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Sequence and context for the Cocina cave neolithic pottery: An approach from social networks analysis

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ABSTRACT

Cocina cave has been considered one of the main sites when explaining the transition from Mesolithic to Neolithic in the Iberian Mediterranean façade. But the current review of its stratigraphy has evidenced important post-depositional disturbances affecting those layers where Neolithic pottery is present. These taphonomic problems question the usefulness of this record in any detailed approach to a potential process of acculturation of the local Mesolithic groups.

Despite this negative preservation, and using decorative traits as a proxy, we have isolated two ceramic contexts with inner coherence. Over these contexts, we have developed a Bayesian approach to compare them with other well-dated regional contexts. To contextualise the obtained sequence, we decided to extend the analysis to a wide set of Neolithic known contexts from an area that covers most of the coastal Iberian Mediterranean region, from the Ebro basin in the North to the Segura basin in the South. These contexts have been organised in chronological windows, and a Social Networks Analysis (SNA) has been applied. Results confirm the insertion of Cocina in the regional Neolithic dynamics. After the first stage, with an important degree of cultural homogeneity, the analysis also outlines the existence of a cultural frontier among Neolithic groups North and South of the Xúquer basin, at least from the mid-seventh millennium cal BP.

1. Introduction

The ceramic levels of Cocina cave appear as a persistent reference when discussing the origins of the Neolithic in Iberia. Despite never been studied in-depth, nor well published, the known presence of some particular decorative techniques gave this assemblage a special relevance when analysing the transition processes between the last Mesolithic hunter-gatherer groups and the first Neolithic (e. g. Fortea, 1973; Fortea et al., 1987; Martí and Juan-Cabanilles, 1987; Utrilla, 2002).

This relevance has also overshadowed other aspects of the ceramic record. In that sense, the interesting set of materials related to a second Neolithic occupation, during the VII millennium cal BP, has gone almost unnoticed among scholars. Traces of uses of the cave by human groups along the Chalcolithic and Bronze Age periods, although scarce, are also present.

For this paper, we have undertaken a complete review of the prehistoric ceramic collections recovered in the different campaigns and works carried out in the cave for the last 80 years. Our main aims are: a) Using a taphonomic perspective, we evaluate the integrity of that ceramic levels and their possibilities in offering relevant information to the aforementioned Neolithisation debate; b) Adopting an approach based on the Social Networks Analysis (SNA), we assess the obtained information to understand the role of Cocina cave in the Neolithic dynamics that took place in the Eastern region of the Iberian Peninsula during the VIII and VII millennia cal BP.

For this last purpose, we will manage a set of contexts from a broad number of sites located between the Ebro and the Segura basins (Fig. 1). We will apply a Bayesian approach to categorise chronologically all that revisited contexts without 14C dates to increase the sample. This will also allow us to organise the contexts in chronological windows that span a century and will provide the database for the SNA.

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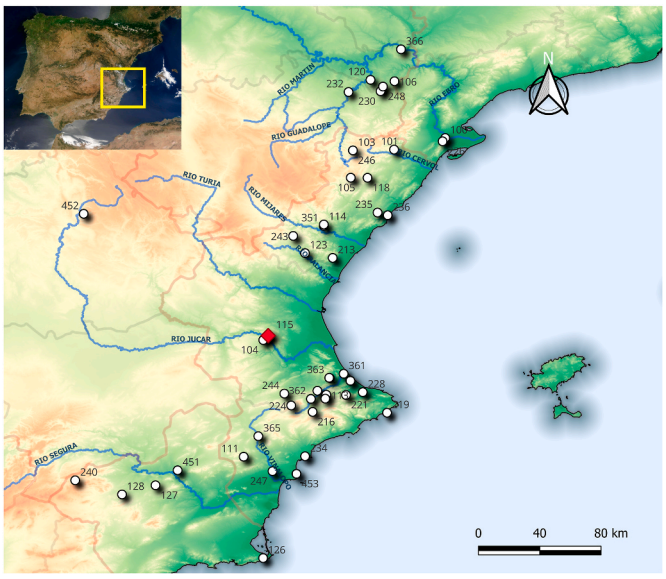

Fig. 1. Central Iberian Mediterranean façade. Location of Cocina cave (red diamond) and the archaeological contexts used in this work. Site Identification Numbers correspond to those that appear in Table 2.

2. Archaeological background

Cocina cave was the first known site of the Iberian Mediterranean façade with a thick Mesolithic stratigraphy. The first fieldworks at the cave were carried out by Lluís Pericot, from 1941 to 1945. The obtained results were used, years later, by Javier Fortea (1971) to build a proposal of sequence that extended along the Mesolithic ("Geometric Epipaleolithic") and the Neolithic periods. The first two stages (named Cocina I and Cocina II) were the reflection of the inner cultural evolution of the Mesolithic groups. Cocina III was characterised by the first presence of a few sherds, corresponding to Early Neolithic moments. This was understood as evidence of an acculturation process of the former hunter-gatherer population.

This relation during the last stages of the sequence between a Mesolithic lithic tradition and Neolithic potteries was newly proposed based on the fieldwork undertaken by Fortea himself between 1974 and 1981. Unit H offered a coexistence between a lithic industry related to his stage Cocina II with some sherds (Fortea et al., 1987), some of them decorated with serrated shell impressions, a distinctive trait of the Western Mediterranean Early Neolithic pottery (Cardial style). This evidence reinforced his view of contacts among both cultural traditions. Despite the significance of this fact, most of the information from his works remained unpublished.

In the following years, new sites were incorporated into the Neolithisation debate (Barandiarán, 1978; Barandiarán and Cava, 1989; Bernabeu, 1989). The newly available information, joined with the review of some data from Pericot excavations (Juan-Cabanilles and Martí, 2002; García-Puchol, 2005), let to question some of the inferences made by Fortea. A lack of consistency in the archaeological record related to the top of the stratigraphy was pointed out, due to the scarcity of artefacts and the evidence of post-depositional disturbances. So, the last stage of his sequence (Cocina IV) was rejected. Also, the revisit of the lithic industry from Pericot works (García-Puchol, 2005) has emphasised the clear cut, both technological and typological, between the top layers of the Cocina II phase and those over them. This break in the lithic traditions has been read as a result of a time gap (*ibid*: 114–118), questioning any kind of possible direct contact.

The presence of ceramic remains and the changes in lithic assemblages are the only aspects of the record that could help in this debate. Domestic faunal remains are very scarce in the context of the whole cave and, when sent to dating, results always relate them to the Chalcolithic and Bronze Age occupations (Pardo-Gordó et al., 2018).

In the context of the current project, we proceed to revisit the documentation and the archaeological record related to Fortea's Unit H. Considering all the previous critics, this was the only possible scenario where we could find evidence of Neolithic artefacts in a Mesolithic context. The obtained results (Pardo-Gordó et al., 2018), allowed us to question the former interpretation as well. Post-depositional processes were responsible for that context, which could be seen as a palimpsest where artefacts from different origins have been relocated together. So, the reliability of Unit H could also be rejected. Now, the existence of any contact episode represented in the Cocina cave record was up in the air.

In the original Fortea proposal, the top last stage of the evolutive sequence was Cocina IV. This moment was characterised by the presence of some potteries with corrugated surfaces, due to the use of a comb for brushing them (*peinada*). This made Fortea consider a long span for the Neolithisation process, given the relation accepted at that moment between that combed pottery and the Chalcolithic period (Fortea, 1985). Some years later, the publishing of the Neolithic sequence of Cendres cave (Teulada-Moraira, Alacant), allowed to relocate that combed ceramics along the VII millennium cal BP, during the middle Neolithic (Bernabeu, 1989), and so, putting them aside from the Chalcolithic period.

The previously mentioned rejection of this last stage of Fortea's sequence, due to the post-depositional problems, has left these materials without a clear context in the cave sequence. But their presence must be noted. Pottery with combed surfaces is relatively common among Neolithic assemblages almost along all the VII millennium cal BP. However, its distribution seems not to be widespread. One focus is located in the SE of the Iberian Peninsula, around an area that extends roughly the current Alacant province. But some examples can be found further South, as far as Eastern Andalusia -Nacimiento cave (Jaén), Cerro Virtud (Almería) (Asquerino and López, 1981; Ruiz-Taboada and Montero, 1999)-. A second focus can be recognised in the North, among the neolithic groups that inhabited the central Catalonian coast (Llobregat basin: e. g. Oms et al., 2021).

This unequal distribution has been understood as the result of a progressive process of cultural regionalisation that tends to consolidate in these moments (Bernabeu et al., 2017b). This process concerns not just pottery productions. Other kinds of items, such as personal ornaments (Pascual-Benito, 1998) or some raw materials for polished stone tools (Orozco, 2000), seem to limit also their geographical dispersion South of the Xúquer river. These evidences suggest the existence of some kind of cultural frontier among Neolithic groups located North and South of this line.

Cocina cave, located just over that limit, can be seen as a prominent point to evaluate the information exchange processes that took place during this period. The role of the site in the different nets involved over time will be analysed using an approach based on Social Networks Analysis (SNA). A recent review of the not well-known sites located North of the Xúquer River (Escribá, 2023), along with the information available from those located South (e. g. Bernabeu et al., 2010, 2011b, 2017a; García-Atiénzar, 2009), will provide the data set to address this question.

3. Materials and methods

The study of the pottery collection has been undertaken using a methodology designed and tested in regional Neolithic contexts from long ago by our team at the University of Valencia (e. g. Bernabeu, 1989; Bernabeu et al., 2009b; García Borja, 2017; García-Martínez de Lagrán et al., 2022; Molina, 2006; Molina et al., 2010).

In the first stage, we collect information from all the pieces of sherd. This information involves data from different aspects: morphology, decorative techniques, fastening systems, preservation, and origin from any piece of sherd. All this data is added to a file included in the Pottery

Data Base of the site.

Taking as reference the morphological, decorative, and technological (surface treatment, wall thickness, firing atmosphere, paste inclusions) characteristics, a Minimum Number of Recipes are considered. With them, we generate a second file in the Data Base, that of the Vessels, where a new set of criteria are involved: metrical, typological, and technological attributes, besides the decorative structure (motives, compositions, organisation: Bernabeu et al., 2011a; Escribá, 2023).

Both files (Sherds and Vessels) are connected, so information from one level can be used to work with the other. This allows us to have a very flexible and fluent working system. This is especially important when evaluating post-depositional movements and shifting of the sherds identified as part of the same vessel.

The set of prehistoric pottery recovered along the different fieldworks in Cocina cave rises until 2060 pieces. 890 come from Pericot campaigns, 1017 recovered in the sectors excavated by Fortea and just 153 are from the current fieldworks. All the detailed information of the whole collection can be consulted in the available supplementary material (Tables S1 and S2).

After revisiting them, we have isolated two different assemblages. These will be the ones used to build the social dynamics approach concerning the Cocina cave occupations during the Neolithic times.

Information provided by archaeological materials is very useful to perform a relational analysis. Material culture is a valid social indicator since the knowledge necessary for the transmission of technical skills and ideas produced by artefacts is always generated in social contexts. Moreover, the decorations, symbolic content, or techniques they contain have the potential to relate to specific social entities (Shennan et al., 2015; White, 2013). Human systems are configured through relationships that connect individuals and those linking collectives. These relationships can be represented by networks in which the nodes are the social actors, and the connections represent interaction between them (Wasserman and Faust, 1994). There is a methodology that enables analysing these networks through a wide range of mathematical metrics: Social Networks Analysis (SNA), which is increasingly applied in the field of Archeology (Brughmans, 2013; Collar et al., 2015; Knappett, 2013).

The SNA makes it possible to observe the diachronic evolution of social interactions between the communities that are part of the chosen framework. For these analyses to be relevant, only those items with traits that present an evident variation in time and/or space will be useful. For these analyses to be relevant, only those traits that present an evident variation in time and a limited dispersion in space will be useful, because otherwise no difference would be detected. Those without distinctive features will mainly provide noise to the analysis. Thus, the selection criteria of material culture must be crafted following those of frequency, diversity, and representativeness, which would guarantee significant results (Jiménez-Puerto, 2022). An adequate selection of the chrono-geographic framework is also important. Due to the nature of the data employed (chronological and material), the analysis will focus on the role each site plays in the network, that is the micro-scale. For this work, the selected geographical scope includes the Ebro, Xúquer, and Segura hydrographic basins, while the chronological scope is defined by the interval 7600-6400 cal BP. The material culture analysed will correspond to ceramic collections of the period on which a series of relevant decorative features will be considered in the Bayesian analysis.

The first step to be carried out has been to locate each of the levels in a time axis, with available radiocarbon series. The 14C determinations have been selected following a previously used method (Bernabeu et al., 2018), in which short-lived dates, with standard deviations less than or equal to 70 years, prevail (Table 1 and Table S3). This protocol guarantees the maintenance of precision at optimal levels. In the future, it is expected to be improved using new radiocarbon series with deviations of less than 50, work currently in progress. Furthermore, as far as possible, we tried not to use long-lived determinations. Only in those cases in which it has not been possible to do otherwise, they have been used. Those dates not consistent with their stratigraphic position have also been excluded. Thus, for example, the dates from level H14 of Cendres cave (Teulada-Moraira, Alacant) have been discarded, as they provide a chronology inconsistent with its stratigraphic position. The 14C dates were calibrated using IntCal20 (Reimer et al., 2020) and placed in a time window of a predefined duration (100 years in this case). To do so, we have used the HDR (95.4%) provided by the R Bchron package (Parnell, 2018) following the protocol described in Fig. S4 (supplementary files).

Tables 1
Radiocarbon dates used for this work. A combination process was carried out when several dates from the same context were available (R_comb). Complete information, with the original 14C dates and the related references, can be consulted in Table S3 of the Supplementary Files.

Archaeological Site	Context	Lab ID/ID Comb.	BP	SD
Cova d'en Pardo	VIIIb	Beta231880	6660	40
Mas d'Is	F4_inf	R_comb_F4_inf	6617	28
Mas d'Is	s80	R_comb_80	6600	32
Barranquet	UE 79	R_comb_UE_79	6510	32
Cova de les Cendres	H19/VII	R_comb_H19	6484	16
Cova de l'Or	K1	UCIAMS66316	6475	25
Cova Fosca Ebo	IIz	OxA26047	6413	33
Cova de les Cendres	H18	R_comb_H18	6409	19
Cova de les Cendres	H17	R_comb_H17	6365	19
Cova de la Sarsa	Bretxa	OxA239226	6341	30
Cova de l'Or	Event_3	R_Comb_Event3	6333	35
Cova de l'Or	K4	Beta298124	6290	70
Cova del Vidre	II	R_comb_Vidre_II	6217	25
Cova Fosca	C	Bayesian Fosca C	7229–6953	
Cova de les Cendres	H15a	R_comb_H15a	6209	24
Cova Bolumini	c.22	Beta569719	6180	30
Botiqueria dels Moros	6 y 8	R_comb_Botiqueria_6_8	6142	36
Mas d'Is	F4_m1	R_comb_F4_m1	6130	20
Valmayor XI	Fase III	Beta341167	6090	30
Alonso Norte	hogar	DAMS018640	6069	27
Mas d'Is	F4_m2	Beta331018	6030	30
Tossal de les Basses	I	Beta225259	6030	40
Cova del Petrolí	6_7	Beta172871	6020	40
Costamar	GE 401/GE 130	R_comb_Costamar_A	5974	21
Cova de les Cendres	H15	R_comb_H15	5938	19
Sima Serreta	Vb	Beta512540	5890	30
Cova Fosca	A	Bayesian Fosca A	6733–6557	
Costamar	GE 389/GE 278	R_comb_Costamar_B	5885	22
Cova de les Cendres	H13	Beta75214	5790	70
Sima de la Higuera	N2/3	UCIAMS174143	5790	20
Montés I	Silo	Beta508344	5730	30
Tossal de les Basses	II	R_comb_II	5711	19
Mas de Nadal	32	Beta599653	5710	30
Los Limoneros	Foso	Beta374796	5700	40
Pontet	B	DAMS020207	5644	42
Mas d'Is	F4_5	R_comb_F4_5 (SUP)	5464	21
Tossal de les Basses	III	R_comb_III	5430	25

Next, a Bayesian procedure has been used to locate chronologically those levels that contain a relevant material culture, but lack determination by 14C, in one of the previously defined windows. This procedure is Dirichlet's multinomial, tested and used in previous works (Pardo-Gordó et al., 2022), providing chronological attribution probabilities based on an *a priori*, configured through the material culture present in well-known archaeological levels. This *a priori* has been configured with those contexts that, presenting relevant ceramic content, are useful to characterise each window chronologically. With this process, collections that would otherwise be discarded can be used, thus allowing the sample to be substantially expanded. In the end, we were able to work with 77 contexts from 46 different sites (Table 2). As long as this was an initial approach, we have employed no threshold, or a minimum number of vessels in the sites without chronological data, to use this Bayesian procedure. The possible bias resulting of this decision is corrected later, when we just consider in the SNA analysis those nodes that reach at least 60% of the maximum value of the Jackard Index in their windows. The particular values for each analysed context and their

Tables 2
Chronological attribution results from the multinomial Dirichlet process for each context. Cocina cave contexts highlighted.

ID site	Archaeological Site	Context	Window 1	2	3	4	5	6	7	8	9	10	11	12
217	Barranquet	UE_79	X	X										
236	Costamar	Costamar V1	X											
215	Cova de'En Pardo	VIIIb	X											
216	Mas d'Is	F4_inf/s80	X											
451	Abrigo II Grajos	SR		X	X	X								
362	Benamer	II		X	X									
236	Costamar	Costamar V2		X										
218	Cova de lOr	Evento 1		X										
219	Cova de les Cendres	H18-19		X										
221	Cova Fosca Ebo	IIz		X	X									
213	Can Ballester	C1N3, C2N3			X	X								
236	Costamar	Costamar V3			X									
218	Cova de l'Or	Evento 1-2-3			X									
224	Cova de la Sarsa	Brecha			X	X								
219	Cova de les Cendres	H17-18			X									
364	Cova de les Rates Penades	c3_4			X	X								
127	Hondo del Cagitán	Sup			X	X								
105	Cingle Mas Nou	Neolitico				X								
215	Cova d'en Pardo	VIII				X								
218	Cova de l'Or	Eventos2-3				X								
219	Cova de les Cendres	H17				X								
226	Cova del Vidre	Vidre_II				X	X	X						
363	Forat Aire Calent	Neolitico				X								
118	Mas de Martí	n2				X	X	X						
450	Penya Roja Catamarruch	Neolitico				X	X	X						
120	Plano del Pulido	cg				X								
230	Botiqueria dels Moros	Botiqueria_68					X	X						
104	Ceñajo de la Peñeta	1					X	X						
228	Cova Bolumini	C22					X	X						
215	Cova d'en Pardo	VII					X	X						
218	Cova de l'Or	evento 5					X	X						
351	Cova de la Maimona	Unic					X	X	X					
219	Cova de les Cendres	H15a					X	X						
229	Cova Fosca	C					X	X						
115	Cueva de la Cocina	Cardial					X	X						
128	Cueva del Calor	n5					X	X						
216	Mas d'Is	F4_m1					X	X						
248	Pontet	C1 sup					X	X						
101	Bruixes	n5						X	X					
103	Castell de Morella	Unic						X	X	X				
106	Costalena	C1-C2						X	X					
236	Costamar	Costamar V6						X						
361	La Vital	Epi						X	X	X				
234	Tossal de les Basses	I						X	X					
232	Alonso Norte	hearth							X	X				
236	Costamar	Costamar V7							X					
235	Cova del Petrolí	6_7							X	X	X			
229	Cova Fosca	B							X	X				
216	Mas d'Is	F4_m1, 2							X					
123	Torre del Mal Paso	Neolítico							X	X				
366	Valmayor XI	III							X	X				
106	Costalena	C2								X				
236	Costamar	Costamar V8								X				
114	Cova Negra de Montanejos	Único								X				
216	Mas d'Is	F4_m2								X				
452	Verdelpino	III								X				
236	Costamar	Costamar V9									X			
219	Cova de les Cendres	H15									X			
229	Cova Fosca	A									X	X		
126	Cueva de los Mejillones	Unic									X	X		
243	Sima de la Higuera	N2_3									X	X		
100	Barranc d'En Fabra	2_3										X	X	
236	Costamar	Costamar V10										X		
219	Cova de les Cendres	H13-H14-H15										X		
111	Cova dels Calderons	Unic										X	X	
115	Cueva de la Cocina	Peinadas										X	X	
247	Los Limoneros	Foso										X	X	
246	Mas de Nadal	UE32										X	X	
244	Montés I	Silo										X	X	
240	Sima Serreta	Vb										X	X	
234	Tossal de les Basses	II										X	X	
236	Costamar	Costamar V11											X	
219	Cova de les Cendres	H14-H13											X	
248	Pontet	B											X	X
234	Tossal de les Basses	III												X
217	Barranquet	UE80_84												X
219	Cova de les Cendres	H8_10												X
216	Mas d'Is	F4_SUP												X

Window	Date cal BP	Contexts
1	≤ 7500	4
2	7499-7400	7
3	7399-7300	10
4	7299-7200	14
5	7199-7100	15
6	7099-7000	21
7	6999-6900	13
8	6899-6800	12
9	6799-6700	6
10	6699-6600	13
11	6599-6500	11
12	6499-6400	5

assignment can be consulted in the supplementary material (Tables S5 and S6).

After chronologically locating all the archaeological levels, a Social Network for each window has been created. To establish the relationships between the different archaeological contexts, the similarities between the material culture have been used, which in this case is circumscribed to the ceramic decorative traits. Given the available data from most of the considered sites, this was the only part of the record useful for our purpose. This resemblance will be established based on the Jaccard Similarity Index (Habiba et al., 2018; Jiménez-Puerto, 2018; Liu et al., 2016), which quantifies the degree of relationship between a pair of sites between 0 and 1. Therefore, the higher this index is, the greater the probability of interaction between two nodes in the network (Borck et al., 2015). It is necessary to apply a normalisation protocol to this index that compensates variability of the existing types between the different windows, as it has been used in previous works (Bernabeu

et al., 2017b).

Finally, an adjacency matrix is generated for each window. They will be expressed with a geographic component with the Gephi 0.9.7 programme (Bastian et al., 2009), using the EPSG4326 *datum* and the Geolayout plugin (Jacomy, 2011). In addition, this programme makes it possible to follow a huge number of analytical metrics. These are divided into structural, group, and individual. In this work, we will focus on individual metrics, which provide information about the role each node plays in the network. This decision is linked to the sample size at some periods which crystallises in a lack of definition at some windows. Therefore, we will work mainly on the micro-scale analysis, leaving structural measures for future works, which are conditioned by an improvement of the sites and radiocarbon-determined samples. In our case, we will focus on two centrality measures: *betweenness* and *eigenvector*. *Betweenness* measures the intermediation role a node plays in the network (Barthelemy, 2004). It can be useful to detect bottlenecks and capital nodes in the information exchange. *Eigenvector* centrality quantifies the quality of the links of a node (Bonacich, 2007). Both, combined, will provide an idea of the importance that a specific node plays in the whole network.

4. Results

4.1. Taphonomic aspects and variability of the ceramic assemblage

Considered as a whole, the first thing to be pointed out is the high degree of fragmentation and attrition that the sherds present. Most of the pieces can be put into a module of 4 cm in length. When considering preservation, we use two traits: the roundness of the sherd edges and erosion of the surfaces. About the first trait, 20% of the total collection has evidence of roundness. Erosion concerns close to 90% of sherds. The use in the mid-twentieth century of acid solutions for cleaning pottery remains can explain that fact. In this way, the Pericot collection has 98% of eroded sherds, while evidence from ceramics recovered in the current works raises just 47%, despite coming from close areas.

This situation has strongly limited the amount of morphometric and typological information available, complicating any good approach to a representative Minimum Number of Recipes. Just 136 sherds (6,6% of the collection) have been incorporated into the Vases level. The Minimum Number of Recipes raises to 77, where just 25% of them are represented by more than one sherd. Also, just 38% of the vessels could be identified at the Typological Class level.

The distribution and conditions of recovery of the ceramic collection vary so much from one sector to other. This implies that we have to evaluate each main sector before offering any global view. This unequal distribution reflects the complex post-depositional dynamics that have taken part in the archaeological record formation.

A detailed explanation of the chrono-stratigraphic sequence of the cave can be consulted in Garcia-Puchol et al. (this issue).

4.1.1. Fortea fieldwork

The central part of the cave (Fig. 2), was the area chosen by Javier Fortea for his fieldwork, opening two sectors. Wider one (Sector E) was located in a higher situation related to the cave entrance. After removing the Units corresponding to the more recent use of the cave as a shelter for sheep flocks, the prehistoric sequence evidenced a strong degree of alteration. Geomorphological studies (Fumanal, 1979, 1986) advise recurrent flooding episodes affecting the area. One of these episodes had eroded part of Units E and G. In fact, both units were absent from the outer part of the excavated area, and the sediments left by this episode (Unit F) laid directly over lower Unit H (whose top layers were supposedly Neolithic) in all these outer squares. In the inner ones, among

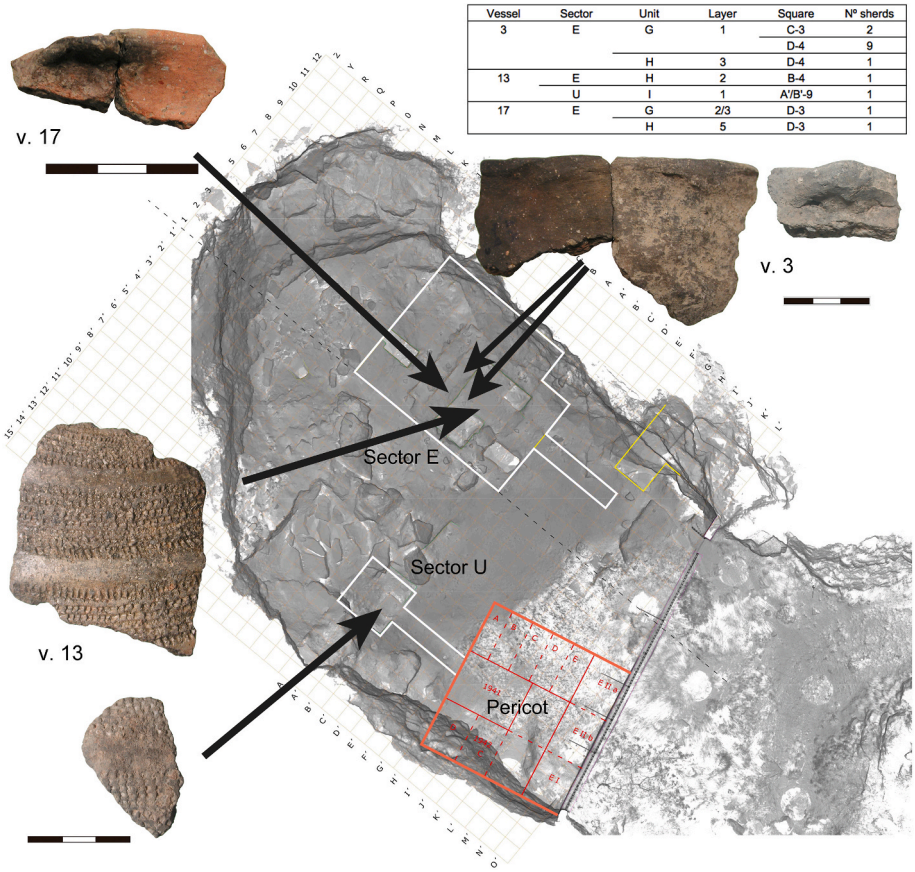

Fig. 2. Cocina cave. Location of Fortea Sectors E and U, and evidence of shifting from different vessels identified in the Fortea fieldworks record.

Units G and H, a stalagmitic crust was identified, due to processes of recurrent swamping.

Unit G is the first one that belongs to prehistoric moments. The main traits of the pottery assemblage point to a recent moment in the sequence: relative importance of the sinuous shapes (33% of distinguished rims), some of them carenated, almost complete absence of decoration (limited to a few reliefs and impressions over the lip), presence of "cheese-strainers". All these traits send us to Chalcolithic and Bronze Age moments (V-IV millennia cal BP).

Despite the stalagmitic crust, the vertical distribution of the ensemble has put evidence of shifting processes among Units G and H. Some of the individualised vessels have sherds that connect the Unit H record with upper contexts (Fig. 2). These disturbances especially concern the D squares and were already recognised by Fortea, who decided to isolate and leave them aside in his study of Unit H. 14C dates obtained recently over samples from these squares (UCIAMS-174145: 4425 ± 25 BP and UCIAMS-174146: 3725 ± 20 BP: Pardo-Gordó et al., 2018: Table 1) have confirmed the information given by the pottery, both about the chronology of the assemblage, and the disturbances itself. Our review of Unit H (Pardo-Gordó et al., 2018) evidenced that disturbances affected the top layers in the whole area, not just the inner squares. So, it could be considered a palimpsest. One of the cardial vessels identified (Vase 13: Fig. 2) can be related to a decorated sherd recovered in the first layer of Unit I of Sector U, a small survey carried out on the eastern side of the cave (Fig. 2). This last sherd has very bad preservation, with its surfaces eroded, but the decorative structure, along with their technology, suggest that both can be part of the same vessel.

The information available about Fortea's works in this Sector U is very scarce. The upper layer was the result of the cave's use as space for producing coal at some moment in the twentieth century. This layer includes some prehistoric sherds that, for the most part, can be related to the Bronze Age occupations. Among this ensemble was recovered the cardial piece mentioned upper.

After this first stage, pottery is very scarce, limiting its presence to the first two excavated Units. The features of the materials recovered in the two lower layers send us to an Early Neolithic context. Despite the limited number of sherds, decoration techniques are well represented (Table S1), not just cardial, but also comb impressions and incisions. All the sherds recovered in this context have technological attributes consistent with those that are distinctive of the pottery productions of this period -reducing pastes with deep black coloured cores, absence of any mineral added temper, and well-finished surfaces-, in the way it has been identified in some prominent regional sites (Clop, 2011).

Considering the little information offered by Fortea about this Sector, our team made a new survey beside the former area (Test Pit 3). A level related to Neolithic remains was identified below the modern layer. The material collection is limited to a handful of sherds that offer the same features. One of them belongs to the same comb-impressed vessel that appeared in Fortea works (Vase 15: Fig. 3A). The 14C obtained over one charcoal from a stratigraphic unit (UE) of this level (UE 1030, Beta-426849: 6340 ± 50 BP: García-Puchol et al. 2018: Table 2), despite

Fig. 3. Characteristic recipes from the two considered contexts. A: *Cocina cardial*: plain cordon (v.16), serrated object (*gradina*) impressions (v.15-v.8), cardial impressions (v.13, v.19), incised and impressed (v.9, v.1). B: *Cocina peinada*: impressed cordon (v.24, v.35), fluted incisions (v.23, v.42), impressions (v.49), combed surfaces (v.77, v.40, v30).

not related with any structure, can be seen as a good proxy for this assemblage.

In summary, the information available doesn't allow us to relate the assemblage from Fortea's works with any preserved Early Neolithic occupation layer. Post-depositional erosive activity has dismantled this possible layer and relocated its materials in different locations. In essence, we recognise these materials among the remains recovered in Unit H of Sector E and Unit I/Layer 2 of Sector U (Table 3 and Fig. 3A). This set of ceramics shows coherence in their technological and decorative attributes, and can be placed in a concrete moment of the regional chronological sequence. This will be the first set of ceramics (*Cocina cardial*) used for the oncoming analysis.

4.1.2. The Pericot area

Located at the SE end of the cave, this sector offered the Mesolithic most complete sequence, and it has been the most intensely studied (Fortea, 1973; García-Puchol, 2005; García-Puchol et al., 2014, 2018). In contrast, ceramic layers have also suffered heavy post-depositional alterations. These are not just natural, but also human, related to the extraction of dung for fertilising fields (activity well tested in the cave during the mid-twentieth century). So, recent prehistoric layers could be identified just in places where they were not removed (Fig. 4).

The different reviews carried out of this area also evidenced that in some of the sectors excavated by Pericot, the mixing of materials from different moments affected the whole sequence. So, for our purpose, just a few contexts could offer coherent information.

The most complete stratigraphic column comes from Sector E1 (campaign 1945), the one used by Fortea for constructing his proposal of chronological sequence. Pottery is present in the top layers of the stratigraphy. In his proposal, layers 1 to 3 were those related to stage Cocina IV, and layers 4 and 5 to stage Cocina III.

Considering the traits of the pottery recovered (Table S1), we can effectively distinguish two different moments in the ceramic sequence based on the decorative features, but not organised in the way Fortea did. Layers 1 and 2 offer a pottery assemblage almost without evidence of decorations and traits that allow us to relate them with the Bronze Age occupations already identified in the inner sectors. In contrast, Layers 3 and 4 show clear decorative evidence enrichment. Along with the addition of cordons (reliefs), incisions and impressions are quite well represented in the assemblage. At the same time, we also see a clear increase in the presence of combed surfaces, which reach 20% of the sherds now. These changes in the assemblage structure are coincident with a change in the preservation of the pottery itself. From restricted evidence of rounded edges in the upper levels (less than 10% of sherds), in layers 3 and 4 this feature reaches 40%, evidencing different depositional dynamics, more aggressive with the remains. After layer 4, a dramatic reduction in pottery is evidenced. The presence of a few sherds in layer 5, just like those recovered in deeper layers, must be seen as intrusive.

The same decorative features identified in layers 3 and 4 can be also recognised in the pottery assemblages recovered in the first layer of the 1943 sectors D and E, and Layer 1 of the 1942 area ("SE corner") (Table S1).

The characteristics of the pottery assemblage recovered can be related to a more recent moment in the regional Neolithic sequence. As its been recognised in different records -Cendres cave (Bernabeu, 1989; Bernabeu and Molina, 2009), Tossal de les Basses (Rosser and Soler-Ortiz, 2016), En Pardo cave (Soler-Díaz et al., 2008)-, combed surfaces are a common means in Neolithic pottery productions from the beginning of the VII millennium cal BP.

The homogeneity in the pottery attributes of these layers brings us the possibility of individualising a second context (*Cocina peinada*: Table 4 and Fig. 3B) to include in our analysis.

In Cocina cave, the presence of pottery with this surface treatment in the ensemble from the inner area is very limited: just a handful of sherds, generally in disturbed contexts. In contrast, in the Pericot sectors, there is no evidence at all of any occupation layer, that we could relate with the Early Neolithic evidence that comes from the Fortea sectors. This gives a sharp contrast between the pottery record recovered in both areas, despite the few meters that separate each other. While the evidence belonging to the Chalcolithic and Bronze Ages can be recognised in both sectors, the Neolithic record exhibits a completely different composition from one to the other. We have to consider post-depositional dynamics as responsible for this situation. The strong erosive episodes suffered by the Neolithic record can be recognised in the high degree of alteration and attrition of these sherds.

4.2. Chronological organisation

Unfortunately, we don't have 14C dates reliable to assess these two ceramic sets in the regional context properly. The date from UE 1030 (see above) could be seen as a proxy for the first sample (*Cocina cardial*). But, as long as it comes from charcoal not related to any structure, it doesn't seem suitable to use it without additional information. Also, the considered ensemble includes ceramics from other sectors not dated, joined following stylistic and taphonomic criteria.

In the case of the *Cocina peinada* set, the absence of 14C dates is due to the lack of suitable samples for dating. The faunal record of the cave offers a scarce presence of domestic remains linked to these levels. And when dated, they were always related to the Chalcolithic and Bronze Age occupations.

To face this problem, we have compared these sets with others from Neolithic sites located in neighbouring areas. We have applied a Bayesian procedure to provide a chronological frame to both contexts. Proceeding in this way, we also get a suitable sample for the SNA, with the Cocina cave assemblages already included.

To obtain a wide and solid chronological framework, our procedure consisted of a) identifying those contexts with 14C dates; b) arranging them in arbitrary windows of 100 years; c) characterise each window using a set of 17 variables concerning the decorative ceramic traits (Table S5); d) identify those sites with no 14C dates that could belong to the considered chronological frame (*c.* 7600-6400 cal BP); e)

Tables 3
Assigned decorative styles for the vessels set belonging to the *Cocina cardial* context. Fortea fieldworks.

Sector	Unit	Layer	Undecorated	11. Simple cardial	71.Incised and impressed	81.Gradina	91.Non-decorated reliefs	93. Decorated reliefs
E	H	1						1
		2		1				
		3			1	1		
		5	2					
		6	1				1	
U	I	1			1			
		2		1		1	1	
		3	1					
Total			4	2	2	2	2	1

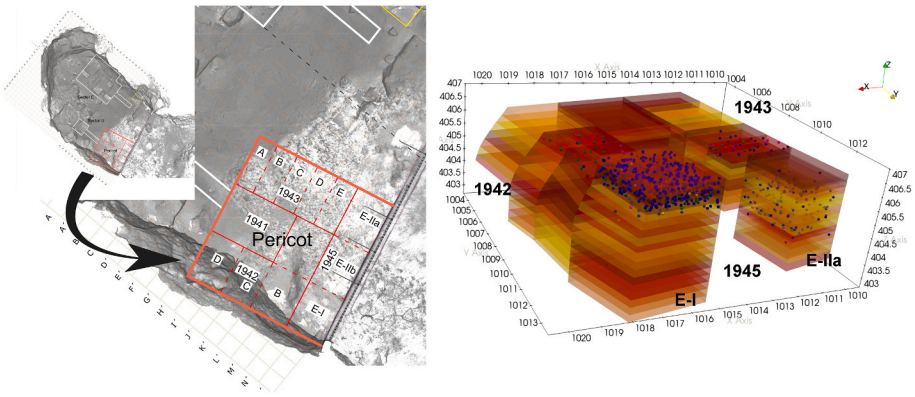

Fig. 4. Left: Location of Pericot excavated area. Right: Reinterpretation from Pericot notes of the excavated layers and vertical distribution of the sherds (dots) in each sector. Layer 1 from "SE Corner" is not represented due to the lack of information for its graphic capture.

Tables 4
Assigned decorative styles for the vessels set belonging to the *Cocina peinada* context. Pericot fieldworks.

Campaign	Sector	Layer	Undecorated	41. Impressed	61. Incised	71.Incised and impressed	91.Non-decorated reliefs	93. Decorated reliefs	101.Simple peinada	102.Mix peinada
1942	SE corner	1		1	2			1	3	
1943	E	1		1		2				1
1945	E−1	3	2						1	
		4			1	2	1	1		
Total			2	2	3	4	1	2	4	1

characterise these other sites using the same variables; and f) apply the Bayesian procedure explained above to assign to each non-dated site a concrete window.

As a result, we've been able to work with a set of 77 contexts from 46 sites, distributed along 12 chronological windows (Table 2). From the obtained distribution, concerning Cocina contexts, some aspects must be highlighted:

1. *Cocina cardial* is placed in windows 4 and 5, between 7300 and 7100 cal BP, with a cumulated probability of 78%. *Cocina peinada* is placed in windows 10 and 11, which means between 6700 and 6500 cal BP. Ordered in this way, a discontinuity among both occupations can be recognised.
2. The chronology assigned to *Cocina cardial* fits with the 14C date over charcoal obtained in UE 1030 (Beta-426849: 6350 ± 30 BP). This date moves the first ceramic occupation of the Cocina cave away from the very first Neolithic moments in the region (windows 1 and 2). These last windows are quite coincident with the more recent 14C date linked to the Mesolithic occupations of the site (Beta-267439: 6760 ± 40 García-Puchol et al., 2018: Table 2). This means there is a gap of at least 200 years between the last Mesolithic presence and the arrival of the first Neolithic evidence to the cave. As will be discussed later, this has major implications for our understanding of the Cocina cave record.
3. As we have seen, the *Cocina peinada* set is separated at least 400 years from the first pottery evidence in the cave. The Bayesian analysis allows us to relate this occupation with several sites distributed along the whole considered region (Table 2). Until recently, Neolithic evidence available for the region between the Xúquer and Ebro rivers was scarce, but after the review undertaken by one of us (Escribá, 2023), this situation has been solved, filling this gap and providing an important record. What must be pointed out now is the differentiation that can be recognised in the ceramic productions offered by the sites located North and South of the Xúquer river. This differentiation is mainly sustained over two indicators (Table S6): the presence in the first moment of combed pottery and of scratched (*esgrafiada*) pottery later (window 12), just South of the aforementioned line. This differentiation in the ceramic productions was not evident during the earlier stages and points to a break in the shared evolution that offered the ceramic industries, at least along the VIII millennium cal BP.

4.3. Cocina in the neolithic nets

Cultural globalisation or regionalisation can be considered as emergent qualities derived from social relations among individuals or groups. The use of SNA is a suitable tool for analysing the arise of these phenomena. As has been explained previously, we will use the pottery decoration as an indicator for defining the interaction nets among groups (sites/levels), considering that the closeness of the characteristics of this trait is directly related to the intensity and/or frequency of the social interactions.

The main aim of this exercise is not to draw the nets' structural dynamics, but to try to understand how the dynamics of the transmission of information at a local level can affect the characteristics of the whole net. We will focus on those chronological windows where Cocina cave is present: windows 5, 6, 10, and 11.

Fig. 5 shows the maximum value of the normalized Jaccard Similarity Index. We have to point out that some of the windows have a poor number of nodes (windows 1, 2, 9, and 12: Table 2), so we must be careful in our assessments. Leaving aside that windows, the Figure shows how the lower values of the Index are all placed in the recent part of the sequence. The stretch between windows 4 and 8 offers higher values than the one between windows 9 to 11. This suggests that nodes on these last windows are more diverse among them.

This question could be related to the way information spread in the communities. To study this point in more detail, we have to focus our analysis on the individual scale, identifying the role of particular nodes

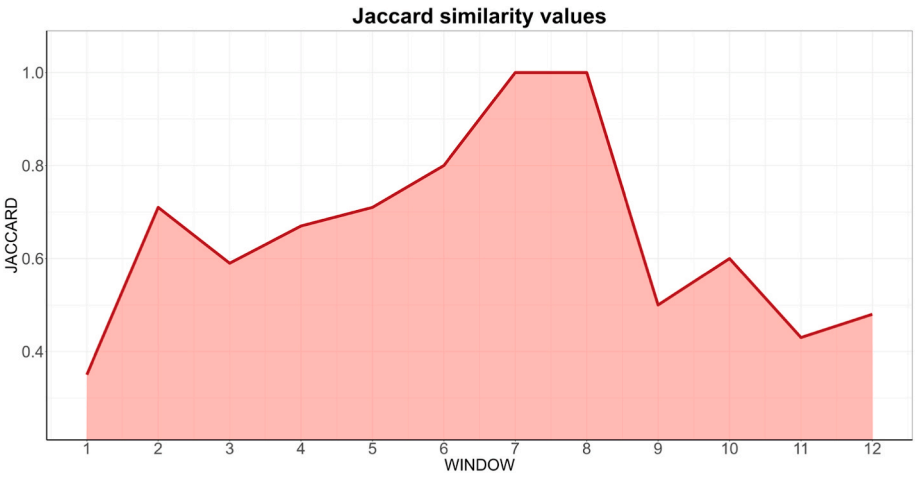

Fig. 5. Plot showing the maximum normalized value of the Jaccard Index in each temporal window.

in that process, helping or limiting the flow of information. The heart of the matter is to verify if the Xúquer river, as it has been pointed elsewhere, could act as a frontier in the cultural transmission process. From the whole set of nodes considered, just two (Cocina cave and Ceñajo de la Peñeta) are located beside the river. So, we will focus our attention on those windows where both (windows 5 and 6) or just one of them (windows 10 and 11: Cocina) are present.

As stated earlier, this decision is also linked to the sample size at some periods which crystallises in a lack of definition. In our case, we will focus on two centrality measures: *betweenness* and *eigenvector*. Both metrics measure the intermediation role that a node plays in the network (Barthelemy, 2004). It can be useful to detect bottlenecks and capital nodes in the information exchange. *Eigenvector* centrality quantifies the quality of the links of a node (Bonacich, 2007). Combined, both provide an idea of the importance of a specific node in the whole network.

Graphics of Fig. 6 are illustrative of the evolutive tendency between windows. At the beginning (window 5), Xúquer Rabin represented by Cocina cave has a major role in the process of information exchange, but immediately later, that node loses its importance as new actors located North and South of the Xúquer appear: in window 6, Costamar, located in the northern region, replaces Cocina as central point; Cocina achieves a medium position, along with Bruixes (in the top North of the study area) and Cendres (in the South). This process reaches window 11 when Cendres and Costamar become the main nodes. This modification has important consequences for the organisation of the net (Fig. 7).

Graphics in Fig. 7 have been designed so each pair of nodes are just related if they reach 60% of the maximum value of the Jaccard Index in their window. This implies that it is a net with strong connections. Ceñajo de la Peñeta (windows 5 and 6) always offers *betweenness* values too poor, so we have to pay attention just to Cocina behaviour, which has significative *betweenness* values.

In window 5 (Fig. 7A), Cocina concentrates the highest value, playing an important role in helping the interconnection between North (red) and South (blue) nodes, by the contact with other two prominent sites: Or cave and Fosca cave. At this point, the network seems well connected, excepting just two small sites.

In the next window (Fig. 7B), different places North and South of the area appear disconnected, but without forming any secondary net. This happens at the time when Costamar replaces Cocina as the site with higher *betweenness*. Despite this new situation, Cocina seems to be well connected with the sites located North of the Xúquer, but not with the southern ones. This tendency to fragmentation continues in window 10 (Fig. 7C): Costamar gets the highest *betweenness* of the net, but, surprisingly, connections with the other northern sites are poor or non-existent. Three of them, located in the inner mountains, are disconnected from the main network, forming a different secondary net (Fosca, Mas de Nadal, Sima de la Higuera).

Finally, in window 11 (Fig. 7D), Cocina recovers some weight as an

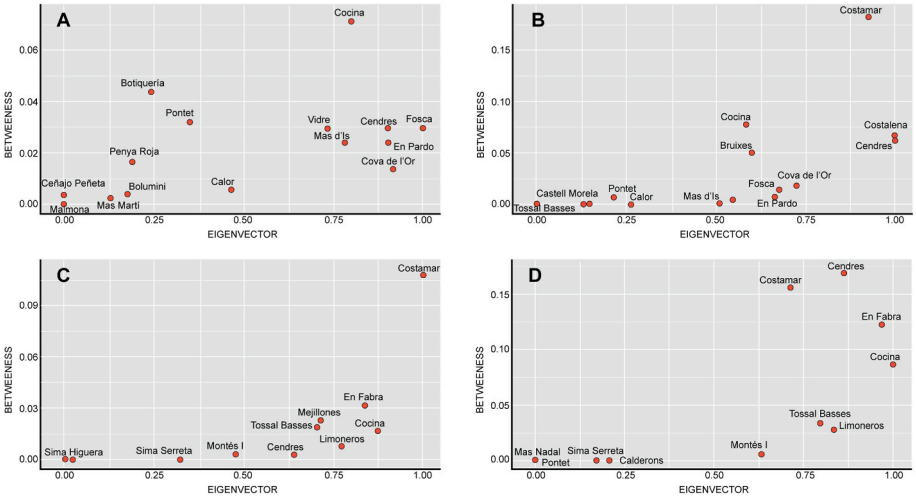

Fig. 6. Scatterplot showing the relationship between *Eigenvector* and *Betweenness* in the four windows where Cocina cave is present. A, Window 5; B, Window 6; C, Window 10; and D, Window 11.

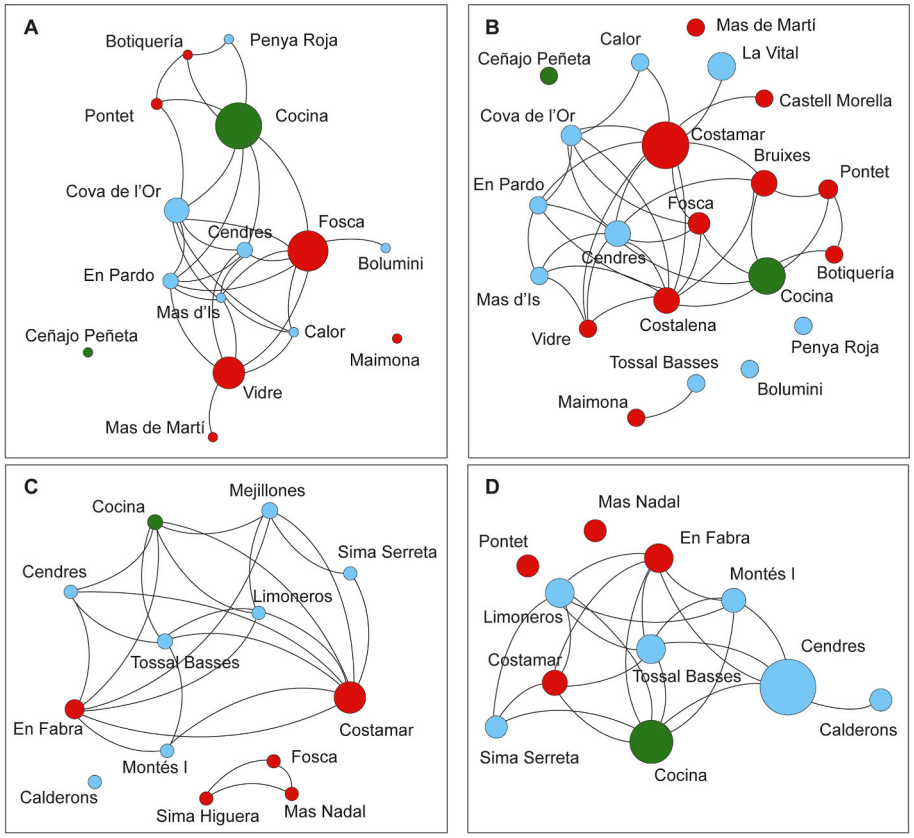

Fig. 7. Network graphs of the four windows where Cocina cave is present (A, window 5; B, Window 6; C, Window 10 and D, Window 11). Colours represent geographical regions; shapes represent the relative importance of *betweenness*. Red: sites located N of Xúquer river; Blue: sites located S of Xúquer River; Green: sites located at Xúquer River.

intermediary, but with different connections. Now Cendres cave, a coastal site located in the South, reaches the highest *betweenness* values. Cocina, despite being the node with the second highest value, is mainly connected with southern sites. Following what was happening in the previous window, northern sites located inland (Mas de Nadal, Pontet) keep disconnected.

The consequences of these dynamics can be followed in the maps of Fig. 8, where windows 5, 10, and 11 have been depicted. Dots represent sites with the relative importance of each of the four main decorative styles identified: Cardial, Incised/Impressed, Reliefs, and Combed. Despite general diversity, the main difference is due to the distribution of combed pottery, mainly restricted to the South of the region. Those sites placed in the North that offer some combed ceramics (Costamar, Barranc d'En Fabra) are both coastal ones, which can be seen as a consequence of a disconnection coast-inland North of the Xúquer river.

5. Discussion

After the pottery taphonomic revision, two sets belonging to two different moments could be isolated. Their fitting within the regional context, using a Bayesian approach, has allowed us to give a framework for both sets. The attachment to those windows has clear implications for understanding the record.

Given the available data, the first Neolithic presence in Cocina is dated close to 200 years later than the last Mesolithic-dated occupations. And, what is more significant, it is also 200 years later than the first Neolithic evidence in the region.

As long as synchrony between the last local Mesolithic populations and the first coastal Neolithic settlements can be argued, the presence of any material evidence of contacts is feasible. The first Neolithic ceramic productions identified at a regional scale are related to the *impressa ligur* tradition (Bernabeu et al., 2009a; Bernabeu and Pardo-Gordó, 2020; Manen, 2000; Manen et al., 2019; Molina et al., 2020). These materials exhibit a wider distribution than considered first (Escribá, 2023). Available dates from these contexts came from sites located yet in inland valleys (Alcoi basin), so, earlier dates could be expected for the first pioneering coastal sites.

Despite this real possibility for a contact phase, the Cocina cave record offers no evidence of this kind of pottery at all. Those last Mesolithic-dated contexts showed no ceramics nor any domestic remains.

Those sherds from the Cocina record identified as the oldest ones are related yet with a classic cardial context. This fact sends these remains to a chronological moment later to any potential contact period. The 14C date available reinforces this view. This kind of ceramic industry is linked to a moment when the Neolithic communities are fully established along a wide area that extends both to the South of the Xúquer river (García-Atiénzar, 2009) and the North (Escribá, 2023).

Layers from Cocina cave where these materials were recovered are quite disrupted by post-depositional processes that question their integrity. The taphonomic review shows attritions and shiftings that annul the stratigraphic relations that could offer those materials. So, we have to accept that the sequence of Cocina cave cannot play any noteworthy role in a Neolithisation process explanation consequence of acculturation dynamics.

This last fact also limits our options for describing the kind of occupations related to these first Neolithic materials. As we have seen, the described morphological and technological characteristics put them inside the pottery tradition that distinguishes the cardial culture of this region. Considering the geographical dispersion of these groups, Cocina cave is placed in, what seems, a peripheral area of their spread. But, as we have seen, this could not be the case. Placed just beside the Xúquer

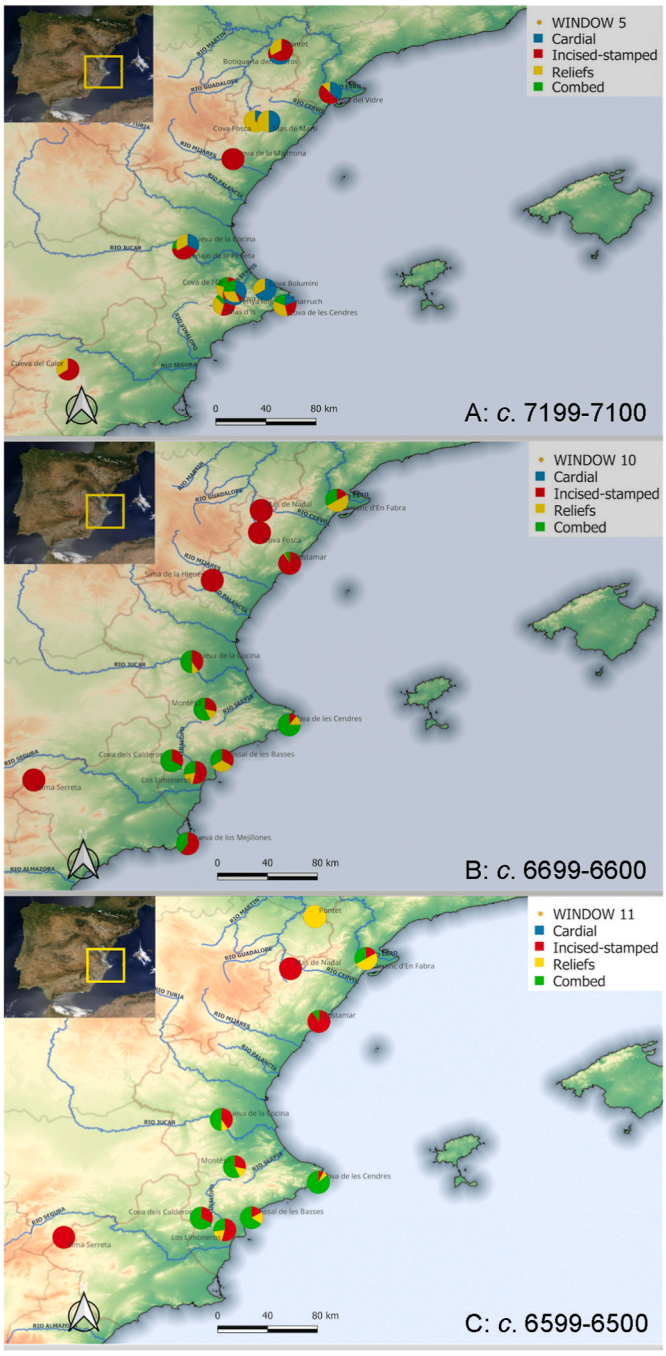

Fig. 8. Geographical distribution of the four major ceramic styles in windows 5 (A), 6 (B), and 11 (C).

river, this location could have played an important role to direct the information fluxes among communities from both sides of the river (Fig. 7A).

The SNA suggests that this situation changes at a later moment. If we pay attention to the distribution along the whole considered area of the main decorative styles (Fig. 8), we can see that in window 5 (7200-7100 cal BP) Cardial, Reliefs and Incised/Impressed styles are widespread, what can be taken as a result of a fluent interaction along the whole area. The situation is quite different in windows 10 and 11 (*c.* 6700-6500 cal BP). Cardial style has already disappeared, and Reliefs decoration, while present, has an erratic distribution: in window 10 (Fig. 8B) it is just present South of the Xúquer and, rarely, in the top North. Incised/Impressed is widespread, but best represented in the inland sites. The main novelty is the combed pottery. In both windows (10 and 11) its distribution is restricted to those sites placed South of the Xúquer river and, always rarely, in the coastal nodes of the northern area. It never penetrates the inland sites.

This scene suggests that the possibility of considering the Xúquer river as a frontier for some cultural traits during the Neolithic period can have sense, but at a second stage in the Neolithic cultural evolution (window 10: *c.* 6700 cal BP). It is possible that this situation started a bit earlier, but, unfortunately, information is very scarce at the previous moments. It seems clear that these dynamics persist later when a new decorative style (*Esgrafiada*, window 12: *c.* 6500 cal BP) appears, but just restricted to the southern area.

We don't have information about this window from the Xúquer basin. We will have to wait until *c.* 5500 cal BP (Late Neolithic) to have any archaeological evidence. Recent studies based on SNA, and using similar methodology, have pointed to the presence of communities culturally differentiated between 4300 and 3900 cal BP (Late Chalcolithic/Early Bronze Age) North and South of the Xúquer river as well (Jiménez-Puerto, 2022: 154–160).

The break-up of what we can call the cardial network (Bernabeu et al., 2017b) could be related to the deep changes in the landscape structure that take place in these moments, South of the Xúquer basin. Those changes imply a complete reorganisation of the settlement systems at a local scale, best represented in the way the caves are used (García-Atiénzar, 2009: 120–121): those big caves that had shown an intensive occupation until this moment, modify their status and become enclosures for the herds, funerary spaces, or they are just abandoned.

6. Final remarks

Cocina cave has been used for years as a key site by the interpretative models that explained the Neolithization process in the Iberian Mediterranean façade. Despite its importance, the ceramic record never had a complete study. Now, with the combination of different approaches and methodologies, we have been able to give sense to this record. With the limitations outlined before, we can say that:

1. Neolithic occupations of the Cocina cave are the result of occasional and recurrent events that span close to 700 years.
2. Compared with the considered intensity of the Mesolithic occupations along their sequence, these events are the result of a completely different use of the cave.
3. The first Neolithic presence is dated in 7300–7100 cal BP, almost 200 years later than the last Mesolithic occupation.
4. This chronological gap is the same that exists concerning the first Neolithic evidence at a regional scale. These two points, along with the post-depositional disturbances recognised, give rise to the fact that the Cocina cave record cannot be used to explain any acculturation process as part of the regional Neolithization process.
5. Despite being not intense occupations, seems that these new dynamics are fully integrated into the social structures and the information exchange networks displayed by the Neolithic communities of the Iberian Mediterranean façade.
6. From a given moment, in the first half of the VII millennium cal BP, we can recognise a regionalisation process in the decorative styles used by the Neolithic groups. This process means that some styles, such as the combed one, are restricted to particular regions.
7. In this new network dynamics, the Xúquer river appears as a cultural frontier, limiting the spread of some styles. Cocina cave, in this context, gets linked to the networks developed in the South.
8. To the North of the Xúquer river, just the coastal sites show some feeble evidence of contact with the southern area. Inland sites seem isolated from that network.

Future works should also tackle the problem of the function of the sites, which couldn't be addressed in this exploratory work, due to the

scarcity of the sample, but will surely provide new insights into the proposed question. We have to warn that these conclusions must be seen as provisional. First of all, the sample used for the analysis is too scarce and lacks continuity for the considered period. So, solid trends cannot be outlined. This is the consequence, in part, of the results from the Bayesian approach, which generates high levels of uncertainty when we organise the non-dated samples chronologically. Indeed, any archaeological analysis has to face the problem of uncertainty at different levels (Crema, 2012) by using suitable tools. In our case, reducing this uncertainty implies improving the efficiency of the Bayesian analysis through two different ways: improving the available 14C database; and expanding the analysis to other kinds of archaeological remains, choosing the most appropriate ones to perform the SNA. We are currently working on both lines as part of an investigation project focused on understanding the evolutive dynamics along the recent Prehistory of Easter Iberia.

Data availability

The information about the Cocina cave pottery collection used in this paper can be found in the Supplementary Files attached to this paper (Tables S1 and S2).

The Pericot and the Fortea collections are guarded in the Museu de Prehistoria de València. The Garcia-Puchol collection is provisionally at the Laboratory of Archeology of the Universitat de València until its definitive move to the same museum.

CRediT authorship contribution statement

Lluís Molina-Balaguer: Conceptualization, Investigation, Writing – original draft, Visualization. **Pilar Escribá-Ruiz:** Methodology, Formal analysis, Investigation. **Joaquín Jiménez-Puerto:** Methodology, Software, Formal analysis. **Joan Bernabeu-Aubán:** Formal analysis, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.quaint.2023.05.006.

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