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The Mouth of the River Ter in the Early Middle Ages in the Mediterranean Coast

Marc Bouzas Sabater [1,*], Josep Burch i Rius [1], Pere Castanyer Masoliver [2], Ramon Julià Brugués [3], Josep Maria Nolla Brufau [1], Pere Pons Mir [3], Jordi Sagrera Aradilla [1] and Joan Solà Sobiranas [3]

[1] Institut de Recerca Històrica, Universitat de Girona, Plaça Ferrater, Mora, 1, 17004 Girona, Spain; josep.burch@udg.edu (J.B.i.R.); josep.nolla@udg.edu (J.M.N.B.); jordi.sagrera@udg.edu (J.S.A.)
[2] Museu d'Arqueologia de Cataluna-Empúries, 17130 L'Escala, Spain; pcastanyer@gencat.cat
[3] Geoarchaeology of Geoservei, Projectes i Gestió Ambiental SL, 17003 Girona, Spain; nomar.ailuj@gmail.com (R.J.B.); p.pons@geoservei.com (P.P.M.); s.sola@geoservei.com (J.S.S.)
* Correspondence: marc.bouzas@udg.edu

Abstract: The River Ter is one of the axes which, in a west-east direction, has historically articulated the population of the extreme north-east of the Iberian Peninsula. Although its upper, middle and part of the lower courses do not present any problems in its course, its mouth in the Mediterrane-an Sea has raised many questions due to the existence of two potential branches, one to the north that would flow into the Gulf of Roses and another to the south that would flow into the Bay of Pals. In 2016, an exhaustive documentary study on the potential southern branch provided exhaustive information on the existence of lake areas and their relationship with the settlement between the 9th and 11th centuries, but raised doubts about the existence of the river in the bay from Pals. Subsequently, between 2020 and 2022, geological studies have been carried out in this area which demonstrate the existence of the river in this area but with a variable course, with changes in the river channel (meandering, diffuse and braided), and with notable changes that conditioned the settlement of this sector of the coast and as was recorded in written documentation between the 9th and 11th centuries.

Keywords: Ter River; Mediterranean coast; early medieval

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1. Introduction

The main river in the extreme northeast of the Iberian Peninsula is the River Ter, which is 208 km long (Figure 1). Its final stretch forms part of the geographical unit known as the Depressió de l'Empordà, which is bounded to the north by the Pyrenees, to the west by an area of low hills called Terraprim d'Empordà, to the south by the Begur and Gavarres massifs and to the east by the sea. In the middle of this space there is a mountainous area, like a kind of island, which is the Montgrí massif.

The southern plain of the Depressió de l'Empordà is known as the Plana (plain) del Baix Empordà. It is a morphological unit limited by the Valldevià mountain range (part of the aforementioned Empordà embankments), the Montgrí massif, the pre-Gavarres (Boada, Fontanilles and Gualta mountain ranges) and the Begur massif (Figure 2).

Contrary to its current course, in ancient times the river entered the aforementioned Depressió de l'Empordà, turned north and flowed into Empúries [1,2]. On the other hand, the existence of the so-called eastern branch (more or less similar to the present one) before the beginning of the 14th century has raised many doubts. Specifically, the person who raised this question at the end of the 19th century was a jurist, politician and historian from the Empordà, Pella i Forgas, who argued that until the beginning of the 14th century the river only flowed into Empúries. According to this author, the Count of Empúries, Ponç Hug IV (1273–1313), promoted works on the course of the river that led to the elimination of the northern branch and the opening of the eastern branch as the main mouth of the river. His aim in redirecting the river was to harm his rival, the Count of Barcelona, by silting up the port of Torroella de Montgrí, at that time in the hands of the rival Count of Barcelona [3,4].

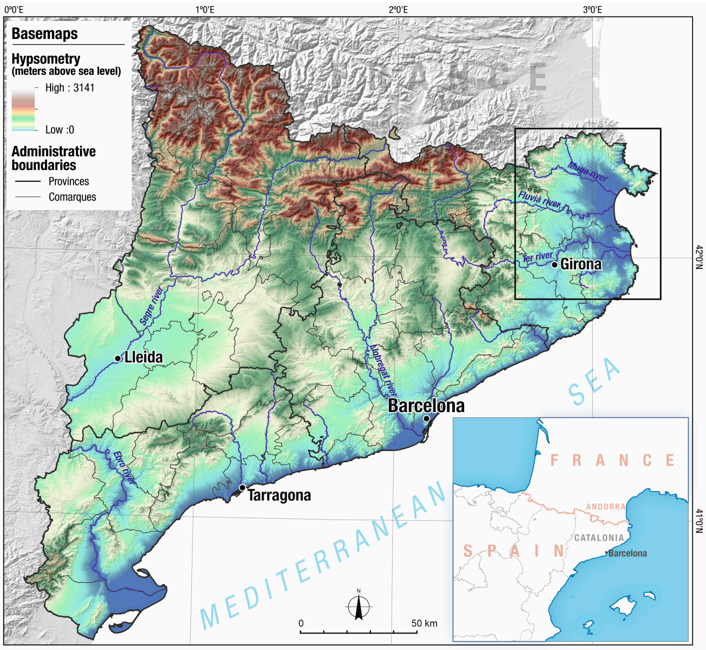


Figure 1. Map of the general situation of the field of study. Source: GEOSERVEI.

Figure 2. Detailed map of the field of study. Source: GEOSERVEI.

A few years later, at the beginning of the 20th century, another scholar, Botet i Sisó, argued that the river Ter had always kept the eastern branch as its main arm [5].

Since then, for more than a century, the historiography that has dealt with this question, the existence of an eastern arm before the 14th century, has been largely aligned with one position or the other.

Among them, the contribution of D. Bramon and R. Lluch, of the University of Barcelona, stands out for its relevance. Between 1998 and 2010, they related an invasion from Al-Andalus that took place in 935 with the eastern branch of the mouth of the river Ter. From that point, part of the fleet, made up of light boats, went up the Ter to reach the vicinity of the city of Girona, although they did not reach it. Therefore, according to the researchers, it can be deduced from this information that in the 10th century the Ter flowed into the bay of Pals and had a sufficient volume of water to almost reach Girona, already in the middle stretch of the river [6–8].

In 2010, several research works, mainly geological, were published which, together with the contribution of Bramon and Lluch, seemed to definitively settle the question in favor of the existence of an eastern arm before the 14th century.

According to these works, in the middle of the first millennium BC, the eastern branch of the Ter was divided into several channels. At the same time, the coastline receded and marshy areas such as Pals and Ullastret were closed. The river dynamics of this period were characterized by a meandering function. There, the river made its way through a substratum that was not very compact. According to this study, between the 4th and 15th centuries, the fluvial contributions to the plain of the lower Ter would have increased and the plain would have finished filling [9,10]. At the same time, the northern branch, well documented throughout the ancient period and with a very significant flow, gradually declined in importance from the 5th century to the modern period (current knowledge does not allow for more precise). In the latter period it was only a stream [2].

However, in 2016 E. Canal, J. M. Nolla and J. Sagrera published an article in which they questioned whether the Ter River had an east arm until the end of the 11th century. The authors of this publication, based on the documentation preserved from the 9th to the 11th centuries, doubted the passage of the river Ter in this area and at that time, as the river is not mentioned in the written sources in the different confrontations of properties and terms that are collected in the documents of the time. This is a difference with the Daró river which, flowing further south than the Ter on the same plain, was mentioned in the documentation of the late 9th century. The aforementioned authors proposed, as a hypothesis, that floods known in Ullà, at the northern end of the plain at the end of the 11th century (specifically in 1074), may have been the moment when the river Ter began to flow in its eastern stretch. The same authors include in their work several lakes mentioned in the sources, especially in the southern part of the lower Empordà plain and which have traditionally been placed as the boundary of the counties of Empúries and Girona. They also mentioned a reference to a church (Sti Petri de Carcer) which, at the time it was mentioned in the documentation, was probably located on the coastline and is currently 1.5 km from it (Figure 3). Therefore, they confirmed that from the Early Medieval period until now there has been a marine regression [11]. After this moment, the presence of the River Ter is no longer in doubt [12].

This whole debate, beyond the controversy as to whether the river passed through one place or another, has very important background historic relevance, given the relationship of part of the inland lands, especially the most important city in the whole area, Girona, with the coast. Specifically, the problem posed is whether this relationship was direct, that is, through the eastern arm, or indirect, that is, through Empúries and the northern arm. At the same time, it is a particularly relevant issue if we take into account the rivalries between the counts of Empúries and Barcelona throughout the Medieval period.

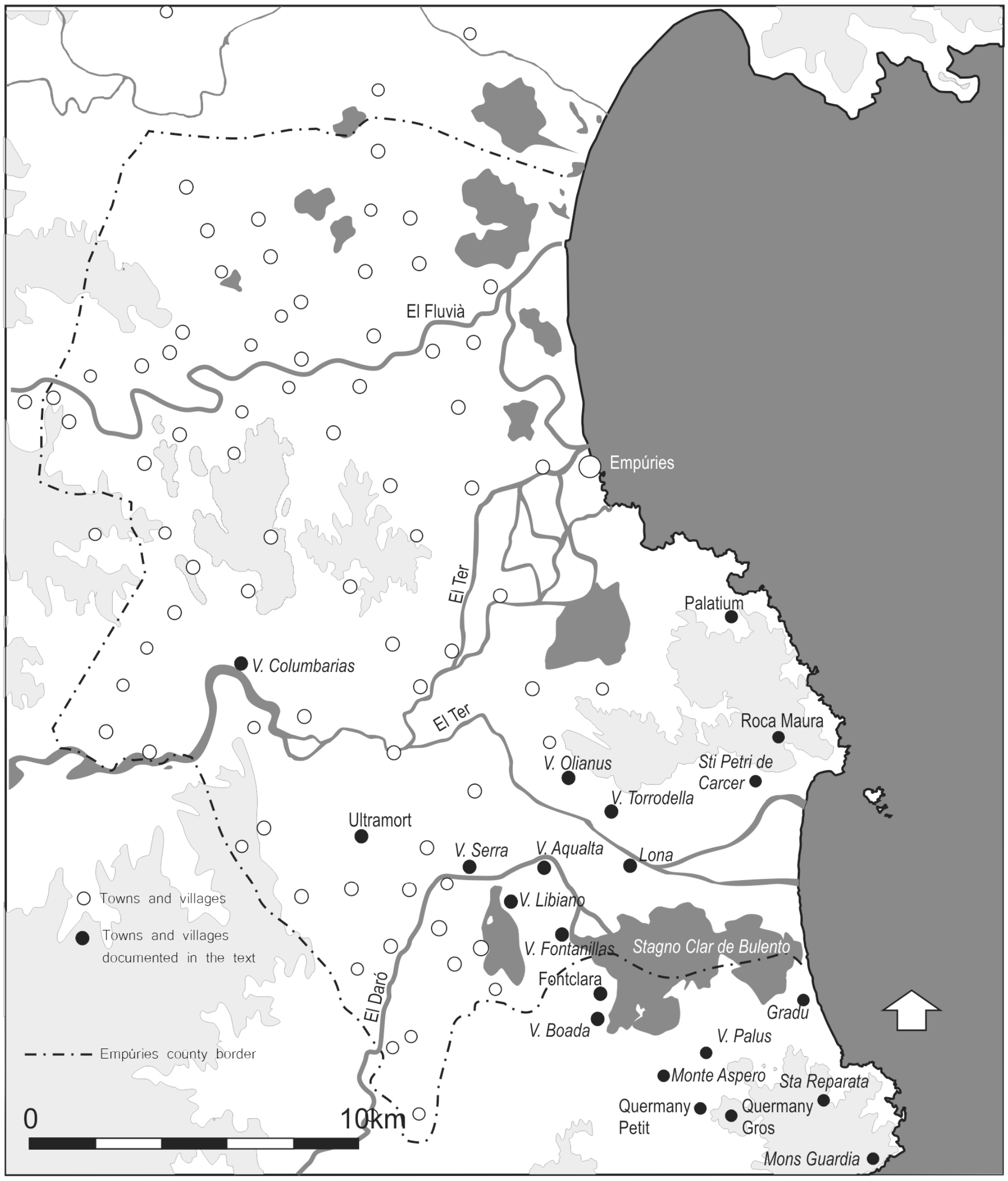


Figure 3. Detailed map of the historical places of the field of the study durint the 9th, 10th and 11th century [11].

In order to clarify this question within the framework of a research project carried out between 2020 and 2023 on paleo-landscape and territorial exploitation of the late Roman and late antiquity periods, the authors of this article promoted the geological research work with the aim of understanding the geomorphology of the lower section of the river Ter (between Ullà, Gualta and Torroella de Montgrí) in the Mediterranean coast throughout the 9th to 11th centuries.

Thus, the main objective of this study was to determine whether during the 9th, 10th and 11th centuries the river Ter flowed through the Gualta-Ullà strait to the bay of Pals (Eastern Sector). This does not imply that the demonstration of this course means the non-existence of the north branch in this same period, a fact that can only be corroborated in later work.

In order to achieve the main objective, the research focused on two major complementary purposes:

- Identify, beyond the current course of the Ter River, the existence of palaeo-fluvial courses based on historical data (documents, maps and plans) and the geological knowledge that is currently possessed about the process of sedimentary filling that has dominated in the Baix Ter plain. To try and determine if the River Ter really flowed through the Gualta-Ullà strait (East Sector) during the 9th, 10th and 11th centuries involves trying to obtain a first knowledge of the age of the paleo-channels existing in this area.
- Determine the age (or age range) of the paleo-channels identified above and the sediments that fill and/or overflow them in order to delimit the time period of the fluvial course-axis or the sedimentary record deposited in each of them.

2. Materials and Methods

In accordance with the objectives set out in the previous section, the following works were undertaken:

- Compilation of geological, palaeogeographical and historical background of the area under study.
- Geomorphological characterization of the lower section of the river Ter between Ullà, Gualta and Torroella de Montgrí. One of the first tasks planned in the study was to carry out a preliminary analysis of the geomorphology in the area of the Baix Ter and, specifically, in the Gualta-Ullà Stratit Sector. This work has carried out on the bases of the study of the Digital Model of Elevations with 2 by 2 grid of the Institut geogràfic I Geològic de Catalunya (ICGC) and the aerial photographs corresponding to the American flights of 1945-56 available at the ICGC. This analysis has made it possible to identify topographically most depressed areas, which correspond to ancient fluvial traces or ancient paleochannels and which would have been functional during the most recent Holocene, which had to be verified by subsequent prospecting work [13–15]. In fact, the available geological and geomorphological cartographies—Especially those corresponding to the L'Escala, Torroella de Montgrí and L'Estartit sheets of the geological map of Catalonia at a scale of 1:25,000 (edited by the ICGC)—Identify ancient traces of the river that are referred to as fossil beds.
- Field reconnaissance and validation of the paleochannels defined/chosen in the previous work phases.
- Prospecting work. Witnessing and sampling by means of a mechanical drill for sedimentological and paleontological studies (identification of sedimentary environments) and for radiocarbon dating. Based on the geomorphological analysis, it was determined where to carry out the geological prospecting work (execution of soundings) in three areas or areas of exploration and characterization (Ullà, Torroella and Gualta) and in this way cover the entire area where the Ter River hypothetically flowed (Figure 4). At the end of the process, a total of 10 boreholes had been carried out with a mechanical auger with a cased head, which has made it possible to obtain a continuous unaltered sample in sections of 60 cm long sections, thus avoiding contamination of the upper sections in each operation of removing and nailing the auger. Prospecting depths were between 3.6 and 4.2 m and were conditioned by the penetration capacity of the chosen method.

At the same time, within the framework of this project, a total of 6 samples were selected for radiocarbon dating and sent to an authorised laboratory (Beta Analytic Radiocarbon Dating Laboratory) for radiocarbon dating (14C) (Figure 5). According the Report of Beta "All works was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional radiocarbon Age" was calculated using the

Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable". Figure 5 shows the stratigraphic position of the 6 selected samples, the dated material, as well as the conventional age and the proposed age (mean age) in each sample. Proposing/calculating a (adjusted) mean age has only one practical reason: to facilitate the understanding of radiocarbon dating, which in turn facilitates the graphic and visual interpretation of the results obtained and the interpretations made. The age adjustment considered does not correspond to the direct arithmetic mean of the range of calibrated ages proposed by the laboratory, with a probability of 95% (2 sigma). The calculation takes into account the age distribution proposed by the laboratory and each of its probabilities. The one considered most probable has been chosen and a standard deviation is proposed depending on the amplitude of the age subrange considered. Obviously, this proposed "average" age is within the range of calibrated ages, but has a lower probability than that considered in the entire range. At the same time, dates already published in previous prospecting campaigns carried out by other re-searchers were also used [16,17]. The radiocarbon age results of the terrestrial samples have been treated according to the protocol of Stuiver, Reimer and Bronk Ramsey [18–21].

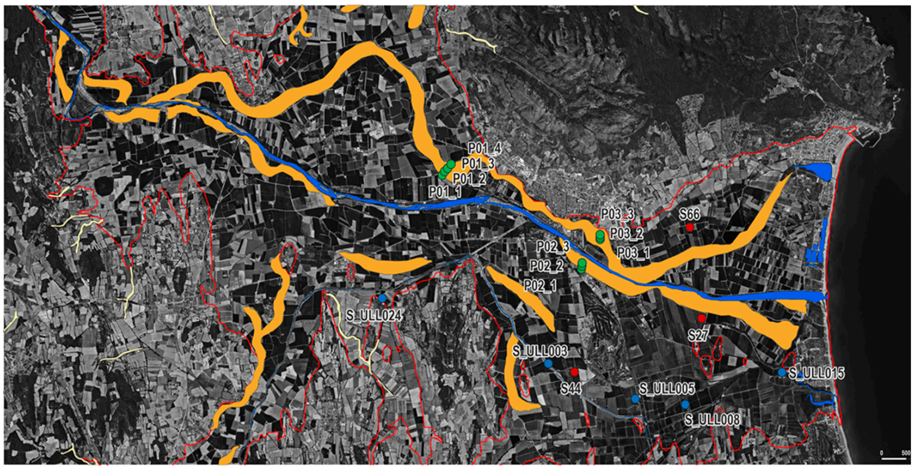


Figure 4. Location of the surveys with dates corresponding to the current GEOSERVICE campaign, 2022 (green dots) and the historical campaigns of Brill et al., 2010 [16] (blue dots) and Rambaud [17], 2005 (red dots). In blue, the current course. In yellow, the palaeochannels identified in the work. Source: GEOSERVEI.

#	BOREHOLE CODE	LABORATORY CODE	RIVER BASIN	REFERENCE	SAMPLE DEPHT (m)	LAND ALTITUDE (masl)	SAMPLE ALTITUDE (masl)	MATERIAL	CONVENTIONAL AGE ^{14}C	$\delta^{13}C$ (‰)	PROBABILITY (%)	CALIBRATED AGE RANGE	MEAN AGE
1	ULLA-P01_1	Beta - 629240	TER	GEOSERVEI*	2.70	10.01	7.31	charred material	720±30 BP	-25.90	95.40	1230 to 1384 cal AD	1281±24 cal AD
2	ULLA-P01_2	Beta - 629241	TER	GEOSERVEI*	2.70	10.30	7.60	charred material	113±0,42 pMCP	-23.70	95.40	1956 to 1994 cal AD	1992±2 cal AD
3	ULLA-P01_3	Beta - 629242	TER	GEOSERVEI*	3.85	10.28	6.43	Plant remains (leaves and stems)	790±30 BP	-25.50	95.40	1214 to 1280 cal AD	1247±33 cal AD
4	ULLA-P01_4	Beta - 629243	TER	GEOSERVEI*	2.90	10.14	7.24	Plant remains (leaves and stems)	650±30 BP	-27.00	95.40	1281 to 1396 cal AD	1338±57 cal AD
5	TORROELLA-P02_2	Beta - 629244	TER	GEOSERVEI*	4.10	6.74	2.64	charred material	2590±30 BP	-25.70	95.40	814 to 593 cal BC	784±30 cal BC
6	GUALTA-P03_2	Beta - 629245	TER	GEOSERVEI*	3.70	7.19	3.49	charred material	80±30 BP	-24.90	95.40	1690 to 1922 cal AD	1824±12 cal AD
7	S27	-	TER	RAMBAUD**	4.30	4.10	-0.20	Marine mollusc	2260±40 BP	-5.10	-	-	1907±40 cal BC
8	S44	-	DARÓ	RAMBAUD**	9.70	3.80	-5.90	Marine mollusc	4750±70 BP	-5.54	-	-	4397±70 cal BC
9	S66	-	TER	RAMBAUD**	4.25	3.50	-0.75	Marine mollusc	2060±40 BP	-5.49	-	-	1707±40 cal BC
10	S_ULL03	-	DARÓ	BRILL***	5.78	2.70	-3.08	Charcoal	3830±50 BP	-26.90	88.20	2464 to 2191 cal BC	2278±186 cal BC
11	S_ULL05	-	DARÓ	BRILL***	10.84	3.80	-7.04	Marine mollusc	5430±70 BP	-0.20	92.40	4373 to 4052 cal BC	4212±160 cal BC
12	S_ULL08	-	DARÓ	BRILL***	2.37	2.40	0.03	*Cerastoderma gloaucum*	1470±50 BP	-5.40	94.90	436 to 659 cal AD	594±64 cal AD
13	S_ULL08	-	DARÓ	BRILL***	4.62	2.40	-2.22	Plant remains	2590±70 BP	-26.60	68.20	554 to 830 cal BC	707±197 cal BC
14	S_ULL015	-	DARÓ	BRILL***	2.80	1.00	-1.80	*Gibbula varia*	2213±46 BP	-0.40	68.20	206 to 363 cal BC	282±104 cal BC
15	S_ULL024	-	ULLASTRET	BRILL***	3.65	10.70	7.05	Plant remains	584±44 BP	-24.80	68.30	1309 to 1409 cal AD	1357±57 cal AD

Figure 5. Results of radiocarbon dating (BP) and proposed chronological interpretation (cal AD and cal BC). In green are the results of the dating of GEOSERVEI, 2022 (6 samples), in red those of Rambaud, 2005 (3 samples) and in blue those of Brill et al., 2010 [16] (5 samples). Rambaud's probability and age range are not detailed because they have not been published. In this case, as these are conventional radiocarbon ages obtained from marine materials, the proposed calibrated mean ages have been calculated taking into account the marine reservoir effect subtracting 353 years from the conventional ages [22] and maintaining the standard deviation already proposed initially. In Brill's datings, the ages calculated by the author have been respected. * GEOSERVEI ** Brill et al. [16] *** Rambaud [17] Source: GEOSERVEI.

During the drilling carried out in each of the three sectors (Ullà, Torroella and Gualta), in addition to the coordination and management work, each one has been monitored and testified, while the drilling work progressed, with a detailed description of the samples obtained. The samples have been described in situ (and later in the labor-atory) highlighting the sedimentological and faunal aspects that have been considered of interest for the objectives of the paleoenvironmental reconstruction.

3. Results

The results of the surveys and observations mentioned in the previous section. They are detailed below, structured by sectors:

3.1. Sector Ullà

3.1.1. Survey P01-1

From 0.0 to 0.8 m deep: filled with disturbed natural soil. From 0.8 to 2.2 m: variable proportions of fine sand and brownish silt. From 2.2 to 2.8 m: thinnest and most laminated section. At a depth of 2.7 m, a charred material was taken for radiocarbon dating, which gave a result of 1281 $\pm$ 24 cal AD (probability 95.40%). From 2.8 to 3.6 m: Fine to medium-wet sand. 3.6 m: End of the borehole. The water table is not intercepted.

3.1.2. Survey P01-2

From 0.0 to 0.4 m deep: agricultural soil. From 0.4 to 2.4 m: brown silty sand. From 2.4 to 3 m: finer section very wet/wet. At a depth of 2.7 m, a charred material was taken for radiocarbon dating, which resulted in a result of 1992 $\pm$ 2 cal AD (probability 95.40%). From 3.0 to 3.6 m: Medium sand with coarse sections. 3.6 m: End of the borehole. The water table is not intercepted.

3.1.3. Survey P01-3

From 0.0 to 0.6 m deep: filled with disturbed natural soil. From 0.4 to 3.0 m: brown-beige sandy silt. The deeper it is, the finer. From 3.0 to 4.0 m: silt with varying proportions of clay and grey-brown sand. At a depth of 3.85 m, a plant remains (leaves and stems) was taken for radiocarbon dating, which gave a result of 1247 $\pm$ 33 cal AD (probability 95.40%). From 4 to 4.2 m: Fine-medium wet sand. 4.2 m: End of the borehole. The water table is not intercepted.

3.1.4. Survey P01-4

From 0.0 to 0.2 m deep: topsoil. From 0.2 to 1.1 m: brown sandy silt. From 1.1 to 2 m: medium and coarse sands. From 2.0 to 3 m: slightly sandy very wet silt of dark brown-grey colour. At a depth of 2.9 m, plant remains (leaves and stems) was taken for radiocarbon dating, which gave a result of 1338 $\pm$ 57 cal AD (probability 95.40%). From 3.0 to 3.6 m: Medium-coarse sands, wet grey. 3.6 m: End of the drilling. The water table is not intercepted.

3.2. Sector Torroella

3.2.1. Survey P02-1

From 0.0 to 0.2 m deep: no sample. From 0.2 to 2.6 m: brown sandy silts. From 2.6 to 2.9 m: Laminated sandy silts. From 2.9 to 3.1 m: Brown sandy silt. From 3.1 to 4.2 m: Fine-medium brown sand. 4.2 m: End of the borehole. The water table is not intercepted.

3.2.2. Survey P02-2

From 0 to 0.2 m deep: no sample. From 0.2 to 3.8 m: Sandy silts that becoming sandy at greater depths. From 3.6 to 4.0 m: laminated sandy silts. From 4.0 to 4.2 m: fine sand. At a depth of 4.1 m, a charred material was taken for radiocarbon dating, which gave a result of 784 ± 57 cal AD (probability 95.40%). 4.2 m: End of the borehole. The water table is not intercepted.

3.2.3. Survey P02-3

From 0.0 to 0.2 m deep: no sample. From 0.2 to 2.4 m: brown sandy silts. From 2.4 to 4.2 m: Wet clay silts. 4.2 m: End of the borehole. The water table is not intercepted.

3.3. Sector Gualta

3.3.1. Survey P03-1

From 0.0 to 0.6 m deep: filled with disturbed soil. From 0.6 to 4.2 m: Medium-coarse sands. 4.2 m: End of the borehole. The water table is not intercepted.

3.3.2. Survey P03-2

From 0.0 to 0.3 m deep: Without sample. From 0.3 to 3.8 m: Intercalations of medium sand and coarse sand levels. From 3.8 to 4.2 m: Silt-wet fine sand. At a depth of 3.7 m, a charred material was taken for radiocarbon dating, which resulted in an age of 1690 to 1922 cal AD (probability 95.40%). 4.2 m: End of the borehole. The water table is not intercepted. The water table is not intercepted.

3.3.3. Survey P03-3

From 0.0 to 0.2 m deep: No sample. From 0.2 to 1.0 m: Brown sandy silts. From 1 to 4.2 m: Medium to coarse sand. 4.2 m: End of the borehole.

4. Discussion

Geological studies carried out on the fill of the Baix Ter plain indicate that it is the result of fluvial avulsion during a large part of the Quaternary period [10]. This process resulted in a continuous sedimentary record on the rocky substrate. It constitutes the filling of the plain up to its present appearance, with three well identified sedimentary sequences (from oldest to most recent): fluvial units from the Pleistocene, fluvial-deltaic units from the Lower and Middle Holocene and progradational fluvial-deltaic units from the Recent Holocene.

From the last glacial maximum (some 18,000 years ago) to the present day, the fluvial dynamics of the lower course of the River Ter have been changing, causing and conditioning quite significant transformations of the territory and, finally, shaping what we know today as the Baix Ter plain. The set of factors that have favoured these changes or transformations have been of various kinds, ranging from climatic, orographic and, more recently, anthropic.

The set of depositional sequences recognised in the Baix Ter reflect the fluvial dynamic processes that have followed one another: from an initial stage with a significant topographic gradient due to a drop in sea level (−120 m above sea level at present), during which erosive dynamics predominate (fluvial incision), through intermediate transgressive stages, caused by rises in sea level, to a final stage caused by the recovery-stabilisation of the sea level at a level close to the present one, and where progradational depositional dynamics predominate (land over the sea) and the definitive filling in of the plain.

The different stages of alluvial progradation of the River Ter evolved, over the last three millennia, from the contributions of sediments or depositional pulses from the Ter and, to a lesser extent, from the Daró, and progressively occupied the fluvial-marine muddy plain (formed in the previous transgressive stages).

The sediments intercepted in the three sectors as a whole are interpreted as fluvial materials with the presence of sandy and sandy silts levels corresponding to the filling of fluvial paleochannels (in green) and with intercalations of silt and silt-clay levels (in brown) typical of overflow and flood levels of the plain (Figure 6).

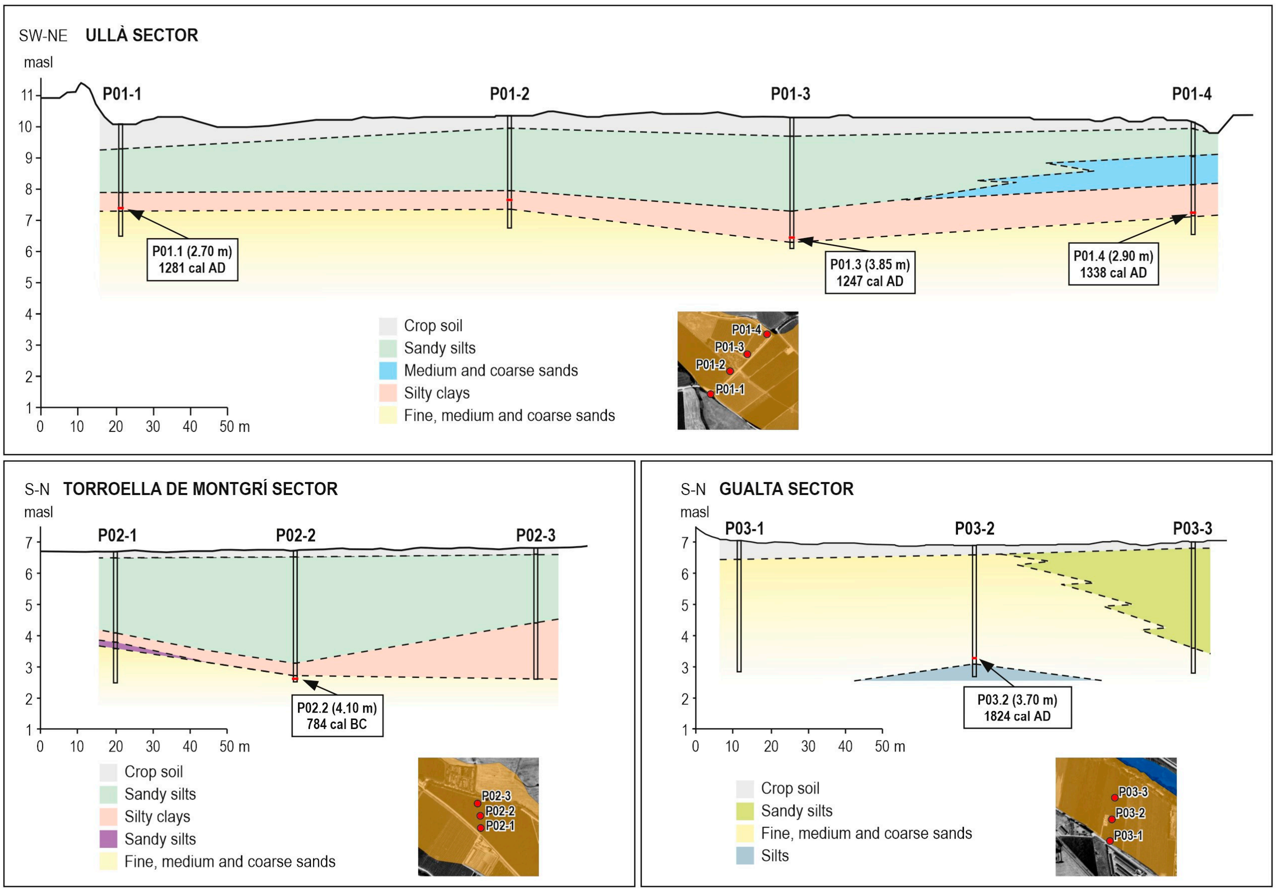
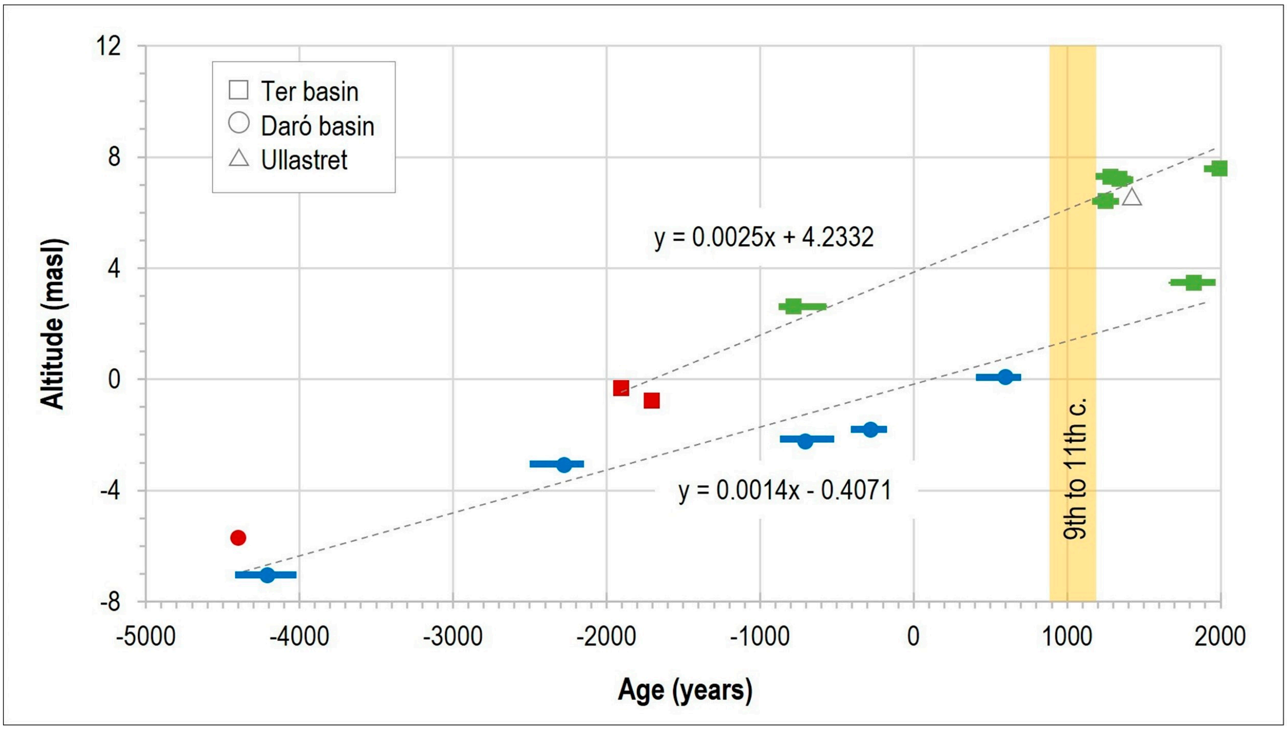


Figure 6. Lithostratigraphic correlation profiles of the surveys carried out in each of the three study sectors and indication of the ages of the dated samples. Source: GEOSERVEI.

Finally, with the results obtained in the current survey campaign, together with previous dating carried out by Rambaud [17] and Brill [16], a chronological model has been defined correlating the stratigraphic position of the sample (in absolute height) and the age obtained (Figure 7).

The representation (Figure 7) of the position of each sample (in absolute level) and the age attributed to each of them allows us to see the position of these in relation to sea level (current zero level) and, at the same time, to observe the slope of the trend lines, which indicate, for a given period and at a specific geographical point, the speed or rate of sedimentation. Although one chronological sample has been obtained per borehole, in reality each one belongs to the same transect of a palaeochannel, so that the dates end up being complementary. Thus, the trend lines observed clearly show two very different sedimentation rates depending on whether it is the Ter River, which is more pronounced, or the Daró river, which is softer. However, the distribution of the points (which represent heights versus age) shows a very low trend line, which would indicate that the sedimentation rate would have been quite constant throughout the period represented and, therefore, making the presence of a nearby and almost permanent fluvial course necessary. If the river Ter had a very marked itinerancy (alternation in its course) between the northern or eastern path, it should be reflected in the distribution of the points and, consequently, the trend line could not be linear in any case (Figure 7). It is this constant sedimentation that justifies the wide difference in meters (7 m by the river Ter and 5 m by the Darró in the same period) between the dates obtained at the lower and upper levels, on a coastline that progressively advanced from the 5th century BC to the present day [16]. It is for this reason that the possibility of deep channels or islands in the territory under study is not proposed. However, it is as a result of these dynamics that palaeochannels and lagoons were opened and closed, as historical documentation from the 9th century onwards indicates.



GEOSERVEI*		
#	Age (years)	Altitude (masl)
1	1281	7.31
2	1992	7.60
3	1247	6.43
4	1338	7.24
5	-784	2.64
6	1824	3.49

RAMBAUD**		
#	Age (years)	Altitude (masl)
7	-1907	-0.30
8	-4397	-5.70
9	-1707	-0.75

BRILL***		
#	Age (years)	Altitude (masl)
10	-2278	-3.08
11	-4212	-7.04
12	594	0.03
13	-707	-2.22
14	-282	-1.80
15	1357	7.11

* GEOSERVEI Field campaign, 2022; ** Rambaud. EMPURIES 54, 2005. 59-70; *** Brill et al. CYPSELA 18, 2010, 283-297
1: ULLA -P01_1; 2: ULLA -P01_2; 3: ULLA -P01_3; 4: ULLA -P01_4; 5:TORROELLA-P02_2; 6: GUALTA-P03_2; 7: S27; 8: S44; 9: S66; 10: S_ULL03; 11: S_ULL05; 12: S_ULL08a; 13: S_ULL08b; 14: S_ULL015; 15: S_ULL024

Figure 7. Chronological model defined for the 3 sectors studied from the Baix Ter to the Strait of Gualta-Ullà. In green are the results of the dating of GEOSERVEI (2022), in red those of Rambaud (2005) and in blue those of Brill et al. [16] (2010). The set of points are represented according to the river basin to which they correspond: a circle for the points of the Daró basin, a square for those of the Ter basin and a triangle for the point of Ullastret (lake dynamics). Source: GEOSERVEI.

Despite the existence of a scattered population and inhabited nuclei, the existing medieval documentation, less than in the late medieval period [12], does not allow us to observe an overly anthropized Ter River. Probably, due to the characteristics of the river. In the early Middle Ages, the River Ter did not follow a single course (or channel) but rather had several channels that flowed in a diffuse and braided manner. While the Ter today is single-channel (see Figure 3 on the map where the current course can be seen in blue), in the early Middle Ages it was multi-channel and meandering.

This proposal coincides with that established by Montaner et al. [10]. According to this, during the period known as the Medieval Climatic Optimum, the progradation of the Baix Empordà plain as a result of the sedimentation of the Ter River produced frequent changes in the course of the river until the 14th century. In fact, medieval documentation confirms this view. It describes several marshes and lagoons in the Baix Empordà plain between the 9th and 11th centuries (Figure 3): *ipsa Lona*, *Dodoni* (in a vague location between *Mons Asperus* and *Mons Guardia*), *Marseu* (near *Aqualta*) y *Clar de Bulento*. In addition, they also describe floods such as the one that occurred in 1074, when reference is made to destroyed rural buildings and land that could not be cultivated as a result of these floods [10]. Medieval documentation is more explicit in relation to later centuries and mentions floods in 1182, 1311, 1327 or 1366. It is very interesting to note a flood that affected several of the inhabited nuclei in the area because the river, according to documentary sources, changed its course [23].

5. Conclusions

The analysis and interpretation of the works carried out and their results indicate that, in the Early Medieval period, specifically during the 9th, 10th and 11th centuries, the river Ter would flow through the Strait of Ullà-Gualta, towards the bay of Pals, in the Mediterranean coast. This is indicated by both the lithostratigraphic sequences studied and the distribution of points in the chronological model established on the basis of the dates and stratigraphic position of the chosen samples. This distribution gives rise to a trend line (sedimentation rate) that would corroborate this fact. However, it cannot be ruled out that, occasionally and in very specific situations, there were no changes in the course of the river. The low gradient and the continuous contributions of sediments caused the formation of a plain furrowed by several more or less functional fluvial arms of the meandering and diffuse braided type (Figure 8). Subsequently, the dynamics of filling continued until the 15th century, when the Ter consolidated its easterly orientation, very similar to the current one.

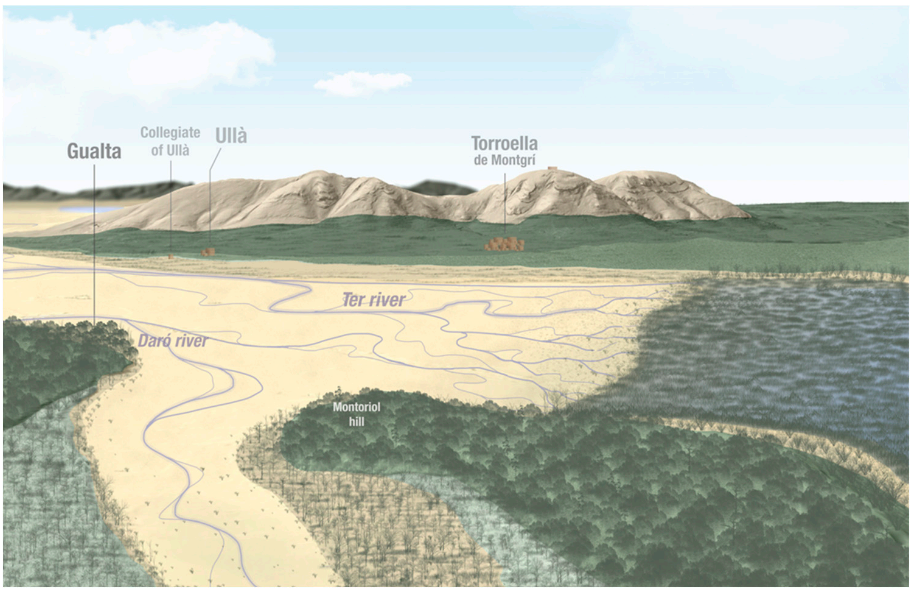


Figure 8. Recreation of the stretch of the river Ter as it passes through the Strait of Gualta-Ullà at an indeterminate moment in the Early Middle Ages, where we can see a wide riverbed furrowed by several channels of the river Ter (and probably the Daró) with a meandering, braided and diffuse character that would flow into a marshland area. Source: GEOSERVEI.

The historical information known from the area for the early medieval period supports the conclusions of the study. Particularly eloquent is the incursion of Al-Andalus up the river Ter from the vicinity of Pals, in the Mediterranean coast. Even the absence of any mention of the river Ter in this area until the end of the 11th century does not contradict the results. In this sense, it is advisable to clarify the nature of the local documentation. Basically, it is a matter of disputes and donations about the public authority of land in the context of the respective villas or administrative conditions. The interest of the parties involved is concentrated on the identification of territorial boundaries. These had to be easily recognizable and, above all, stable. The absence of references to the river Ter can only mean that either the river did not flow through it or, as is the case, that its course was not sufficiently stabilized to serve as a reference for property or administrative boundaries.

The problems of flooding were solved by various constructions already in the late Middle Ages, although no similar works are known from the early Middle Ages [23]. Subsequently, the dynamics of infilling continued until the 15th century, when the Ter consolidated its eastern orientation, very similar to the present one [10]. In the same period, the main agricultural irrigation canals of the area began to be built, but it was not until the 17th and 18th centuries that the network of irrigation ditches and canals was fully consolidated [22].

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