eight to ten groups suggested by macroscopic analysis.
- The first two groups are likely of local origin and constitute the majority of the collection, present throughout the analysed period.
- Groups 3 to 5 are of regional origin, while group 6 is non-regional, consisting of four exogenous vessels.
- Of the four glazed samples analysed, three are from regional production (specifically from groups 3 and 4).
- Most pottery samples were fired between 600 and 900 ºC, except for NMR054 and possibly NMR007, which exceed 900/950 ºC.
- The Early Medieval (6th-7th centuries) pot NMR071 is probably of northern origin, though the specific site is uncertain.
- The Medieval (9th-11th centuries) vessel NMR007 is the only one from group 6 with a clear origin, showing several similarities with ceramics from Silves in the Algarve region.

In summary, our study confirms the presence of continuous pottery production in Idanha-a-Velha throughout the Medieval period, demonstrating a persistence of craft traditions dating back to Roman times. Furthermore, our analysis provides clear evidence that the city remained integrated within regional and interregional trade networks following the decline of Terra Sigillata commerce in the 5th and 6th centuries. While the exact scale of this trade is yet to be fully understood, our findings underscore the city's sustained economic and cultural interactions with other centers, particularly hi-

ghlighting its connections to Islamic ceramic traditions. Future research should focus on elucidating these trade networks in greater detail and exploring the broader implications of these findings for understanding medieval economic systems in the region.

These conclusions are an important step forward in the medieval pottery studies in the Beira region. They illuminate a territory that had, until recently, very few medieval ceramic investigations. However, they also bring several questions with difficult answers or, for the moment, without them, as we already showed before. Future research should try to investigate more on the subject, specifically on the question of a production center for glazed ware in the Beira Interior region and the commercial circuits that are reaching Egitânia. What more, besides pottery, is coming to the city and what is being sold in return for are topics that, with further studies, we might be able to answer. We hope that the current paper will inspire the continuation of these efforts and bring even further and deeper inquiries.

7. ACKNOWLEDGEMENTS

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