



Data Article

New multiproxy data obtained from the sedimentary fill of the Ría de Ferrol, NW Iberia



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ABSTRACT

Several gravity cores and vibro-cores were recovered from selected sites in the inner sector of Ría de Ferrol, NW Iberia (Muñoz Sobrino et al., 2021) [1]. These sediment cores were obtained during the surveys ECOMER-2014 and ECOMER-2015, developed from 2014 to 2015 on-board the R/V *Mytilus* (Consejo Superior de Investigación Científica) and the *Amaradores Mil* (Amaradores del Puerto y Ría de Ferrol, S.L.), respectively. Sedimentary and other multiproxy data presented here belong to four selected sediment cores located in the innermost part of the study area. Two were recovered using a gravity corer and another two using a vibro-corer. The depth of the cores and samples obtained is referred to the NMMA (the mean sea level in Alicante), which is the Spanish orthometric datum. One half of each core was subjected to non-destructive analysis using an ITRAX core scanner providing

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X-ray fluorescence (XRF) elemental data. Particle size distribution was characterised by laser diffraction. For radiocarbon dating, well-preserved articulated valves, small remains of wood and very organic bulk sediment from one location free of biogenic gas were selected. Palynological analyses were performed on selected sections of the sediment. All samples were spiked with *Lycopodium* spores for absolute palynomorph estimation and analysed using 400x and 600x magnifications. The ratio of dinoflagellate cyst concentrations to pollen, fern spore and dinoflagellate cyst concentrations (D/P ratio, ranging between 0 and 1) was calculated for each sample to show the temporal variation. Combined seismic, lithological, elemental, chronological and palynological data enable reconstructing the environmental changes that occurred during the local marine transgression. Besides, the combination of evidence identified may also be applied to other areas or periods in order to perform local reconstructions of changing coastal ecosystems. This type of high-resolution spatial-temporal reconstructions of past changes in estuarine environments may be a valuable tool for modelling, predicting and managing the changes and threats linked to the global warming and sea-level rise associated.

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Specifications Table

Subject	Earth and Planetary Sciences
Specific subject area	Biogeochemical and palaeontological data applied to sea-level and coastal studies
Type of data	Table, figure
How the data were acquired	Marine survey, high resolution seismic records, gravity corer, vibro-corer, X-ray fluorescence, laser diffraction, radiocarbon dating, light microscope, Tilia (software)
Data format	GPS coordinates and depths of the cores studied. Radiocarbon data and other age inferences enabling to build the age-depth models adopted. Selected elemental raw counts (i.e., measured values for elements analysed, without units) for each core studied. Age estimated for each sample analysed. Raw data of total pollen, total non-pollen palynomorphs and total dinoflagellate cysts in every sample analysed.
Description of data collection	Dinoflagellate cyst/Pollen ratio calculated for each sample analysed. 4 cores were recovered in the inner sector of Ría de Ferrol, NW Iberia, during the surveys ECOMER-14 and ECOMER-15. Each core was subjected to non-destructive analysis using an ITRAX core scanner, and particle size distribution characterised by laser diffraction. Radiocarbon analysis enable dating the sediment cores. Palynological analyses were performed on selected sections of sediment.
Data source location	<ul style="list-style-type: none"> • Ría de Ferrol, Galicia, NW Iberia, Spain. • Core name, survey and GPS coordinates: GC2X; ECOMER-2014; 563962,5; 4813236,3 GC2P; ECOMER-2014; 563929,017; 4813222,13 VC3; ECOMER-2015; 564861,1; 4813525,3 VC7; ECOMER-2015; 560721,4; 4812982,5

(continued on next page)

Data accessibility	The details of the cored sites, and the chronological benchmarks used to build the age-depth models are available as tables in this article. Primary data sources: primary data are available in the Mendeley Data (https://data.mendeley.com/) open repository: https://data.mendeley.com/datasets/wxp929jykf/2 , DOI: 0.17632/wxp929jykf.2
Related research article	C. Muñoz-Sobrino, V. Cartelle, N. Martínez-Carreño, P. Ramil-Rego, S. García-Gil, The timing of the postglacial marine transgression in the Ría de Ferrol (NW Iberia): a new multiproxy approach from its sedimentary infill, <i>Catena</i> 209 (2022) 105847, https://doi.org/10.1016/j.catena.2021.105847

Value of the Data

- Combined seismic, lithological, elemental, chronological and palynological data enable reconstructing the environmental changes that occurred during the local marine transgression.
- For the first time in this region, these new data enable to generate a high-resolution spatial-temporal interpretation of environmental changes linked to the relative sea-level variations using subtidal sediments from the same sub-basin (free of substantial/differential post-depositional deformations) that describes in detail the flooding of the ancient coastal plains of this region.
- This type of high-resolution spatial-temporal reconstructions of past changes in estuarine environments may be a valuable tool for modelling, predicting and managing the changes and threats linked to Global Change.
- The combination of identified evidence may also be applied to other areas or periods in order to perform local reconstructions.

1. Data Description

All the samples studied were collected between June 30th and July 5th of 2014 (ECOMER-2014) and between October 7th and October 8th of 2015 (ECOMER-2015) at the innermost embayment of the Ría de Ferrol, a confined tide-dominated incised valley in the mesotidal passive Atlantic margin of NW Iberia. Fig. 1 indicates the location of the study area and the sampling location where each of the four sediment cores were obtained. Data presented in Table 1 indicates the GPS coordinates and depths of the four cores analysed. Table 2 shows all the chronological benchmarks used to build the age-depth models, including radiocarbon dates and other elemental and pollen inferences. All the selected elemental datum from cores VC7, GC2X, GC2P and VC3 is available as supplementary data files (Supplementary S1 to S4). Those data summarise

Table 1

Cores studied in the Ría de Ferrol, indicating position, length, water depth, the seismic units recovered [1,2] and the sections in which multiproxy analyses have been made. Water depth is expressed as m NMMA corresponds to the differences respect to the mean sea level in Alicante, i.e., the Spanish orthometric datum.

Core	Survey	Position (UTM)		Laboratory length (m)	Water depth (m) NMMA	Seismic units recovered	Grain size and geo-chemical analysis	Pollen analyses sections ITRAX	(cm)
		X	Y						
GC2X	ECOMER-2014	563962,5	4813236,3	2.87	−10.7	U7/U6	YES	YES	200-285
GC2P	ECOMER-2014	563929,017	4813222,13	2.44	−10.5	U7/U6	YES	YES	0-236
VC3	ECOMER-2015	564861,1	4813525,3	3.35	−10.3	U7/U6	YES	YES	160-325
VC7	ECOMER-2015	560721,4	4812982,5	2.26	−18.8	U7/U6	YES	YES	60-220

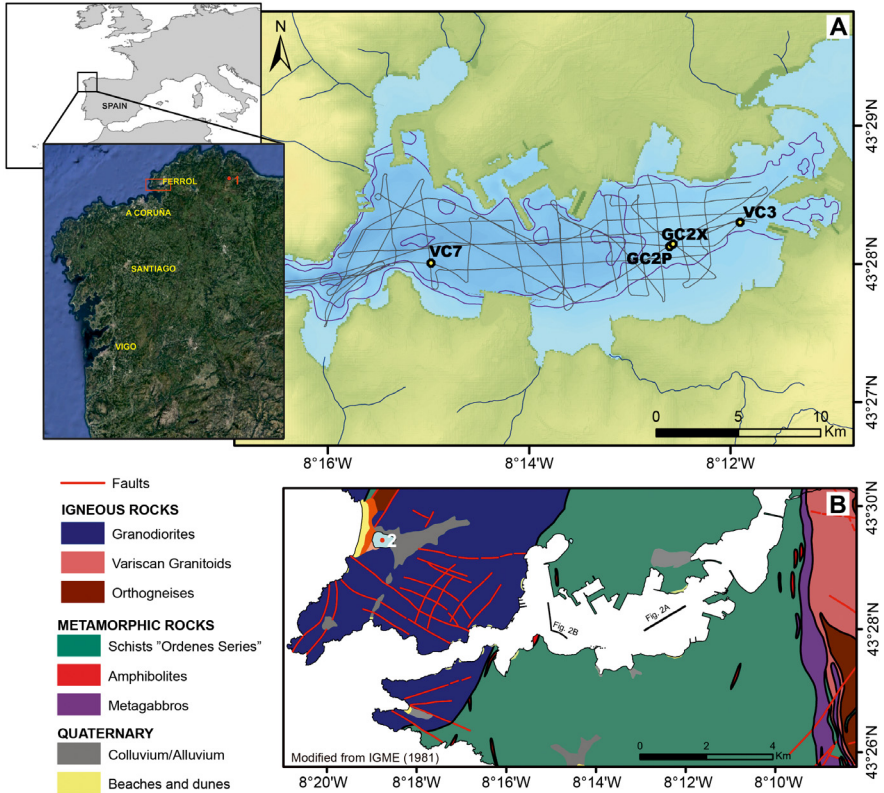


Fig. 1. (A) Location of the study area, showing seismic tracklines and vibro/gravity core positioning: VC7, CGPX, CGP2 and VC3. (B) Map with the emerged geology of the Ria de Ferrol, showing the selected seismic profiles to illustrate architectural elements. 1: Situation of the site Rio das Furnas 2 (RF2) cited in Table 2.

the geochemical evidence related to the changing marine/terrestrial influences recorded in each site cored. Raw data (counts) of pollen, non-pollen palynomorphs (NPP), and dinoflagellate cysts obtained in every section of sediment studied in cores VC7, GC2X, GC2P and VC3 are also available as supplementary data files (Supplementary S5 to S8). Other necessary data (sample weight, number of tablets added per sample, average of *Lycopodium* spores per tablet, and the exotic *Lycopodium* spores counts per sample) to calculate the absolute abundances and the Dinoflagellate cyst/Pollen ratios (D/P) in each sample are also reported.

2. Experimental Design, Materials and Methods

To reconstruct the past changes affecting the coastal ecosystems developed on a fluvio-marine system, a new multiproxy approach was performed that combines detailed studies of seismic profiles [2] and several sedimentary sequences obtained from the subtidal area of the Ria de Ferrol, an inner embayment in NW Iberia (Fig. 1).

2.1. Seismic surveys and coring

All the seismic data and cores studied were obtained from 2014 to 2015, during the surveys ECOMER-2014 and ECOMER-2015, which were respectively developed on-board the R/V *Mytilus*

Table 2

Chronological benchmarks used to build the age-depth models [1] for each core analysed, including radiocarbon dates, pollen inferences [1] and X-ray fluorescence evidence [9]. All dates are given in calibrated years before present (cal yr BP). Error range assumed for radiocarbon dates corresponds to two the sigma calibration (Calib). (*) Rio das Furnas 2 (RF2) corresponds to site 1 in Fig. 1. (**) Both depths have been exchanged to avoid inversions in the age-depth curves and to estimate the time interval to which the hiatus could correspond. This type of inversions may be expected in the levels of erosion related to the seismic discontinuities [1].

Core	Depth (cm)	Type	Age	Error range	Calibration curve	Events
VC7	0.5	Surface	-60	-56/-64		
VC7	25	Br	270	235/305		Mouder Minimum [9]
VC7	41.5	¹⁴ C	552	239/901	MARINE20	
VC/	61	¹⁴ C/Pollen stratigraphy	8257	8072/8356	INTCAL20	8.2 event dated in RF2 (*) [1]
VC7	90.5	¹⁴ C	8560	8161/9001	MARINE20	
VC7	165.5	¹⁴ C	10237	10193/10290	INTCAL20	
VC7	172	Pollen stratigraphy	10500	10237/10290	INTCAL20	10.5 event [1]
VC7	192	Pollen stratigraphy	11400	10483/10735	INTCAL20	11.4 event
VC7	215	Pollen stratigraphy	11650	11487/11733	INTCAL20	Holocene onset [1]
GC2X	0.5	Surface	-60	-56/-64		
GC2X	120	¹⁴ C	961	629/1300	MARINE20	
GC2X	184	¹⁴ C	6771	6377/7165	MARINE20	
GC2X	219	¹⁴ C	7899	7562/8274	MARINE20	
GC2X	235	¹⁴ C/Pollen stratigraphy	8257	8072/8356	INTCAL20	8.2 event dated in RF2 (*) [1]
GC2X	236	Pollen stratigraphy	10500	10237/10290	INTCAL20	10.5 event [1]
GC2X	238	¹⁴ C	10950	10790/10966	INTCAL20	
GC2X	276	Pollen stratigraphy	11400	10483/10735	INTCAL20	11.4 event [1]
GC2P	0.5	Surface	-60	-56/-64		
GC2P	31	Pollen stratigraphy	-10	-20/10		Reputations with <i>Eucalyptus</i> [1]
GC2P	71	Pollen stratigraphy	230	220/240		Reputations with <i>Pinus</i> [1]
GC2P	73	Br	270	235/305		Mouder Minimum [9]
GC2P	137(**)	¹⁴ C	864	544/1214	MARINE20	
GC2P	129.5 (**)	¹⁴ C	6603	6220/7002	MARINE20	
GC2P	167.5	¹⁴ C	7600	7265/7937	MARINE20	
GC2P	185.5	¹⁴ C	7858	7507/8217	MARINE20	
GC2P	221	¹⁴ C/Pollen stratigraphy	8257	8072/8356	INTCAL20	8.2 event dated in RF2 (*) [1]
VC3	54	¹⁴ C	6916	6516/7293	MARINE20	
VC3	105	¹⁴ C	7189	6808/7539	MARINE20	
VC3	135	¹⁴ C	7466	7130/7826	MARINE20	
VC3	202	¹⁴ C/Pollen stratigraphy	8257	8072/8356	INTCAL20	8.2 event dated in RF2 (*) [1]
VC3	321	Pollen stratigraphy	10500	10237/10290	INTCAL20	10.5 event [1]

(Consejo Superior de Investigación Científica) and the Amarradores Mil (Amarradores del Puerto y Ría de Ferrol, S.L.). A total of 105.8 km of new high-resolution seismic records were acquired covering both the outer and inner sectors of the Ría de Ferrol (Fig. 1A). Besides, three gravity cores and nine vibro-cores were recovered from selected sites (Fig. 1A, [2]). The equipment used to acquire the seismic data consisted of a 'modified Boomer' (AAE CSP 300) and a single Boomer source (AA200) produced by Applied Acoustic Engineering Limited (Great Yarmouth, UK) and two receivers, including a single-channel streamer and the ceramics of a sub-bottom profiler.

Precise locations (error <1 m) of seismic lines and cores were determined using a differential global positioning system (dGPS) that used an AgGPS 132 receiver (Trimble Inc., Sunnydale, CA, USA). Geographical information was acquired and stored using HYPACK® Navigation Software (Xylem Inc., Rye Brook, NY, USA). To eliminate the distortions of the tide and the swell, seismic

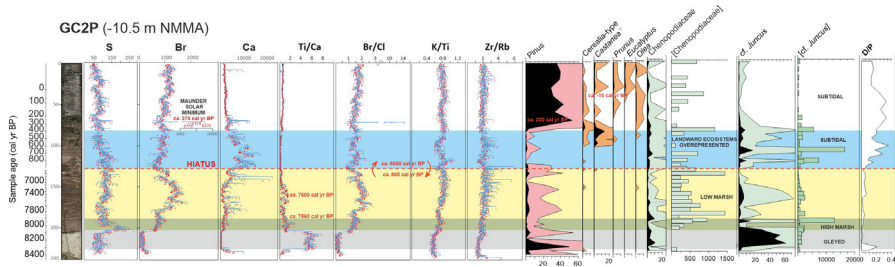


Fig. 2. An example of the main elemental (X-ray fluorescence) data compared to selected pollen evidence for one of the different cores presented, GC2P, including chronological evidence and environmental interpretations [1].

profiles were firstly subjected to a light processing using RadExPro Professional v2015 (DECO Geophysical SC, Moscow, Russia); and then, they were integrated into IHS Kingdom Suite® (IHS Markit Limited, London, UK) software to assist interpretation.

Sedimentary and other multiproxy data from cores presented here only corresponds to four selected sections of sediment located in the innermost part of the Ría de Ferrol (Fig. 1A; Table 1). Both the gravity and vibro-corer consisted of a 4 m-long, 9 cm-diameter steel core barrel, the first ballasted with more than 500 kg of lead in its top, and the second equipped with vibration and water-pumping systems. In all the cases, the depth of the cores and samples is referred to the NMMA (the mean sea level in Alicante), which is the Spanish orthometric datum defined in the Mediterranean coast. The reference level of NMMA is 0.29 m below local modern mean sea level in the Ría de Ferrol.

Four organic-rich sections from the subtidal zone were studied in detail: VC7, GC2X, GC2P and VC3 (Fig. 1). Sediment cores were split lengthwise in the laboratory, described and subsampled for analyses. One half was subjected to non-destructive analysis using an ITRAX core scanner (Cox Analytical Systems, Mölndal, Sweden) and subsequently used for pollen analyses; and the other half was reserved for grain size and other geochemical analyses.

2.2. XRF-analysis

Geochemical evidence related to the changing marine/terrestrial influences recorded in each site cored may be synthesised by using a small number of elemental parameters (S, Br, Ca) and ratios (Ti/Ca, Br/Cl, K/Ti, Zr/Rb). In each case, the complete XRF results are the raw data (Supplementary S1 to S4) representing counts (measured values for elements analysed, without units). Nevertheless, the large number of data produced can obscure its interpretive value (Fig. 2). Thus, trends are more adequately observed by using the running average of 20 data (blue curves). In Fig. 2 some of these data are directly compared with some selected pollen curves (percentages, concentrations and D/P ratios) that can support both the ecological reconstructions and the chronological inferences described in [1].

2.3. Chronologies and age-depth models

Several well-preserved articulated valves (shells) in the sediment and without signatures of reworking were selected for radiocarbon dating. Besides, small remains of wood and very organic bulk sediment from one location free of biogenic gas [3] were also occasionally used for dating (Table 2). All radiocarbon dates were performed by the Beta Analytic Laboratory (Miami, USA). Radiocarbon ages (Table 2) are given in calibrated years before present (cal yr BP) after calibration using CALIB 8.2 [4]. The Marine20 radiocarbon calibration curve was used [5] in the case of bivalve and gastropod shells. For these samples, a minor local reservoir correction [6] also

was applied, because the area is not affected by older upwelled waters or ^{14}C depleted surface runoff, as the drainage basin lacks carbonate rocks. This correction (Weighted Mean $\Delta R=12$; Uncertainty = 163) was calculated from the 10 closest data available in [4].

Besides, the IntCal20 database was used for dating wood material [7]. Finally, the mixed Marine & NH Atmosphere (50:50) of calibration of [4] was used to date on bulk sediment [3]. On the other hand, different pollen-inferred ages were also used when possible to develop comparable spline (Table 2, [8]). Selected tie-points were the onset of the Lateglacial Interstadial, the onset and end of the Younger Dryas (YD), and the onset of other well-dated cold-events in the region, namely the 11.4 ka, 9.3 ka, and 8.2 ka events. Other chronological inferences (Table 2) could be made for the most recent periods from the results of the XRF analyses (Br maximum, related to the Maunder Solar Minimum [9] and dated at ca. 270 cal yr BP) and the interpretation of selected pollen curves (repopulations with *Pinus* and *Eucalyptus* [1], respectively started at ca. 230 and -10 cal yr BP).

2.4. Pollen analyses: pollen, dinoflagellate cysts and NPP

Palynological analyses were only performed on four different sections of sediment (Table 1). Two of them correspond to gravity cores GC2P (0-240 cm) and GC2X (200-285 cm) and the others to vibro-cores VC3 (160-325 cm) and VC7 (60-220 cm). Most of the core sections studied were subsampled at regular 10-cm intervals. Nevertheless, some key parts of the sequences needed to be studied with higher resolution and then sampled at 2-, 3-, 4-, 5- or 6-cm intervals. Depending on the organic content of the sediment, pollen samples of 1 or 3 cm³ of fresh sediment were prepared in each case and processed using a standard HCl+HF treatment [10]. Before chemical treatment, all the samples were spiked with *Lycopodium* spores (Batch 1031, University of Lund, May 2011: average concentration = 20,848 spores/tablet) for absolute palynomorph estimation [11]. Later, coarse (>250 μm) and fine (<10 μm) fractions of sediment were eliminated by sieving. Finally, the slides were mounted in glycerol and analysed using a Nikon B50 microscope at 400x and 600x magnifications.

87 pollen samples were studied in total. 42 of them correspond to the entire GC2P core (Supplementary S7, Fig. 2), while other 21, 14 and 9 samples belong to different complementary sections studied in cores VC7 (Supplementary S5), GC2X (Supplementary S6) and VC3 (Supplementary S8), respectively.

A mean of 256 grains of pollen were counted per each GC2P sample (minimum 19, maximum 366). Only four of those samples show low pollen concentrations and, therefore, had poor (<90 grain) or very poor (<20 grains) pollen counts. The total pollen sum for the VC7 samples ranges between 53 and 401 (204 on average), and for the GC2X samples ranges between 108 and 567 (308 on average). Finally, most of the VC3 samples had low pollen concentration and pollen diversity. The keys for pollen identification and the nomenclature of the pollen types mainly follow [10].

On the other hand, dinoflagellate cysts content was low in most of the samples of the four sections of sediment studied, but notably increased in the uppermost 130 cm of the core GC2P. Types of dinoflagellate cyst groups follow [12], and their percentages were calculated in relation to the total dinoflagellate cysts count.

Non-pollen palynomorph (NPP) percentages, including mainly microforaminiferal linings [13] and fungal and fresh/brackish-water algae remains [14–17], were based on total pollen plus NPP. Finally, the ratio of dinoflagellate cyst concentrations to pollen, fern spore and dinoflagellate cyst concentrations (D/P ratio, ranging between 0 and 1; modified as the inverted ratio used by [18]) was calculated for each sample to show the temporal variation. TILIA 2.6.1 software [19] was used to process the data and prepare the diagrams. All the pollen records were independently zoned using a constrained incremental sum of squares (CONISS) cluster analysis with Euclidian distance. Due to the scarce cyst content of most of the sediment sections studied, their dinoflagellate records were not independently zoned, but their main changes are discussed following their local pollen assemblage zonation (LPAZ).

CRedit Author Statement

Castor Muñoz Sobrino: Conceptualisation, Methodology, Formal Analysis, Investigation, Resources, Writing – Original Draft preparation; **Victor Cartelle:** Investigation, Resources, Data curation, Writing – Review & Editing; **Natalia Martínez Carreño:** Investigation, Formal analysis, Resources, Writing – Review & Editing; **Pablo Ramil-Rego:** Writing – Review & Editing, Validation, Supervision; **Soledad García-Gil:** Writing – Review & Editing, Supervision, Project administration, Funding Acquisition.

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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