



Humans and their environment on the Médoc coastline from the Mesolithic to the Roman period

Florence Verdin, Frédérique Eynaud, Pierre Stéphane, Gilles Arnaud-Fassetta,
Mathieu Bosq, Frédéric Bertrand, Grégor Marchand, Serge Suanez, Clément
Coutelier, Florent Comte, et al.

► To cite this version:

Florence Verdin, Frédérique Eynaud, Pierre Stéphane, Gilles Arnaud-Fassetta, Mathieu Bosq, et al..
Humans and their environment on the Médoc coastline from the Mesolithic to the Roman period.
Quaternaire, 2019, Evolution de l'environnement et archéologie du littoral lord-médocain (Gironde,
France), 30 (1), pp.77-95. 10.4000/quaternaire.11201 . halshs-03886901

HAL Id: halshs-03886901

<https://shs.hal.science/halshs-03886901>

Submitted on 6 Dec 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

HUMANS AND THEIR ENVIRONMENT ON THE MÉDOC COASTLINE FROM THE MESOLITHIC TO THE ROMAN PERIOD

Florence VERDIN¹, Frédérique EYNAUD², Pierre STÉPHAN³, Gilles ARNAUD-FASSETTA⁴, Mathieu BOSQ⁵, Frédéric BERTRAND⁴, Serge SUANEZ³, Clément COUTELIER¹, Florent COMTE¹, Stefanie WAGNER⁶, Christelle BELINGARD^{7,8}, Vincent ARD⁹, Claire MANEN⁹, Guillaume SAINT-SEVER⁹ & Grégor MARCHAND¹⁰

ABSTRACT

The northern coast of the Médoc between Soulac-sur-Mer and Montalivet-les-Bains has a rich archaeological heritage that is being directly impacted by coastal erosion. A series of clay-peat palaeosols that formed in ancient estuarine marshes holds evidence of intensive occupation from the Mesolithic until the end of the Roman period. Within this framework, our research focused on the two key sites of La Lède du Gulp (Grayan-et-l'Hôpital) and L'Amélie (Soulac-sur-Mer), where an interdisciplinary approach based on comparison of archaeological, sedimentary and palaeo-environmental data has made it possible to situate the main phases of occupation in their environmental context. This work has benefited from field documentation that is exceptionally well-preserved in wet sediments sealed beneath the present-day dune system. The most fleeting traces (animal tracks) like the sturdiest anthropic structures are preserved, as are many organic remains. These items provide access to first-rate documentation for reconstructing the range of activities practised in a specific ecosystem: salt production, livestock grazing, shellfish collecting, passage and carriage, and funerary and symbolic practices. Study of occupation over the long term reveals an alternating pattern of dynamic phases and decline phases that seem to be correlated with changes in the local environment.

Keywords: archaeology, environment, marsh, coast, erosion, Holocene, Neolithic, Bronze Age, Iron Age, Antiquité, Gironde, Aquitaine

RÉSUMÉ

L'HOMME ET SON ENVIRONNEMENT SUR LE LITTORAL MÉDOCAIN DU MÉSOLITHIQUE À L'ANTIQUITÉ

La côte nord médocaine, entre Soulac-sur-Mer et Montalivet-les-Bains, possède un riche patrimoine archéologique directement impacté par l'érosion littorale. Une succession de paléosols argilo-tourbeux appartenant à d'anciens marais littoraux recèle les témoignages d'une intense occupation depuis le Néolithique jusqu'à la fin de l'Antiquité. Les recherches se sont focalisées sur deux sites-clés : La Lède du Gulp (Grayan-et-l'Hôpital) et l'Amélie (Soulac-sur-Mer) où une approche interdisciplinaire fondée sur le croisement des données archéologiques, sédimentaires et paléoenvironnementales – au sens large du terme – a permis de replacer les principales phases de peuplement dans leur contexte environnemental. Ces travaux ont bénéficié d'une documentation de terrain exceptionnellement conservée dans des sédiments humides scellés sous le système dunaire actuel. Les traces les plus fugaces (empreintes) comme les aménagements anthropiques les plus robustes sont préservés, de même que de nombreux restes organiques. Ces éléments nous donnent accès à une documentation de premier ordre pour retracer la palette des activités pratiquées dans un écosystème spécifique : production du sel, pacage des animaux, agriculture, collecte des coquillages, circulation, pratiques funéraires et symboliques. L'étude du peuplement sur la longue durée révèle une alternance de phases dynamiques et de phases de déprise qui semblent corrélées avec les changements du milieu.

Mots-clés : archéologie, environnement, marais, littoral, érosion, Holocène, Néolithique, Âge du Bronze, Âge du Fer, Antiquité, Gironde, Aquitaine

¹ Laboratoire AUSONIUS (UMR 5607 CNRS), Université Bordeaux Montaigne, Maison de l'Archéologie, 8 esplanade des Antilles, FR-33607 PESSAC cedex. *Emails :* florence.verdin@u-bordeaux-montaigne.fr, clement.coutelier@u-bordeaux-montaigne.fr, florent.comte@u-bordeaux-montaigne.fr

² Laboratoire EPOC (UMR 5805 CNRS), Université de Bordeaux, allée Geoffroy Saint Hilaire, CS 50023, FR-33615 PESSAC. *Email :* frederique.eynaud@u-bordeaux.fr

³ Laboratoire LETG (UMR 6554 CNRS), Université de Bretagne Occidentale, Institut Universitaire Européen de la Mer, place Nicolas Copernic, FR-29280 PLOUZANÉ. *Emails :* pierre.stephan@univ-brest.fr, serge.suanez@univ-brest.fr

⁴ Laboratoire PRODIG (UMR 8586 CNRS), Université Paris-Sorbonne, Institut de Géographie, 191 rue Saint-Jacques, FR-75005 PARIS. *Emails :* gilles.arnaud-fassetta@univ-paris-diderot.fr, frederic.bertrand@sorbonne-universite.fr

⁵ Laboratoire PACEA (UMR 5199 CNRS), Université de Bordeaux, allée Geoffroy Saint Hilaire, CS 50023, FR-33615 PESSAC. *Emails :* mathieu.bosq@gmail.com

⁶ Laboratoire BIOGECO (UMR 2012), INRA, Site de recherches Forêt Bois de Pierroton, 69 route d'Arcachon, FR-33612 CESTAS cedex. *Email :* stefwag2002@gmail.com

⁷ Dtalents Ingénierie, 29 avenue du Général Leclerc, FR-87100 LIMOGES. *Email :* christelle.belingard@orange.fr

⁸ Laboratoire GEOLAB (UMR 6042), MSH, 4 rue Ledru, FR-63057 CLERMONT-FERRAND cedex 1.

⁹ Laboratoire TRACES (UMR 5608), Université Toulouse Jean Jaurès, Maison de la Recherche, 5 allée Antonio-Machado, FR-31058 TOULOUSE cedex 9. *Emails :* vincent.ard@univ-tlse2.fr, claire.manen@univ-tlse2.fr, guillaumesaintsever@yahoo.fr

¹⁰ Laboratoire CReAAH (UMR 6566 CNRS), Centre de Recherche en Archéologie Archéosciences Histoire, Campus Beaulieu, bât. 24-25, 263 avenue du Général Leclerc, CS 74205, FR-35042 RENNES cedex. *Emails :* gregor.marchand@univ-rennes1.fr

1 - INTRODUCTION

The sandy Aquitaine coast has been densely populated since Neolithic times, but the scope and complexity of palaeogeographical changes since the Holocene means that interdisciplinary approaches are required to understand the relationship between societies and their territories. Further to these changes, certain sectors have become extraordinary repositories of archaeological remains. Lakes formed along the coast of the Landes drowning small alluvial valleys such as the Gourgue valley where a string of sites currently lies beneath the waters of the lac de Sanguinet (Maurin, 1998). The dune du Pilat has fossilized palaeosols containing remains from various periods that can be seen on the dune's coastal slopes (Jacques, 2013). In the north of the Médoc, between the pointe de Grave and Montalivet, various clayey sedimentary levels have trapped plentiful traces of occupation which now lie in an intertidal setting.

Our research has focused on this last sector (fig. 1) because of the abundant archaeological discoveries reported in recent decades but which paradoxically are poorly documented although exceptionally well preserved. The rapid sedimentation of these ancient wetlands and their burial beneath the modern dune system saved the sites from depredation until the severe winters of 2013/2014. Moreover, the wet and compact clay sediments form a suitable setting for preserving organic materials and sometimes transient marks (such as footprints), evidence that has disappeared from environments on dry land.

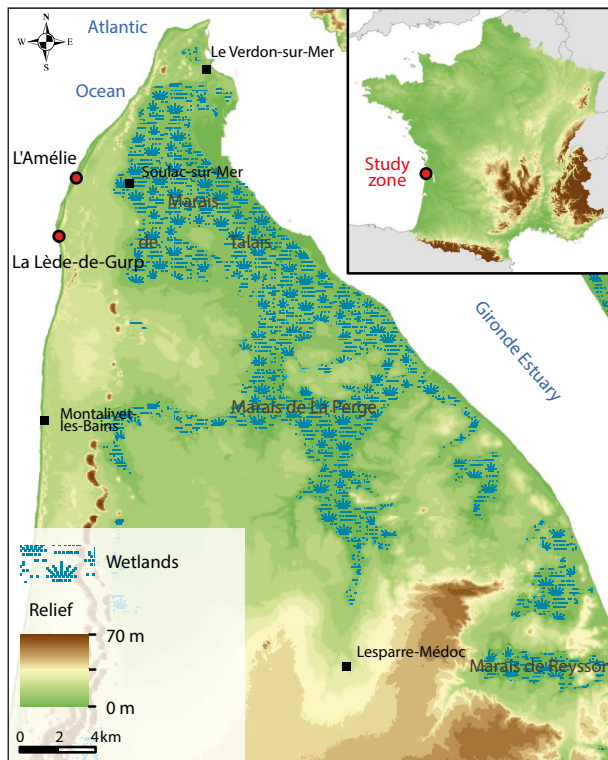


Fig. 1: Map of sites studied as part of the LITAQ project (by C. Coutelier).

Corine Land Cover, Agence de l'Eau du Bassin Adour - Garonne; RGE ALTI® - IGN.

Fig. 1 : Carte des sites étudiés dans le cadre du projet LITAQ (par C. Coutelier). Corine Land Cover, Agence de l'Eau du Bassin Adour - Garonne ; RGE ALTI® - IGN.

The North Médoc coastal areas therefore form a palimpsest of human activities over several thousands of years. And yet, the very intensive erosion of the north coast of the Gironde – of the order of several metres per year – means that research teams are racing against the clock to develop suitable strategies for intervention and study of these unusual but doomed environments.

The quality of the information collected from the sites of La Lède du Gurp (Grayan-et-L'Hôpital) and the beach of L'Amélie Nord (Soulac-sur-Mer) in the frame of the LITAQ project provides major insights into the occupation dynamics associated with environmental changes and the ways food resources specific to these ecosystems were exploited. This paper presents the archaeological findings made as part of the LITAQ project and situates them within the context of palaeo-environmental knowledge set out in the other contributions of this issue. Beyond the local scale, the objective is to understand the challenges facing these marginal areas at the interface between sea and land and at the seaward outlet of the major line of communication formed by the Garonne River and to determine how they were connected with the surrounding regions.

2 - THE GEOGRAPHICAL SETTING

The geographical setting and the sedimentary entities of the Lower Médoc have been the subject of many studies since the early twentieth century (Fabre, 1939; Buffault, 1942; Dubreuilh *et al.* 1995; fig. 2). The Médoc

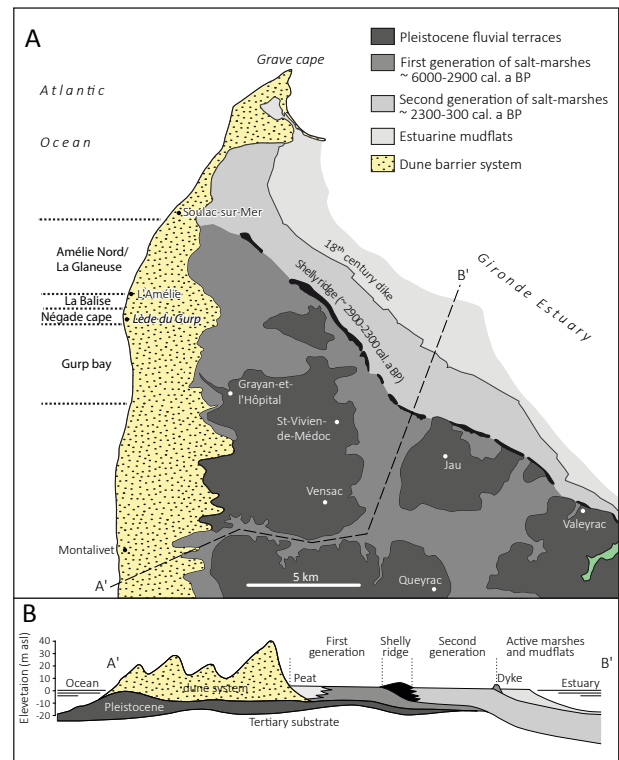


Fig. 2: Simplified geological map of the Late Quaternary coastal formations of the North Médoc peninsula (A) and schematic geological west-east cross-section through the Médoc peninsula (B) (from Pontee *et al.*, 1998, revised by Stéphane *et al.*, 2019).

Fig. 2 : Carte géologique simplifiée des formations côtières fini-quaternaires du Nord Médoc (A) et coupe schématique est-ouest des dépôts (B) (d'après Pontee *et al.*, 1998, repris par Stéphane *et al.*, 2019).

is mostly underlain by a karstic substrate of Tertiary marine sediments (e.g. Allen *et al.*, 1974; Courrèges, 1997). The incision of the Garonne valley and the formation of the gravel terraces flanking it began in the mid Pleistocene and were accompanied by the progressive north-eastward migration of the river. The major stages of palaeogeographical transformation of the Médoc peninsula during the Holocene have been traced by N. Pontee (Pontee *et al.*, 1998; fig. 3). Some 10000 to 6000 years ago, driven by climatic warming, the sea level rose by about 1 m per century and then stabilized around its present-day level. Wide and deep bays opened between the Pleistocene terraces, the upstream parts of which began to fill around 5 ka BP. This first generation of marshes is referred to locally as “palus”. Then between 3175 and 2110 cal. a BP, recurrent storms progressively caused the build up of a shelly ridge known as the “Cordon de Richard”, along the estuary (Diot & Tastet, 1995; Massé, written comm. in Clavé, 2001, p. 165-178). This ridge accelerated the filling of the back marshes and contributed to the formation of a second generation of marshes at the front (“les mattes”). Around the change of the geological era, the estuarine marshes were almost completely filled.

In parallel, aeolian sand accumulated on the coastline where two generations of coastal dunes can be identified: the older or “primary” parabolic dunes underwent two phases of mobility (5000-3500 cal. a BP and 3000-2300 cal. a BP) and the “modern” dunes, which are of various forms, built up during the main three aeolian phases (4000-3000, 1300-900 and 550-250 cal. a BP, during the “Little Ice Age”) (Marionnaud & Dubreuilh, 1972; Tastet, 1998; Clarke *et al.*, 1999, 2002).

There are still too few data to reconstruct the history of the Holocene relative sea level (RSL) along the Aquitaine coast. Research on the marshes of the Charente and Gironde areas has been used to build a model that was completed during the LITAQ project (Stéphan & Goslin, 2014; Stéphan *et al.*, 2019).

3 - A SHORT HISTORY OF THE ARCHAEOLOGICAL RESEARCH

Despite the well-known wealth of the archaeological heritage of the northern part of the Médoc, scientific data acquired before the late 1990s, the time when research gradually came to a halt, cannot readily be exploited. Only two sites were excavated in a planned manner over several years: La Lède du Gurd from 1972 onwards, directed first by G. Frugier and then J. Roussot-Larroque between 1984 and 1993, and La Négade (Soulac-sur-Mer), from 1966 to 1985, directed by J. Moreau (Sion, 1994, p. 301-303). At the same time, a few rescue excavations were carried out on sporadic remains unearthed by erosion, while the Association Médullienne d'Archéologie et d'Histoire du Médoc, chaired by J. Moreau, brought together a network of volunteer researchers monitoring sites and collecting miscellaneous data picked up by walkers. This research gave rise to a handful of succinct publications. The lack of supervision by research institutions led to an accumulation of confused data from undifferentiated settings that were poorly located and dated and could not therefore be easily interpreted.

Moreover, the archaeological data of the Gironde coastline were only marginally integrated in interdisciplinary approaches, despite projects such as the CNRS Programmed Thematic Action “Holocene morphogenesis, landscapes and settlements of the Aquitaine coastal area” directed by J. Burnouf, P. Garmy, J.-M. Froidefond and J.-P. Tastet (begun in 1991), or the European LIFE programme “Coastal Change, Climate and Instability” (1997-2000), jointly directed for the south-west by J.-P. Tastet and J. Roussot-Larroque. The results of these programmes were more about the estuary marshland than the Atlantic shoreline for which there were comparatively few archaeological studies (Tastet *et al.*, 1996; Clavé, 2001; Coquillas, 2001). Faced with this heritage that had been left abandoned for twenty years or

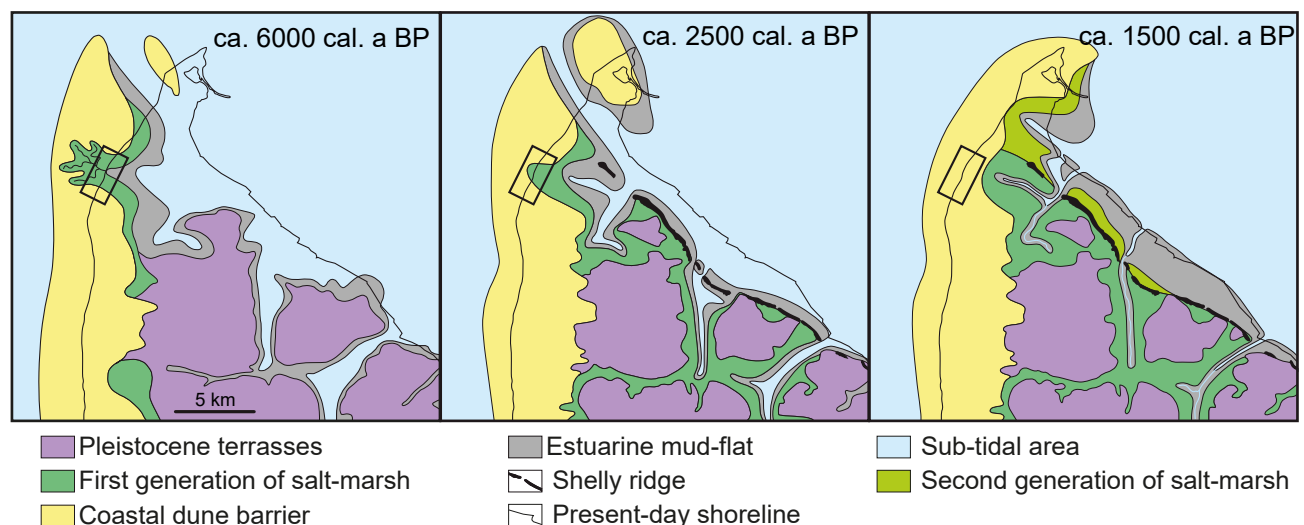


Fig.3: Palaeogeographic reconstructions of the North Médoc peninsula from ca. 6000 to 1500 cal. a BP (from Pontee *et al.*, 1998, revised by Stéphan *et al.*, 2019).

The rectangle indicates the location of the Amélie beach.

Fig. 3 : Reconstitution des changements paléogéographiques de la péninsule du Nord-Médoc de 6000 à 1500 cal. BP (d'après Pontee *et al.*, 1998, repris par Stéphan *et al.*, 2019). Le rectangle indique la plage de l'Amélie.

so, it was essential to reinvestigate the scale of the coastal sites in order to precisely define their chronostratigraphic framework and to correlate the observations made on the banks of the estuary with those made on the Atlantic coast.

4 - SPECIFICITIES OF THE AREA AND METHOD OF INTERVENTION

Archaeological research was conducted in two sectors some 2 km apart exhibiting different topographic and taphonomic conditions. Of the previously excavated La Lède du Gulp (Grayan-et-L'Hôpital) site there remains only an isolate of about 150 m² corresponding to the floor of a wet depression filled by peats and organic clays and currently located in the middle of the intertidal zone (see Faye *et al.*, 2019). On the beach of L'Amélie Nord, between Soulac-sur-Mer and L'Amélie, the remains cover on the contrary the whole of the intertidal zone, an area some 2 km long and 200 m wide at low tide. The intermediate sector, between L'Amélie and the pointe de La Négade, has also yielded many remains in the past, but at present the taphonomic conditions are less suitable, both because the boulder barriers built to protect the village of L'Amélie cause permanent deposition that masks the remains and because of the topography changes south of L'Amélie: the Holocene soils that might contain archaeological clues rise progressively above the intertidal zone. The scarce remains are then visible only in the dune cliffs. Below, in the intertidal zone, which are known as the "du Gulp" Pleistocene basal clays contain elephant remains (see Beauval *et al.*, 2019; Bosq *et al.*, 2019).

Occupation sites and indications of occupation have been identified in several prospection campaigns, generally in winter when the beach is scoured and at the times of the lowest astronomical tides. These works also benefit from the efforts of voluntary researchers who regularly monitor erosion and alert the institutions if anything is discovered. Remains are systematically located by GPS and photographed. Characteristic material is collected and observations recorded in a Geographical Information System. Depending on how much interest the structures observed hold for science and how vulnerable they are to erosion, spot excavations may be made.

Even so, interventions are subject to specific constraints. The first difficulty is the sand mattress that masks the remains and alters the topography of the beach with each change of the tide. Observations can therefore only be made on comparatively small portions of terrain. The strategy of systematically surveying each archaeological entity has produced a cloud-point map that it has been progressively possible to interpret in terms of the spatial and chronological distribution of remains, which are at the same time connected with a precise sedimentary context. The second difficulty relates to the short intervention time of just a few hours because of the tides (the tidal range is between 1.5 m and 6.5 m: Castelle

et al., 2018, p. 215). During excavation, the need to drain the waterlogged ground is a third major constraint which requires the permanent use of a mechanical digger.

The exceptional preservation of remains because of the waterlogged clay sedimentary settings provides us with archaeological information that is seldom found in inland settings. The presence of organic materials implies specific protocols for excavation and study. Building timbers are generally sampled for xylological studies, for radiocarbon dating and for compiling a dendrochronological reference chart that is lacking for south-western France before the Roman period. The other plant macro-remains (stumps, branches, twigs, seeds, leaves, pine cones) and the insects found in archaeological levels are also the subject of specialized studies to be published later. The plastic character of the sediments means tracks are easily preserved: animal or human footprints, vehicle ruts, etc.

The data are recorded and made available to team members via a website hosted on the TGIR Huma-Num platform (<http://litaq.huma-num.fr>) and managed by the Geomatics and Digital Humanities cell of the Ausonius Institute (ausoHNum).

5 - LA LÈDE DU GULP

5.1 - THE RESEARCH CONTEXT

The archaeological site of La Lède du Gulp, in an ancient wetland depression, now lies on the shoreline where it is subject to severe erosion that has destroyed almost all of it. The recurrent winter storms of 2013-2014 shifted the coastline back by several tens of metres, affecting the site, part of which became detached from the dune cliff to form an islet in the middle of the intertidal zone made up of highly compact clayed and peaty sediments (figs. 4 & 5).

The stratigraphic sequence, which is exceptional in Europe, covers a period from the Mesolithic to the Iron Age, as identified during several excavation campaigns from 1972 to 1993 directed by G. Frugier and then J. Roussot-Larroque. The longevity of occupation seems to be explained by the presence of a permanently water-filled depression. Faced with the inevitable disappearance of this rich archaeological heritage, a first intervention was conducted in March 2014, in order to study more specifically the remains of occupation in their palaeo-environmental context. The eastern and southern sections of the residual stack were straightened, cleaned, surveyed and sampled vertically. A core was also sampled from the dune cliff so that the very different stratigraphies of the islet and the dune cliff could be correlated (see Bosq *et al.*, 2019; Faye *et al.*, 2019). These operations were followed by a rescue excavation in October 2014, with the mobilization of the SRA Aquitaine and exceptional funding from the Ministry of Culture, and with the creation of a scientific team from the research units of Ausonius, EPOC, TRACES, CReAAH, supported by



Fig. 4: Erosion of the site at La Lède du Gulp (Grayan-et-L'Hôpital).

(A) April 2012. (B) March 2014 (photos F. Verdin).

Fig. 4 : Progression de l'érosion sur le site de La Lède du Gulp (Grayan-et-L'Hôpital). (A) Avril 2012. (B) Mars 2014 (photos F. Verdin).



Fig. 5: La Lède du Gulp, first survey and sampling campaign in March 2014 (photo N. Prévôt).

Fig. 5 : La Lède du Gulp, première campagne de terrain en mars 2014 (photo N. Prévôt).

the LITAQ project and ANR Procome (Verdin *et al.*, 2018). As the entire site could not be excavated further interventions were required to save some remains exposed by erosion.

5.2 - THE STRATIGRAPHIC AND ENVIRONMENTAL CONTEXT

The stratigraphic column observed above beach level is some 3 m high, but is merely the visible part of a thicker formation filling the depression (figs. 4 & 5). Being thicker in the centre than on the edges, the strata tilt inwards. The deepest layers reached by the excavation are at about 5.50 m below the top of the stack, that is close to -1 m asl. The base of the peat fill could not be reached but additional works are still underway to characterize the style of contact with the local bedrock (EC2CO DRIL FAST-LITAQ project directed by F. Eynaud).

Three main sedimentary units have been identified (fig. 6; cf. Faye *et al.*, 2019). At the base, dark brown to black levels of sandy and peaty clay with no visible bedding contain numerous macro remains of plants. They are capped by discontinuous coarse sand lenses grading into a shelly sand level in the centre of the basin. Datings range from the Mesolithic to the Middle Neolithic (~8500-3700 BC).

Above these, clayed, compact, plastic, less organic levels alternating with more silty grey streaks date from the Late Neolithic and Early Bronze Age (~3700-1600 BC). Lastly the top of the stack is capped with a thick peaty level containing well preserved branches and abundant organic remains formed in the Middle Bronze Age period (~1600-1400 BC).

The predominance of clayed horizons, probably because the sector newly excavated represents the middle of the depression, contrasts a little with the sectors studied in the 1990s (closer to the sea) that contained more levels in which sand prevailed, alternating with clay and peat and interpreted as a series of dry and wet phases (Roussot-Larroque & Villes, 1988; Roussot-Larroque, 2007, p. 286-287).

The synthesis of stratigraphic, archaeological and palaeo-environmental data supported by radiocarbon dates (fig. 6) provides better defined patterns of occupation of the site in their environmental context.

5.3 - FROM THE MESOLITHIC TO THE MIDDLE NEOLITHIC: THE LOWER CLAY-PEAT SEQUENCE

The oldest levels are located in the centre of the depression, about 2.50 m below the present-day level of the beach (ca. -1 m asl). They are made up of compact peaty clay containing large ligneous remains (whole trunks) that collapsed into the peatbog, together with branches, twigs, leaves and seeds. These peat deposits, accumulated progressively in the estuary floodplain further to the sea level rise in the late Pleistocene (Pontee *et al.*, 1998; Diot, 1999). They contain plant species belonging to a riparian and/or swampland context (Marambat & Roussot Larroque, 1989; Faye *et al.*, 2019). The environment must have been constantly flooded and had a positive hydrological budget.

Anthropic input is virtually absent, except for a hammer. We have six ¹⁴C dates acquired in March 2014 by S. Wagner (Biogeco), from oak wood collected from the sections around the edges of the stack for

Site	US	Laboratory Code	Nature of sample	Age BP	Std. Dev	Age (cal. a BC) 2 sigma
Lède du Gulp (LITAQ)	4B	Vera-51329	wood	9064	90	8542-7968
	5B	Vera-51331	wood	9016	75	8425-7954
	1B	Vera-51330	wood	8908	90	8279-7755
	6	Vera-51327	wood	8948	50	8277-7958
	2B	Vera-51332	wood	8489	70	7630-7354
	7B	Vera-51328	wood	8339	70	7536-7184
Lède du Gulp (fouille)	US1039 – B002	Gif-48068-PR5	wood	8725	40	7874-7604
	US1037 – B004	Gif-48067-PR4	wood	8345	40	7521-7321
	US1029 – 03/1B	Gif-48065-PR2	wood	5600	30	4488-4360
	US1031 – B010	Gif-48066-PR3	wood	5470	30	4361-4311
	US 1029	Beta - 423538	potsherd residue	5380	30	4330-4080
	US 1031	Beta - 423539	potsherd residue	5260	30	4225-3985
	US1028-B02	Gif-48064-PR1	wood	5270	30	4175-4032
	US 1028	Beta - 423542	potsherd residue	5230	30	4145-3970
	1023	Beta-430228	potsherd residue	4930	30	3650-3370
	ST7	Beta-423524	wood	4440	30	3325-2940
	1018	Beta-423541	potsherd residue	3760	30	2280-2045
	1035	Beta-430229	potsherd residue	3510	30	1915-1745
	1004	Beta-425528	potsherd residue	3180	30	1505-1410
L'Amélie	AML-N-001-ST1-BO5	Beta-448485	wood	5110	30	3970/3800
	AML-N-002-ST4-P7	Beta-448486	wood	4110	30	2865/2575
	AML-N-004	Vera-51336	wood	3984	70	2853-2286
	AML-N-008	Vera 51402	wood	2570	40	821-542

Tab. 1: Table of radiocarbon ages.

Tab. 1 : Table des datations radiocarbones.

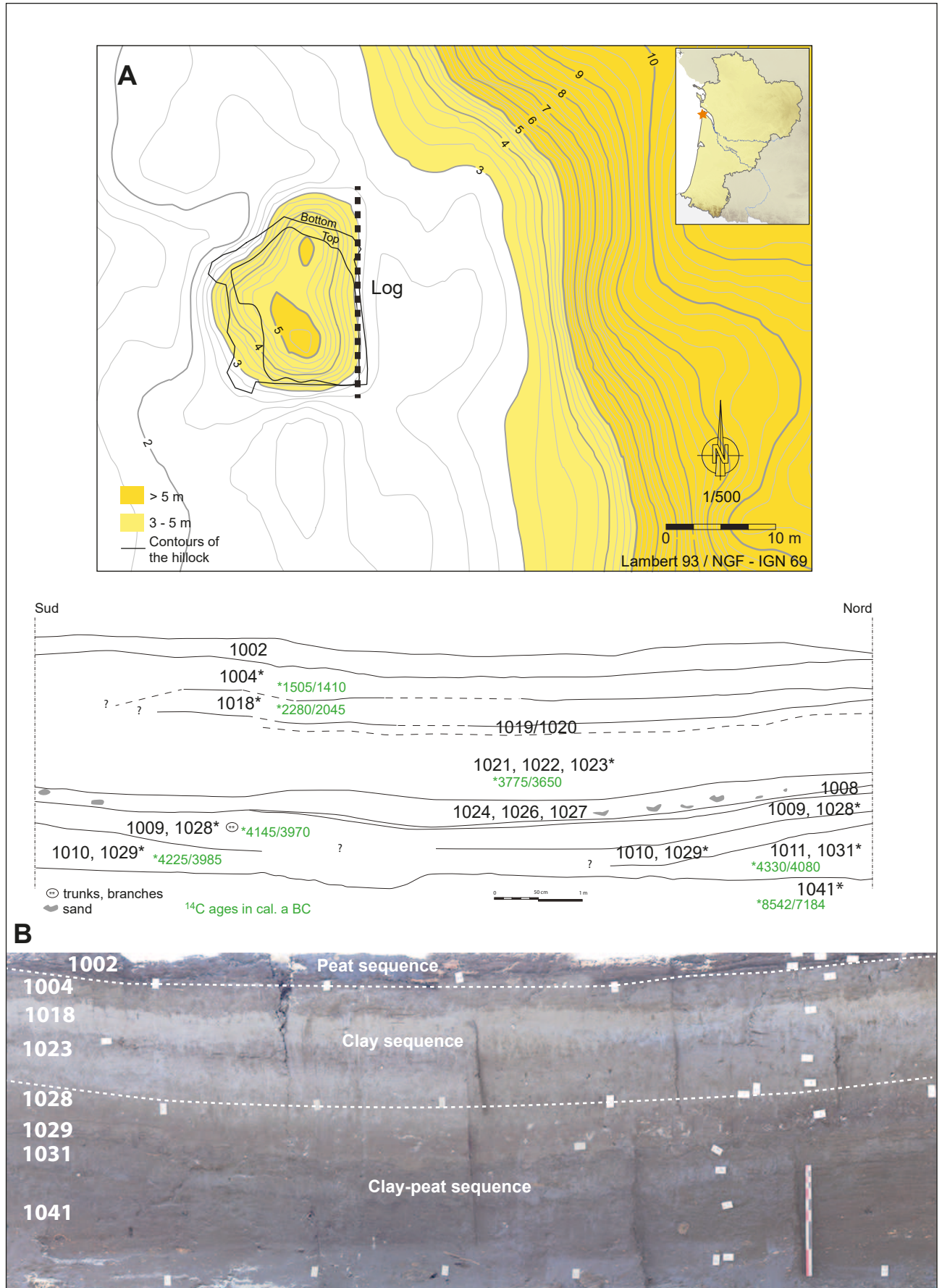


Fig. 6: La Lède du Gulp.

(A) Map (F. Bernard, Inrap). (B) Eastern stratigraphic section showing the three main sedimentary horizons and radiocarbon ages (C. Manen, E. Rousseau & F. Verdin).

Fig. 6 : La Lède du Gulp. (A) Plan (F. Bernard, Inrap). (B) Coupe stratigraphique est montrant les principales unités sédimentaires et dates radiocarbone (C. Manen, E. Rousseau & F. Verdin).

palaeobiogenetic research (Wagner *et al.*, 2018); they range between 8542 and 7184 cal. a BC (tab. 1: Vera-51327 to 51332). Two other dates, based on samples from the deepest two levels of the excavations, as part of the FAST-LITAO project under the Artemis programme, lie between 7874 and 7321 cal. a BC (tab. 1: Gif-48068 and Gif-48067). They agree generally with the eight dates indicated by J. Roussot-Larroque in equivalent horizons ranging from 8400 to 5900 cal. a BC (Roussot-Larroque, 1995, p. 76; <http://www.arar.mom.fr/banadora>). However, the latter seem to have yielded clearer evidence of human occupation than the recent excavations (Roussot-Larroque & Villes, 1988, p. 56-58; Roussot-Larroque, 1995, p. 76-80).

According to radiocarbon ages, there is then an important chronological gap in the sedimentary record regarding human artefacts from 7000 to 4300 BC (fig. 6; tab. 1). No trace of early Neolithic settlement was found in the 2014 excavation. Settlement at the site seems to have resumed only in the Middle Neolithic (Chassean), at the end of the fifth millennium (4400 and 4000 BC) and fits into the same sedimentary context as the earlier period, that is, very peaty clays, with some discrete sand inputs containing many plant remains, visually little different from the Mesolithic levels. Although the stratigraphy is quite developed, it is difficult to identify levels of occupation; surface removal highlights instead successive beds of plant remains and small pebbles. Less has been identified in the way of anthropic structures: a flat-bottomed, v-shaped pit (approximately 1.80 m in diameter at the top and 1.15 m deep), dug in the top of the upper peat horizon, may have served as a well or silo, or for extracting peat for fuel or building material. The earlier excavations report a timber-lined pit associated with a wooden latticework, scattered human bones and cattle footprints (Roussot-Larroque, 1995, p. 80-84).

5.4 - THE LATE NEOLITHIC (MATIGNONS AND PEU-RICHARD): THE MIDDLE CLAY SEQUENCE

Above the peaty formations lies a grey clayey sequence with levels containing varying amounts of silt and organic matter dated to the Late Neolithic (Faye *et al.*, 2019). These levels lie between about -2.5 and -4 m asl. The fine grain-size of the overlying clays implies sedimentation in slack water conditions, such as a marsh or wetland. The compact clays attest to a high water level. The sharp break with the underlying levels attests to a radical change in sedimentary dynamics. Ages of 4145-3970 and 3775-3650 cal. a BC have been obtained in the upper part of the clay-peat and in the lower part of the overlying clay sequence respectively. However, owing to the presence of other undated intermediate layers (fig. 6), this 300-year age difference is not sufficient to confirm the occurrence of a chronological gap. In the current state of knowledge, it is impossible to determine whether the cause of this change in sedimentary dynamics is of anthropogenic or natural origin.

At the interface, lens-shaped deposits of light-grey sand fill the wavy surface of the peat. In the past, these formations yielded animal footprints that could not be found in 2014. This level exhibits a very different facies from the others and a high concentration of sulphur, the origin of which is yet to be explained (see Faye *et al.*, 2019).

This sedimentary environment corresponds to two chrono-cultural phases. A pit in the Late Neolithic I (Matignons) deposits contains numerous cattle bones. In the Late Neolithic II (Peu-Richard), the site was much developed probably in connection with salt harvesting. Three pits dug in the clay sequence were shored up by wattle and rested on the interface between peat and sand of the Middle Neolithic.

The best conserved wattle structure (ST7) measures about 1.50 m in diameter and 0.70 m in height (fig. 7) and seems to be formed by two concentric walls separated by a clay filling. The vertical armature is made up of bundles of three to four branches between which the horizontal strands are woven, stopping just above the bottom, leaving the base of the vertical components protruding to be stuck into the ground. The basketwork therefore had no bottom. The vertical armature, which was stouter than the woven strands, is grouped by twos on the outer facing and singly on the inner facing. Lastly three long stays were inserted by force across the inner wall to brace it. The structure has been dated to between 3325 and 2940 cal. a BC (tab. 1: Beta-423524).



Fig. 7: La Lède du Gulp, wattle structure ST7 (photo F. Verdin).
Fig. 7 : La Lède du Gulp, structure en clayonnage ST7 (photo F. Verdin).

A second model (ST8) that is circular, smaller and slightly less well preserved (1 m diameter by 0.30-0.35 m high) has been found in the same chronostratigraphic context (fig. 8). Of the third wattle item (ST5) all that remained was a semi-circular section of wattle of about 1 m diameter with a vertical wall about 0.30 m high (fig. 9). At the top of the wall, a stay found in a horizontal position served to shore up the inside of the basket.

The siting of these features in pits that all reached the same sedimentary horizon and the choice of the wattle technique are indicative of structures for trapping fresh or salt water, known in several salt producing regions at different periods (Verdin *et al.*, 2018).



Fig. 8: La Lède du Gurp, wattle structure ST8 (photo F. Verdin).
Fig. 8 : La Lède du Gurp, structure en clayonnage ST8 (photo F. Verdin).



Fig. 9: La Lède du Gurp, wattle structure ST5 (photo F. Verdin).
Fig. 9 : La Lède du Gurp, structure en clayonnage ST5 (photo F. Verdin).

5.5 - THE EARLY AND MIDDLE BRONZE AGE: THE UPPERMOST PEAT SEQUENCE

The Bronze Age sequence marks another change in sedimentary dynamics with the transition from plastic grey clays, already present in the Late Neolithic and still dominant in the Early Bronze Age (2280-2045 cal. a BC: tab. 1, Beta 423541), to peat deposits containing branches and various macro-remains of plants in the Middle Bronze Age (1505-1410 cal. a BC: tab. 1, Beta-425528). The peat deposits, located at approximately -4 m asl, are indicative of wetter climatic conditions more amenable to the development of forest cover on the site itself (Faye *et al.*, 2019).

Several anthropic structures have been discovered. In the Early Bronze Age, an alignment of small closely-spaced stakes, duplicated by a row of more widely-spaced stakes, looks like a lightweight fence or a fishing structure (fig. 10). During the Middle Bronze Age, the large number of potsherds, animal bones and stone items discarded in the peatbog attest to intensive occupation. A large pit 1.10 m wide at the top and some 1.50 m deep (1917-1745 cal. a BC: tab. 1, Beta-430229) was dug, but its function remains unknown. In the sector excavated in 2014, occupation was interrupted after the Middle Bronze Age. There are no Late Bronze Age remains.

In light of the latest field operations, the most dynamic periods – from the perspective of human occupation – were therefore incontrovertibly the Middle and Late



Fig. 10: La Lède du Gurp, alignment of stakes ST2 (photo F. Verdin).
Fig. 10 : La Lède du Gurp, alignement de piquets ST2 (photo F. Verdin).

Neolithic and the Early and Middle Bronze Age. The Mesolithic and Late Bronze Age saw breaks in occupation that are reflected by stratigraphic gaps.

6 - L'AMÉLIE

The beach at L'Amélie has a thick and unbroken scatter of archaeological remains (fig. 11), visible in the intertidal zone and at the base of the dune cliffs along a 2 km stretch of coast. The stratified levels contain sites ranging from the Neolithic to the end of the Roman period which are gradually and differentially exposed by erosion depending on the topography. Thus, Roman peat soils emerge in the northern half of the beach at the base of the dune, whereas the Neolithic levels are directly exposed in the middle of the intertidal zone. In the southern half, these Neolithic levels are higher-lying, perched atop the sandy terraces cropping out beneath the dunes (unit 1: see Stéphan *et al.*, 2019) (fig. 12).

Although prospecting by volunteer archaeologists had already highlighted the same broad chronological spectrum of settlements, recent research has led to a more precise evaluation of the archaeological potential while

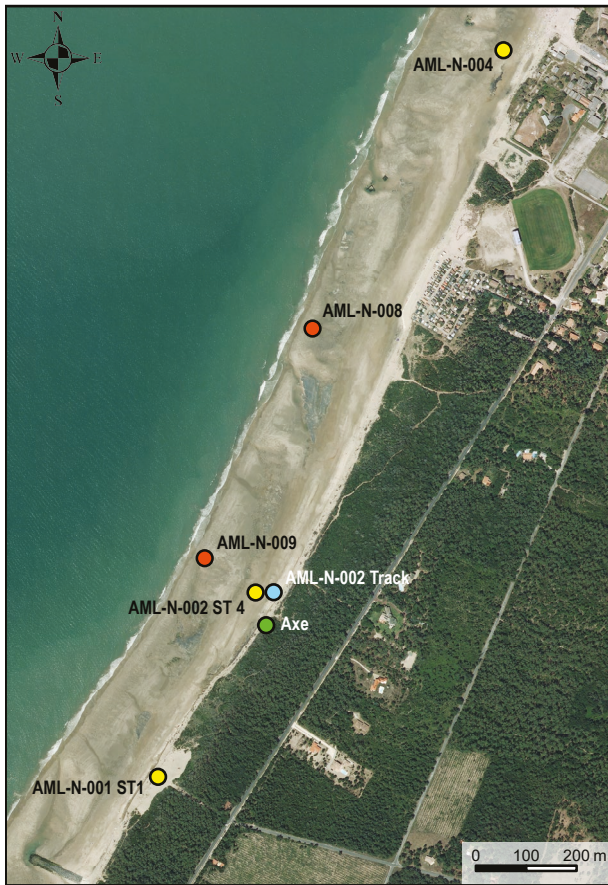


Fig. 11: L'Amélie (Soulac-sur-Mer), map of the main archaeological remains mentioned in the text (by C. Coutelier and F. Verdin; RGE Alti® - IGN).

Fig. 11 : L'Amélie (Soulac-sur-Mer), carte des principaux vestiges archéologiques mentionnés dans le texte (par C. Coutelier et F. Verdin ; RGE Alti® - IGN).

re-integrating the data acquired earlier into a general framework. The stratigraphic context of each period has been defined in relation to palaeogeographic changes and relative sea level (see Stéphan *et al.*, 2019: fig. 13), the chronological ranges have been narrowed by the study of the material combined with radiocarbon dates, and surface observations together with the excavation of several structures have made it possible to advance interpretations about the specific activities carried out in these ancient wetlands. This review of the state of our knowledge directs the new research towards more targeted scientific objectives while facilitating the choice of rescue excavation operations.

6.1 - THE NEOLITHIC (UNITS 2 AND 3)

Discoveries of Neolithic objects have long been reported by prospectors, but the LITAQ project has unearthed several structures the number and state of preservation of which were wholly unexpected, making the Middle-Late Neolithic one of the most richly documented periods in the sector.

The earliest structures are on the Pleistocene sand terraces (unit 1b, locally referred to as “grès de l'Amélie”) that topographically dominate a broad tidal channel lined by brackish marshes developing into salt meadows (units 2a, 2b, 3a). The earliest of these structures is a pit (AML-N-001 ST1) discovered in the southern part of the beach, dug into the surface of the Pleistocene terrace and topped by a horizon of grey-blue gleyed sands (unit 6) containing Bronze Age potsherds (Stéphan *et al.*, this 2019).

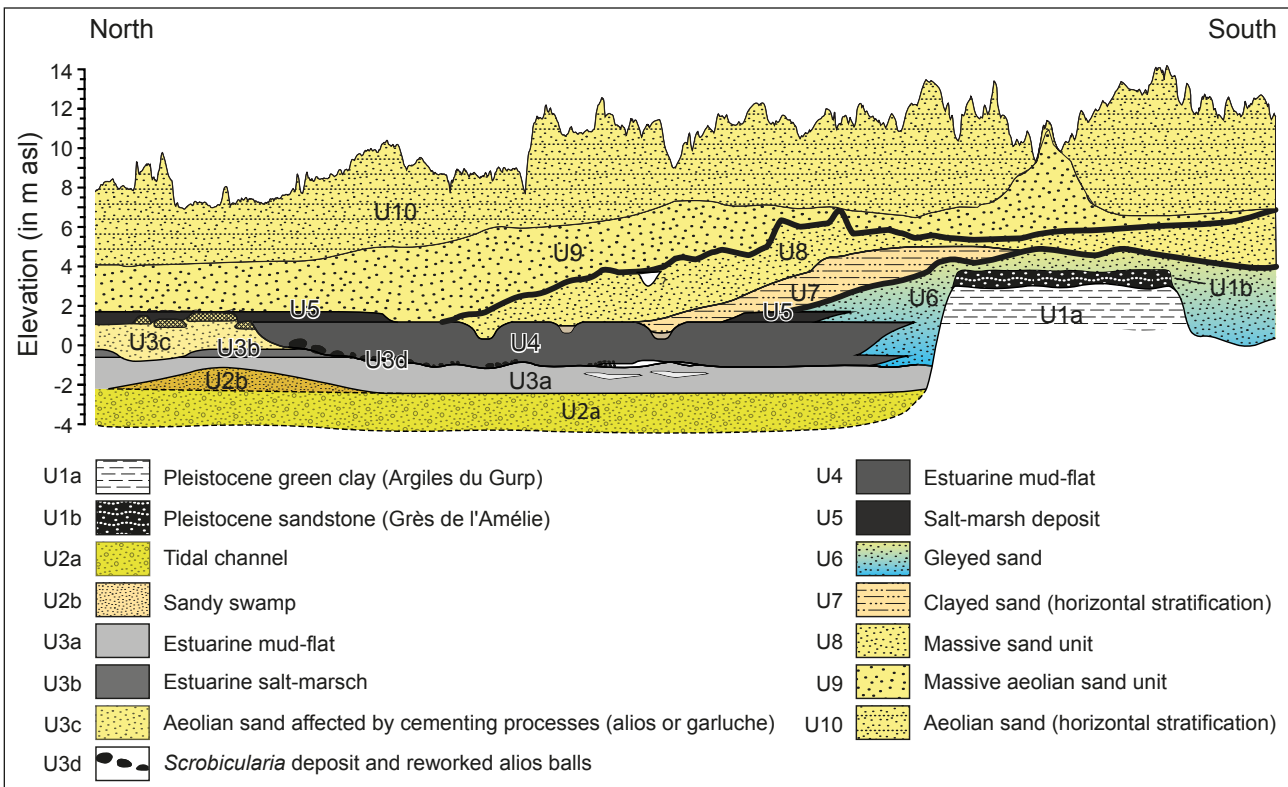


Fig. 12: Mid-Holocene sedimentary filling sequence of L'Amélie beach (Stéphan *et al.*, 2019).

Fig. 12 : Séquence de remplissage sédimentaire de la plage de l'Amélie (Stéphan *et al.*, 2019).

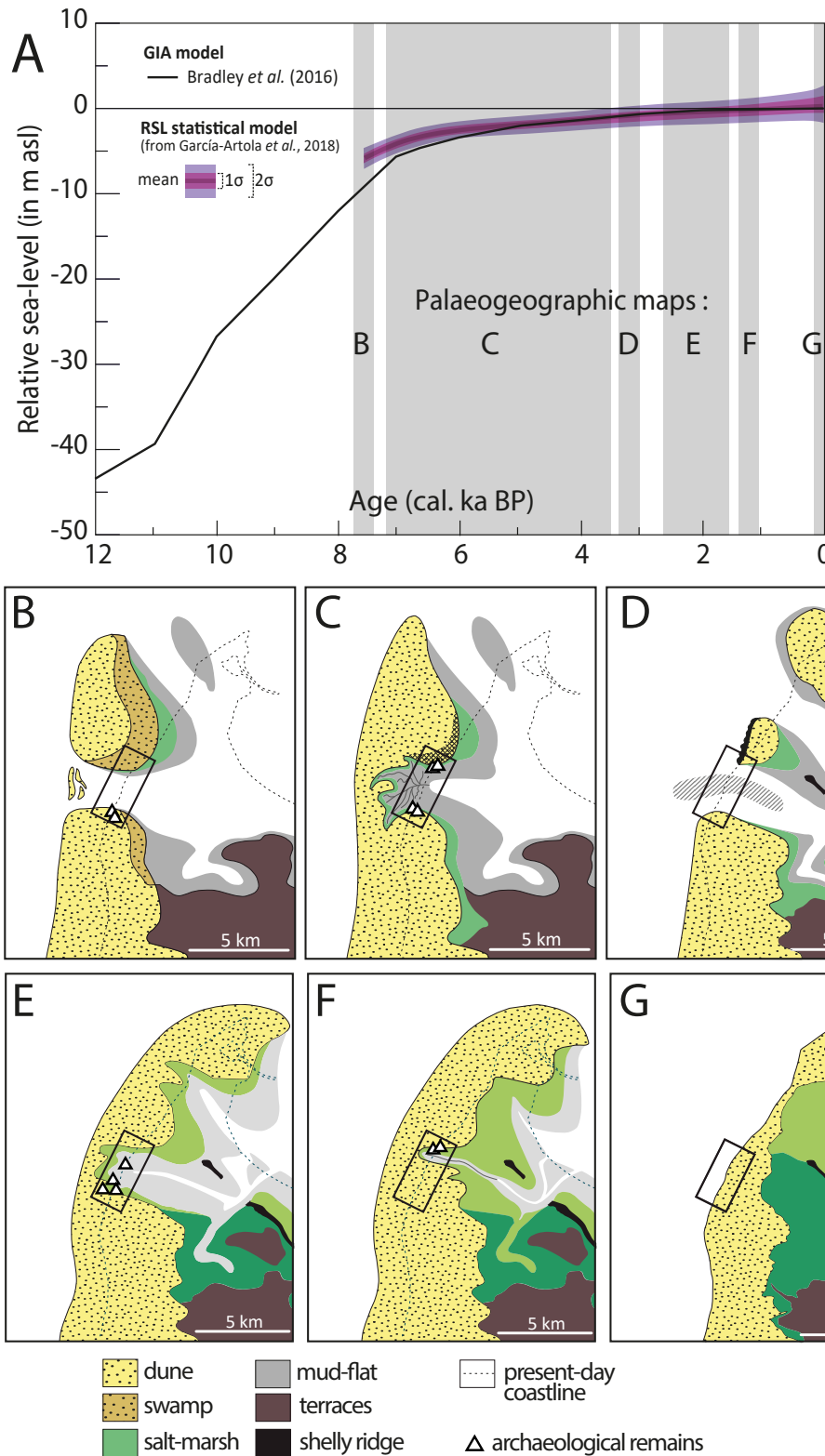


Fig. 13: Sea level rise and paleogeographical changes.

(A) RSL records produced in the LITAQ programme. (B) Mid-Holocene sedimentary filling sequence of L'Amélie beach and interpretation of associated palaeogeographical changes prior to ~7300 cal. a BP. (C) from ~7300 to 3500 cal. a BP. (D) between ~3500 and 3000 cal. a BP. (E) from ~2700 to 1640 cal. a BP. (F) from ~1640 to 1000 cal. a BP. (G) from ~1000 cal. BP to today (Stéphan et al., 2019).

Fig. 13 : Evolution du niveau marin et changements paléogéographiques. (A) Enregistrements du niveau marin relatif produits dans le programme LITAQ. (B) Séquence de remplissage sédimentaire de la plage de l'Amélie et interprétation des changements paléogéographiques associés antérieurs à ~7300 cal. BP. (C) de ~7300 à 3500 cal. BP. (D) de ~3500 à 3000 cal. BP. (E) de ~2700 à 1640 cal. BP. (F) de ~1640 à 1000 cal. BP. (G) de ~1000 cal. BP à aujourd'hui (Stéphan et al., 2019).

The pit is oval (3.70 m to 2.80 m in diameter, and 1.60 m deep relative to the present-day ground level) and has two successive types of fill. At the top, a small basin-shaped pit containing remains of combustion (fragments of reddened clay, charcoals, splinters of burnt bone, potsherds and flints). The remainder of the backfill was made up of a homogenous grey-blue sand with many small charcoals but few potsherds and flint fragments. At the bottom of the pit several more or less upright oak stakes were found, the bases of which were sharpened,

together with fragments of wood, some of which had been worked (fig. 14). The deepest post was dated 3970-3800 cal. a BC (tab. 1, Beta-448485), making it Middle Neolithic. The arrangement of stakes and the presence of forked branches suggest it was a complex structure, anchored in the pit and supporting a superstructure the form and function of which we know nothing of.

In the central stretch of the beach, a circular wattle structure (AML-N-002 ST4) has been discovered quite low in the intertidal zone (ca. -1 m asl). The wall was



Fig. 14: L'Amélie, pit AML-N-001 ST1 (photo F. Comte).
 Fig. 14 : L'Amélie, fosse AML-N-001 ST1 (photo F. Comte).



Fig. 15: L'Amélie, wattle structure AML-N-002 ST4 (photo D. Brocheriou).
 Fig. 15 : L'Amélie, structure en clayonnage AML-N-002 ST4 (photo D. Brocheriou).



Fig. 16: L'Amélie, pit AML-N-004 (photo F. Verdin).
 Fig. 16 : L'Amélie, fosse AML-N-004 (photo F. Verdin).

preserved over a height of some 30 cm and a diameter of about 1.10 m (fig. 15). The bottomless structure rested on a highly bioturbated, grey and ochre sand-clay level (unit U2b), overlying a less bioturbated grey-blue sand horizon-reminiscent of unit U1. The silty sand of Unit U2b is interpreted as the deepest fill of a large tidal channel, probably the Soulac channel according to Allen *et al.* (1974) (Stéphan *et al.*, this issue).

The technique used for the armature is strictly identical to that used for the structures at La Lède du Gurd:

the vertical stakes are assembled in groups of three and lashed together by horizontal strands. One of the strands was radiocarbon dated to 2865-2575 cal. a BC (tab. 1, Beta-448486), that is, the Late Neolithic. The interior of the structure is plugged by a compact blackish clay-peat sediment, containing at the base a tangle of shreds of wood from where the wall has crumbled away.

At the northern end of the beach, an oblong pit (1.20 m × 0.85 m) was shored up by a ring of oak stakes of 10 cm or so in diameter (AML-N-004) (fig. 16). The lower fill was made up of dark grey, clayey sand, with no archaeological material (unit 2b). One of the stakes was dated 2853-2286 cal. a BC (tab. 1, Vera-51336) corresponding to the Late Neolithic.

The function of these structures remains unclear. The presence of wattle pit bottoms similar to those at La Lède du Gurd directs interpretations towards the trapping of fresh or saltwater for salt production. The other structures could be related to the same activity, whether the storage of brine, rinsing of sands or other practices that were an integral part of the same sequence of operations. Further analyses are underway to answer these questions.

6.2 - THE BRONZE AGE (UNIT 3 AND 6)

In the Early to Middle Bronze Age (2200-1300 BC), characteristic potsherds (with plastic and cord decoration) attest to the frequentation of the entire stretch of beach; these are found in grey organic clayey-sandy horizons designated unit 3a (Stéphan *et al.*, 2019). This unit consists of intertidal estuarine sediments, located at an elevation ranging from -2.5 to -0.9 m asl, close to the lowest astronomical tide level and corresponding to the first phase of filling of the marsh.

The discovery – without a metal detector – of a Médoc type bronze axe, stuck vertically in the clay palaeosol, cutting edge up, in the vicinity of a Roman-period track was more exceptional (fig. 11). The isolated object, plainly found in a secondary position, may have been part of a deposit reworked by erosion. A few metres to the west, Bronze Age potsherds and portions of vases broken on the spot were found. However, in the current state of research, no built structure can be dated to this period.

On the southern part of the beach, the base of dune front (unit 6) contains Bronze Age ceramics too. The grain-size characteristics of this unit 6 – encountered at an elevational range from +3.2 to +5 m asl – are consistent with an aeolian origin (Stéphan *et al.*, 2019).

6.3 - THE EARLY IRON AGE (UNITS 4 AND 5)

After an interruption in the Late Bronze Age, the marshland was resettled from the Early Iron Age (eighth-sixth centuries BC). Remains have been found in units U4 (clayey-silt deposit, between -1 and +1.3 m asl) and U5 (organic-rich clayey-silt, from +0.7 to +1.8 m asl). These sedimentary units correspond to the second level of filling of the marsh (cf. Stéphan *et al.*, 2019).

6.3.1 - A bridge or pontoon

The oldest structure is built from three parallel rows of posts (AML-N-008), located at the boundary of the low tide mark and visible when the lowest spring tides occur (figs. 11, 17 & 18). While preserved over a length of 24.50 m and a width of 3 m, it is not known how far it extended to the west, now under water. However, it did not extend any further east. Some posts have tilted in the mud, others are submerged, and yet others exist only as negative prints, which gives the impression in plan view that they are not aligned. They are made of pine and their average diameter is some 20 cm. One of them has been dated to 816-544 cal. a BC (tab. 1, Vera 51402). It has a diameter of 0.17 m and the preserved height is 1.04 m; its base is sharpened and the shaft bears marks of branch removal and hewing. It is set in the fill of a palaeochannel the bed of which is a midden of *Scrobicularia* shells dated 1430-1150 cal. a BC (unit 3d: Stéphan *et al.*, 2019; Clavé, 2001, p. 161-162).



Fig. 17: L'Amélie, bridge/pontoon AML-N-008 (photo F. Verdin).
Fig. 17 : L'Amélie, pont/ponton AML-N-008 (photo F. Verdin).

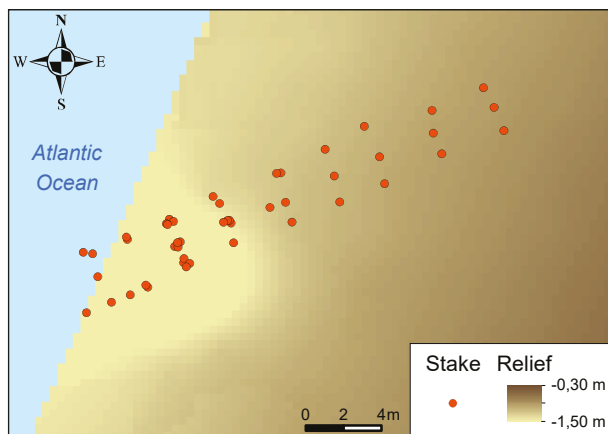


Fig. 18: L'Amélie, plan of bridge/pontoon AML-N-008 (by C. Coutelier and LETG-Brest Géomer CNRS).
Fig. 18 : L'Amélie, plan du pont/ponton AML-N-008 (by C. Coutelier et LETG-Brest Géomer CNRS).

This alignment of posts has been known since the 1980s, in the vicinity of two or three others that no longer stand out above the sand and have never been georeferenced. The very particular plan of the structure suggests a pontoon or a bridge nine piles of which are extant. Likenesses can be found with Iron Age bridges known in Switzerland, in

particular the almost contemporary Desor bridge on the La Tène site, (~ 660 BC) (Reginelli *et al.*, 2007, p. 378-380). The hypothesis of a bridge might be corroborated by the point that only the central piles were reinforced by several supporting stakes, perhaps in the location where the channel was deepest and subject to strong currents.

6.3.2 - Salt working

The clay palaeosols of the northern half of the beach belong to the second generation of marshes (unit 5). They yield many fragments of briquetage together with cast offs that ceramic studies attribute to a period ranging from the late seventh to fifth centuries BC. The organic sediment is studded with charcoals, earthenware nodules, burnt pebbles, stones and animal bones. Indications of salt production include fragments of evaporation vessels, solid or hollow supporting pillars, coarse clay pans, pieces of ovens and lenses of reworked reddened clay. All of these items, which were still visible in recent years, are gradually vanishing although they used to be very extensively scattered as far as L'Amélie and were recorded by volunteer prospectors over 20 years or so (Verdin, 2015). The same characteristic fragments of earthenware have sometimes filled postholes and pits (fig. 19).

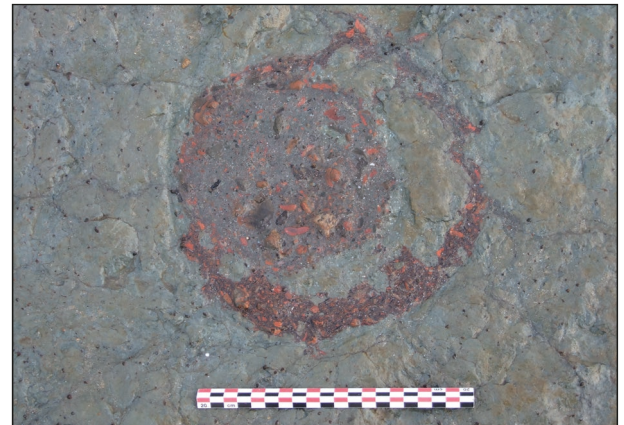


Fig. 19: L'Amélie, discarded briquetage in a post hole (photo F. Verdin).

Fig. 19 : L'Amélie, résidu de briquetage dans un trou de poteau (photo F. Verdin).

Further south, on the edge of the lowest spring tides, a highly reddened clay plaque, eroded by the sea, probably belongs to the bottom of a salt oven (AML-N-009: fig. 20). Although nothing has been discovered by which it can be dated, this type of structure matches Iron Age salt cake heating techniques.



Fig. 20: L'Amélie, salt oven AML-N-009 (photo F. Verdin).
Fig. 20 : L'Amélie, four à sel AML-N-009 (photo F. Verdin).

The soils of the period were covered by a peat formation bearing numerous tracks of animal hooves (fig. 21) that are undated here for want of material, but are dated to the Roman period in other sectors (below). In places parallel linear tracks are observed, some 1.34 m apart, resembling wheel ruts.

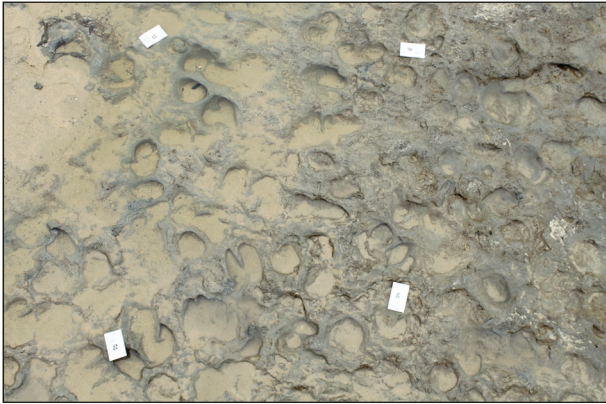


Fig. 21: L'Amélie, animal tracks (photo A. Dumas, T. Constantin).
Fig. 21 : L'Amélie, pistes et empreintes d'animaux (photo A. Dumas, T. Constantin).

6.4 - THE SECOND IRON AGE AND THE ROMAN PERIOD

After a gap corresponding to the fourth-third centuries, the settlement at the end of the Second Iron Age (second to first centuries BC) raises questions as no material remains were identified during recent prospecting.

The Roman period levels (first-fifth centuries AD) cap the second generation clays of the marshland (unit 5). Their very peaty facies contain tree stumps in life position indicating an environment with increasing plant cover. According to the foraminiferal assemblage, the environment corresponded to both a low and high marsh (Stéphan *et al.*, 2019). After this period, the salt marsh was buried by the coastal dune barrier.

The median part of the beach was crossed by a roadway in the first-second centuries AD bearing multiple rut marks (AML-N-002: figs. 11 & 22). The roadway was identified several years ago by local prospectors and was formed from two parallel tracks separated by a central reservation. In 2016, the retreat of the dune revealed a new sector of some 500 m² corresponding to a plane dark grey sandy surface compacted by use and containing numerous antique coarse ceramic potsherds, Roman amphorae (particularly Italic ones), tiles and slag. The rut marks, some 1.30 m apart, lead in different directions showing this was probably a fork in the road. Two main routes are visible over a stretch of some 20 m. One runs north-south and the other north-west-south-east. The tracks are lined and sometimes capped by a very organic peaty horizon containing stumps and roots of plants and/or shrubs as well as animal footprints.

At the northern end of the beach, levels containing material from the High Empire (first-second centuries) are interlayered with oyster deposits (unit 4), which raises the question of whether they were collected for food. Oysters, among other shellfish, were consumed



Fig. 22: L'Amélie, ancient roadway with rut marks AML-N-002 (photo Y. Ceinturet).

Fig. 22 : L'Amélie, ancien chemin creusé d'ornières AML-N-002 (photo Y. Ceinturet).

at coastal sites from the Neolithic onwards, but it was only in Roman times that they were consumed in large quantities and the subject of long-distance trade both in the Mediterranean and on the Atlantic (Bardot-Cambot, 2013; Bardot-Cambot & Forest, 2013). Ausonius (fourth century) reports that oysters of the Medulli were particularly sought after (Ausonius, *Letters*, 7). Is the Antique material evidence though of frequentation related to the collection of shellfish? It is besides highly diversified and would not be out of place in an urban setting because it includes fine earthenware (terra sigillata, thin walls), coarse ware, amphorae and coins. The forms of deposition also raise questions. Some batches are scattered in the level underlying that of the oysters whereas other are highly localized, or even included in sedimentary pockets that cannot readily be interpreted as anthropic structures.

7 - DISCUSSION

Although their topographic and taphonomic characteristics differ, La Lède du Gulp and L'Amélie exhibit the same settlement dynamics over the long run. Apart from the Mesolithic and Early Neolithic which are attested solely at La Lède du Gulp, human activities experienced the same surges and lulls in intensity. The Middle and Late Neolithic, the Early and Middle Bronze Age, the First Iron Age and the Roman period yield the most archaeological remains and correspond to "peaks" in settlement. Conversely, there

is scant material for the Mesolithic, Early and Latest Neolithic, the Late Bronze Age and the Second Iron Age, reflecting a relative decline of the area.

These observations are closely correlated with sedimentation conditions and so with environmental change: phases of sedimentation of the marshland and peatbogs facilitate the preservation of archaeological contexts whereas phases of drying and sand deposition produce thinner sedimentary horizons that are more prone to erosion. It is inferred that during wetter and milder episodes, the wet zones were a focus for human activities whereas in stormier conditions and/or when the vegetation was more degraded by human activity sand became predominant making the sector inhospitable. This observation, which has already been made for the Médoc (Roussot-Larroque, 2007), has been fully confirmed by the research under the LITAQ programme.

Comparison of recent and early research provides further information for the model giving a better understanding of the relations between societies and their environment and revealing the gaps in documentation. However, earlier archaeological data must be considered with care since chronological arguments are unsound because of the imprecision of radiocarbon dating performed in the 1990s and the potentially disturbed stratigraphic contexts.

7.1 - THE MAIN PHASES OF ATTRACTION OF WET ZONES FOR HUMAN SOCIETIES

7.1.1 - The Middle and Late Neolithic (fifth-fourth millennium BC)

The LITAQ project shows that settlement of the northern coast of the Médoc intensified from the fifth millennium onwards. Earlier evidence is scarce and poorly dated, either because settlement was anecdotal or because the submerged or deeply buried levels remain beyond our reach. The earliest anthropic structures are found at La Lède du Gulp and L'Amélie; they proliferated in the Late Neolithic with the development of salt harvesting. The discovery of several pits with wattle walls or stakes for the trapping and/or storage of fresh or saltwater is reminiscent of other analogous structures reported in the intertidal zone since the 1980s but rarely dated in the absence of any associated material. The presence of a few rare hand-built ceramic potsherds suggests an Iron Age date (Verdin, 2015).

At La Lède du Gulp, the fine grain size of the clay materials attests to calm water deposition and a phase of high water in the marshland, which was synchronous with the first generation of deposits in the estuary marshes – with which the marsh of L'Amélie connected. The relative sea level evolved from -3.0 ± 2.9 m asl at ca. 6500 cal. a BP to -1.5 ± 2.6 m asl at ca. 4700 cal. a BP (Stéphan *et al.*, 2019). For the same period, the Reysson marsh was probably open again and a high sea level is identified in the *marais poitevin* (Marambat & Roussot-Larroque, 1989, p. 88; Roussot-Larroque, 2007, p. 286; Diot *et al.*, 2001, p. 160). Pollen analyses show that the oak wood began to decline and aquatic plants to spread from the Middle Neolithic onwards, perhaps

under the growing anthropic pressure and/or the rise in the groundwater table in the Early Holocene. In the Late Neolithic the continuing retreat of the forest appears to have been concomitant with increased frequentation of the sector, with the multiplication of animal tracks, forest clearance and the spread of pastureland all being associated.

7.1.2 - The Early and Middle Bronze Age (second millennium BC)

The second major phase of occupation began in the Early Bronze Age and peaked in the Middle Bronze Age. The onset of the period is comparatively hard to ascertain because ceramic material is not very abundant and is poorly characterized compared with that of the Middle Bronze Age and because the metallic material (Palmela arrow heads, small copper axe heads) has invariably been found out of context. At La Lède du Gulp, occupation is attested as early as the Early Bronze Age by the recent excavations whereas J. Roussot-Larroque reports the site was almost deserted. The vegetation attests to alternating phases of regeneration and retreat of the forest cover.

The Middle Bronze Age saw a surge in human activities. The sediments and pollen evidence indicate a high level of marsh, which was “perhaps slightly brackish, occupied by a reed bed” (Roussot-Larroque, 2007, p. 288). The relative sea level stood approximately between ca. -1.0 ± 2.5 m asl at ca. 2900 cal. a BP and $+0.5 \pm 2.8$ m asl at 600 cal. a BP (Stéphan *et al.*, 2019). The forest cover was lastingly reduced and replaced by heathland. The presence of two trails of animal tracks (cattle, horses, sheep or goats, dogs) is evidence that the waterhole was frequented by herds and flocks. Two foundry moulds found at the site reveal there was local metal production which must have entailed substantial consumption of wood, even if no particular pressure on the forest environment has been detected from pollen diagrams (Marambat & Roussot-Larroque, 1989, p. 88; Roussot-Larroque & Villes, 1988, p. 38-39).

Signs of agricultural activity are also found 100 m or so south-east of the residual stack, on the present day cliff, in a position slightly dominating the marshland. Sealed beneath the dune system, a highly organic sand-clay horizon, indurated at depth and dated 1650-1570 cal. a BC, displays grid-like traces interpreted as ridge cultivation (Roussot-Larroque, 2007). These are evenly spaced about 0.65 m apart and delimited by regular quadrilaterals. The working of small fragments of material into the earth (Middle Bronze Age potsherds, charcoals, earthenware flakes, stones and burnt pebbles) is suggestive of soil improvement or drainage techniques over an area some 500 m long on the edge of the dune cliff.

At L'Amélie, recent observations are part of a long series of finds by volunteer researchers. Several whole vases have been unearthed, some containing Médoc axe deposits, as in 1993 when erosion and the construction of breakwaters unearthed 72 axes, i.e. 53 kg of metal (Coffyn *et al.*, 1995). Such metal deposits almost exclusively containing axes are plentiful in the Médoc.

However, their meaning is subject to debate: are they stashes of metal meant to be melted down again or symbolic offerings in wetlands? In any event they reveal a flourishing local metal industry in a region with no metal-bearing resources (tin, copper). The nearest copper and tin deposits were in Brittany, on the edges of the Massif Central, in the British Isles and in north-western Spain. The Médoc was therefore in a particularly favourable location along the major trade routes linking the Atlantic arc and the Mediterranean. The coastal marshes, which were at the time largely open to the estuary, could serve as harbours for boats on the Bay of Biscay and as off- and on-loading points where there was a switch with river transport (Roussot-Larroque, 2001, p. 262-264; Lagarde, 2012; Couderc, 2017) (fig. 3).

7.1.3 - The First Iron Age (seventh to fifth centuries BC)

The First Iron Age marks the third important phase of activity on the sites of La Lède du Gulp and L'Amélie. Although the levels for this period are no longer to be found in the part excavated in 2014, earlier research attests that La Lède du Gulp was resettled from the sixth century BC until about the fifth century, with a fresh wet episode reactivating the peatbog where aquatic plants predominated. Oak gave way lastingly to maritime pine. Funerary areas were found nearby, as evidence by a tumulus and an isolated grave (Roussot-Larroque, 2005, p. 78-79). The production of indigenous salt is attested by briquetage debris at La Lède du Gulp and substantial levels of the same type of material strewn at L'Amélie attest to the presence of a large-scale operation (Verdin, 2015). Several pits lined with planking, wattle and stakes, mentioned previously, suggest a function related to salt production, using techniques similar to those implemented in the Neolithic, in the same type of intertidal estuary marshland. The presence of a bridge in the Early Iron Age is indicative of the need to develop the area to facilitate access to it.

7.1.4 - Antiquity (first to seventh centuries)

Roman antiquity left many traces of intensive settlement of the marshland. The only site that could be interpreted as a permanent habitat is that of la pointe de la Négade, excavated in the 1970s-1980s by J. Moreau (Sion, 1994, p. 301-303). The remains located on the dunes overlooking the intertidal zone, back from what are now submerged bunkers, have been entirely destroyed by coastal erosion. The site about 1 km north of La Lède du Gulp in all likelihood superseded the latter which was gradually abandoned by the end of the Iron Age. Wooden structures, pits and a funerary area have been dated to the first and second centuries AD, but excavation conditions and the absence of any publication mean these observations are unreliable.

Below, in the intertidal zone of L'Amélie at Soulac, previous research unearthed antique ceramic material and above all large coin hoards (Verdin, 2015). It was also at L'Amélie that a brass wild-boar standard from the end of the first century BC was unearthed (Moreau *et al.*, 1990).

Unfortunately the “chance” and unofficial character of these discoveries deprives us of any interpretable context. It does not seem that salt production continued beyond the first century. Should the coins and the wild boar standard be associated with practices of deposits in wetlands, as has been contemplated for the Bronze Age axes? Recent observations argue more for areas of shellfish collection, areas of repositories and travel and transport among nearby settlement sites, before the sector was gradually covered by the dune system.

7.2 - THE PHASES OF SCANT OCCUPATION

These periods of intense frequentation of the wetlands are punctuated by chronological and sedimentary gaps that are sometimes documented only by previous excavations, and therefore difficult to understand. Only the ongoing re-examination of the material – the chronotypology of which has greatly advanced in recent years – resituated in its context in light of current research, will make it possible to refine the dating and even specify the nature of occupation.

7.2.1 - From the Mesolithic to the Early Neolithic (eighth to fifth millennia)

The dates obtained near the base of the stratigraphic sequence of La Lède du Gulp in 2014 reveal a chronological gap between 7300 and 4500 cal. a BC, also shown by earlier excavations but over a shorter time span of the order of a millennium (seventh-sixth millennia) (Roussot-Larroque & Villes, 1988, p. 56-58; Roussot-Larroque, 1995, p. 76-80). This stratigraphic gap was perhaps caused by an erosional episode. However, the skimpy archaeological clues and the variability of datings depending on the excavation sectors plead for caution as to the causes of the phenomenon which were probably far more complex.

7.2.2 - The end of the Neolithic (third millennium)

The situation of the Late Neolithic is contrasted. According to recent research at La Lède du Gulp, the transition between the end of the Neolithic and the early Bronze Age (between 2950 and 2300 cal. a BC) corresponds to a break in the sedimentary record while, in the years 1980-1990, Artenacian deposits were observed. These were thin, made up of “sometimes clayey, sometimes highly friable yellowish sands” and were intensively trampled by small ruminants (Roussot-Larroque & Villes 1988, p. 45). Pollen diagrams reveal intense anthropization of the environment through the degrading of the forest cover, the high percentage of grasses and the presence of plantain (Roussot-Larroque, 2007, p. 287). At L'Amélie settlement is attested by a pit lined by stakes (AML-N-004). It may be therefore that this period does not mark an actual decline in occupation but that its discreet nature is the result of certain horizons being eroded by causes that remain to be identified. This might also indicate a shift in the areas occupied.

7.2.3 - The end of the Bronze Age (end of the first millennium)

The gap at the end of the Bronze Age observed at La Lède du Gulp and L'Amélie has also been highlighted by previous research. After 1275-1260 BC, thick aeolian sand deposits devoid of archaeological material overlay the peatbog of La Lède du Gulp (Marambat & Roussot-Larroque, 1989, p. 88; Roussot-Larroque, 2007, p. 290). In the northern part of the beach at L'Amélie, recent research tends to confirm the impact of these climatic variations: the erosion of indurated sand formations (*alios* or *garluches*), their shaping into balls, their remobilization and deposition in the marshes by high-energy waves, reflect a major phase of retreat of the line of dunes and of erosion of the underlying levels (unit 3d: cf. Stéphan *et al.*, 2019).

At the end of the Bronze Age, between the middle of the thirteenth and the ninth centuries BC, the Médoc as a whole seems to have suddenly been void of any trace of human activity (Roussot-Larroque, 2007, p. 290-291). The worsening climate that then affected Europe at the turn of the first millennium may have been responsible in part for this phenomenon. The stratigraphic record for the Holocene reveals several phases when storms became more frequent on the Atlantic coasts of Europe, especially between 3200 and 2400 cal. a BP. (Sorrel *et al.*, 2012, 1; Van Vliet-Lanoë *et al.*, 2014, p. 448). Recurring storms and the gradual closure of outlets from the marshes to the estuary by the formation of the "cordon de Richard" (Diot & Tastet, 1995) could have greatly destabilized a socio-economic system based on the exploitation of a vulnerable environment, even if other causes probably contributed. In the current state of research, this period at the end of the first millennium is therefore the only one for which the absence of archaeological evidence can be correlated with major environmental changes that may have affected human settlement.

7.2.4 - The Second Iron Age

Occupation seems to have dwindled in the course of the Second Iron Age and shifted, after the Roman conquest, to about 1 km north of La Lède du Gulp, to the site of La Négade which grew under the High Empire. Excavation reports indicate that material can be attributed to the very end of the Iron Age (late first century BC), but no structures are mentioned. Apart from the discovery of coin hoards of the second to first century BC at L'Amélie and La Glaneuse, items from the Second Iron Age remain rare. It seems that exploitation of salt was interrupted from the end of the First Iron Age (~ fifth century BC) while it flourished on the right bank of the estuary in the second and first centuries BC (Coquillas, 2001). It may be wondered whether this phenomenon was not related to the gradual drying out of the marshes which would have forced the salt makers to move their activities to more suitable areas.

7.3 - HABITAT AND RESOURCES

Salt production was plainly the main reason for frequenting the estuary marshes during the Iron Age,

which is also true of other Atlantic regions. The development of this activity as early as the Neolithic (Ard and Weller 2012) was new in Aquitaine. The Early-Middle Bronze Age was a tipping point in this dynamic. First because it seems to mark an interruption in salt production that is not attested by any tangible indication whereas there was salt production at the same time at the dune du Pilat. Next because the dominant phenomenon is the deposition of axes, which was probably symbolic, but for which no satisfactory interpretation has been given not just for the Médoc but for Europe as a whole.

In terms of animal resources, no matter during which period, trails of tracks made by herds attest that animals grazed freely, perhaps in salt meadows, and attest to the presence of watering holes where they could drink. The potential for supply of shellfish for food seems geographically limited to the northern part of the beach at L'Amélie. At the end of the Bronze Age, middens of *Scrobicularia* (peppery furrow shells, *lavagnons*) were deposited in large quantities in the backfill of a channel, but it is unknown whether they were eaten. Oysters appear only in the levels of the Roman period. Given that archaeology and texts show they were very much sought after and consumed, it can be assumed that those of L'Amélie were collected. The intense frequentation of these areas is also obvious from the rutted tracks made by wagons.

Strong human pressure was therefore exerted on the wetlands. This implies the presence of nearby dwelling areas that must have been on the edges of the vulnerable "depressions", sheltered from storms and fluctuations in marsh water levels, probably on the Pleistocene terraces of the Garonne. Although several high spots located on the edge of the estuary are good candidates for the location of permanent settlements – the existence of which is merely assumed –, the retreat of the coastline has probably meant the disappearance of huge expanses that may well also have been ideal places. The ancient track from L'Amélie that heads towards the islet of Cordouan lighthouse proves there was probably a centre of settlement at the tip of the peninsula that is now submerged. Off the coast of Soulac, the shoal of Les Olives probably held potential for permanent settlement, as suggested by a few structures glimpsed during underwater prospection that might accredit local legends about lost cities (Vernhet, 1989).

8 - CONCLUSIONS

Interdisciplinary work as part of the LITAQ project has resulted for the first time on the Médoc coast in the development of a chrono-stratigraphic framework combining archaeological and palaeo-environmental data over the *longue durée*. It has made it possible to lay down foundations for thinking about the relations between societies and their environment and to highlight the means of exploiting resources specific to such estuarine environments.

The archaeological and natural heritage has proved to be richer than ever suspected before and underestimated.

Promising lines of research are opening across all domains and for all periods. The data gathered now call for verification and closer study in order to refine our interpretative models. Among the promising perspectives related to the exceptional conservation of certain items, the study of organic materials should be pursued so as to better understand the changes in vegetation and the exploitation of forest resources. Sampling of the many timber pieces will serve as a basis for compiling a dendrochronological reference scheme. The combined study of animal tracks, insects and parasites will shed new light on the local fauna, both domesticated and wild, and its state of health. Let us hope, then, that this rich coastal heritage, doomed because of the quickening pace of coastal retreat under the effects of global change, will not be swallowed up before it can be studied thanks to the development of suitable rescue archaeology techniques for these particular contexts.

ACKNOWLEDGEMENTS

This study was initiated and supported by the LITAO project («Du Pléistocène à l'Anthropocène : connaître les mécanismes passés d'évolution des populations - végétales, animales, humaines - et des milieux pour prédire les réponses futures. L'exemple du Littoral Aquitain», inter - Cluster of Excellence COTE and LaScArBx - ANR-10-LABX-45), funded by the Agence Nationale de la Recherche under the Programme Investissement d'Avenir (reference ANR-10-IDEX-03-02). The authors would like to thank other Project LITAO members for fruitful contributions: Pascal Bertran (UMR 5199 PACEA), Anne Colin (UMR 5607 Ausonius), Stéphane Costa (UMR 6554 LETG), Antoine Kremer (UMR 2012 Biogeco), Nathalie Prévôt (UMR 5607 Ausonius). They are also grateful to the team of volunteer prospectors and students for monitoring erosion of these sites: D. Brocheriou, Y. Ceinturet, N. Dickès, R. Lopes, O. Mornon and M. Seutin; to all those who played active parts in the field and post-excavation missions: M. Bernier, I. Carrère, E. Defranould, A. Dumas, B. Ephrem, A. Hoffmann, T. Mauduit, E. Rousseau; and to SRA Nouvelle-Aquitaine, DRASSM, LabEx LaScArBx and UMR Ausonius. Thanks to Christopher Sutcliffe for translation of this paper.

REFERENCES

- ALLEN G.P., BOUCHET J.-M., CARBONEL P., CASTAING P., GAYET J., GONTHIER E., JOUANNEAU J.-M., KLINGEBIELA., LATOUCHE C., LEGIGAN P., ORGERON C., PUJOS M., TESSON M. & VERNETTE G., 1974 - Environnements et processus sédimentaires sur le littoral nord-Aquitain. *Bulletin de l'Institut de géologie du Bassin d'Aquitaine*, **15**, 3-183.
- ARD V. & WELLER O., 2012 - La céramique. 2. Les vases de « type Champ-Durand » : témoins d'une exploitation du sel au Néolithique récent dans le Marais poitevin. In R. Jousaume (ed.), *L'enceinte néolithique de Champ-Durand à Nieul-sur-l'Autise (Vendée)*. Association des Publications Chauvinoises, Chauvigny, 319-343.
- BARDOT-CAMBOT A., 2013 - *Les coquillages marins en Gaule romaine. Approche socio-économique et socio-culturelle*. BAR International Series 2481. Archaeopress, Oxford, 275 p.
- BARDOT-CAMBOT A., & FOREST V., 2013 - Ostréiculture et mytiliculture à l'époque romaine? Des définitions modernes à l'épreuve de l'archéologie. *Revue archéologique*, **2** (56), 367-388.
- BEAUVAL C., MICHEL P., BOSQ M., BERTRAN P., LACRAMPE-CUYAUBÈRE F. & PASTY S., 2019 - A new straight-tusked elephant tooth from Soulac-sur-Mer (Gironde, France). Review of elephant discoveries in the Northern Médoc. *Quaternaire*, **30**, 21-30.
- BOSQ M., BERTRAN P., BEAUVAL C., KREUTZER S., DUVAL M., BARTZ M., MERCIER N., SITZIA L. & STÉPHAN P., 2019 - Stratigraphy and chronology of Pleistocene coastal deposits in northern Aquitaine, France : a reinvestigation. *Quaternaire*, **30**, 5-20.
- BUFFAULT P., 1942 - *Histoire des dunes maritimes de Gascogne*. Editions Delmas, Bordeaux, 446 p.
- CASTELLE B., GUILLOT B., MARIEU V., CHAUMILLON É., HANQUIEZ V., BUJAN S. & POPPESCHI C., 2018 - Spatial and temporal patterns of shoreline change of a 280-km high energy disrupted sandy coast from 1950 to 2014: SW France. *Estuarine, Coastal and Shelf Science*, **200**, 212-223.
- CLARKE M., RENDELL H., PYE K., TASTET J.-P., PONTEE N.I. & MASSÉ L., 1999 - Evidence for the timing of dune development on the Aquitaine coast, south-west France. *Zeitschrift für Geomorphologie*, **VI** (116), 147-163.
- CLARKE M., RENDELL H., TASTET J.-P., CLAVÉ B. & MASSÉ L., 2002 - Late-Holocene sand invasion and North Atlantic storminess along the Aquitaine Coast, southwest France. *The Holocene*, **12** (2), 231-238.
- CLAVÉ B., 2001 - *Évolution des paléo-environnements côtiers à l'Holocène : l'exemple de l'Aquitaine septentrionale*. Thèse de Doctorat, Université Bordeaux 1, Bordeaux, 310 p.
- COFFYN A., MOREAU J. & BOURHIS J.-R., 1995 - Les dépôts de Bronze de Soulac-sur-Mer (Gironde). *Aquitania*, **13**, 7-31.
- COQUILLAS D., 2001 - *Les rivages de l'estuaire de la Gironde du Néolithique au Moyen Âge*. Thèse de Doctorat, Université Bordeaux Montaigne, Bordeaux, 1296 p.
- COUDERC F., 2017 - Synthèse sur la pratique des dépôts métalliques au Bronze moyen en Médoc. *Bulletin de la Société Préhistorique Française*, **114** (3), 553-572.
- COURRÈGES M., 1997 - Le crypto-karst de la péninsule du Médoc. Crypto-altération, dissolution, karst sous-marin et évolution quaternaire. *Quaternaire*, **8** (2), 289-304.
- DIOT M.-F., 1999 - Le Pléistocène de la façade atlantique du Nord-Médoc (France) : synthèse sur la palynologie des « Argiles du Gupr » s.l. et comparaison avec les données de l'Aquitaine. *Quaternaire*, **10** (2-3), 213-225.
- DIOT M.-F. & TASTET J.-P., 1995 - Paléo-environnements holocènes et limites chronoclimatiques enregistrés dans un marais estuarien de la Gironde (France) [Holocene paleo-environments and chrono-climatic limits recorded in a reclaimed marsh of the Gironde estuary (France)]. *Quaternaire*, **6** (2), 63-75. doi : 10.3406/quate.1995.2039.
- DIOT M.-F., MARAMBAT L., MASSÉ L. & TASTET J.-P., 2001 - Etude palynologique du remplissage holocène du marais de Reysson, rive gauche de la Gironde, Nord-Médoc (France). Relations avec l'occupation humaine. In J. L'Helgouach & J. Briard (eds), *Systèmes fluviaux, estuaires et implantations humaines de la Préhistoire aux grandes invasions : actes du 12^e Congrès national des sociétés historiques et scientifiques, Section de pré- et protohistoire, Nantes 1999*. CTHS, Paris, 143-162.
- DUBREUILH J., CAPDEVILLE J.-P., FARJANEL G., KARNAY G., PLATEL J.-P. & SIMON-COINÇON, 1995 - Dynamique d'un comblement continental néogène et quaternaire : l'exemple du bassin d'Aquitaine. *Géologie de la France*, **4**, 3-26.
- FABRE A., 1939 - *Les terrains de revêtement du Médoc*. E. Drouillard, Bordeaux, 344 p.
- FAYE S., EYNAUD F., BOSQ M., LAMBERT C., VERDIN F., VEQUAUD P., LODYGA O., DÉRNIENNIC H., LEBLEU P., BUJAN S., BILLY I., MARTIN B. & ROUSSOT-LARROQUE J., 2019 - Holocene palaeoenvironmental evolution of the Médoc peninsula (SW France) : insights from the sedimentological study of the "Lède du Gupr" archaeological site. *Quaternaire*, **30**, 31-46.
- JACQUES P. (dir.), 2013 - *Histoire de La Teste de Buch : mythes et réalités*. Association des Amis de la préfiguration du musée maritime et forestier de La Teste de Buch, La Teste, 80 p.
- LAGARDE C., 2012 - *Production métallique en Aquitaine à l'âge du Bronze moyen : techniques, usages et circulation*. Thèse de doctorat, Université Bordeaux Montaigne, Bordeaux, 401 p.

- MARAMBAT L. & ROUSSOT-LARROQUE J., 1989 - Paysage végétal et occupations humaines sur la côte atlantique : l'exemple de la Lède du Gulp. *Bulletin de l'Association française pour l'Étude du Quaternaire*, 26 (2), 73-89.
- MARIONNAUD J.-M., avec la collaboration de DUBREUILH J., 1972 - Carte géologique de la France à 1/50000 (n°729-730), St-Vivien-de-Médoc, Soulac-sur-mer (XIII-33 et XIV-33). Notice explicative. Bureau de Recherches Géologiques et Minières, Orléans, 45 p.
- MAURIN B., 1998 - 3000 ans sous les eaux. Vingt ans de fouilles archéologiques dans le lac de Sanguinet. Gaïa, Larbey, 122 p.
- MOREAU J., BOUDET R. & SCHAAF V. 1990 - Un sanglier-enseigne gaulois à Soulac-sur-Mer. *Archäologisches Korrespondenzblatt*, 20, 439-442.
- PONTEE N.I., TASTET J.-P. & MASSÉ L., 1998 - Morphosedimentary evidence of Holocene coastal changes near the mouth of the Gironde and on the Medoc Peninsula, SW France. *Oceanologica Acta*, 21 (2), 243-261.
- REGINELLI G., BECZE-DEÁK J. & GASSMAN P., 2007 - La Tène revisitée en 2003 : résultats préliminaires et perspectives. In P. Barral, A. Daubigney, C. Dunning, G. Kaenel & M.J. Roulière-Lambert (eds.), *L'âge du Fer dans l'arc jurassien et ses marges. Dépôts, lieux sacrés et territorialité à l'âge du Fer : actes du XXIX^e colloque international de l'AFEAF, Bienne, 5-8 mai 2005, volume 1*. Annales Littéraires de l'Université de Franche-Comté, série Environnement, société et archéologie. Presses universitaires de Franche-Comté, Besançon, 373-389.
- ROUSSOT-LARROQUE J., 1995 - La séquence néolithique de la Lède du Gulp et sa chronologie. In C. Billard & M. Lemerrier (eds), *Actes du 20^{ème} colloque interrégional sur le Néolithique, Evreux 1993*. Revue Archéologique de l'Ouest, 7. PUR, Rennes, 75-87.
- ROUSSOT-LARROQUE J., 2001 - Bronze moyen et final autour de l'estuaire de la Gironde. In J. L'Hélégouach & J. Briard (eds), *Systèmes fluviaux, estuaires et implantations humaines de la Préhistoire aux grandes invasions : actes du 124^e Congrès national des sociétés historiques et scientifiques, Section de pré- et protohistoire, Nantes 1999*. CTHS, Paris, 253-271.
- ROUSSOT-LARROQUE J. 2005 - Le Premier âge du Fer (ou époque de Hallstatt). La protohistoire de la Gironde. In M. Figeac (ed.), *La Gironde de la Préhistoire à nos jours*. L'Histoire des départements de la France, Editions J.-M. Bordessoules, St-Simon de Pellouaille, 72-83.
- ROUSSOT-LARROQUE J., 2007 - Le temps qui passe et le temps qu'il fait : emprises et déprises agricoles en Médoc durant l'Âge du Bronze. In H. Richard, M. Magny & C. Mordant (eds), *Environnements et cultures à l'Âge du Bronze en Europe occidentale, actes du 129^e Congrès national des sociétés historiques et scientifiques, Section de pré- et protohistoire, Besançon, avril 2004*. Documents préhistoriques, 21. CTHS, Paris, 285-293.
- ROUSSOT-LARROQUE J. & VILLES A. 1988 - Fouilles pré- et protohistoriques à la Lède du Gulp (Grayan-et-l'Hôpital, Gironde). *Revue Archéologique de Bordeaux*, 79, 19-60.
- SION H., 1994 - Carte archéologique de la Gaule. La Gironde, 33/1. Editions de la Maison des sciences de l'homme, Paris, 360 p.
- SORREL P., DEBRET M., BILLEAUD I., JACCARD S. L., MCMANUS J.F. & TESSIER B., 2012 - Persistent non-solar forcing of Holocene storm dynamics in coastal sedimentary archives. *Nature Geoscience*, 5, 892-896.
- STÉPHAN P. & GOSLIN J., 2014 - Evolution du niveau marin relatif à l'Holocène le long des côtes françaises de l'Atlantique et de la Manche : réactualisation des données par la méthode des « sea-level index points ». *Quaternaire*, 25 (4), 295-312.
- STÉPHAN P., VERDIN F., ARNAUD-FASSETTA G., BERTRAND F., EYNAUD F., GARCÍA-ARTOLAA., BOSQ M., CULIOLI C., SUANEZ S., COUTELIER C., BERTRAN P. & COSTA S., 2019 - Holocene coastal changes along the Gironde estuary (SW France): new insights from the north Médoc peninsula beach/dune system. *Quaternaire*, 30, 47-75.
- TASTET J.-P., 1998 - Chronologie et cartographie d'un complexe dunaire côtier holocène, l'exemple aquitain du Nord-Médoc (France). *Quaternaire*, 9 (3), 157-167.
- TASTET J.-P., BURNOUF J., DIOT M.-F. & CARBONEL P. 1996 - Morphologie, paysages et occupation du sol entre Atlantique et Gironde aux époques historiques. In M. Colardelle (ed.), *L'homme et la nature au Moyen Âge, paléoenvironnement des sociétés occidentales : actes du 5^e Congrès international d'archéologie médiévale, Grenoble, 6-9 octobre 1993*. Errance, Paris, 206-211.
- VAN VLIET-LANOË B., GOSLIN J., HALLÉGOUËT B., HÉNAFFA., DELACOURT C., FERNANEA., FRANZETTINI., LE CORNEC E., LE ROY P. & PENAUD A., 2014 - Middle-to late-Holocene storminess in Brittany (NW France): Part II – The chronology of events and climate forcing. *The Holocene*, 24, 434-453.
- VERDIN F., 2015 - Habiter les marais estuariens à l'âge du Fer : quelques exemples en Médoc. *Aquitania*, 31, 85-106.
- VERDIN F., ARD V., CARRÈRE I., EYNAUD F., HOFFMANN A., MANEN C., MARCHAND G. & SAINT-SEVER G., 2018 - Nouvelles recherches sur le site de la Lède du Gulp (Grayan-et-l'Hôpital, Gironde) : résultats préliminaires. In P. Marticorena, V. Ard, A. Hasler, J. Cauliez, C. Gilibert & I. Sénépart (eds.), « Entre deux mers » et actualité de la recherche : actes des 12^e Rencontres Méridionales de Préhistoire Récente, Bayonne (Pyrénées-Atlantiques) - du 27 septembre au 1^{er} octobre 2016. Archives d'Ecologie Préhistorique, Toulouse, 209-220.
- VERNHET E., 1989 - Essai de prospection sous-marine sur le littoral nord-médocain. In Soulac et les pays médocains : Actes du XLI^e Congrès d'études régionales de la fédération historique du Sud-Ouest, Soulac, Pauillac, Saint-Germain-d'Esteuil, 16 et 17 avril 1988. Fédération historique du Sud-Ouest, Bordeaux, 151-156.
- WAGNER S., LAGANE, F., SEGUIN-ORLANDO A., SCHUBERT M., LEROY T., GUICHOUX, E., CHANCEREL E., BECH-HEBELSTRUP I., BERNARD V., BILLARD C., BILLAUD Y., BOLLIGER M., CROUTSCH C., CUFAR K., HEUSSNER K.-U., KÖNINGER J., LANGENEGGER F., EYNAUD F., LEROY F., LIMA C., MARTINELLI N., MOMBER G., BILLAMBOZ A., NELLE O., PALOMO A., PIQUE R., RAMSTEIN M., SCHWEICHEL R., STÄUBLE H., TEGEL W., TERRADAS X., VERDIN F., PLOMION C., KREMER A. & ORLANDO L., 2018 - High-Throughput DNA sequencing of ancient wood. *Molecular Ecology*, 27 (5), 1138-1154. doi: 10.1111/mec.14514.