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A multi-proxy analysis of the evolution of the Portus to Ostia Canal

Ferréol Salomon, Ludmilla Lebrun-Nesteroff, Jean-Philippe Goiran, Giulia Boetto, Antonia Arnoldus Huyzendveld, Paola Germoni, Alessandra Ghelli, Ilaria Mazzini, Cécile Vittori, Sabrina Zampini

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The Isola Sacra Survey

Ostia, Portus and the port system
of Imperial Rome

Edited by Simon Keay, Martin Millett,
Kristian Strutt and Paola Germoni

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On the cover: Aerial view of the northern part of the Isola Sacra with the hexagonal Trajanic harbour of Portus in the background. (Photograph: Simon Keay).

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Chapter 5

The Portus to Ostia Canal

Abstract

This chapter builds upon the results of the previous chapter and provides additional evidence for the Portus to Ostia Canal. It first presents a detailed analysis of the sediments in the geoarchaeological boreholes drilled at three different points along the line of the canal and its immediate vicinity. These confirm its identification as a navigable watercourse, even though there remains some uncertainty as to whether the Isola Sacra 1 and 2 shipwrecks were deposited in the canal or in an associated palaeo-lagoon close to the ancient coastline. The study suggests that the canal was probably dug in the Trajanic period, had various phases of use, and that it was abandoned in the early third century AD. The second part of the chapter comprises a study of these two shipwrecks.

Introduction

Simon Keay

One of the most significant discoveries made by the survey on the Isola Sacra was the Portus to Ostia Canal, a key element of infrastructure that helped convert the island into a landscape that integrated the functions of both ports. The previous chapter documented the geophysical evidence for its path southwards from the south bank of the 'Fossa Traiana' opposite the *Canale Romano*, and left open the question of its southernmost stretch, which either met the Tiber opposite Ostia, or veered south-westwards into the Tyrrhenian sea north of the Tiber mouth. The canal is on a greater scale than any of the other canals detected at Portus and it also displays some differences in terms of its morphology. Furthermore, there are important questions to be answered relating to its chronology and function. This chapter addresses these questions with two studies. The first analyses the canal from a geoarchaeological perspective and also attempts to understand its potential as a navigable watercourse; the second complements

this with a preliminary discussion of two ships that sank in the canal in antiquity. Issues raised in the chapter are incorporated into the overall discussion presented in Chapters 6 and 7.

A multi-proxy analysis of the evolution of the Portus to Ostia Canal

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The study of the Portus to Ostia Canal has been conducted in three phases. A first traverse of boreholes was drilled during the excavation of the boats Isola Sacra 1 and 2 in 2011, and was followed by a second in 2013 in the segment of the canal east of the *Necropoli di Porto (G35)* at the point where the canal seems to divide into two different branches. A preliminary study of this latter cross-section was published in 2016 and brought together Electrical Resistance Tomography data and core stratigraphy (Salomon *et al.* 2016b) (Figs 5.1, 5.2 and 5.3). Finally, between June and December 2017, 270 core sequences were obtained from boreholes drilled as part of preliminary planning for a new bridge close to the existing Ponte della Scafa, which crosses the Tiber between the Isola Sacra and Ostia (Figs 5.2 and 5.3). They were situated within the line of the Portus to Ostia Canal and the palaeo-river mouth of the Tiber. This chapter provides a detailed analysis of the chrono-stratigraphic sequences of the cores drilled across north and south of the Portus to Ostia Canal, with new palaeo-environmental data, radiocarbon dates and archaeological dates, and summarises results from the 2017 cores. In the light of this information, the chapter aims to understand the sedimentological and palaeo-environmental characteristics of this canal, how long it remained in use, the characteristics of its

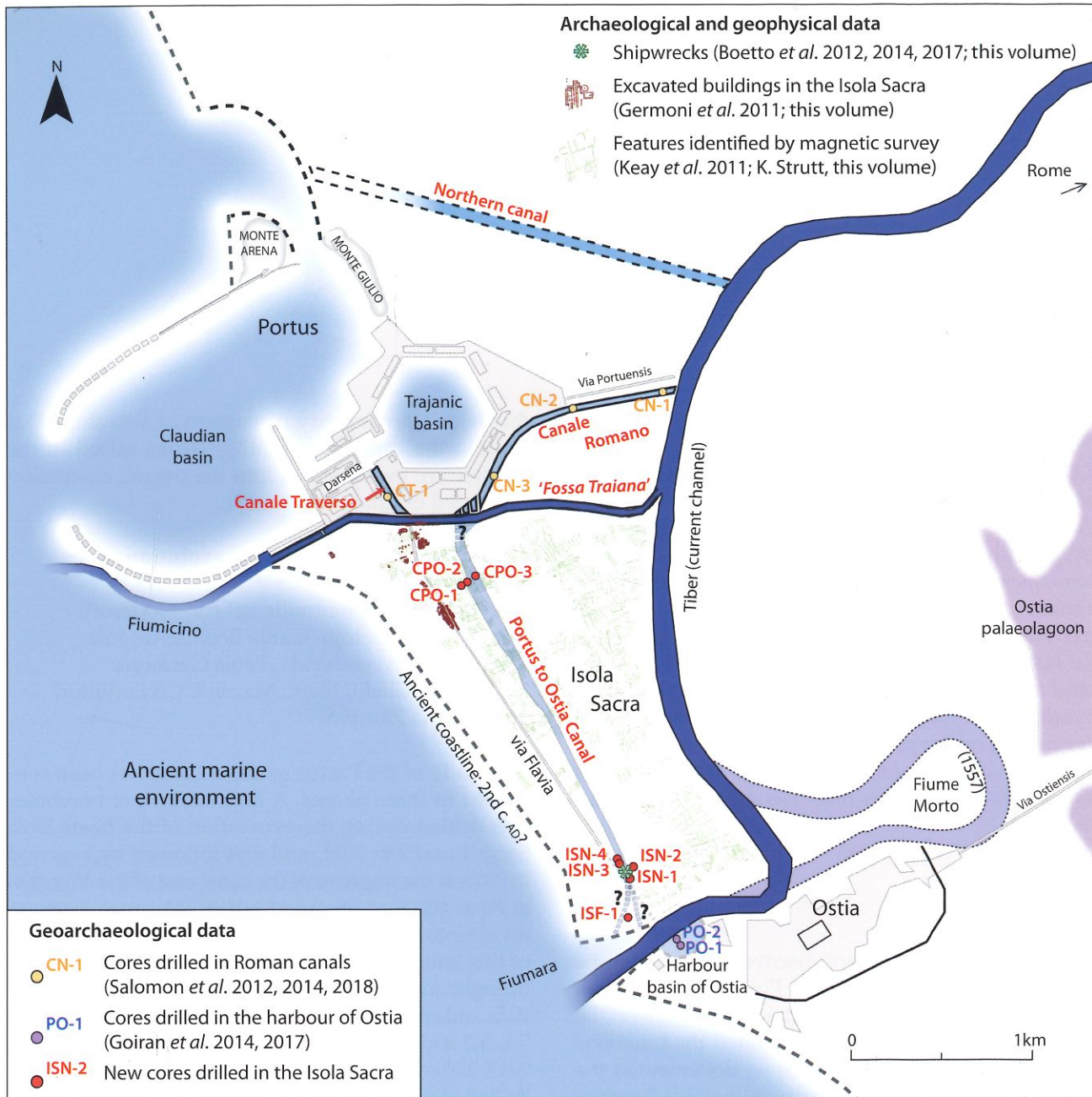
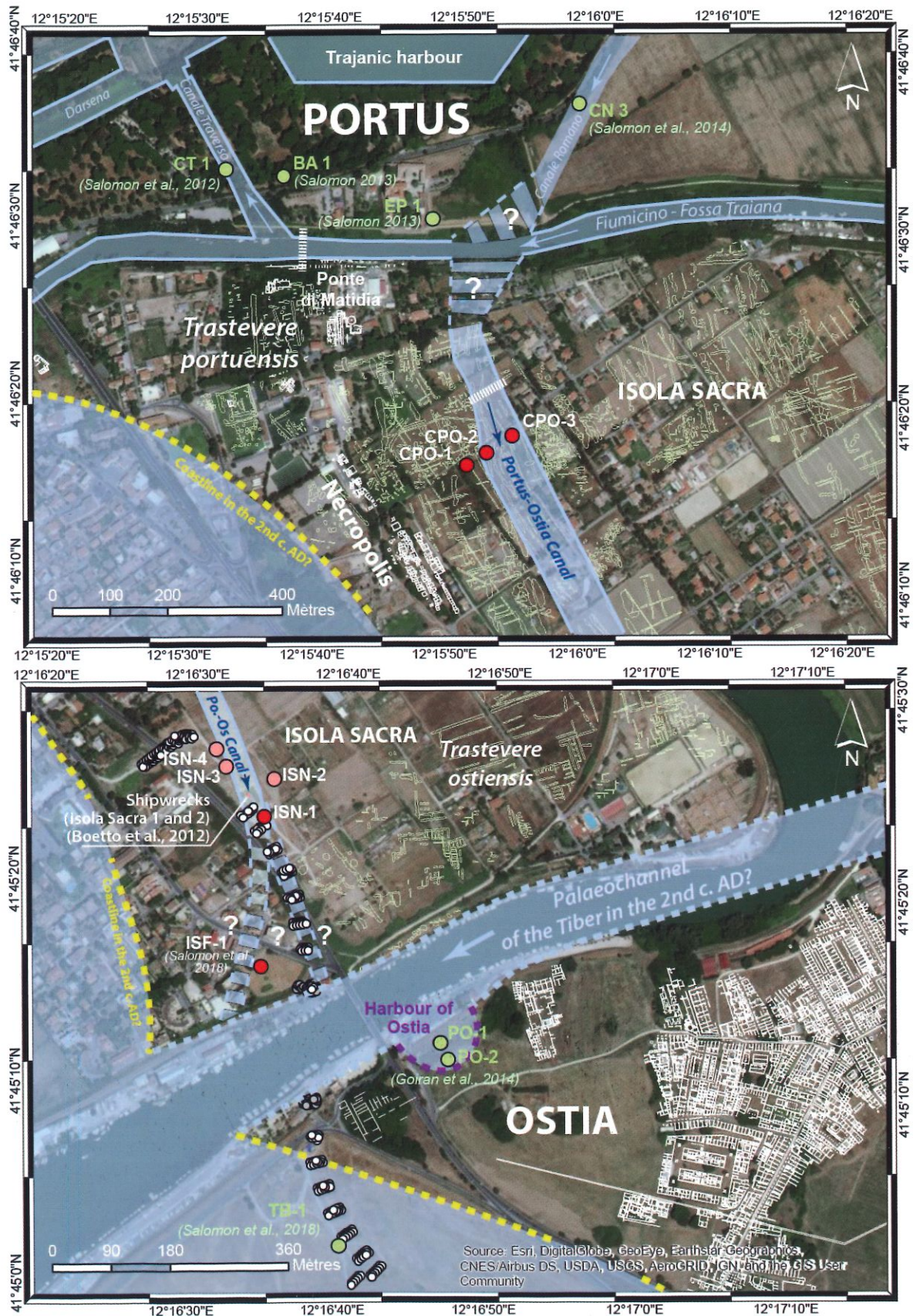


Figure 5.1 (above). General location of the Ostia-Portus system and the Isola Sacra in the Tiber delta. (Drawing: Ferréol Salomon.)

Figure 5.2 (opposite). Detailed map of the two areas studied: north of the Isola Sacra (top) and south of the Isola Sacra (bottom), with key below. (Drawing: Ferréol Salomon.)



The Portus to Ostia Canal



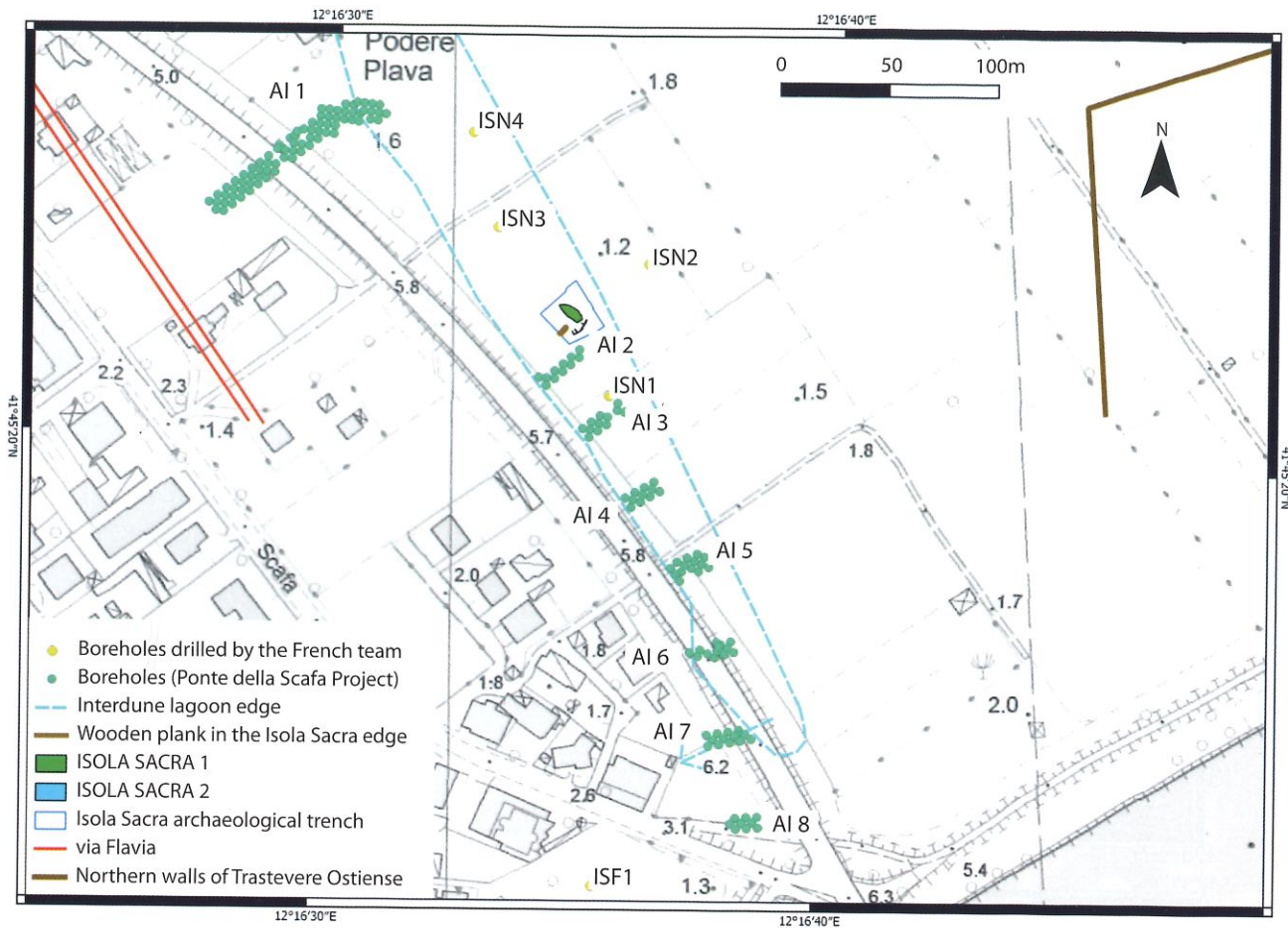


Figure 5.3. Detailed map of the area investigated in 2017 by 160 geotechnical boreholes in anticipation of the construction of the new Ponte della Scafa. (Drawing: Carlo Rosa and Alessandra Ghelli.)

navigability through time, and the nature of its connections to the Tiber and the broader canal system of Portus.

The geological and geoarchaeological context

The Tiber delta was formed in the Late Pleistocene/Early Holocene era during a general period of rapid sea level rise and coastal transgression. The morphology of the Tiber mouth at that time is often associated with a delta within a semi-protected bay (Bellotti *et al.* 1995; Marra *et al.* 2013; Milli *et al.* 2013; 2016). From 7000–6500 yr. cal. BP, the sea level rose slowly and the current delta with a prograded plain started to build up (above, Fig. 2.1). Today, the subaerial plain of the Tiber delta is divided into two parts: the inner and outer Tiber delta. The inner delta in the east corresponds to the area of the palaeo-lagoons that were reclaimed at the end of the nineteenth and beginning of the twentieth centuries. In the west, the outer delta corresponds to the prograded deltaic plain. Detailed analyses of the different phases

of coastal progradation have been proposed by Giraudi (2004), Bicket *et al.* (2009) and Salomon (2013).

Geoarchaeological studies in the Tiber delta have been conducted over the last twenty years, focusing mainly on the Roman period. The maritime harbour of Portus (Giraudi *et al.* 2009; Goiran *et al.* 2010; Sadori *et al.* 2010; Mazzini *et al.* 2011; Bellotti *et al.* 2009; Delile *et al.* 2014b; Salomon *et al.* 2016a) and the fluvial harbour of Ostia (Goiran *et al.* 2014; Hadler *et al.* 2015; Sadori *et al.* 2016; Salomon *et al.* 2016a; Delile *et al.* 2018) have been the main foci of interest. Parallel to this, the Roman canal network at Portus has also been studied through geoarchaeological methods (Salomon *et al.* 2012; 2014; 2017a; Lisé-Pronovost *et al.* 2018). Studies relating to the canals have mainly focused on the instability of the bedload across time, the processes leading to their abandonment, their navigability, the dredging phases, and the possible existence of locks. An extensive range of techniques has been applied to the analysis of the sediment trapped in the canals in order to reconstruct

the hydrodynamics of their differing environments (sedimentology, geochemical indicators, palaeo-magnetism), the freshwater-marine balance (bioindicators such as malacofauna, ostracods, foraminiferae and geochemical indicators), the vegetation (macro-vegetal remains, pollen - *Canale Traverso* in Sadori *et al.* 2010), palaeo-pollution using geochemical analyses (*Canale Romano* in Delile *et al.* 2014a), and chronology largely derived from an analysis of radiocarbon dates.

Methodology¹

Northern and southern sections across the canal

Three cores were drilled into the northern part of the Portus to Ostia Canal to the east of the *Necropoli di Porto* (CPO-1; CPO-2; CPO-3) (Figs 5.1 and 5.2). The magnetometry results suggest that what appears to be a small island within the northern stretch of the canal was created by two channels flowing around it simultaneously or in succession. Additionally, five cores were drilled around the Roman ships excavated in the southern part of the Isola Sacra 2011 (ISN-1; ISN-2; ISN-3; ISN-4) and along the river Tiber (ISF-1) (Table 5.1).

The stratigraphic units within the core sequences were defined by the visual recognition of colour, texture and structure combined with magnetic susceptibility measurements (Dearing 1999; Salomon *et al.* 2012). Magnetic susceptibility measurements were taken every centimetre using a Bartington MS2E1 high-resolution surface sensor and are expressed in $\times 10^{-6}$ CGS (SI = CGS value $\times 0.4$). Sediments from each stratigraphic unit were sampled, and wet sieving was performed in order to measure the relative content of the coarse fraction (> 2 mm), sand (2 mm at 63 μ m) and silt/clay (< 63 μ m). Further detailed

grain-size measurements were obtained using a Malvern Mastersizer 2000 laser grain-size indicator, which expressed the hydrodynamic context of the samples during deposition (Folk and Ward 1957; Cailleux and Tricart 1959). Complementary information about the palaeo-environmental context was obtained from a dry 10 g sub-sampled sediment, which was heated at 375°C for sixteen hours to measure the organic content (Ball 1964). In the wet sieved sediments (fraction < 1 mm), all ostracods (small bivalved crustaceans) were collected, normalised to 10g of sediment weight, and identified in order to deduce the characteristics of their original environments, being particularly indicative of freshwater and marine influences (Carbonel 1988; Frenzel and Boomer 2005; Ruiz *et al.* 2005; Mazzini *et al.* 2011; Vittori *et al.* 2015). The ceramics discovered in the core samples were identified and dated (Table 5.3).² Different organic materials were dated by Accelerator Mass Spectrometry (AMS), obtained from the linear accelerator of Saclay (Artemis - University Lyon 1), while calibration of the dates was performed using an existing published curve (Reimer *et al.* 2013) and processed with the software OxCal, with all dates cited at 2 sigma (<https://c14.arch.ox.ac.uk/oxcal/OxCal.html>) (Table 5.2).

Finally, a Palaeoenvironmental Age-Depth Model chart (PADM) was created for Cores ISN-1 and ISF-1 (Salomon *et al.* 2016a) (Fig. 5.6). Six radiocarbon dates and four dated ceramic fragments provided a reliable sedimentation curve in the age-depth model. The Roman sea level was reconstructed based on the upper limit of barnacles (*biological sea level*) found attached to the northern mole of the Claudian basin at Portus. Barnacles were dated using the radiocarbon technique (2115 ± 30 BP, = 230–450 cal AD – Goiran *et al.* 2009). The different reconstructed draughts of the ships that may have been used in the canal are reported on the right-hand side of the PADM (Boetto 2010). Additionally, the depths of the bottom of the Roman ship Isola Sacra 1 and its date of sinking were included in the chart. This ship probably sank prior to the first half of the third century AD, according to the dating of archaeological evidence found during its excavation (pp. 139–45; Boetto *et al.* 2012a; 2012b; 2017) (Tables 5.2 and 5.3).

Section across the river mouth and the western end of the canal

In 2017, 270 new cores were drilled near the Roman palaeo-river mouth of the Tiber near Ostia and in the Portus to Ostia Canal. This work was conducted for geotechnical purposes in preparation for the construction of the new *Ponte della Scafa* bridge,³ and the boreholes were situated on the sites of planned

Table 5.1. Location and heights of the cores drilled.

Core	X	Y	Z
CPO-1	272620.534	4628000.206	+1.31m
CPO-2	272648.789	4628019.725	+0.68m
CPO-3	272700.925	4628051.561	+0.26m
ISN-1	273569.512	4626325.030	+1.27m
ISN-2	273585.149	4626382.897	+1.29m
ISN-3	273512.658	4626401.853	+1.29m
ISN-4	273497.753	4626428.264	+1.12m
ISF-1	273563.491	4626096.872	+2.24m

Coordinate reference system (CRS): EPSG: 32633, WGS 84 / UTM zone 33N
 Heights: In reference to the to the national tide gauge from Genoa, Italy (s.l.m.) – Corrected values from Salomon *et al.*, 2016b for CPO-1, 2 and 3 (calibration of the LiDAR data)

Table 5.2. Radiocarbon dates. (*= Calibrated using the Marine13 curve; **= heights in relation to modern sea level are given with reference to the national tide gauge at Genoa).

Core	Samples	Depth below surface (m)	Depth below current sea level**	Laboratory samples	Dating support	Radiocarbon age: ^{14}C yr BP	\pm	Age calibrated BC-AD (Reimer et al., 2013) - 2σ	Comments
ISN-1 (+1.27m)	ISN-1 / 324	3.24	1.97	Lyon-10126 (SacA-32778)	Wood	1850	30	cal AD 80–240	-
ISN-1	ISN-1 / 365	3.65	2.38	Lyon-10129 (SacA-32780)	Charcoal	1835	30	cal AD 85–245	-
ISN-1	ISN-1 / 443	4.43	3.16	Lyon-10128 (SacA-32795)	Shell	11 710	45	11,730–11,485 cal BC	Rejected
ISN-1	ISN-1 / 516	5.16	3.89	Lyon-10133 (SacA-32796)	Shell	11 830	50	11,835–11,645 cal BC	Rejected
ISN-1	ISN-1 / 552	5.52	4.25	Lyon-10131 (SacA-32782)	Vegetal matter	1835	30	cal AD 85–245	-
ISN-1	ISN-1 / 610	6.10	4.83	Lyon-10130 (SacA-32781)	Charcoal	1865	30	cal AD 75–235	-
ISN-1	ISN-1 / 722	7.22	5.95	Lyon-10127 (SacA-32779)	Vegetal matter	2585	30	805–675 cal BC	-
ISN-1	ISN-1 / 809	8.09	6.82	Lyon-10132 (SacA-32783)	Vegetal matter	2660	30	840–795 cal BC	-
CPO-1 (+1.31m)	CPO-1 / 797	7.97	6.66	Lyon-11787 (SacA40134)	Organic matter	3390	30	1,750–1,620 cal BC	-
CPO-2 (+0.68m)	CPO-2 / 525	5.25	4.57	Lyon-11788 (SacA40135)	Wood	2055	30	170 cal BC– cal AD 15	-
CPO-2	CPO-2 / 870	8.70	8.02	Lyon-11789 (SacA40136)	Wood	3865	30	2,465–2,210 cal BC	-
CPO-3 (+0.26m)	CPO-3 / 284	2.84	2.58	Lyon-11790 (SacA40137)	Wood	1965	30	45 cal BC– cal AD 115	-
ISF-1 (+2.24m)	ISF-1 / 606–609	6.08	3.84	Lyon-11216 (SacA37194)	Charcoal	2110	30	205–45 cal BC	-
ISF-1	ISF-1 / 693–697	6.95	4.71	Lyon-11217 (SacA37195)	Wood	2245	30	395–205 cal BC	-
ISF-1	ISF-1 / 734–737	7.36	5.12	Lyon-11218 (SacA37196)	Posidonia*	2560	30	365–190 cal BC	-
ISF-1	ISF-1 / 785	7.85	5.61	Lyon-9322	Posidonia*	2620	35	455–220 cal BC	-
ISF-1	ISF-1 / 879–882	8.81	6.57	Lyon-11219 (SacA37197)	Charcoal	41500	1500	-	-
ISF-1	ISF-1 / 910	9.10	6.86	Lyon-11220 (SacA37219)	Shell*	37040	840	40,265–37,695 cal BC	Rejected
ISF-1	ISF-1 / 1298	12.98	10.74	Lyon-11221 (SacA37220)	Shell*	3195	30	1,160–930 cal BC	-
ISF-1	ISF-1 / 1330–1335	13.33	11.09	Lyon-11222 (SacA37221)	Shell*	3145	30	1,090–880 cal BC	-

bridge piers and approach ramps. This exceptional opportunity generated a considerable amount of new stratigraphic data relating to the southern part of the Isola Sacra and in the north-west sector of Ostia. The cores were between 15m and 20m deep and spaced out along a north-south cross-section on both sides of the river. More than 160 boreholes were drilled within nine sectors across an area of 2,600 square

meters across the southern part of the Isola Sacra (Figs 5.2 and 5.3).

The large amount of stratigraphic data generated for processing, the absence of a budget for palaeo-environmental analyses and the limited time available for producing a final report, meant that effort was focused upon studying the complex context of the river mouth.⁴ The amount of stratigraphic data obtained in

The Portus to Ostia Canal

Table 5.3. Archaeological dates – Identification by S. Zampini (* heights in relation to modern sea level are given with reference to the national tide gauge at Genoa).

Core	Sample	Depth below surface	Depth below modern sea level*	Sample description	Age estimation
ISN-1 (+1.27m)	ISN-1 / 659–666	659–666	532–539	Two body sherds of <i>sigillata italica</i> , and two body sherds, possibly thin-walled ware.	30 BC–AD 150
ISN-1	ISN-1 / 600–609	600–609	473–482	A body sherd of Baetican amphora, probably a Dressel 20.	AD 1–300
ISN-1	ISN-1 / 595–575	595–575	468–448	A body sherd of African amphora.	AD 100–700
ISN-1	ISN-1 / 559–563	559–563	432–436	Four fragments of brick; two body sherds of African amphora (form not identifiable).	AD 100–700
ISN-1	ISN-1 / 609–614	609–614	482–487	A rim from a closed cooking vessel in common ware.	AD 1–300
ISN-1	ISN-1 / 600–607	6,00–607	473–480	A handle attachment from a Baetican Dressel 20 amphora.	AD 1–300
ISN-1	ISN-1 / 908–905	908–905	781–778	A body sherd of common ware or amphora.	Not dateable
ISN-1	ISN-1 / 917–921	917–921	790–794	Unidentifiable pottery chips and a fragment of red painted wall-plaster.	Not dateable

doing this combined with the extensive knowledge of the territory and scientific experience of the team in charge of the analyses, made it possible to carry out a detailed reconstruction of the paleogeographic evolution of this part of the Isola Sacra. The data have been entered and processed in a G.I.S. (made with QGIS open source) to reconstruct the principal phases in the geomorphological evolution of the area.

Analysis of the northern cross-section

Cores CPO-2 and CPO-3 were drilled within the Portus to Ostia Canal, while Core CPO-1 was drilled in the beach-ridge plain to the west of it (Fig. 5.4). Core CPO-1 exhibits a stratigraphic sequence composed mainly of well-sorted sand (Unit A to D) with a silty layer on top of it (Unit E). The bottom layer (Unit A) is composed of finely laminated sand (75%) and silty sand (25%), with few coarser particles (0.11%). No shells were identified within it. Unit B exhibits a wide range of different environments and hydrodynamic contexts. It is composed of bedded grey silty clay (up to 47% of silts and clay), well sorted fine sand (up to 98%), but coarse sand is also present on top of this unit. Organic matter trapped in the deposits was dated to 3390 ± 30 BP (Lyon-11787, = 1750–1620 cal BC). Unit C corresponds to a more homogeneous deposit composed of yellow well-sorted medium sand (82 to 93% of sands – 125 to 500 μ m), better sorted at towards the top, and is generally laminated. Above this is Unit D, which consists of well-sorted medium to coarse yellow and black sands. Finally, this stratigraphic sequence is covered by 2m of laminated silty deposits, with a colour gradient ranging

from light brown at the bottom to dark brown at the top. Furthermore, the grain-size decreases from silty sand (60% of sand for 40% of silts and clay) to sandy silt deposits (80% of silts and clay for 20% of sand). Ceramics were found at 0.5m, 0.8m, 1.80m and 1.95m below the topographic level but were not sufficiently well preserved to be identified or dated.

The stratigraphic sequences of cores CPO-2 and CPO-3 (Fig. 5.4) reveal three major depositional phases: (1) yellow laminated well sorted sand (Unit A); (2) coarse deposits (Units B, C and D); and (3) overlying fine deposits (Units E, F and G in Core CPO-2 and Unit E in Core CPO-3). Units A in Cores CPO-2 and CPO-3 exhibit facies of laminated sandy deposits that are distinct to that in Core CPO-1. The average sandy content varies between 68% and 78%. The higher content of silt and clay is observable at the bottom of core CPO-3, with 46% of the total dry sediment. The upper part of the Unit A in Core CPO-3 comprises 93% of sand and 7% of silt and clay. None of the units in cores CPO-2 and 3 resembles Unit B in Core CPO-1 with a wide range of hydrodynamic contexts. Units A in Core CPO-2 and 3 had been cut by the Portus to Ostia Canal at different depths. Unit A in cores CPO-2 and CPO-3 ends at a depth of 3.5m below the Roman sea level (Ro.s.l.) of the third to fifth century AD. The radiocarbon date obtained from a fragment of wood in Core CPO-2/Unit A provided an older date than another sample in Core CPO-1/Unit B, with 3865 ± 30 BP (Lyon-11789, = 2465–2210 cal BC). Unit B in Core CPO-3 has a thickness of around 2.5m, from -2 m Ro.s.l. to +0.5 m Ro.s.l. Sediment is composed mainly by medium to

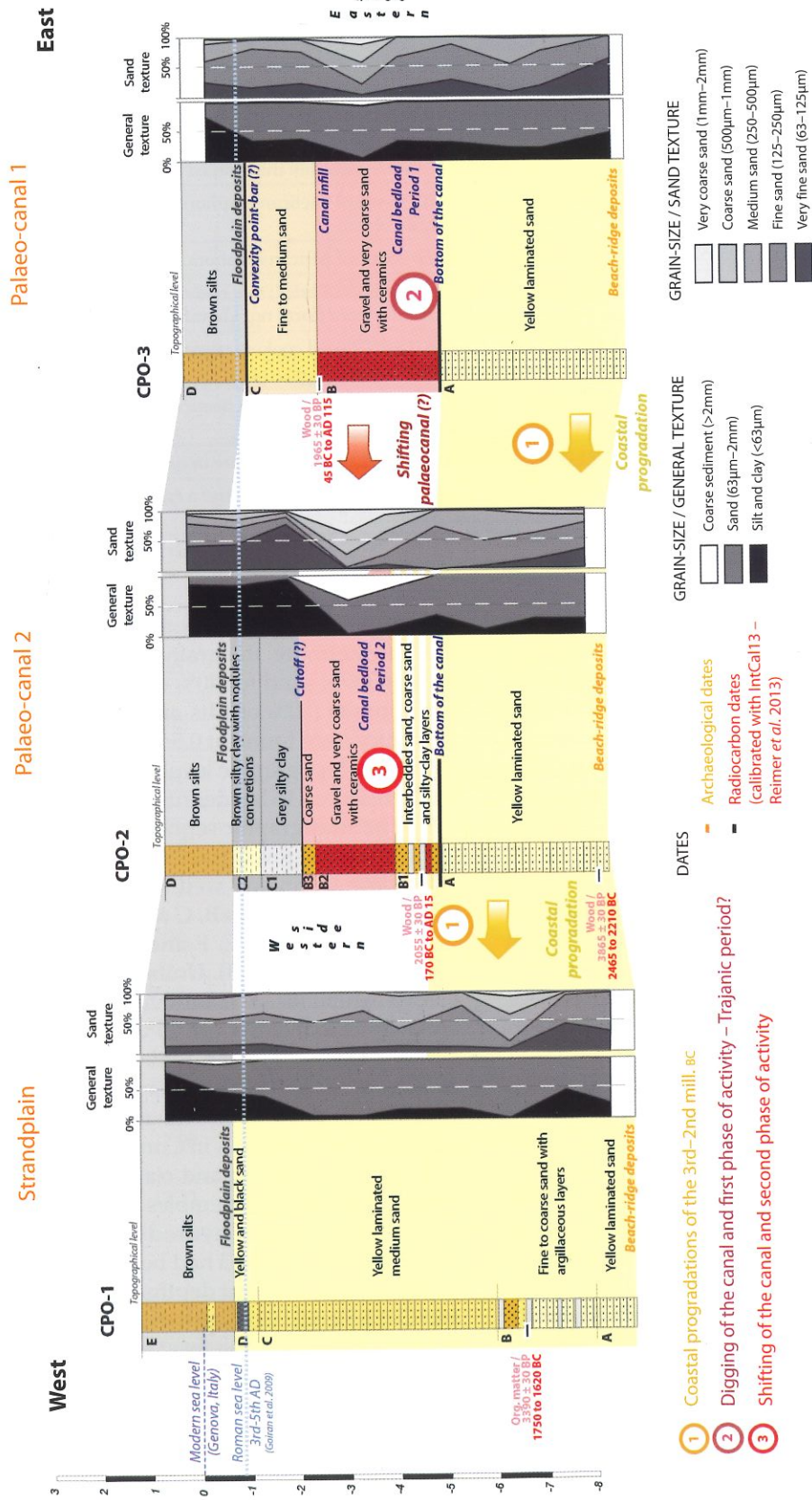


Figure 5.4. Cross-section of sedimentary cores from the boreholes drilled in the northern part of the Ostia Canal. (Drawing: Ferréol Salomon.)

very coarse sand with a coarse fraction above 2mm. Fragments of ceramics were also observed in this layer. This unit was dated to 1965 ± 30 BP (Lyon-11790) calibrated to 45 cal BC–cal AD 115. Unit C is a silty sand deposit composed of 35% of silt and clay and 65% of sand. The sand fraction contained between 46% and 60% of fine sand. It is important to note that this 1.5m thick unit was deposited above the Roman sea level. Unit D on top of Core CPO-3 is a brown sandy silt deposit was composed of 75% of silt and clay, 24.5% of sand and 0.5% of coarse fraction.

The upper units of Core CPO-2 reveal different deposits to those recorded for Core CPO-3. Unit B starts at a depth of around -3.50 m Ro.s.l. At the bottom, sub-unit B1 is composed of interbedded sand, coarse sand and silty-clay layers revealing unstable hydrodynamic depositional conditions. A piece of wood uncovered in a clayey-silt layer had a radiocarbon date of 2055 ± 30 BP (Lyon-11788) calibrated to 168 cal BC – cal AD 16. Sub-units B2 and B3 are indicative of high energy depositional contexts that contain ceramic fragments. The coarse fraction corresponds to between 22 and 45% of the total dry fraction of the sediments, with 55 to 67% of sand and 1 to 30% of silt and clay. No dates were obtained for this layer. Unit C is a silty-clay deposit subdivided into two sub-layers. Sub-unit C1 is a grey silty clay deposit composed of 95% of silts and clay, and sub-unit C2 is a brown silty clay layer in a lower proportion (85%). The distinction between the two sub-units is also related to the concretion observed in the coarse fraction of sub-unit C2, but not in C1. Finally, the top of Core CPO-2 is composed of brown silty clay (87%), which is a facies similar to Unit D in Core CPO-3.

Analysis of Cores ISN-1 and ISF-1 in the southern cross-section

Five cores were drilled in a southern section of the Portus to Ostia Canal. Here are presented details relating to Core ISN-1, which was drilled within the line of the canal, and Core ISF-1 which was drilled further south on the right-hand side of the current Tiber river course (Fig. 5.5). No detailed analyses have yet been conducted on Cores ISN-2, 3 and 4.

Analysis of Core ISF-1

Core ISF-1 reveals six stratigraphic units, whose deposits are characterized by their poor sorting index (Figs 5.5–5.6).

At a depth of between 12.00m to 7.50m below sea level (b.s.l.), Unit A was a grey-beige deposit composed of medium sand with silty sand layers. The sand fraction is around 78% of the total dry weighted samples for 22% of the silt and clay. Medium, coarse to very coarse

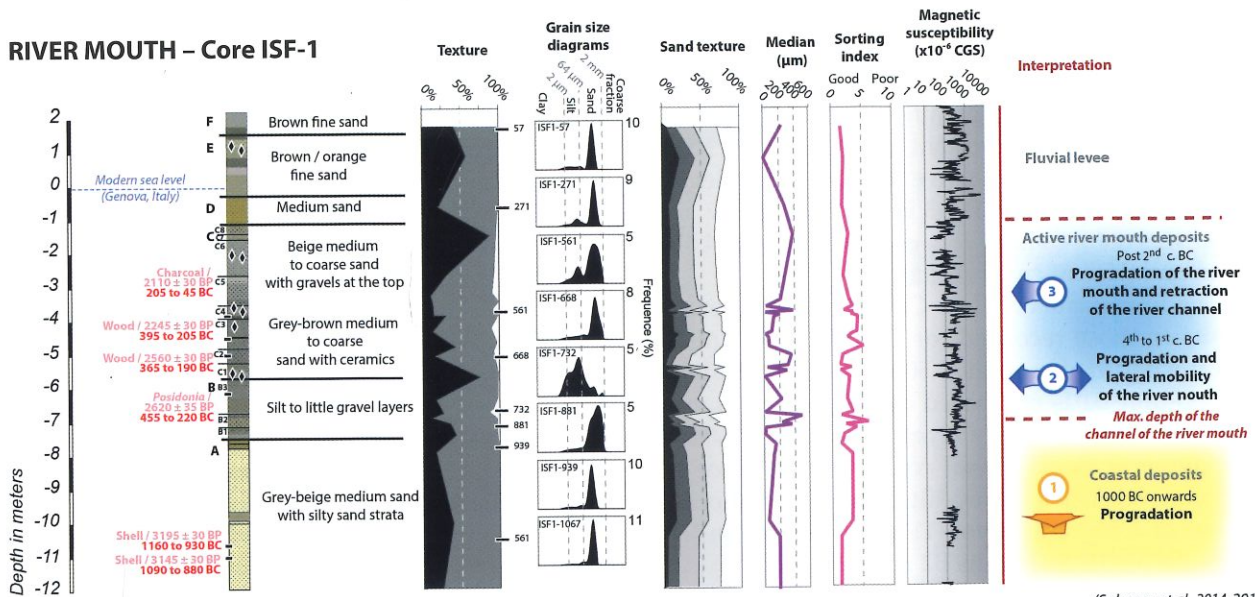
sand each represented 25% of the total sand fraction present. This deposit is well sorted. Two shells were dated by radiocarbon, providing a date at the end of the second millennium BC/beginning of the first millennium BC (Lyon-11222, 3145 ± 30 BP = 1091–881 cal BC; and Lyon-1122, 3195 ± 30 BP = 1160–930 cal BC). Magnetic susceptibility values were between 18 and 192 CGS for a median of 192 CGS.

Between 7.50m and 5.70m b.s.l., Unit B is a rather complex grey to dark grey and mainly sandy (74%) deposit. Very coarse sands represent an average of 30% of the total sand fraction present. However, the unit is composed of a succession of different layers. Sub-unit B1 is composed of 40% silt-clay and 60% sand. Samples analysed in sub-units B2 and B3 comprise as much as 88% sand. Gravels also appeared in these two sub-units (<8mm B-axis). The Trask sorting index is relatively poor at between 1.6 and 6. Magnetic susceptibility from 7.50m b.s.l. through to the top of the stratigraphy has a high variability between 12 and 6027 CGS with a median of 252 CGS. No ostracods were found in these unstable and high energy environments. *Posidonia* fibres were also observed in this unit and some were dated to 2620 ± 35 BP (Lyon-9322, = 455–220 cal BC). Two radiocarbon dates of $37,040$ 840 BP (Lyon-11220) and $41,500 \pm 1500$ BP (Lyon-11219) derived from shell and charcoal were rejected on the grounds of being too old and suggest that the material had been re-deposited.

Unit C is composed of eight sub-units between 5.70m to 1.10m b.s.l., which reveal a very unstable environment. The colour of individual deposits ranges between mainly grey to dark grey at the bottom of the unit to beige towards the top. The texture is generally sandy (67%), although coarse particle inputs were sometimes detected, especially in the sub-units C2, C4 and C5. Thin deposit laminations were observed in sub-units C1 and C7 (with 70% to 85% of silt and clay). The particles reached a diameter of 8mm in C4 and C5 (B-axis). The median grain has an average of 170 μ m within a range from 14 to 380 μ m. The overall sorting index was medium to poor. Three dates were obtained in the lower part of this unit, from both abundant ceramics and from radiocarbon dates derived from charcoal and wood in the lower part of Unit C. The dates range between the fourth and first centuries BC (Lyon-11218, 2560 ± 30 BP = 365–190 cal BC; Lyon-11217, 2245 ± 30 BP = 395–205 cal BC; Lyon-11216, 2110 ± 30 BP = 205–45 cal BC).

Unit D is a small unit of less than 1m-thick (1.10m to 0.25m b.s.l.) composed of yellow to medium sand. The sand fraction is 86% of the total dry weighted samples. Silt and clay are 16%, while the coarse fraction is no longer present. Unit E is made of brown to orange fine sand. The percentage of silt and clay rises

RIVER MOUTH – Core ISF-1



(Salomon et al., 2014, 2018)

PORTUS-OSTIA CANAL – Core ISN-1

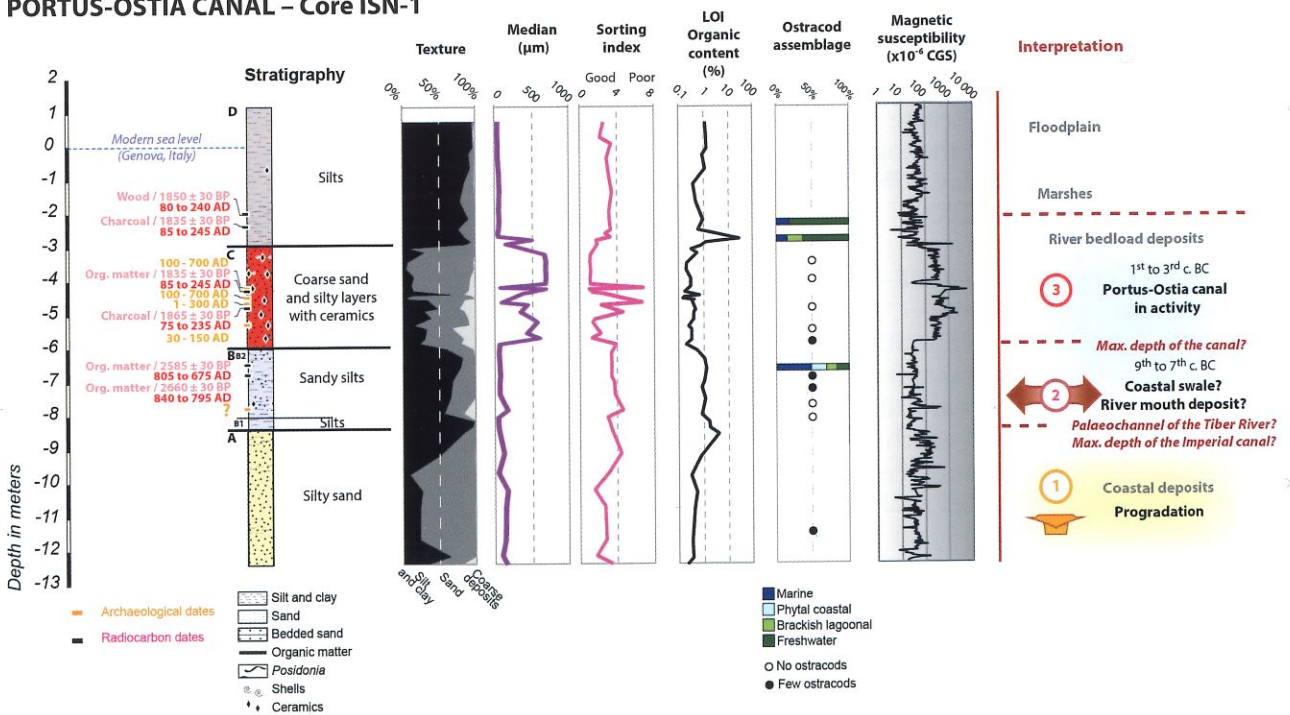
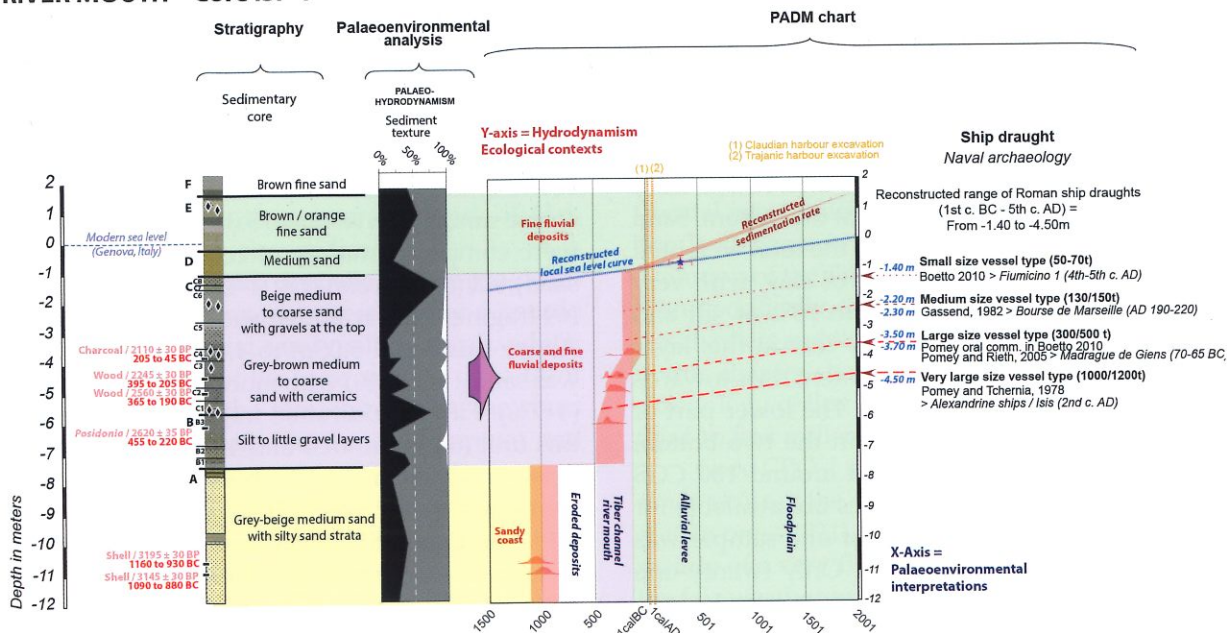


Figure 5.5. Detailed palaeoenvironmental analyses of Cores ISF-1 and ISN-1. (Drawing: Ferréol Salomon.)

RIVER MOUTH – Core ISF-1



PORTUS-OSTIA CANAL – Core ISN-1

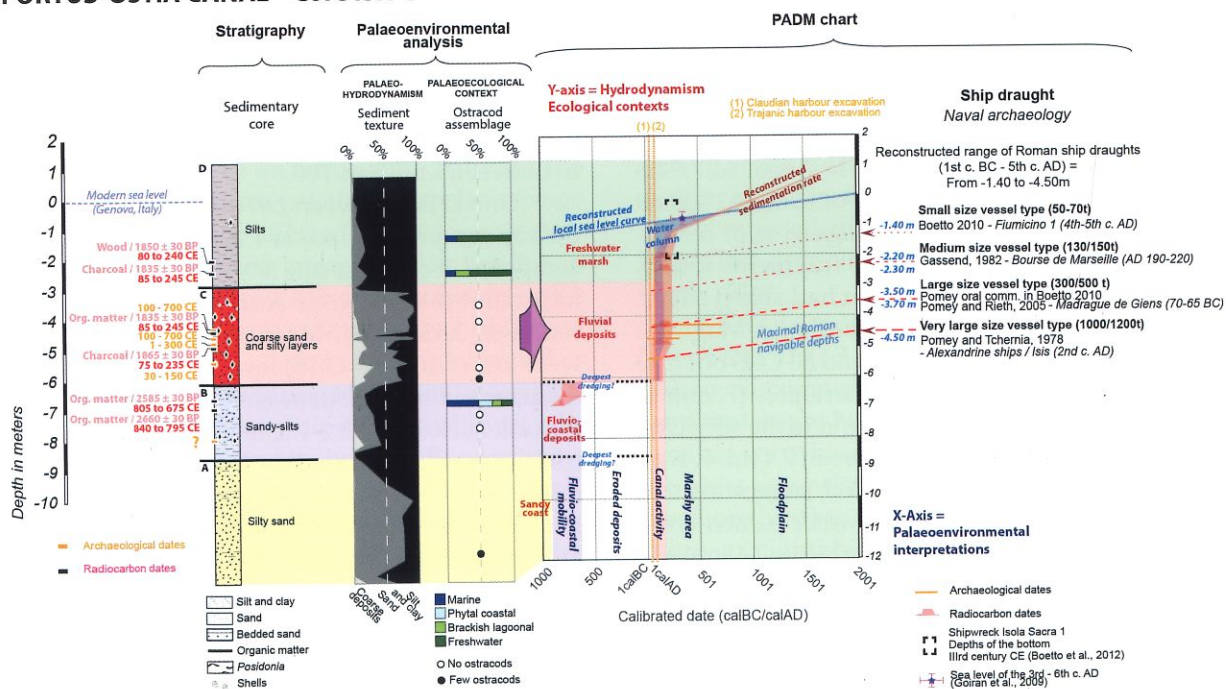


Figure 5.6. Palaeoenvironmental Age-Depth Model (PADM Chart) of Cores ISF-1 and ISN-1. (Drawing: Ferréol Salomon.)

to 40–55%, while sand remains an important fraction (45 to 60%). Few ceramics were identified at the top of this unit. Finally, Unit F consisted of brown fine sand and sandy-silt. No radiocarbon dates are available for these three units.

Analysis of Core ISN-1

Core ISN-1 is composed of four stratigraphic units (Figs 5.5–5.6).

Unit A is between 12.43m and 8.53m b.s.l., mainly sands with some sandy-silt layers at the bottom. Sand represented an average of 65% of the total weighted samples, with 25% silts and 10% of clay, with very fine sandy laminated silts (25% to 75% of silt and clay). Organic matter is relatively low in this layer with a value lower than 1%. Its content rises towards the top of the unit, reaching 4%. The lower part of the Unit is lower than 100 CGS in the two bottom metres but rises to an average of around 100 CGS in the upper two metres. No dates are available for this unit. The ostracod content of one sample was analysed at 11.73m–11.70m b.s.l. Only twenty-one ostracods were observed in the sample and seven species identified (*Cyprideis torosa* – brackish water, and *Cytheridea neapolitana*, *Leptocythere* sp., *Palmoconcha* sp., *Paradoxostoma* sp., *Carino cythereis*, *Semicytherura* sp. – Marine water), mainly adults (62%).

Unit B was situated at between 8.53m and 5.98m b.s.l., and was mainly composed of silts (Sub-unit B1 – 75% with 4.4% of organic matter) or sandy silts (Sub-unit B2 – 55 to 67% of silt with organic matter content around 1). Small fragments of ceramics were observed but not identifiable. From 7.90m to 7.94m b.s.l., there was a layer composed of sand (62%), silt (32%) and clay (6%) with small fragments of ceramics present. Out of the 34 ceramic fragments found, nineteen were rounded and fifteen had sharp edges. None of them could be identified or dated. Magnetic susceptibility was generally at around 50 CGS but rose above 100 CGS in the layer with ceramics (7.90m to 7.94m b.s.l.). No ostracods were found in the silty Unit B. Few ostracods were found at between 7.44m–7.47m, while two *Candona* sp. were identified, suggesting that this had been deposited in a freshwater palaeo-environment. At 7.09m–7.12m b.s.l., fragmented ostracods were observed but were not identifiable. Finally, some twenty-three ostracods were observed at 6.24m–6.27m b.s.l., of which 40% were freshwater species (*Candona* sp., *Limnocythere imopinate* and *Cyprideis* sp. from a brackish environment), 34% were marine species (*Leptocythere* sp., *Xestoleberis* sp., *Henryhowella* sp., *Cytheridea* sp.) and 26% were coastal species (*Paradoxostoma* sp.; *Procythereis* sp.). Two radiocarbon dates obtained from organic matter in this unit revealed

similar dates of the first half of the first millennium BC (Lyon-10132, 2660±30 BP = 840–795 cal BC and Lyon-10127, 2585±30 BP = 805–675 cal BC).

Unit C lay between 5.98m and 2.97m b.s.l. (or -5.18m and -2.17 Ro.s.l.) and was mainly composed of coarse to very coarse sand (80 to 95 % of the total weighed dry samples). No ostracods were observed in this unit, probably on account of the high energy deposition. However, many small shells were observed between 4.24m and 3.09m b.s.l. mixed in with a very coarse sand. From 6.00m to 5.03m b.s.l., the sediments were composed mainly of coarse sand (81–92% of sand), silt (6–15%) and clay (1–2%) with many ceramics (69 fragments: 28 rounded and 41 with sharp edges). Above this, from 5.03m to 4.82m b.s.l., the deposit was sandy (70–78%) with more silt (18–24%) and clay (4–7%). Fifty-one ceramic fragments were found in this unit (60% rounded and 40% with sharp edges). Between 4.82m and 4.68m b.s.l., the content of sand continued to decrease (51%), while that of the silt (41%) and clay (8%) increased. Ceramics were also observed, with amphora sherds appearing at the bottom of the subunit at 4.82m–4.73m b.s.l. The sandy content increased again at 4.68m b.s.l. until 2.97m b.s.l. together with many ceramic fragments. Some layers show a higher tenor of finer deposits, such as those at 4.36m–4.24m b.s.l. where they were 45% silt. Two radiocarbon dates were taken in this layer, ranging between AD 70 (post-Claudian) and the earlier third century AD (Lyon-10130, 1865±30 BP = 75–235 cal AD (Charcoal); Lyon-10131, 1835±30 BP = 85–245 cal AD (Organic matter)). Ceramics found in this unit dated to between AD 1 and 700.

Unit D lies between 2.97m b.s.l. (-2.17 Ro.s.l.) and the topographic surface at 1.27m a.s.l., and is mainly composed of compact silts (60–75%), clay (10–18%) and local sand (6–20%/30%). A single ceramic sherd was found at 0.53m b.s.l. Magnetic susceptibility values were low (< 100×10⁶ CGS) for the whole unit. Organic matter was also rare but peaked at 32% at the bottom of the unit at 2.63m b.s.l. (-1.83m Ro.s.l.). At 2.84m–2.86m b.s.l., ostracods are mainly indicative of freshwater influence (13 ostracods - *Candona* sp., *Limnocythere* sp., *Cypria ophtalmica*) although some marine species are also present (3 ostracods - *Aurila* sp., *Xestoleberis* sp. - 2.84m–2.86m b.s.l.). More freshwater influence is observed in the ostracod assemblage of sample 2.39m–2.36m b.s.l. (*Candona* sp., *Heterocypris salina*, *Darwinula stevensoni*, *Limnocythere* sp., *Cyprideis torosa* for freshwater species, *Ilyocypris* sp. living in freshwater to brackish environments, and *Aurila* sp. living in a marine environment). In a manner akin to Unit C, Unit D is dated to sometime between the end of the first and the middle of the third centuries AD on the

basis of radiocarbon evidence (Lyon-10129, 1835 ± 30 BP = 85–245 cal AD (Charcoal); Lyon-10126, 1850 ± 30 BP = 80–240 cal AD (wood)).

Preliminary results from the north–south cross-section in the southern part of the Isola Sacra

In the set of 160 core stratigraphies obtained from the boreholes drilled on the north side of the Tiber in 2017 (Figs 5.2 and 5.3), the stratigraphies generally begin with a grey silt sediment at 20m or 15m b.s.l. and continue upwards to an average depth of 11m b.s.l. with a grey silty-clay sediment. This layer is interpreted as having been deposited in the pro-delta. From c. 11m b.s.l. upwards, there follow a couple of meters of a laminated sandy-silty deposit, which hints at the presence of the approaching delta front and the coastline. In the remaining 10m, the cores exhibit a gradual increase in the sand content and coarser grain-size, due to the gradual decrease in depth of the seabed and up to the submerged beach or emerged beach facies. Overall, this kind of stratigraphic succession would appear to be typical of a deltaic progradational coast. However, differences in stratigraphic successions from 7m to 8m b.s.l. up to the modern ground level have been observed across the study area. Descriptions and preliminary interpretations of these follow here (Fig. 5.3).

In Areas AI8 and AI1, there was a complex sandy beach facies that was covered by silty alluvial sediments derived from Tiber activity. These younger deposits are yellow-beige silts and partially pedogenised. In Area AI7, the stratigraphy is complex, probably on account of an association between the palaeolagoon and the sea. At the top, yellow-beige alluvial silts are partly affected by pedogenic processes; these deposits are interpreted as floodplain deposits. In Areas AI6 and AI5 areas, a five to seven metre thick grey silty-clay deposit was observed between 10m and 0m b.s.l., and can be interpreted as a palaeolagoon that had formed between two ridges. On top of this, the same yellow-beige alluvial silts were deposited and related to the Tiber flood activity. Two different types of stratigraphic successions can be observed in area AI4. The cores drilled to the west displayed facies similar to AI6 and AI5, with a thick greyish-green silty-clay deposit. The cores drilled on the east comprise a 0.60m thick layer of coarse sand with ceramic fragments from -3.20m to -3.80m a.s.l. followed by fine palaeolagoon sediments. The uppermost part of the stratigraphy comprises yellow-beige alluvial silts. In Areas AI3 and AI2, layers of silty-clay are interbedded with sand or coarse sand deposits with ceramic fragments. The stratigraphy is similar to that in Core ISN-1 and to the stratigraphy observed

in the archaeological trenches where the Isola Sacra 1 and 2 shipwrecks were found. Wood fragments are present in the two cores closest to the excavation trench. Yellow-beige alluvial silts were again observed in the uppermost part of the cores.

Discussion

The Isola Sacra prior to the establishment of Portus

Coastal progradation

The Isola Sacra is a key area for understanding the evolution of the Tiber delta during the late Holocene. More specifically, the survey results presented in previous chapters and the new sedimentary cores presented in this chapter shed new light on the extent and the chronology of fluvial and coastal mobility during the third to first millennia BC (Fig. 5.7).

Core CPO-1 reveals deposits characteristic of a sandy shore of the Tiber delta (Salomon 2013; Salomon *et al.* In press 2021). At the bottom, Unit A is composed mainly of a very fine sand that was deposited below the fair weather wave base (FWWB) or the outer line of offshore breakers. Unit B reveals different layers of fine and coarse sand that probably settled in the longshore trough, which lies behind the longshore bars and the shore breaker zone. The very well sorted yellow laminated fine to medium sand of Unit C originates from the shore breaker zone. Finally, Unit D reveals bedded yellow and black sand deposits characteristic of the upper part of the wash zone. The black sand layers are placer formations issued from a selective sorting of the particles driven by their density as well as their size. The final and uppermost layer (Unit E) was composed of brown silts and corresponds to floodplain deposits settled after the formation of the beach ridge.

Coastal sands were also noted in Cores CPO-2 / Unit A and CPO-3 / Unit A. The bottom of these sandy units was composed of a higher tenor of very fine sand that might have been deposited close to the fair weather wave base (FWWB), while the upper part of the units comprised medium sand that is related to the shore breaker zone. The upper part of the sandy shore stratigraphic succession was removed by the construction and the evolution of the Roman Portus to Ostia Canal (Units B). Surprisingly, no facies can be clearly related to longshore trough deposits in the lower part of Cores CPO-2 and -3. The piece of wood in CPO-2 / Unit A is dated to the end of the third millennium BC, earlier than the date obtained from core CPO-1.

Similar coastal facies have been observed from deposits underlying Portus (Salomon 2013; Salomon *et*

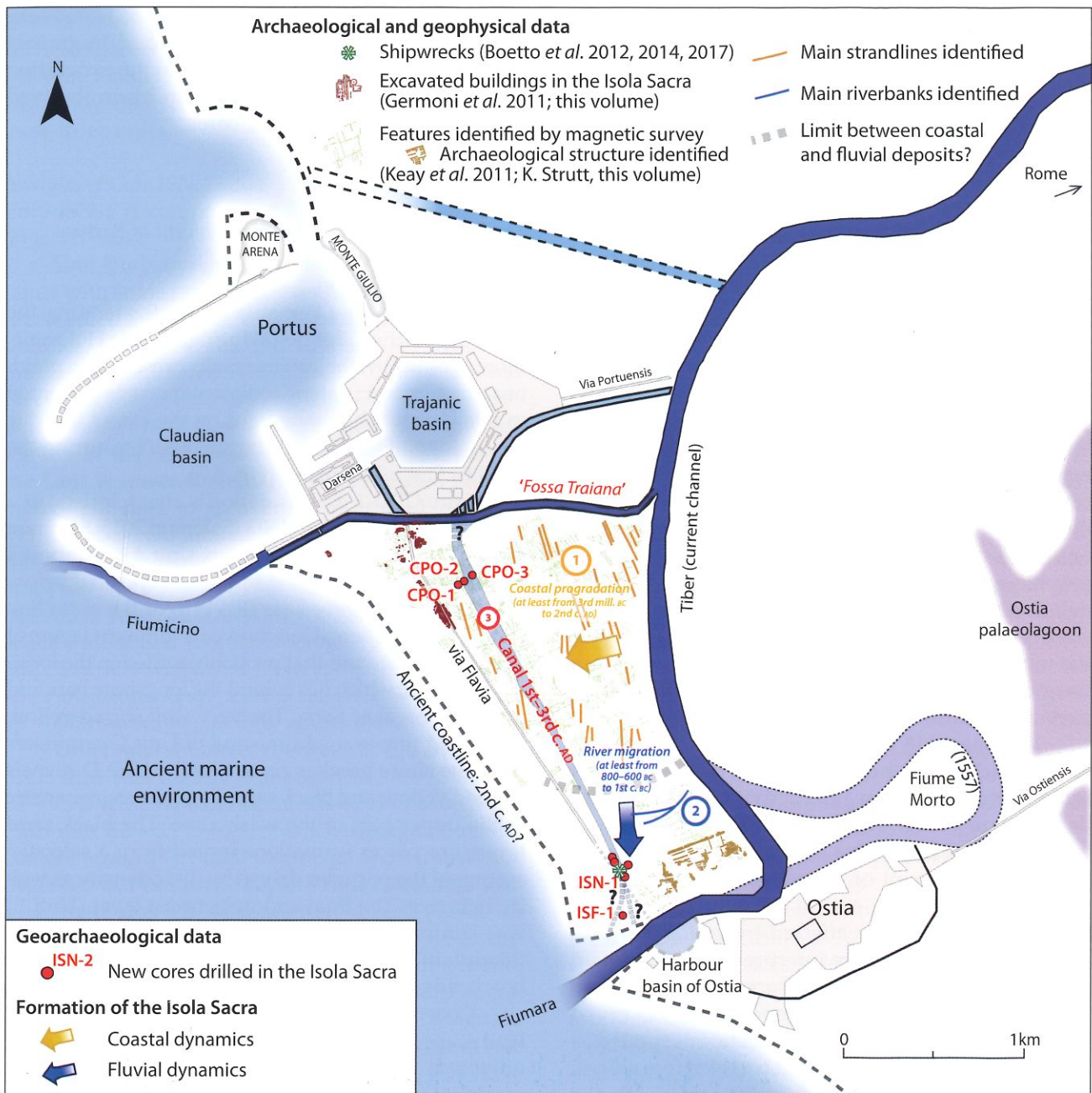


Figure 5.7. Main phases in the formation of the Isola Sacra. (Drawing: Ferréol Salomon.)

al. In press 2021) and Ostia (Goiran *et al.* 2014; Salomon *et al.* 2018). Dates from the sandy shore stratigraphic succession analysed in Cores CPO-1 and CPO-2 suggest that the northern part of the Portus to Ostia Canal was excavated in one or several progradational phases dated between the end of the third (2465 to 2210 cal BC in Core CPO-2, Lyon-11789) and the beginning of the second millennium BC (1750 to 1620 cal BC in Core CPO-1, Lyon-11787). Later progradational phases

on the southern side of Portus, north of the Ponte di Matidia, were dated to the first millennium BC (Cores BA-1 and EP-1 in Salomon 2013).

Fluvial mobility

North–south strandlines identified in the survey results in the northern part of the Isola Sacra, curve toward the east while continuing south (Fig. 5.7). These correspond to beach-ridges, and the dating evidence

from Cores CPO-1 and 2 and suggests that there was already a cuspidate Tiber river mouth in the southern part of the Isola Sacra during the third to second millennia BC. Although none of the radiocarbon dates from fluvial deposits confirm directly the presence of a palaeochannel in the south of the Isola Sacra at this date, first millennium BC river mouth deposits were identified in Cores ISF-1 and ISN-1.

At the bottom of Cores ISN-1 and ISF-1 (Units A), very well sorted silty-sands were interpreted as shoreface deposits. In the latter they were dated to the beginning of the first millennium BC (1160–930 cal BC, Lyon-11221; 1090–880 cal BC, Lyon 11222), and formed part of a prograding coast. This would have been offshore and below the contemporaneous sea level, and which would then have been covered, and probably partially eroded, by fluvio-coastal deposits. In the same core, Units B and C clearly exhibit the characteristics of fluvio-coastal facies deposited in the inner part of a river mouth: these two units are a complex intercalation of gravels, coarse and finer sands with layers of clayey-silts. The presence of many ceramic fragments in these layers is indicative of the proximity of Ostia. *Posidonia* fibres, fragments of wood and small pieces of charcoal provided a radiocarbon date of between the fifth and first centuries BC (455–220 cal BC, Lyon 9322; 365–190 cal BC, Lyon 11218; 395–205 cal BC, Lyon 11217; 205–45 cal BC, Lyon 11216). Unit B in Core ISN-1 corresponds to a fluvio-coastal deposit of fine sediments either laid down in a deep swale between two ridges, or as a result of flocculation in a palaeochannel (Salomon *et al.* 2017b). These fine deposits were dated to between the ninth and sixth centuries BC. Taken together with the geophysical evidence, this palaeo-environmental analysis suggests that the beach ridges observed in the north of the Isola Sacra and deposited during the third to second millennium BC were eroded by river mouth dynamics in the south part of the Isola Sacra during the first millennia BC.

Reconstruction of the fluvio-coastal landscape dynamics

The new palaeo-environmental data from Cores CPO-1, 2, 3, ISN-1 and ISF-1, together with the survey results discussed in Chapter 4, help provide us with a better understanding of the evolution of the Tiber delta from the third to the first millennia BC. Five clear steps in this process can be summarised as follows. First, coastal progradation occurred across the Isola Sacra between the third and first millennia BC, based on Cores CPO-1, 2 and 3 and additional dates from Portus (Salomon 2013: EP-1 and BA-1; see Fig. 5.2). Second, there was a high degree of fluvial mobility in the southern part of the Isola Sacra in the first millennium BC, eroding the

earlier prograded plain of the third–second millennium that still existed in the north of the Isola Sacra (Units A in Cores CPO-1, 2, and 3), and generating new coastal progradation toward the north (Salomon 2013: EP-1 and BA-1) and the south below Ostia (Salomon *et al.* 2018: CAT-2; Hadler *et al.* 2015: OST-4). Third, the river channel migrated from the central part of the Isola Sacra to the south between the eighth and sixth centuries BC; Unit B in Core ISN-2 can be related to the fluvial mobility at this period or to the formation of beach ridges following the migration of the river mouth southwards. Fourth and finally, the river mouth stopped migrating south of the Isola Sacra (Salomon *et al.* 2018); Core ISF-1 deposits of the fourth to first centuries BC can either date the last stage in the migration of the river mouth toward the south, or a reduction of the width of the river mouth of the palaeochannel.

Palaeoenvironments of the canal

In the cores CPO-2 and CPO-3 derived from the Portus to Ostia Canal, Units B reveal high energy deposits with a facies similar to the fluvial bedload observed in the *Canale Romano* on the north side of the '*Fossa Traiana*' (Core CN-1/Unit C, CN-2/Unit D and CN-3/Unit C in Salomon *et al.* 2014). Interbedded layers of fine and coarse deposits in Unit B1 correspond to an instability similar to that observed in the *Canale Romano* (Core CN-3/Unit B in Salomon *et al.* 2014). Fine deposits were interpreted as resulting from flocculation, on account of the influence of the salt-water edge extending inland through the mouth of the '*Fossa Traiana*'. These phases of flocculation would have been regularly interrupted by the higher energy of Tiber flood waters flowing into the Portus to Ostia Canal.

Surprisingly, the record of the infilling of the canal that is evident in Core CPO-2 differs from the stratigraphy recorded in CPO-3. The former reveals the classic sequence of a cut-off channel, with coarse bedload at the bottom (Unit B) and finer deposit for the filling (Unit C). A similar stratigraphic succession was observed in the *Canale Romano* (Salomon *et al.* 2014) and in the palaeomeander of Ostia (Salomon *et al.* 2017b: Cores MO-1 and MO-2). The full canal sequence of Core CPO-3 is composed of gravel and sands (Unit B). Part of this coarse facies is deposited above the reconstructed height of the Roman sea level of the third to fifth centuries AD (Goiran *et al.* 2009), and is overlaid by 1.5m of fine to medium sand. These deposits could be interpreted as corresponding to a point bar derived from a lateral movement of the canal during one or several flood event(s), as the survey results from northern part of the island demonstrate the canal was wider in this area (Chapter 4). Since the Tiber was a meandering river within the delta during the Roman

period (Salomon *et al.* 2017b; 2018), similar processes could have been active along the canal itself after its excavation. In the light of this, the stratigraphic evidence that we have suggests that there was a migration of the canal from the position of Core CPO-3 to that of Core CPO-2. The piece of wood in Core CPO-2 / Unit B dates to 170 cal BC–cal AD 15 (Lyon-11788), prior to the establishment of Portus. Although this fragment may have been residual in this canal context, as is often the case in such contexts, the radiocarbon date obtained from Core CPO-3 (45 cal BC–cal AD 115, Lyon-11790) is interpreted here as corresponding to the primary phase of canal use. It is a date which suggests that the canal moved laterally quickly after its excavation; it also fits with the archaeological and historical dates for the construction of Portus and its canal, and corresponds to the dates of the canal sediments and the boats in the south of the Isola Sacra.

Navigability

The Portus to Ostia Canal measures between *c.* 90 m in the north and *c.* 40m further south. Due to lateral mobility (see above), the width of the northern part of the canal is most probably over-estimated. Additionally, the lack of magnetometry coverage in some areas may lead us to under-estimate of its downstream width. The actual width before and after lateral migration of the canal is also difficult to reconstruct with certainty. The minimum width is broadly similar to the 35m widths of the 'Fossa Traiana' and the *Canale Romano*, but wider than the 25m of the *Canale Traverso*. In terms of comparative scale, the Isola Sacra 1 ship is 12m long and 4.88m wide (Boetto *et al.* 2017; see below), meaning that there would have been sufficient space for it to turn and manoeuvre within the canal.

The PADM chart created for the canal presents data in such a way as to allow its changing water-depth to be more easily understood (Salomon *et al.* 2016a) (Fig. 5.6). In contrast to enclosed harbour environments, the depth of canals can change in response to flood events. In other words, the bottom of a canal sequence can either be explained in terms of the deepest point reached in dredging, or by hydrodynamic conditions. Additionally, the stratigraphy in a core from a borehole drilled at one side of the canal may not represent its deepest part. However, Electrical Resistivity Tomography undertaken across the line of the canal in the context of the geoarchaeological fieldwork confirmed the observations made in relation to the two cores (Salomon *et al.* 2016b).

In accordance with our hypothesis, Cores CPO-2 and 3 provide a record of the two phases of activity within the canal, with a water depth of -2m Ro.s.l. This means that a ship with 2.20m–2.30m of loaded

draught, such as the 150 ton vessel from the Bourse de Marseille, could have used this part of the canal (Gassend 1982; Pomey and Rieth 2005; Boetto 2010). It is possible, however, that the bridge identified in the geophysical survey (Chapter 4: Area 6, G33 and m6.6) could have presented an obstacle to them. The piers (*c.* 5m by 9m) in this stretch of the canal are spaced at *c.* 6m apart and the roadway carried along them would have been an obstacle to their masts unless they could be temporarily taken down. Core ISN-1, which was extracted from the southern part of the canal near the excavation of the ships, reveals a maximum water depth of -5m Ro.s.l. Although the draught of a fully loaded Isola Sacra 1 has yet to be calculated, most sizes of Roman ships could have been accommodated in this part of the waterway (Boetto 2010; Pomey and Tchernia 1978).

Connectivity of the canal within the Portus system and in relation to the Tiber river mouth

Connectivity is of primary importance in considering whether the Portus to Ostia Canal was built for navigation or for flood relief. How was it integrated into the canal system of Portus? What role did it play in relation to the river-mouth system of Ostia, which included the fluvial harbour basin of Ostia?

In contrast to the *Canale Romano*, the 'Fossa Traiana' and the *Canale Traverso* but similar to the *Northern Canal*, the riverbanks of the Portus to Ostia Canal do not seem have been built with reinforced banks, and appear instead to have been cut directly into coastal deposits in the north and fluvial deposits in the south. It was precisely these loose riverbanks that led to the lateral mobility of the canal. According to the magnetometry results presented in Chapter 4, the orientation of the northern stretch of the canal is not aligned on beach-ridges, although its eastern banks indicate that the erosion of some sections might have been constrained by the beach-ridge system. More investigation will be necessary to attest whether or not the southern sector of the canal followed any pre-existing natural feature.

Ostian side

It is still difficult to establish whether the canal was connected to the Tiber opposite Ostia, to the river channel downstream of the curve initiated by the canal near the excavation of the shipwrecks, or directly into the sea in the west. The old aerial photographs presented in Chapter 4 (Figs 4.71–4.72) are not as clear as one would like, and do not provide any evidence for any canal-related features, except perhaps for a small westward curve. Furthermore, it has not been possible to undertake any geophysical survey downstream to

the west in the area which is now heavily built-up. However, it is worth pointing out that the river mouth is the most morphologically active part of a delta. Consequently, a direct connection to the Tyrrhenian sea would have led to the rapid sedimentation of the mouth of the canal. The littoral drift on the north side of the river mouth is oriented to the north and would have easily created beach ridges after flood events. Even if there was lateral mobility of the palaeochannel, the connection of the canal to the channel close to the Tiber mouth would have probably lasted longer.

The north–south cross-section of cores drilled by Ghelli, Rosa and Germoni suggests that there was coarse and sandy sedimentation between 2m and 8m b.s.l. in the area of Core ISN-1 (Areas AI2 and AI3) that was associated with the Portus to Ostia Canal, and mostly fine deposits toward the south (AI6, AI5) which are identified as a palaeolagoon between two sandy coastal ridges. Absolute dates would be necessary to confirm whether this palaeolagoon existed during the period of use of the canal and whether it could have been used as a waterway. Figs 5.1, 5.2 and 5.7 show different hypotheses for the connection of the Portus to Ostia Canal with the Tiber near Ostia.

Portus side

It is possible that the junction of the Portus to Ostia Canal and the *Fossa Traiana* may have been bordered by an embankment since not doing so would probably have led to destabilisation of the riverbanks. The banks of the latter comprised solid structures that are discussed in Chapter 2, and furthermore there is north–south anomaly (m5.5) in Area 5 which could indeed mark the line of such an embankment. In the light of this, Figs 5.1 and 5.2 present a hypothetical interpretation of the possible morphology of the intersection between the *Canale Romano*, the Portus to Ostia Canal and the *Fossa Traiana*. It is based in part upon the better-known junction between the *Fossa Traiana* and the *Canale Traverso*.

It is also possible that the canal could have been used for flood management in the same way as the *fossis* mentioned in the famous Claudian inscription of AD 46 from Portus (CIL XIV, 85 – Keay *et al.* 2005: 315, A1, fig. 9.1). The coarse sediments in CPO-2 and 3/Units B are similar to the bedload found in the *Canale Romano* and suggest that floods passed through the Portus to Ostia Canal. Sediment transfer continuity is then attested with the *Fossa Traiana* and the *Canale Romano*, ultimately to the river Tiber upstream.

Conclusion

The Isola Sacra provides the ‘missing piece’ for reconstructing the Tiber delta dynamics before the Roman

Imperial period, and for better understanding the broader harbour system of Portus and Ostia. In particular, the two cross-sections of cores drilled in the northern part of the Portus to Ostia Canal (CPO-1, 2, and 3) and its southern part (ISN-1, 2, 3, 4 and ISF-1) shed new light on these two issues.

The new geophysical and sedimentary data show firstly that the Tiber mouth lay in the area that later formed the south of the Isola Sacra as early as the third to second millennia BC, and secondly that there was no sudden or catastrophic defluviation of the river channel southwards from the area later occupied by Portus in the eighth to sixth centuries BC (Segre 1986; Giraudi *et al.* 2009). It suggests instead that there was a progressive southwards migration of the mouth of the river channel in the southern area of the Isola Sacra from the latter date onwards (Bellotti *et al.* 2011; Salomon *et al.* 2018).

In terms of chronology, combined archaeological and radiocarbon dates relating to the cores are consistent. The Portus to Ostia Canal was built between the end of the first century AD and the beginning of the second century AD and was abandoned between the late second and early third centuries AD. The waterway could have been used for navigation by small to medium size boats and ships with water depths of between 2m and 5m, and perhaps also as a flood-relief canal. The absence of constructed riverbanks in conjunction with the lateral mobility of the canal suggests that the waterway was not designed to be a harbour-canal in the same way as the *Canale Romano*, the *Fossa Traiana* or the *Canale Traverso*. The dissociation of the southern stretch of the canal with the newly discovered northern extension of Ostia in the *Trastevere Ostiensis* and the bridgehead settlement on the north side of the Isola Sacra are possible arguments in favour of this.

The Isola Sacra shipwrecks

Giulia Boetto, Alessandra Ghelli and Paola Germoni

The Isola Sacra 1 shipwreck (G52) was discovered at the beginning of February 2011 during archaeological excavations undertaken on behalf of the City of Rome and by the Soprintendenza Speciale per i Beni Archeologici di Roma (present-day Parco Archeologico di Ostia Antica), c. 300m to the north of the north bank of the Tiber, in advance of the construction of a replacement for the Ponte della Scafa. The excavation, study and documentation of the find lasted for about five months, during which time a second shipwreck, the Isola Sacra 2, was discovered lying perpendicular to the Isola Sacra 1 and partially covered by it (Fig. 5.8); only the southern side of this shipwreck could

References

Abbreviations

- ACEA Azienda Comunale Elettricità e Acque
 ADSBAO Archivio di Disegni della Soprintendenza di Beni Archeologici di Ostia
 ASBAO Archivio della Soprintendenza di Beni Archeologici di Ostia
 CIL *Corpus Inscriptionum Latinarum*. (Berlin, 1863-).
 RIC 1 C.H.V. Sutherland and R.G.A. Carson (eds) *Roman Imperial Coinage I*. (revised edition, 1984)

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